Agenda Item G.1
Situation Summary
September 2013

# NATIONAL MARINE FISHERIES SERVICE REPORT

National Marine Fisheries Service (NMFS) Northwest Region will briefly report on recent regulatory developments relevant to groundfish fisheries and issues of interest to the Council.

NMFS Northwest Fisheries Science Center (NWFSC) will also briefly report on groundfish-related science and research activities.

**Council Task:**

**Discussion.**

Reference Materials:

1. Agenda Item G.1.b, Attachment 1: *Federal Register* Notices Published Since the Last Council Meeting.

Agenda Order:

a. Agenda Item Overview — Kelly Ames
b. Regulatory Activities — Frank Lockhart
c. Northwest Fisheries Science Center Activities — John Stein and Michelle McClure
d. Reports and Comments of Advisory Bodies and Management Entities
e. Public Comment
f. Council Discussion

PFMC
08/09/13

**Groundfish and Halibut Notices**
**5/30/13 through 8/21/2013**

**Documents available at NMFS Sustainable Fisheries Groundfish Web Site**
**http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/index.cfm**

78 FR 43125. Pacific Coast Groundfish Fishery Management Plan: Commercial, Limited Entry Pacific Coast Groundfish Fishery; Program Improvement and Enhancement - 7/19/13

78 FR49190. Pacific Coast Groundfish Fishery Management Plan: Biennial Specifications and Management Measures; Inseason Adjustments - 8/13/13

**UNITED STATES DEPARTMENT OF COMMERCE**

**NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION**

In the Matter of:

**Jason Robinson and**
**Shane William Robinson,**

Respondents.

Docket Number:

**SW1002974, F/V Risa Lynn**

## INITIAL DECISION AND ORDER

**Date**: August 29, 2013

**Before**: Susan L. Biro, Chief Administrative Law Judge, U.S. EPA[1]

**Appearances**: For the Agency:

Paul A. Ortiz, Esquire
Office of General Counsel for Enforcement and Litigation, Southwest Region
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
501 West Ocean Boulevard, Suite 4470
Long Beach, CA 90802

For Respondents:

Robert L. Brace, Esquire
Hollister & Brace
1126 Santa Barbara Street
Santa Barbara, CA 93101

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[1] The Administrative Law Judges of the United States Environmental Protection Agency are authorized to hear cases pending before the National Oceanic and Atmospheric Administration pursuant to an Interagency Agreement effective for a period beginning September 8, 2011.

## I. PROCEDURAL HISTORY

On April 23, 2012, counsel for the National Oceanic and Atmospheric Administration ("NOAA" or the "Agency"), on behalf of the Secretary of Commerce, instituted this action by issuing a Notice of Violation and Assessment of Administrative Penalty ("NOVA") to Jason Robinson and Shane William Robinson ("Respondents"). The NOVA charges Respondents in one count with violating the Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1857(1)(A), and Agency regulations at 50 C.F.R. § 660.306(h)(4), by operating the fishing vessel ("F/V") "Risa Lynn inside a Rockfish Conservation Area while having non-trawl gear on board, not being registered to a limited entry permit, while retaining groundfish, and not continuously transiting the Rockfish Conservation Area." NOVA at 2. The NOVA proposes the assessment of a civil penalty of $17,345 for the violation. NOVA at 3.

On May 22, 2012, Respondents, acting pro se, filed a notice of denial and hearing request, which the Agency forwarded to this Tribunal on May 29, 2012. On May 30, 2012, the undersigned issued an Assignment of Administrative Law Judge and Order to Submit Preliminary Positions on Issues and Procedures (PPIP) ("PPIP Order"). In the PPIP Order, the parties were directed to submit their PPIPs in accordance with 15 C.F.R. § 904.240 no later than June 29, 2012. By orders dated June 26, 2012, and August 24, 2012, the filing deadline was subsequently extended twice at the request of the parties. The parties then completed the PPIP process and on October 16, 2012, a Hearing Order was issued setting forth deadlines for the filing of any additional discovery motions, joint stipulations, or prehearing briefs, and scheduling the hearing for February 5, 2013.

On October 16, 2012, the Agency filed a Motion for Issuance of Subpoena for Matthew Heasley ("Subpoena Motion"), requesting that the undersigned order Mr. Heasley to appear for a telephonic deposition. Respondents had identified Mr. Heasley, the operations manager at Faria Watchdog, Inc., as a potential witness in their PPIP filed on August 23, 2012. Respondents did not oppose the request, and by order dated November 1, 2012, the Subpoena Motion was granted in part, allowing Mr. Heasley's deposition to be taken, and denied in part as to the issuance of a subpoena. Also on November 1, 2012, attorney Robert L. Brace of Hillister & Brace, filed a Notice of Appearance on Respondents' behalf.

On December 6, 2012, the Agency filed a Notice of Amendment to Agency Pleading amending "the NOVA to specify that the Respondents' actions on the date of violation included the retention or possession of groundfish within the U.S. Exclusive Economic Zone (EEZ)," and to provide the complete language of the relevant regulatory prohibition at 50 C.F.R. § 660.306(h)(4). Notice of Am. to Agency Pleading at 1.

By order dated January 10, 2013, the parties' Joint Motion Requesting a Change of Hearing Date was granted and the hearing in this matter was postponed and rescheduled to begin on April 9, 2013. The parties subsequently filed a Joint Motion for Additional Discovery requesting leave to take a second deposition of Matthew Heasley, as well as the telephonic deposition of Joseph Albert, whom the Agency had listed in its PPIP as a potential witness on the "structure and operation of the VMS [Vessel Monitoring System] program." Agency PPIP at 12. By order dated January 30, 2013, the Joint Motion for Additional Discovery was granted.

Respondents filed a Pre-Hearing Brief on March 22, 2013. On March 25, 2013, the parties filed a Joint Stipulation to Facts and Admission of Evidence ("Stipulations" or "Stips."). A Protective Order was issued, sua sponte, by this Tribunal on April 19, 2013, in regard to the disclosure of certain sensitive personal information relating to one of the named Respondents in a proposed hearing exhibit. The parties were given until April 29, 2013 to set aside or revise the Protective Order for cause, but neither party did so.

The hearing of this matter was held in Ventura, California, on April 9, 2013. A copy of the transcript of the hearing was received on April 23, 2013.[2] At the hearing, the Agency offered the testimony of two witnesses, William Struble and Joseph Albert, and the Respondents offered the testimony of two witnesses, Jason Robinson and Don Radon. A total of thirty-two exhibits were admitted into the record, consisting of two Court Exhibits, twenty-seven Joint Exhibits, and two Agency exhibits.[3] Tr. 6–7, 9, 74, 301, 305–06.

On April 26, 2013, this Tribunal issued an Order Scheduling Post-Hearing Briefs. Thereafter, on May 15, 2013, the parties filed a Joint Motion to Conform Hearing Transcript to Testimony, which was granted by order dated May 20, 2013. The parties filed their initial post-hearing briefs on May 31, 2013. The Agency filed its reply brief on June 17, 2013, and Respondents filed their reply brief one day later on June 18, 2013. With those filings, the record closed.

## II. THE LAW AND REGULATIONS APPLICABLE TO LIABILITY

Finding that a "national program for the conservation and management of the fishery resources of the United States is necessary to prevent overfishing, to rebuild overfished stocks, to insure conservation, to facilitate long-term protection of essential fish habitats, and to realize the full potential of the Nation's fishery resources," in 1976, Congress enacted the Fishery Conservation and Management Act ("the Act") (later amended and renamed the Magnuson-Stevens Fishery Conservation and Management Act) (codified as amended at 16 U.S.C. § 1801–1891d). 16 U.S.C. § 1801(a)(6); *see* Pub. L. No. 94-265, 90 Stat. 331 (1976); Pub. L. No. 96-561, 94 Stat. 3275 (1980); Pub. L. No. 104-297, 110 Stat. 3559 (1996); Pub. L. No. 109-479, 120 Stat. 3575 (2007) (reauthorization). The purpose of the Act is "to promote domestic commercial and recreational fishing under sound conservation and management principles" and "to provide for the preparation and implementation, in accordance with national standards, of fishery

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[2] Citations to the transcript are hereinafter abbreviated "Tr."

[3] The parties' Stipulations filed on March 25, 2013 were marked and admitted at hearing as Court Exhibit 1. Tr. 5. Court Exhibit 2 is a list of common acronyms and terms prepared by the Agency for the court reporter. Tr. 8–9. The Court's Exhibits are hereinafter cited as Ct. Ex. 1 and Ct. Ex. 2. The parties' twenty-eight Joint Exhibits and the Agency's two additional exhibits admitted into the record at hearing are hereinafter cited as "Jt. Ex." and "Agency Ex.," respectively.

management plans which will achieve and maintain, on a continuing basis, the optimum yield from each fishery." 16 U.S.C. § 1801(b)(3)–(4); *see also* Jt. Ex. 13. Under the Act, "[i]t is unlawful . . . for any person. . . to violate any provision of [the Act] or any regulation or permit issued pursuant to this [Act]."[4] 16 U.S.C. § 1857.

The Pacific Coast Groundfish Fishery regulations that were issued pursuant to the Act,[5] were in effect in May 2010, and were set forth in 50 C.F.R. Part 660 (2009),[6] provided in pertinent part as follows:

> [I]t is unlawful for any person to:
>
> . . . .
>
> (4) Operate any vessel in an applicable GCA [(Groundfish Conservation Area)] (as defined at § 660.383(c)) that has non-trawl gear onboard and is not registered to a limited entry permit on a trip in which the vessel is used to take and retain or possess groundfish in the EEZ [(Exclusive Economic Zone)] . . . except for

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[4] The Act provides, in pertinent part, that "[a]ny person who is found . . . to have committed an act prohibited by section 1857 of this title shall be liable to the United States for a civil penalty." 16 U.S.C. § 1858(a). At the time of the alleged violation, the maximum civil penalty for each violation was $130,000, as adjusted for inflation pursuant to the Federal Civil Penalties Inflation Adjustment Act of 1990, Pub. L. No. 101-410, 104 Stat. 890 (1990), as amended by the Debt Collection Improvement Act of 1996, Pub. L. No. 104-134, 110 Stat. 1321 (1996). 15 C.F.R. § 6.4(e)(14).

[5] The Pacific Coast Groundfish Fishery extends 200 miles into the Pacific Ocean (the U.S. "Exclusive Economic Zone" ("EEZ")), from the coasts of California, Oregon, and Washington, and includes more than ninety species of "groundfish," i.e. those that dwell near the sea floor. *Pac. Coast Fed'n of Fishermen's Ass'ns v. Blank*, 693 F.3d 1084, 1088 (9th Cir. 2012); 18 U.S.C. § 1602(11); 50 C.F.R. §§ 660.301, 660.302; Jt. Ex. 12 at 2 (defining "Fishery management area"); Tr. 35; Ct Ex. 2.

[6] The violation at issue here is alleged to have occurred on May 17, 2010, and the Agency's Prehearing Exchange cites to the 2010 edition of the Code of Federal Regulations in regard to the provision allegedly violated (50 C.F.R. § 660.306). However, section 50 C.F.R. § 660.306 does not appear in the 2010 edition of the Code, perhaps due to the fact that at that point in time NOAA was in the process of restructuring the entire Pacific Ground Coast regulations at 50 C.F.R. Part 660, including distributing the prohibitions in section 660.306 among five new regulatory provisions (50 C.F.R. §§ 660.12, 660.112, 660.212, 660.312, and 660.352). *See*, Pacific Coast Groundfish Fishery Management Plan, 75 Fed. Reg. 32,994, 33,016 (Jun. 10, 2010) (proposed rule); Pacific Coast Groundfish Fishery Management Plan, 75 Fed. Reg. 60,868 (Oct. 1, 2010) (Final Rule effective Nov. 1, 2010). In the interim, the section at issue here, 50 C.F.R. § 660.306, remained in effect as set forth in the 2009 edition of the Code. Therefore, all citations to the Code in this memorandum refer to the 2009 edition, unless otherwise noted.

> purposes of continuous transiting, with all groundfish non-trawl gear stowed . . . .

50 C.F.R. § 660.306(h)(4); Ct. Ex. 2.

As defined in § 660.383(c), Groundfish Conservation Areas include—

> The non-trawl RCAs [(Rockfish Conservation Areas)] . . . defined by specific latitude and longitude coordinates (specified at §§ 660.390 through 660.394) designed to approximate specific depth contours, where fishing for groundfish with non-trawl gear is prohibited. Boundaries for the non-trawl RCA throughout the year are provided in the open access trip limit tables, Table 5 (North) and Table 5(South) of this subpart and may be modified by NMFS inseason pursuant to § 660.370(c).[7]
>
> (i) It is unlawful to operate a vessel in the non-trawl RCA that has non-trawl gear onboard and is not registered to a limited entry permit on a trip in which the vessel is used to take and retain or possess groundfish in the EEZ, or land groundfish taken in the EEZ, except for the purpose of continuous transiting . . . .

50 C.F.R. § 660.383(c)(12);[8] *see also* Jt. Ex. 13 at 1; Tr. 175; Ct. Ex. 2.

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[7] The latitude and longitude coordinates for the RCA around the Northern Channel Islands relevant here were established by regulation in 2009. Jt. Ex. 12 at 4 (Pacific Coast Groundfish Fishery 2009–2010 Biennial Specifications, 74 Fed. Reg. 9874, 9911 (Mar. 6, 2009)); Jt. Ex. 14 at 3; Tr. 97.

[8] The term "Groundfish Conservation Area is also defined at 50 C.F.R. § 660.302, which states:

> *Groundfish Conservation Area or GCA* means a geographic area defined by coordinates expressed in degrees latitude and longitude, wherein fishing by a particular gear type or types may be prohibited. GCAs are created and enforced for the purpose of contributing to the rebuilding of overfished West Coast groundfish species. Regulations at § 660.390 define coordinates for these polygonal GCAs. . . . GCAs also include Rockfish Conservation Areas or RCAs, which are areas closed to fishing by particular gear types, bounded by lines approximating particular depth contours. RCA boundaries may and do change seasonally according to the different conservation needs of the different overfished species. Regulations at §§ 660.390 through 660.394 define RCA boundary lines with latitude/longitude coordinates; regulations at Tables 3 5 of Part 660 set RCA seasonal boundaries. . . .

50 C.F.R. § 660.302.

"Non-trawl gear" is defined as "[a]ll legal commercial groundfish gear other than trawl gear," and includes longlines, traps, pots, set nets, and stationary hook-and-line gear.[9] 50 C.F.R. § 660.302 (defining "fishing gear"); Jt. Ex. 12 at 2 (same). A "limited entry permit" is a Federal permit that allows commercial fishing in the Pacific Coast groundfish limited entry areas, and includes any gear, size, or species endorsements affixed to the permit. 50 C.F.R. §§ 660.302, 660.333(a); Tr. 36. Absent a limited access permit, commercial fishing is lawful only in the "open access" fishery areas. *See* 50 C.F.R. §§ 660.333, 660.383. Groundfish include sharks, skates, ratfish, morids, grenadiers, roundfish and rockfish. 50 C.F.R. §§ 660.301, 660.302; Jt. Ex. 12 at 1; Tr. 35–36. Most significantly here, "[c]ontinuous transiting or transit through means that a fishing vessel crosses a groundfish conservation area . . . on a constant heading, along a continuous straight line course, while making way by means of a source of power at all times, other than drifting by means of the prevailing water current or weather conditions." 50 C.F.R. § 660.302; Jt. Ex. 12 at 2.

The regulations further provide that vessels that take species managed under the Pacific Coast Groundfish Fishing Management Plan must have on board an approved "vessel monitoring system" ("VMS"). 50 C.F.R. §§ 660.302, 606.312(b); Ct. Ex. 2. A VMS consists of a mobile transceiver unit that uses the government-maintained satellite global positioning system ("GPS") to automatically determine a vessel's position, which it transmits to an approved mobile communications service provider, which then relays the position to NOAA's National Marine Fisheries Service ("NMFS"), Office of Law Enforcement ("OLE"), Northwest Division. 50 C.F.R. §§ 660.312(a), 660.302; Jt. Ex. 19 at 12–13, 18: Tr. 179–80; Ct. Ex. 2. Vessels are required to maintain their mobile transceiver unit in good working order and the unit "must transmit a signal accurately indicating the vessel's position at least once every hour, 24 hours a day, throughout the year . . . ."[10] 50 C.F.R. § 660.312(d)(3); Tr. 181, 183. NMFS mandates that the location tolerance for VMS systems be accurate to within a hundred meters. Jt. Ex. 19 at 19; Tr. 185–86.

To prevail on its claim that Respondents violated the Act and the regulation, the Agency must prove the alleged violation by the preponderance of the evidence. *Cuong Vo*, NOAA Docket No. SE010091FM, 2001 WL 1085351, at *6 (ALJ Aug. 17, 2001) (citing 5 U.S.C. § 556(d); *Dep't of Labor v. Greenwich Colleries*, 512 U.S. 267 (1994); *Steadman v. SEC*, 450 U.S. 91, 100–03 (1981)). "Preponderance of the evidence means the Agency must show it is more likely than not a respondent committed the charged violation." *Tommy Nguyen*, NOAA Docket No. SE0801361FM, 2012 WL 1497024, at *4 (ALJ Jan. 18, 2012) (citing *Herman & MacLean v. Huddleston*, 459 U.S. 375, 390 (1983)). A sanction may not be imposed "except on consideration of the whole record," and must be "supported by and in accordance with the reliable, probative, and substantial evidence." 5 U.S.C. § 556(d); *see also* 15 C.F.R. § 904.251

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[9] "Trawl gear" are nets towed through the water, and groundfish trawl gear may only be used "under the authority of a valid[ly issued] limited entry permit" endorsed for trawl gear. 50 C.F.R. § 660.302(11); Jt. Ex. 12 at 1.

[10] Vessel operators are unaware as to when the signal is transmitted and it appears that the time of transmission periodically changes. Tr. 92; Jt. Ex. 5.

("All evidence that is relevant, material, reliable, and probative, and not unduly repetitious or cumulative, is admissible at the hearing."); 15 C.F.R. § 904.270 (stating that the exclusive record of decision consists of the official transcript of testimony; exhibits admitted into evidence; briefs; pleadings; documents filed in the proceeding; and descriptions or copies of matters, facts, or documents officially noticed in the proceeding). Direct and circumstantial evidence may establish the facts constituting a violation of law. *Cuong Vo*, 2001 WL 1085351, at *6 (citation omitted).

## III. FACTUAL BACKGROUND

Respondents, Jason and Shane William Robinson, are brothers and commercial fishermen operating out of Santa Barbara, California. Tr. 226; Jt. Ex. 1 at 8–9; Jt. Ex. 7 at 1. They own or operate the F/V Risa Lynn, a 29-foot long, 9-foot wide, single engine Radon boat. Stips. 3, 4; Tr. 227—29, 285, 289: Jt. Ex. 2; Jt. Ex. 7 at 1. The Risa Lynn is equipped with a Faria Watchdog, Inc. VMS. Stip. 10.

Beginning in August 2009, Respondents started to longline for sablefish (black cod), a groundfish, primarily in a deep (300–400 fathom)[11] area of the open access fishery located approximately fifty-five miles south and west of Santa Barbara Harbor, around the back or ocean side of San Miguel Island, the westernmost channel island off the Santa Barbara Coast. Tr. 227–29, 233, 235–36; Jt. Ex. 7 at 2; Jt. Ex. 14a. Also along the back side of the Island, running west to east, between the Island and Respondents' fishing area, lay a two-mile wide stretch of the Nontrawl RCA within the Pacific Groundfish Fishery.[12] Stip. 8; Tr. 90, 235; Jt. Ex. 14a. At all relevant times, Respondents did not possess a valid Pacific Coast Groundfish Limited Entry Permit that would have allowed them to fish in the RCA. Stip. 5.

On the day at issue, May 17, 2010, Respondents set out to fish from Santa Barbara Harbor between 3:00 a.m. and 4:00 a.m., and caught and retained approximately $3,190.00 worth of federally-managed groundfish and other fish species. Stips. 15, 30, 31; Tr. 230; Jt. Ex. 2 at 7; Jt. Ex. 3 at 1; Jt. Ex. 14 at 4. During the course of that fishing trip, their VMS provided hourly transmission reports of their location to the NMFS. Stips. 13, 14. The transmission reports sent

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[11] A fathom is six feet. Stip. 7.

[12] The RCA around the San Miguel Island is designated as an area within a series of straight lines drawn between sets of latitude and longitude coordinates. Jt. Ex. 14(a), Stip. 7; Jt. Ex. 14 at 3; Tr. 97, 130, 167-68. The eastern contour line of the RCA (i.e. the one closest to the Island) generally marks the point where the water is approximately 60 fathoms deep and the western seaward contour line is the point where the water reaches 150 fathoms in depth, but within the RCA itself there are points of deeper and shallower water. Stips. 7, 8; Tr. 72–73, 97, 160–61.

at 6:57 a.m., 8:57 a.m., and 9:57 a.m.[13] reported Respondents' vessel as being located within the RCA, with a speed of "0" knots[14] and a heading of "0" degrees. Stips. 19, 21, 22.

On November 3, 2010, approximately six months after this particular fishing trip occurred, the NMFS issued an incident report to the OLE regarding a possible Nontrawl RCA violation by the Risa Lynn. Stip. 32. About four months later, on March 16, 2011, an NMFS Special Agent interviewed Jason Robinson regarding the alleged violation. Jt. Ex. 7. A year later, on April 23, 2012, the Agency instituted this action against Respondents. Jt. Ex. 23.

## IV. ISSUES IN DISPUTE

The NOVA, as amended, alleges that on or about May 17, 2010, Respondents violated Section 307(1)(A) of the Act, 16 U.S.C. § 1857, and the regulation at 50 C.F.R. § 660.306(h)(4), by operating their fishing vessel inside an RCA while having non-trawl gear on board, not being registered to a limited entry permit, retaining or possessing groundfish in the EEZ, and not continuously transiting the RCA. *See* Notice of Am. to Agency Pleading, Dec. 6, 2012.

The parties have stipulated that Respondents are "persons" subject to the jurisdiction of the Act. Stips. 1, 2. They further stipulate that on May 17, 2010, Respondents were fishing using a longline, a type of non-trawl gear, they did not possess a limited entry permit authorizing them to fish in the RCA, and they possessed and retained federally managed groundfish in the EEZ of the United States. Stips. 5–6, 30. There is no dispute that on the day at issue Respondents were at times in the RCA near San Miguel Island. Stips. 7, 19, 21–24, 27; Jt. Ex. 12 at 4, 5. As such, the parties have stipulated to all elements of the alleged violation save one—whether Respondents were "continuously transiting" while they were in the RCA that day.[15] Agency's Post-Hearing Brief (May 31, 2013) ("Agency's Br.") at 10.

In support of its claim that Respondents were in violation, the Agency begins its Brief by explaining that the prohibition on operating any vessel in a GCA/RCA is broad and "goes beyond just barring fishing." Agency's Br. at 6 (citing 50 C.F.R. § 660.306(h)(4)). "However, because [the Agency recognizes that] fishing vessels must be able to cross the RCA in order to access fishing grounds in deeper depths, the regulation includes a single exception—vessel operation for purposes of 'continuous transiting' across the RCA." *Id.* "Continuous transiting," it reiterates, has been defined by regulation to mean "a fishing vessel crosses a groundfish

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[13] The time indicated here is Pacific Standard Time, which on the day at issue here was seven hours earlier than the Coordinated Universal or Greenwich Mean Time, in which the VMS information was recorded and transmitted. Jt. Ex. 18; Jt. Ex. 19 at 35, 68–69.

[14] A "knot' is a unit of speed equal to one nautical mile (1,852 meters or 6,076.12 feet) per hour, or approximately 1.151 land miles (1,609.347 meters or 5,280 feet) per hour. Tr. 25, 228.

[15] The NOVA does not allege and the Agency did not specifically claim in this action that Respondents fished in the RCA or that their gear was not stored while they were in the RCA. Tr. 20.

conservation area . . . on a constant heading, along a continuous straight line course, while making way by means of a source of power at all times, other than drifting by means of the prevailing water current or weather conditions." *Id.* (citing Pacific Coast Groundfish Fishery Vessel Monitoring System, 72 Fed. Reg. 69,162, 69,168 (Dec. 7, 2007) (codified at 50 C.F.R. § 660.11)).

Based upon this definition, the Agency makes a two-pronged legal argument. First, it asserts that the Risa Lynn was not "making way" within the RCA on the day in question. *Id.* at 10. The Agency claims "the only logical interpretation of the VMS data," specifically the transmissions at 6:57 a.m., 8:57 a.m., and 9:57 a.m., reporting a speed of 0.0 knots and a heading of 0.0 degrees for positions "well within the RCA," is "that on three occasions the vessel was stopped within the RCA." *Id.* at 10–11 (citing Stips. 19, 21, 22). In support of this conclusion, the Agency cites the deposition testimony of Matthew Heasley, Faria's Operations Manager, to the effect that such reports of "0/0" are "indicative of a vessel that is either stationary or traveling at less than 1 knot along a true north heading (0.0–0.9 degrees)," and cautions that "[o]nly the former option is credible given the facts of the case." *Id.* at 11 (citing Jt. Ex. 21 at 122–24; Stip. 12). Those facts are that the 0/0 position report was given for one hourly report when the vessel "was tied up at the dock prior to departing on the fishing trip, . . . and for two hourly reports when the vessel was outside the RCA" at the end of its fishing trip. *Id.* (citing Jt. Ex. 20 at 71–75; Stips 25, 26). The Agency contends the alternative explanation for each of the three VMS reports, that the vessel was going less than 1 knot (0.0–0.9) and true north (0.0–0.9 degrees), "strains credulity" because San Miguel Island, where Respondents claim they waited while their fishing gear was soaking, "is not true north from the fishing grounds, but north northeast." *Id.* at 11–12 (citing Jt. Ex. 14(a); Tr. 269). Further, the Agency claims it is "exceptionally unlikely" that Respondents' autopilot would have taken their vessel on a true north heading "by mere happenstance on three separate occasions, while also maintaining a speed less than 1 knot each time." *Id.* at 12. Relying on the testimony of Agent Struble, the Agency adds that the "alignment of timing, speed, heading, position and vessel activity," which would have allowed it to exit and enter the RCA and be back within the half-mile circle at each polling hour, "approaches the impossible." *Id.* (citing Tr. 50–51).

Moreover, the Agency suggests, "[e]ven if one could conceive that scenario playing out for the 8:57a.m. and 9:57a.m. position reports when the vessel might have been heading toward San Miguel Island, Respondents provide no valid explanation as to why they would have been traveling in that manner at 6:57 a.m.—prior to their claimed arrival at their fishing grounds." *Id.* (citing Tr. 259–61). Rather, the Agency asserts, "[i]t is far more likely than not that the Risa Lynn was simply dead in the water at 6:57 a.m., 8:57 a.m., and 9:57 a.m., while in the RCA, and therefore not making way as required by the regulation." *Id.*

Relying on the same three position reports, the Agency introduces the second prong of its legal argument by stating: "There is no reasonable argument that a stationary vessel is somehow also operating on a continuous straight line course," as required by the regulation. *Id.* at 13. In support of this point, the Agency cites to chart plotting, described by Agent Struble at hearing, that shows the "extraordinary journey" the vessel would have had to undertaken to travel in a straight line course from its position reported at 9:57 a.m. in order to arrive at its position at 10:58 a.m., and then to its position at 11:58 a.m. *Id.* at 13–14 (citing Jt. Ex. 14a; Tr. 79–80).

The Agency decries that "[s]uch navigational acrobatics" are "simply not plausible" and that "[i]t is more likely than not that the vessel either never left the RCA and was just driving or drifting around to the various nearby positions at each VMS polling interval, or the vessel otherwise deviated from a straight course transit on several occasions within the RCA." *Id.* at 14. Based upon these two arguments, the Agency asserts that it has established the violation "by a preponderance of the evidence." *Id.*

Respondents counter in their Post-Hearing Brief, albeit a bit inartfully, that "it is impossible . . . to maintain a constant course in wind and waves," i.e., to technically comply with the regulatory requirement to transit on a "constant heading along a continuous straight line course," citing the testimony of Agent Struble for support. Respondents' Post-Hearing Brief (May 31, 2013) ("Rs' Br.") at 1, 4, 8 (citing Tr. 77–83). Additionally, Respondents alternatively argue that the Agency has failed to meet its burden of proof, asserting that "NOAA's only evidence . . .is six *hourly* VMS transmission reports . . . which recorded a total of 30 seconds of Respondents' activities while in the RCA," and which does not show they were drifting, stationary, or turning in the RCA. *Id.* at 2 (emphasis in original). "Without any eyewitnesses," Respondents argue that the Agency "has failed to prove its case," claiming further that the "lack of direct evidence is NOAA's fault because it could have flipped the VMS transmission frequency switch to five-minute increments to see the actual course of travel" of the vessel. *Id.*

In an effort to further undermine the Agency's case, Respondents note in their defense that there is no regulatory prohibition on being in the RCA, nor a limit on the number of times one may transit the RCA, nor a minimum or maximum speed requirement for transiting, nor a requirement to maintain a constant speed while transiting. *Id.* at 2, 4 (citing Tr. 40, 88–90, 93, 209, 211). As such they could "cross and re-cross the RCA as many times and on any constant course they choose." *Id.* (citing Tr. 90, 209). Respondents claim that in this case, in a fishing boat with a cruising speed of 16 knots and a maximum speed of 20 knots, they fished adjacent to the RCA and crossed it to seek the safety of San Miguel Island, re-crossing several times during the day to check on their gear, and "[t]his is not illegal behavior." *Id.* at 2–5 (citing Tr. 92, 270–71). Moreover, "Respondents do not have to prove they were on a constant course or provide explanations for the six hourly VMS transmission reports. NOAA must prove by evidence that Respondents are guilty of some activity other than driving their boat through the RCA, which they must do in order to fish," and "the Government has no idea what was occurring on the [F/V Risa Lynn] on May 17, 2010." *Id.* at 2–3, 9.

Nevertheless, Respondents specifically affirmatively deny in their Brief that they were "drifting" in the RCA on the day in question as concluded by Agent Struble in his investigation report, and assert that there is no evidence in the record that they were. *Id.* at 3, 9 (citing Jt. Ex. 1). Respondents argue the VMS transmission reports "prove nothing," and Agent Struble's opinion at hearing, that drifting was one of many "possible" scenarios supported by the evidence, was refuted by the Agency's witness Joseph Albert, and Respondents' witness Don Radon, and does not satisfy the Agency's burden of proof. *Id.* at 3, 6, 8, 10-11 (citing Tr. 116, 119, 122, 131–32, 134–35, 141–43, 218–19, 241). More specifically, Respondents cite the testimony of Don Radon, the builder of their boat, to the effect that "drifting without power on May 17, 2010 would be dangerous, uncomfortable and serve no known purpose," and Respondent Jason Robinson's testimony to the same effect. *Id.* at. 3, 6 (citing 241–43, 286–88).

Further, Respondents argue they also were not "stopped or stationary" in the RCA on the day in question. *Id.* at 12. In support they cite the evidence in the record that in the early morning on May 17, 2010, the winds in the RCA were blowing in the 19–22 knot range, decreasing thereafter down to 10 knots by 4 p.m. *Id.* at 5 (citing Tr. 108; Jt. Ex. 10). Under such conditions, they note, Mr. Radon testified that it would be "impossible" to keep the vessel stationary or stopped for five seconds against such wind and seas. *Id.* at 3–7, 12 (quoting Tr. 288–89). Thus, Respondents conclude, "the VMS transmissions showing '0' knots at a '0' heading meant the Robinson brothers must have been heading north [toward San Miguel Island for safety] at up to .9 knots," as testified to by Jason Robinson. *Id.* at 3, 6, 12 (citing Stips. 11–12). While the Agency may argue that it is statistically unlikely they "could hit a due north heading at a speed of less than 1 knot on three separate occasions," Respondents assert, it has not offered a statistician or other competent witness on this issue. *Id.* at 12. As an alternative explanation for the same 0/0 hourly transmissions inside the RCA, Respondents claim they "transit the RCA using autopilot, which tries to keep them on a constant course," and they return repeatedly to the same GPS location for their gear and then head north toward San Miguel Island. *Id.* at 3–4. In addition, they note they frequently steer the boat into the wind and waves, turn on the autopilot and travel at slow speeds to conserve fuel and perform work on the boat, including preparing themselves and the vessel for fishing. *Id.* at 7 (citing Tr. 270–71, 277–79).

Moreover, Respondents argue they were not "turning" their boat in the RCA, noting the VMS transmissions provide no information regarding the vessel's activities during the other 59 minutes and 55 seconds between the hourly transmissions, and that they can change the speed of their vessel "at any time, and often do." *Id.* at 5, 12–13 (citing Tr. 92, 138, 212, 214; Stips. 10, 13). Based upon the wind and the waves, Respondents challenge the validity of Agent Struble extrapolating the vessel's constant course from the individual VMS hourly heading readings of 157 degrees and 211 degrees, noting Jason Robinson testified that the straight lines drawn by Agent Struble at hearing to reflect those headings did not accurately describe the course of his vessel's travel on the day in question, and advising that the wind and the waves can swing even a boat on autopilot 15 degrees off course. *Id.* at 8, 13 (citing Tr. 77–80, 275; Jt. Ex. 14). Explicitly, Respondents deny they traveled around in circles in the RCA on the day in question, or that they fished or had any reason or capability to fish in the RCA on that day, noting they had only one set of fishing gear on the boat. *Id.* at 9, 12 (citing Tr. 236–37, 249).

In its Reply Brief, the Agency reiterates its argument that the evidence of record supports a finding that the vessel was "stopped" in the RCA, characterizing Respondents' focus on whether the vessel was "drifting" as "misplaced." Agency's Post-Hearing Reply Brief (June 17, 2013) ("Agency's Reply Br.") at 2. The Agency contends drifting is only one of "a myriad of possib[le]" activities Respondents were engaged in that day while in the RCA, and "what matters . . . is not what Respondents were or could have been doing in the RCA, but what they were *not* doing." *Id.* (citing Tr. 119, 121) (emphasis in original). The Agency suggests the VMS data, which it characterizes as "accurate" and "reliable" even at hourly intervals, "provides more than sufficient evidence" to support a finding that Respondents were not continuously transiting, as required by the regulation. *Id.* at 2, 5 (citing 50 C.F.R. 660.306(h)(4); Stips. 19–26). Moreover, the Agency argues Respondents' claim that their vessel was not stationary "is simply wrong," noting that the 0/0 VMS reports "make it clear that on at least three occasions the vessel was stationary in the RCA." *Id.* at 2–3 (citing Stips. 14, 19, 21, 22; Tr. 187). The argument that the vessel was captured by the VMS three times alternatively traveling below 1 knot and true north is "simply not persuasive," the Agency further asserts. *Id.* at 3. The Agency suggests that in evaluating the likelihood of that scenario the Court should consider that Respondents "had no reason to travel true north," because San Miguel Island is "north-northeast" of their fishing grounds and that Jason Robinson never testified to steering "with th[e] level of accuracy or attention required for a true north heading." *Id.* (citing Jt. Ex. 14(a); Tr. 269). The Agency further suggests that Mr. Radon's testimony regarding it being "impossible" to be stationary was not absolute, noting he qualified the opinion by stating it was "almost impossible" and "pretty close to impossible," and he had no knowledge of the actual weather conditions the vessel was subject to that day. *Id.* at 4 (citing Tr. 289, 291). In fact the weather that day allowed for the vessel to be stationary, the Agency implies, citing a U.S. Coast Guard analysis of drifting patterns which concluded that on the day "environmental factors were light." *Id.* (citing Jt. Ex. 16 at 1).

Additionally, the Agency counters that a statistician is not necessary to infer from the record that Respondents' scenario is not plausible "when common sense dictates such an interpretation," noting that judges are permitted to rely on their common sense and experience to reach their decision. *Id.* (citing *Firestone Pac. Foods, Inc.*, EPA Docket No. EPCRA-10-2007-0204, 2009 WL 5326309 (ALJ, Mar. 24, 2009)). The Agency further reiterates its point that a stationary vessel cannot be on a "constant heading" and asserts that "[t]he dizzying array of speed and headings required" to find the vessel on a constant course between 9:57 a.m. and 11:58 a.m. "is just not believable." *Id.* at 5 (citing Agency Br. at 13–14; Jt. Ex. 14(a); Tr. 79–80). The Agency concludes by stating that "Respondents were obligated to transit the RCA in an uninterrupted manner, in as straight a line as possible, but failed to do so" as evidenced by the VMS data. *Id.* at 5–6.

Respondents' Reply Brief declares in response that "'possible' speeds and heading of the Robinsons' boat do not establish a violation," and that "NOAA has failed to prove anything but six 5-second VMS transmissions and the landing of regulated fish at the harbor," reiterating the claim that the Agency has not fulfilled its "burden of persuasion" to "show that it is more likely than not that Respondents were [unlawfully] operating in the RCA." Respondents' Reply to Agency's Post-Hearing Brief (June 18, 2013) ("Rs' Reply Br.") at 1. Specifically, in reply to the Agency's argument that the vessel was not "making way," Respondents point out that the Agency admits the VMS 0/0 reports can mean the vessel was illegally stationary or that "the vessel was headed north at up to .9 knots" which "is legal." *Id.* at 2. They quip "this is not a coin toss competition." *Id.* Moreover, they ask that the evidence comparing the weather at Santa Barbara Harbor with the seas around San Miguel Island be "rejected," and while acknowledging that they cannot state they were headed due north during each five-second VMS transmission, "Respondents can honestly say they were never 'stationary' on May 17, 2010 and they headed in a northernly direction to San Miguel Island for safety." *Id.*

Further, Respondents complain that "NOAA did not make a claim against Respondents about the 6:57 a.m. 0/0 Position Report in Agent Struble's charging report," and "[n]ow this 6:57 a.m. 0/0 Position Report appears to be NOAA's only claim." Rs' Reply Br. at 2 (citing Jt. Ex. 1). They suggest Agent Struble did not raise any issue with the 6:57 a.m. report because he "knew that Respondents set their fishing gear outside the RCA, which is shown in the 7:57 a.m. transmission." *Id.* at 2–3. They recall, without citation, Jason Robinson's hearing testimony that this particular transmission "was most likely caused by slowing the boat down (after three hours of transit) in order to put on foul-weather gear in preparation for fishing outside the RCA." *Id.* at 3.

As to the second prong of the Agency's argument, which Respondents characterize as not being "on [a] [c]onstant [c]ourse [u]nder [p]ower," Respondents suggest that "NOAA is stuck with Agent Struble's conclusion that Respondents were drifting at 10:58 a.m. and 11:58 a.m.," which at hearing they proved "would be insane," a conclusion with which "NOAA's expert witness Joe Albert agreed." Rs' Reply Br. at 3. Then when "[c]onfronted with an improbable and unsupportable argument, NOAA shifted course to say that Respondents had to be driving under power and making turns in the RCA," the evidence of which consisted of two straight lines drawn through the RCA by Agent Struble at headings of 157 degrees and 211 degrees, and the argument that Respondents "would have had to make an 'extraordinary journey' into and out of the RCA to avoid turning in the RCA." *Id.* Respondents suggest "there was no 'extraordinary journey' on May 17, 2010, or they would have remembered it when Agent Struble interviewed them ten months later." *Id.* Rather, they declare "drawing straight lines backwards and forwards based on two 5-second position reports (as Agent Struble did) does not establish Respondents' actual course of travel on the day in question," claiming without citation that even Agent Struble testified "it is impossible to drive a small boat in rough seas on an absolute constant course." *Id.* at 3–4. Respondents suggest that from the evidence "it is impossible to decide what Respondents' actual course of travel was at 9:58 a.m. and 10:58 a.m." *Id.* at 4. Their Reply Brief concludes with the assertion that "NOAA has failed to prove that Respondents were drifting, stationary, or turning inside the RCA on May 17, 2010." *Id.*

## V. IMPOSSIBILITY DEFENSE

As indicated above, the Act makes it unlawful to "[o]perate any vessel in an applicable GCA . . . except for purposes of continuous transiting." 50 C.F.R. § 660.306(h)(4) (2009). "Continuous transiting" is defined by regulation to mean "that a fishing vessel crosses a groundfish conservation area . . . on a constant heading, along a continuous straight line course, while making way by means of a source of power at all times . . . ." 50 C.F.R. § 660.302. Respondents have raised in their post-hearing briefs the argument that compliance with this regulatory requirement was "impossible" i.e., they could not cross the RCA on the back side of San Miguel Island "on a constant heading, along a continuous straight line course." Rs' Br. at 1, 4, 8 (citing Tr. 82–84); Rs' Reply Br. at 3.

It has long been generally held that "the law does not require the performance of impossibilities . . . and if a statute requires performance of something which cannot be performed, the court may hold it inoperative." *Ivaran Lines, Inc. v. Waicman*, 461 So. 2d 123, 125 (Fla. 1984) (citing *Gigliotti v. New York, Chicago & St. Louis R. Co.*, 157 N.E.2d 447, 452 (Ohio 1958)) (holding "with the prevailing law that violation of a statute or regulation . . . is excused where it appears without dispute that compliance with the statute is impossible even in the exercise of reasonable diligence"); *see Int'l Bank v. Faber*, 79 F. 919 (C.C.D.N.Y. 1897)

("The law does not require performance of impossibilities."); *Hoopes v. N. Nat'l Bank*, 102 F. 448 (3d Cir. 1900) ("The law does not require performance of impossibilities."); *Johnson v. Troy*, 24 A.D. 602 (N.Y. App. Div. 1898) (same); *Power v. Hamilton*, 22 N.D. 177 (N.D. 1911) (same); *Artukovich v. Astendorf*, 131 P.2d 831 (Cal. 1942) (same); *Tolbert v. Birmingham*, 81 So. 2d 336 (Ala. 1955) (same); *McCleary v. Mowery,* 231 N.E.2d 165 (Ind. App. 1967) (same); *FTC v. Baine*, 308 F. Supp. 932 (N.D. Ga. 1970) (same); *Arlington Seating Co. v. New Philadelphia School Distric*t, 176 A. 221 (Pa. 1935) (same); *Willing v. United States*, 30 F. Cas. 46 (3d Cir. 1804) (same); *see also* Restatement (Second) of Torts § 288A(2)(c) (1965) ("Unless the enactment or regulation is construed not to permit such excuse, its violation is excused when . . . [the actor] is unable after reasonable diligence or care to comply . . . .").

Such a defense has been recently addressed in a NOAA enforcement action. *See Frontier Fishing Corp. v. Evans*, 429 F. Supp. 2d 316, 330–34 (D. Mass. 2006) (remanding decision for reconsideration of plaintiff's impossibility theory), *rev'd sub nom. Frontier Fishing Corp. v. Locke*, 2013 U.S. Dist. LEXIS 67704 (D. Mass. 2013) (finding impossibility defense not sufficiently supported by the facts); *cf. Earth Island Inst. v. Evans*, No. C 03-0007 TEH, 2004 U.S. Dist. LEXIS 15729 *29–30 (D. Cal. 2004) (addressing NMFS's proffered excuse of "not achievable" mandatory sampling in relation to impossibility defense) *aff'd*, 136 Fed. App'x 34, 2005 (9th Cir. 2005).

Thus, Respondents' "impossibility" defense will be considered here. In that regard, however, it is noted that "impossibility" of compliance is an *affirmative* defense as to which Respondents bear the burden of proof. *See Cleveland Consol., Inc. v. Occupational Safety & Health Review Comm'n*, 649 F.2d 1160, 1167 (5th Cir. 1981); *1833 Nostrand Ave. Corp.*, Docket No. II-RCRA-93-0205, 1995 EPA ALJ LEXIS 48, at *20 (ALJ, Aug. 10, 1995).

In support of the defense that it is "impossible" for them to have crossed the RCA "on a constant heading, along a continuous straight line course," Respondents cite in their briefs primarily the testimony of Agency witness William Struble. Rs' Br. at 4–5, 8 (citing Tr. at 77–80, 82–84); Rs' Reply Br. at 3. Mr. Struble testified at hearing that he is a NOAA "Special Agent" stationed in Santa Maria, California, and has been for the past five years. Tr. 31–32. His duties include investigating and enforcing the rules and regulations of the Act in the Pacific Coast groundfish fisheries, including in the waters off Southern California's Channel Islands, and he was the investigator on this case. Tr. 31–33, 41. Agent Struble indicated that he was already familiar with the waters of the Channel Islands prior to joining NOAA, as a result of a previous five-year stint with the National Park Service where he was tasked with conducting marine patrols in the waters encompassing the Channel Islands National Park.[16] Tr. 33–34, 59. In total, Agent Struble estimated he had 3000 hours of experience with small vessel operation in the waters around the Channel Islands. Tr. 34. This experience was in addition to the other marine experience he had gathered from prior positions with the U.S. Fish and Wildlife Service in Alaska and Florida. Tr. 34–35.

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[16] Those waters make up the Channel Islands National Marine Sanctuary, an underwater national park consisting of the waters up to six nautical miles of the four northern Channel Islands (Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands) and Santa Barbara Island. Tr. 59.

Regarding the weather and water around San Miguel Island where the alleged violation occurred, Agent Struble testified that "San Miguel [I]sland often has very harsh weather" and he agreed that the channel waters can be "very, very rough ocean . . . on certain days." Tr. 63, 81. However, he said "that doesn't mean that the weather is horrible every day," and based upon the buoy data and Coast Guard analysis, he thought the weather on May 17, 2010, was "fairly mild for San Miguel [I]sland." Tr. 63. Nevertheless, when asked whether, based upon his maritime experience, he had ever been able to "go on a constant course for a continuous amount of time" in those waters, Agent Struble replied: "You can maintain, depending upon weather conditions[,] a fairly steady course. It's not going to be an exact course because the ocean's moving, the wind's blowing, the motors maybe countering each other a little bit." Tr. 82. Following up on this response, Respondents' counsel and Agent Struble had the following exchange at hearing—

> Q: So the answer is you cannot go on a constant course for a continuous period of time on the ocean?
> A: As far as an absolute perfect straight line—
> Q: That's correct.
> A: No, but you can come pretty close to it.
> Q: Thank you. So is [the] reality that you cannot go on an absolute constant course included in the parameters of the statute?
> A: I think on interpreting the statute we're going to be looking at what would be an approximate line, what would be a reasonable attempt to stay on a continuous course.
> Q: And who's making that decision? You?
> A: The vessel operators are.
> Q: No, I know but I mean the statute says constant course under power. Correct?
> A: The statute is strict liability and then I'm going to have discretion in enforcement on what's the bigger picture here on is this something I want to move forward with as an enforcement case or not?
> Q. I got you. So you agree with me that it is literally physically impossible to comply with the statute?
> A: As far as an absolute razor sharp straight line from A to B, yes.
> Q: And then as a result of that, as a result of the impossibility of complying with that statute and the enforcement of that statute is subject to the discretion of you and people like you, is that correct?
> A: Correct.

Tr. 82–84.[17]

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[17] In addition to the issue of the "impossibility" of literally complying with the regulation, Agent Struble's testimony appears to potentially raise an issue of "fair notice" or the corollary doctrine of "vagueness," specifically whether the regulation, which cannot be technically complied with, provides vessel owners with fair notice of what variance is lawful, or whether it is too vague and

In addition, Jason Robinson testified without contradiction at hearing in response to questioning by Agency counsel that even when utilizing autopilot to direct his vessel on a straight course, the system is "constantly correcting" due to the wind and the waves, and "it could be within 10 or 15 degrees [of the set course] at any time." Tr. 275.

A fair reading of the foregoing hearing testimony supports Respondents' assertion that, even exercising due diligence, e.g., using autopilot, it would still have been literally impossible for them to have transited the RCA on the day in question "on a constant heading" or a "straight line course," as required by the regulation. Thus, to the extent that evidence shows Respondents exercised due diligence and still failed to maintain a "constant heading" or "straight course," such violation would be excusable. However, to the extent that evidence shows that Respondents were not "crossing" the RCA or "making way" under power, but were stopped or "drifting" without power as the Agency alleges in its briefs, such impossibility defense would not be relevant.[18]

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such determination is left to the unfettered discretion of NOAA enforcement. As the Supreme Court recently stated:

> A fundamental principle in our legal system is that laws which regulate persons or entities must give fair notice of conduct that is forbidden or required. . . . . This requirement of clarity in regulation is essential to the protections provided by the Due Process Clause of the Fifth Amendment. . . . It requires the invalidation of laws that are impermissibly vague. A conviction or punishment fails to comply with due process if the statute or regulation under which it is obtained "fails to provide a person of ordinary intelligence fair notice of what is prohibited, or is so standardless that it authorizes or encourages seriously discriminatory enforcement."
> . . . .
> [T]he void for vagueness doctrine addresses at least two connected but discrete due process concerns: first, that regulated parties should know what is required of them so they may act accordingly; second, precision and guidance are necessary so that those enforcing the law do not act in an arbitrary or discriminatory way.

*FCC v. Fox TV Stations, Inc.*, 132 S. Ct. 2307, 2317 (2012) (citing *Connally v. General Constr. Co.,* 269 U.S. 385, 391 (1926); *Papachristou v. Jacksonville*, 405 U.S. 156, 162 (1972)). However, as Respondents did not specifically raise a fair notice or vagueness argument in this action, the issues are not addressed herein.

[18] Interestingly, there is also testimony in the record discussed further herein that it would be "impossible" for Respondents to have been stopped in the waters around the Channel Islands. As such, this evidence raises a very similar "impossibility" claim to that made in *Frontier*

## VI. DISCUSSION OF THE EVIDENCE

In an effort to meet its burden of proof on the violation alleged, the Agency's case relies heavily, if not exclusively, on the VMS data reporting the position of Respondents' vessel on the date in question at 6:57 a.m., 8:57 a.m., and 9:57 a.m. (PST) as being within the RCA and having a 0 degree heading and a 0 knots per hour speed, which it refers to as the "0/0 position reports." Agency's Br. at 10–11 (citing Stips. 19, 21, 22); *see* Jt. Ex. 4 at 3; Jt. Ex. 18; Jt. Ex. 19 at 158. The Agency suggests this data proves that on May 17, 2010, Respondents' "vessel was stopped within the RCA," "simply dead in the water," "never left the RCA and was just driving or drifting around," "was not reporting a speed over ground or a course over ground," and was thus in violation of the requirement of continuous transiting—crossing the RCA "on a constant heading, along a continuous straight line course, while making way by means of a source of power." Agency's Br. at 10–14.

To explain the significance of these 0/0 position reports, the Agency offered at hearing the testimony of Joe Albert, its VMS Program Manager for the NOAA Northwest Regional Office in Seattle, Washington, which monitors the groundfish fishery areas in California. Tr. 171–72, 174. Mr. Albert explained that since 2004, NOAA has used a VMS system to monitor vessels in support of its law enforcement program regarding limited access fisheries. Tr. 172–73. Under the system, every commercial fishing vessel is affixed with a transponder, essentially an "electronic box with a GPS chip and [a] computer chip and some software that runs an antenna." Tr. 178–79. Once every hour, 24 hours a day, 365 days per year, the transponder takes a GPS reading of a vessel's geographic coordinates, i.e. latitude and longitude, and transmits that data to a satellite, which sends it on to a mobile communications service provider's land station, which ultimately transmits the information to the NOAA fisheries database. Tr. 179–81, 183, 221–22. Through this system, NMFS is able to monitor the location of the approximately 1000 commercial fishing boats operating in the Pacific groundfish fishery area, 700 of which are active on a daily basis. Tr. 180–81.

At the time relevant to this case, Respondents' fishing vessel, the Risa Lynn, was equipped with a Faria WatchDog 750 VMS transponder, in good working order. Tr. 179, 183–84, 196–97; Stip. 10; Jt. Ex. 15. The Faria transponder system uses the Iridium satellite network which gives it the ability to transmit not only location information, purportedly within two and one half meter accuracy range, but also hourly data on a vessel's speed and heading.[19] Tr. 183, 187, 200–01; Stip. 10. Mr. Albert explained that since vessels without limited access permits, such as the Risa Lynn, are without exception required to continuously transit through RCAs, his Office considers VMS data received reflecting 0 to 4 or 5 knots per hour "fishing speeds," i.e. suspicious, and "something you'd be looking at." Tr. 176, 178, 201–11.

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*Fishing Corp. v. Evans*, 429 F. Supp. 2d 316, 330–34 (D. Mass. 2006), which is the only NOAA enforcement case found addressing an impossibility defense.

[19] From the hourly speed and hourly data reported, NOAA's V-track system also calculates a theoretical "average" course and speed between the data reported for the successive hourly points. Tr. 198–99.

In or about mid-September 2010, two recent dates of "incursion" by the Risa Lynn into an RCA at low speeds came to his Office's attention. Jt. Ex. 1 at 4. A review of VMS data traced back to a third, earlier incursion date of May 17, 2010, which had not previously caught the Office's attention. Tr. 205. On that May day, three of the hourly VMS data reports received by NOAA, specifically those at 6:57 a.m., 8:57 a.m., and 9:57 a.m., placed the Risa Lynn in the Non-trawl RCA off the coast of California with both a course heading and speed of "0." Jt. Ex. 4 at 3, 4; Stips. 19–22. In response, a VMS technician put together an informational packet of the incursions, which was forwarded to NOAA's OLE for assignment to an agent for investigation. Tr. 206–08; Jt. Ex. 1 at 4, 5. As part of the investigation, the VMS Office prepared charts with straight track lines "connecting the dots" of hourly VMS data for the vessel for that day, and the two other days in September. Tr. 197–98; Jt. Ex. 1 at 6; Jt. Ex. 4 at 1–2; Jt. Ex. 5; Jt. Ex. 6; Jt. Ex. 8. Mr. Albert implied in his testimony that he considered Respondents' incursions into the RCA on those days to have been clandestine, explaining that fishermen frequently call into his office upon returning from trip to provide an exculpatory declaration if they have had an issue regarding non-continuous transit in the RCA, and suggesting that a review of a contacts log showed no such call from Respondents in regard to those days. Tr. 177, 208–09, 217–18; Jt. Ex. 2.

Approximately six months after the VMS Office's referral, on March 1, 2011, Respondents' case was assigned for investigation to Special Agent William Struble, whose testimony the Agency also offered at hearing as indicated above. Tr. 31–32, 41; Jt. Ex. 1 at 5. Agent Struble testified that as part of the investigation, he reviewed the vessel's VMS data and landing reports. Tr. 42; Jt. Ex. 1 at 5; Jt. Ex. 17. The data revealed that six of the hourly incursion points into the RCA on three of the days investigated (May 17th, September 2nd, and September 12th) seemed to be "in a very small circle over a unique bottom feature." Tr. 50–52; Jt. Ex. 4 at 1; Jt. Ex. 8. Specifically, while the majority of the RCA is 60 to 150 fathoms deep, charting indicated that four of the six incursion points "were on top of [a] 200 fathom line," reflecting a "canyon with deeper water that goes inside of the RCA." Tr. 53–55, 94–95, 97, 160, 162; Jt. Ex. 14 at 7; *see* Jt. Ex. 8 at 3. Some of the VMS data points in the RCA were close to a 300-fathom line. Tr. 163. Knowing that Respondents landed sablefish caught in depths of 200 fathoms and deeper, he found the idea that they had fished in the RCA on the dates in question was a "potential reasonable conclusion," but admitted he realized that "[i]t may not be *the* conclusion," since he had no specific evidence of exactly what Respondents were doing in the RCA on those days. Tr. 86–87 (emphasis in original). Agent Struble said he just knew that "there's activity that was occurring in that location," and though he did not "know what the activity was, . . . typically . . . there's a reason for somebody to be there, that people don't randomly end up in the same spot all the time." Tr. 55–56. He analogized his suspicions to hunters in Yellowstone National Park where he said elk are protected from hunting until they crossed the Park boundary line and then they are fair game. He suggested "some hunters would want to come inside the park to get an early chance at the biggest buck." Tr. 96.

On March 16, 2010, Agent Struble interviewed Respondent Jason Robinson at the vessel's slip at the Santa Barbara Harbor. Tr. 44–45; Jt. Ex. 1 at 8; Jt. Ex. 7 at 1. Respondent Shane Robinson was present during part of the interview. Jt. Ex. 7 at 1. This appears to be the first time Respondents were made aware that NOAA had any qualms regarding certain fishing trips they had made six to ten months earlier. As part of the interview, Respondent Jason

Robinson was shown the plotted VMS points of the three trips and asked about his fishing activities generally, and on numerous dates of interest to Agent Struble. Tr. 139; Jt. Ex. 1 at 8, 10; Jt. Ex. 7 at 1, 3; Jt. Ex. 10. In response, Agent Struble testified that Jason Robinson explained to him that it takes Respondents three to four hours to transit from the Santa Barbara to their fishing spot in the vicinity of San Miguel Island. Jt. Ex. 7 at 2; Tr. 45. Then they spend fifteen minutes getting their fishing gear ready and twenty minutes setting it, after which it soaks for about four hours. Tr. 45; Jt. Ex. 1 at 9, 10; Jt. Ex. 7 at 2. Jason Robinson told the Agent that he decides where to set his gear after checking the currents, and marks where he sets his gear in his GPS. Tr. 46; Jt. Ex. 1 at 9, 10; Jt. Ex. 7 at 2. He fishes at 300 to 400 fathoms for sablefish. Jt. Ex. 1 at 10. Further he asserted to Agent Struble that while the RCA coordinates are no longer in his plotter, they used to be and so he knows where the boundary is and tries to stay at least one quarter mile from it. Tr. 46–47; Ex. 1 at 10; Jt. Ex. 7 at 2. As to why he may have been in the RCA at slow speeds during his fishing trip on May 17, 2010, some ten months earlier, Jason Robinson said he was not "100 percent" sure, which Agent Struble accepted as fair "given that it had been several months prior," but thought that was the trip where he had needed to secure some items on the deck of his boat before returning to Santa Barbara Harbor due to bad weather conditions. Tr. 48, 56, 140–41; Jt. Ex. 1 at 10. Mr. Robinson also provided explanations for the other days of incursion, some of which Agent Struble found upon further investigation to be truthful or reasonable. Tr. 49–50. For example, Mr. Robinson advised the Agent that on one of the dates his vessel had broken down and, as a result, he was left drifting in the RCA until a friend came to tow him in. Tr. 49. After the interview, Agent Struble stated that he went into the VMS program and plotted the activities of both vessels and found "the tracks for both vessels lined up exactly with what his explanation was" and he "didn't see any need to pursue that incursion any further." Tr. 49

After concluding his investigation, on May 16, 2011, Agent Struble put together a "Case Package" including a written Investigation Report dated April 13, 2011, recommending the case be forwarded to NOAA General Counsel for civil prosecution on a violation of 50 C.F.R. § 660.306(h)(4) regarding three fishing trips, only one of which, the May 17, 2010 trip, Agency Counsel has pursued through the instant action. Tr. 43, 88, 100; Jt. Ex. 1 at 14; NOVA at 2. As explanation for recommending referral for the May fishing trip, Agent Struble wrote in his Report that "VMS records indicate that the [F/V Risa Lynn] had 5 points of low speed activity ranging from 0.0 to 1.6 knots within the non-trawl RCA." Jt. Ex. 1 at 6. Further:

> I reviewed . . . the VMS track location and times, and found they differ from the explanation given by ROBINSON. . . . VMS tracks show the F/V Risa Lynn first stopping in the RCA, as shown under the 'speed' column . . . which records actual vessel speed at time of VMS point transmission. The F/V Risa Lynn then departed and returned . . . back to the RCA in a stopped position very close to the initial stop. The VMS tracks have [a] pattern consistent with drifting from 1057 hours to 1357 hours with the first two points being in the RCA and the last two being outside and west of the RCA before the VMS tracks show return travel to port at speeds of approximately 16 knots.

Jt. Ex. 1 at 11–12. At hearing, Agent Struble softened his opinion regarding the VMS data based upon weather information he subsequently acquired from two sources, suggesting that the vessel "may have been going in a different direction but it's not absolute. . . . [I]t's possible that it was drifting but it may have been doing another activity."[20] Tr. 103–04, 115–16; Jt. Ex. 9. The other activities he suggested Respondents could have been engaged while in the RCA was "working gear off the boat" or "working on the deck of the boat." Tr. 104, 121.

At hearing, Agent Struble also defended his opinion that the vessel could have been essentially "stopped" in the RCA for hours on May 17th, relying upon data set forth in his Supplemental Investigation Report of August 2, 2011. Jt. Ex. 9. Specifically, based upon buoy and coast guard records, he claimed that during the time of Respondents' fishing trip, the winds ranged from 13 knots to 5 knots. Tr. 63–64; Jt. Ex. 16. Agent Struble opined that those wind speeds would not have required the boat to "attack the sea" to be stable. Tr. 123. Moreover, he implied that the Risa Lynn could well withstand such winds, describing it as a heavy, well-built boat, with an enclosed cabin. Tr. 113–14, 124. He noted such boats are used by fire rescue companies and California Fish and Game authorities for patrol. Tr. 124.

To encapsulate the Agency's VMS evidence in support of the violation, Agent Struble testified in detail to a chart he created of the ocean area exhibiting sixteen dots for the data points from the vessel's hourly VMS reports for May 17, 2010, relying upon his training in both navigation and plotting nautical charts. Tr. 67–69, 76, 128–29, 131, 133; Jt. Ex. 14; Jt. Ex. 14a. He explained that the VMS reports from 2:57 a.m. and earlier locate the vessel in Santa Barbara Harbor at 0.0 knots and a 0.0 heading, consistent with the vessel being tied up at the dock. Tr. 67; Jt. Ex. 6 at 3; Jt. Ex. 14; Jt. Ex. 14a. Points identified as 1 through 3 (at 3:57, 4:57, and 5:57 a.m.) on the chart track the vessel departing the harbor and traveling south/southwest at 13 to 18 knots toward San Miguel Island. Tr. 68–69; Jt. Ex. 14; Jt. Ex. 14a. Then points 4 through11 (6:57 a.m.–1:58 p.m.) generally put the vessel at "the fishing ground." Tr. 69; Jt. Ex. 14 Jt. Ex. 14a. The return trip back to the harbor is covered by points 12 through 16 (2:58 p.m.–6:58 p.m.).

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[20] Agent Struble's Supplemental Investigation Report, dated August 12, 2011, indicates he obtained weather data for the vicinity of San Miguel Island from two sources. Jt. Ex. 9 at 1. The first was a NOAA weather buoy located in western Santa Barbara Channel, fifteen miles north of San Miguel Island. *Id.*; Jt. Ex. 10; Jt. Ex. 11 at 2. The second was from a land based "Remote Automated Weather Station" on Santa Rosa Island, about twenty miles east of San Miguel. Jt. Ex. 9 at 1; Jt. Ex. 11. The later data shows that on May 17, 2010, at 10:00 a.m. and 11:00 a.m., the wind was blowing at 11 mph and then 7 mph, in a northeast, east northeasterly direction (61° and 40°), but at noon it had changed course and was blowing northwest (317°) at 9 mph, and by 1:00 p.m. had changed course back and was blowing exactly north, north east at 23 degrees. Jt. Ex. 11 at 2, 4; *see* Jt. Ex. 16 at 3; Jt. Ex. 21 at 32; Tr. 119–20. A Drift Calculation for the vessel was prepared by the U.S. Coast Guard in 2012, with an analysis beginning at 12:00 p.m. local time, which appears to show the vessel would initially drift in a northerly (353°) direction, and then northwest (318°) at 3:00 p.m. Jt. Ex. 16 at 1–5. However, Mr. Struble testified at hearing that to the extent the VMS reports are indicative of Respondents "drifting" during those hours, they indicate the vessel moving in a "slow westerly direction," i.e. against the current. *See* Tr. 103–04, Jt. Ex. 14a points 8–12.

Tr. 69; Jt. Ex. 14; Jt. Ex. 14a. He emphasized the significance of point 4, the 6:57 a.m. VMS data report locating the vessel in the RCA at a speed of 0.0 knots and a heading of 0.0, when it was purportedly headed out to Respondents' fishing grounds south and west of the RCA. Tr. 70; Jt. Ex. 14; Jt. Ex. 14a; Jt. Ex. 18. He acknowledged that the next hourly report at 7:57 a.m. did locate the vessel outside the RCA traveling at 5 knots with an eastward heading of 91 degrees. Tr. 71; Jt. Ex. 14 Jt. Ex. 14a. However, again at 8:57 a.m. the VMS transmission point located the boat within the RCA with a speed of 0.0 knots and a heading of 0.0. Tr. 72; Jt. Ex. 14; Jt. Ex. 14a. Similarly, at 9:57 a.m. the boat was again located in the RCA, "a little bit to the left of the 8:57 [point] . . . [with a ] speed of 0.0 knots and a heading of 0.0." Tr. 72; Jt. Ex. 14; Jt. Ex. 14a. At 10:57 a.m., the data also shows the vessel in the RCA but now moving at 5.0 knots on a south southeast heading of 157.0 degrees. Tr. 72, 76; Jt. Ex. 14; Jt. Ex. 14a. The 11:57 a.m. report shows the vessel again in the RCA travelling slowly at 1.0 knot, south southwest at a 211.0 degrees heading. Tr. 73, 77; Jt. Ex. 14; Jt. Ex. 14a; Jt. Ex. 18. Agent Struble alleged that by using the hourly directional headings at each point and time, he could plot where the vessel would have had to enter and exit the RCA to have been continuously transiting on a continuous course, as required by the regulation. Tr. 78–80.

In response to questioning by the Tribunal, Agent Struble summed up his investigation stating that he considered the foregoing data and looked at data from other dates, in an effort to get the "bigger picture" and try to "figure out exactly what's going on and if it's a recurring problem," noting that Respondents had a prior history of violation.[21] Tr. 167. He even spoke to Jason Robinson "to find out if there's some reason that . . . would make sense for me maybe to give them a verbal warning." Tr. 167. However, he found no "reasonable explanation" for the course of Respondents activities that day, and so referred the case for civil enforcement. Tr. 86.

At hearing, Respondents proffered testimony and evidence in support of their claim that there was an alternative reasonable explanation for their activities on the day in question and the VMS 0/0 position reports upon which the Agency's case relies. As background, Respondent Jason Robinson explained that a typical fishing day for them at the relevant time generally involved them baiting their gear in port and leaving Santa Barbara Harbor between 3:00 a.m and 4:00 a.m. Tr. 230–31, 233–34, 244, 259. Then, using their autopilot, they would make way on a constant course without stopping for about three to four hours at 16 knots out to their fishing spot past the island and the RCA, spend about twenty minutes setting their gear in the water, wait four to four and a half hours for it to "soak," retrieve it, and then head home, returning at about 8:30 p.m. Tr. 227, 229–31, 233–34, 244, 263, 267.

During the four to four and a half hours their gear is soaking, Mr. Robinson indicated he and his brother do not keep their vessel circling around or "drifting" in neutral in the open ocean as the Agency claims, stating if they did their "boat would be throwing things from rail to rail."

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[21] The prior violations to which Agent Struble refers occurred in March of 2008 and involved Respondents fishing with bottom contact gear (sablefish traps) in an Essential Fishing Habitat. Jt. Ex. 25; Jt. Ex. 27; Tr. 250–56. In 2009, Respondents admitted the violations and agreed to pay half of the proposed penalty pursuant to a settlement, although they claimed at the hearing that the violation was the result of "entrapment." Jt. Ex. 26; Jt. Ex. 27; Tr. 250–56.

Tr. 230, 242. He noted "[i]n general the weather on the west end of San Miguel is rough, windy, lot of swell, lot of current." Tr. 239. In 15 knot winds, the ride on the boat is bumpy, which can be made "a lot worse" by the current, requiring them to hold onto something for safety. Tr. 241. Thus, when out on the water they keep the boat moving "pointed either into [the wind] or going down with it." Tr. 242. During the four hours their gear takes to soak, they head north northeast through the RCA towards the calmer waters near San Miguel Island, explaining that "[o]nce you get past that edge out there you're just getting further away from land, further away from anyone that could help you if you had a problem." Tr. 245–48, 269. The Risa Lynn has only one engine and that engine has failed in the past. Tr. 228–29, 247. Mr. Robinson explained: "We'd be in trouble" if it failed again. Tr. 228–29, 247. If the engine did fail, Respondents would have to paddle to shore, and Mr. Robinson noted that they keep a surfboard and wet suits on board in case this occurs. Tr. 247.

Moreover, Mr. Robinson stated, they do not generally go all the way to the Island, nor do they stay close to it all day. Tr. 248, 269, 272–73. Instead, it is their practice to periodically travel back out to check on their gear, since it can move with the current.[22] Tr. 245. Mr. Robinson explained that at the time of the alleged violation, he and his brother were new to longlining sablefish and had only been doing it for eight or nine months. Tr. 233. As such, they felt a particularly strong need to keep tabs on their gear and so he believed that, at the time in question, they were traveling back through the RCA to check the gear on an hourly basis. Tr. 245, 267, 269. During such checks, he would "hit," or check, each flag on his gear as marked in his GPS, and then circle back up using his autopilot towards the Island. Tr. 267–68, 248.

Mr. Robinson claimed at hearing that at the time of the alleged violation he was aware of the RCA coordinates, that he has a "Farino [sic] Navnet" navigational system with a ten or twelve-inch screen, which has a plotter that tells him when he's reached his fishing grounds, radar, and a depth sounder that "shows [them] the bottom." Tr. 237–38, 262–63, 273–74. Further, he understood they had to "keep [their] gear out of the [RCA] area" and "need[ed] to transit through there on a constant course and maintain that course and not stop or turn around." Tr. 238–39. He testified he believed that "as long as my boat was in gear and my pilot was set and I was going, I was fine" in traveling back and forth through the RCA to check on his gear. Tr. 248. There was no way he could make a mistake and not realize he was in the RCA, he said.

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[22] The Robinsons' gear consists of two anchors separating a horizontal set of lines a mile and a half long with 3000 hooks on them, and weights to keep the lines on the ocean floor. Tr. 263–64. At each end of the lines is a down line about 420 fathoms long which goes up to two 2-foot high rubber or plastic buoys at the surface, tied to which are 8-foot high poles that sit upright in the water with radar reflectors. Tr. 264–66. Mr. Robinson testified that this is the length of the buoy line he uses to fish in 300 to 400 fathoms, and when he fishes in lesser depths he puts on a shorter buoy line to avoid "too much scope . . . because it gets tangled on the bottom." Tr. 265. On a clear day, Mr. Robinson says he can locate his gear though visual sighting of the poles, but in fog or swell conditions he needs to use his radar to locate it. Tr. 266, 268. Mr. Robinson noted that on occasions when the weather is very bad, he has not been able to locate the gear at all, and has had to come back for it at a later time. Tr. 268.

Tr. 238. Mr. Robinson characterized himself as an environmentalist, and testified that he honors the fishing rules and has never "poached fish" in the RCA. Tr. 249–50.

As such, Mr. Robinson said he was surprised and confused by Agent Struble's chart with track lines allegedly showing him drifting in the RCA or going around in circles, testifying there was no legitimate reason to put a boat in neutral and "I'm thinking I don't go around in circles in the RCA." Tr. 242–43, 249. Mr. Robinson also testified that it did not make sense to him that the chart would have him traveling sideways to the sea from 8:57 a.m. to 9:57 a.m., stating he would never do that because it would be "unsafe and uncomfortable." Tr. 242–44.

As to the first 0/0 position report showing him inside the RCA at 6:57 a.m. on May 17th, Mr. Robinson guessed from the time that he was likely "going out to his fishing grounds," as he thought he was likely finishing setting up his gear by the time of the next VMS transmission at 7:57 a.m. Tr. 260, 276. He disagreed with VMS data at 6:57 a.m. to the extent the Agency interpreted it as showing that he was not moving, stating that at the time he "wouldn't be going zero speed." Tr. 260–61. Instead, he thought he might be going under 1 knot at the time. Tr. 261. As explanation for the slow speed, he offered a variety of suggestions. First, he said he might have been washing something down, using his deck hose. Tr. 270–71. He explained the deck hose requires the hydraulic system, which "means that I have to be at a slower or low rpm to use it." Tr. 271. As such, he thought he might have throttled down the engine transmission to "one click in gear idling," with the propeller still turning, resulting in him traveling at less than 1 knot per hour. Tr. 269–71, 278. Alternatively, he suggested that the wind and the waves can "slow you down significantly." Tr. 277. In addition, he noted that at the time of the 6:45 a.m. VMS report he was about a "mile and a half" away from where he fished, or five minutes out. Tr. 279. Mr. Robinson suggested that "I might [have] need[ed] time to get things squared away so that I can just go up and make my set and not have to bob around out there and wait and get ready." Tr. 279. Thus, "[I]f I was approaching my area . . . I would drop my speed," noting that "[w]e're kind of getting ready, I'm dropping my speed and I'm getting my foul weather gear out." Tr. 277. This was true on May 17, 2010, he said, when the winds had been blowing at 20 knots the previous night but were declining, making it an appropriate day for him to go out fishing. Tr. 240–41.

For other times during May 17th when the VMS data showed him in the RCA at 0 speed, 0 heading, or traveling slowly, Mr. Robinson testified that he normally throttles down, that is, sets the engine transmission "one click in gear idling" on the way back to the island and surmised from the data that "I think I entered in the RCA going at low speeds. That's what I think. I found my gear, came down on it[,] turned back towards the island and just pressed auto, or turned and just pressed the pilot again. That's what the data shows me." Tr. 270, 280–81. Mr. Robinson testified that his fuel costs "a lot," as he uses over 100 gallons of diesel on each fishing trip. Tr. 280–81. Therefore, like many fisherman, Mr. Robinson explained, he throttles down and transits slowly to save fuel, claiming"[y]ou don't burn any fuel there when you've got a really low rpm." Tr. 280–81. He also said he goes at such a slow speed for comfort, noting "I've got no reason really to be in a big hurry. I've got four hours." Tr. 270–71.

Further, as to the VMS reporting a zero degree or true north heading, Mr. Robinson noted that San Miguel Island is in a "north direction" from his fishing ground. Tr. 272–73. Further, he explained that a VMS report at a certain moment is not reflective of the entire direction in which a vessel is going. Tr. 275. Autopilot, he testified, takes the boat in the direction it is headed at the time the button starting the system is pushed. Tr. 262, 272. However, the system is "constantly correcting" to stay on the course and "could be within 10 or 15 degrees at any time." Tr. 275. Also, he could have hit "the back of a wave and" been pushed in a different direction when the VMS transmission occurred. Tr. 275.

At hearing, Mr. Robinson explicitly denied ever having "poached fish in the RCA[.]" Tr. 249. While he admitted being aware of points of unusual depth in the RCA, including a point that is 1400 feet deep (about 233 fathoms), he testified that he fishes for sablefish at the bottom of the ocean at a target depth range of 300 to 400 fathoms, or 1800 to 2400 feet, stating "we get bigger fish out deeper and we don't fish under 300 fathoms." Tr. 235–36, 282. Further, he asserted he has only one set of fishing gear, thus implying that he could not have simultaneously fished in his spot and in the RCA. Tr. 237.

Mr. Robinson buttressed his testimony by offering that of Don Radon, the Santa Barbara commercial boat builder who built the Risa Lynn. Tr. 283, 285. Mr. Radon testified that he is familiar with San Miguel Island having grown up the child of a commercial fisherman, and had "spent a lot of time out there as a kid," adding "I go out there for sport fishing now." Tr. 284. As to Respondents' claim regarding the rough weather on the far side of San Miguel Island where Respondents fish, Mr. Radon confirmed "it's fully exposed to the northwest kind of trade winds that run down the coast and the swells are pretty [big]—you know there's nothing that slows them down, it's wide open ocean. And there's a big up-welling which creates a lot of current." Tr. 285. Winds of 15 knots and swells of three to four feet, "[t]hat's a normal day out there," Mr. Radon contended, and characterized the water in the channel as "one of the roughest in the world." Tr. 284, 286.

Mr. Radon explained he builds boats "so they work for the Santa Barbara [C]hannel [I]slands really well and they're designed to handle the rough water." Tr. 284. He touted that "[o]ur boats work pretty much everywhere because they work here." Tr. 284. Still, he said, boats in rough seas are rocky, and even on a normal weather day out in the waters around San Miguel, the Risa Lynn "would feel small probably." Tr. 285–86. Confirming Mr. Robinson's testimony, Mr. Radon suggested that as long as the boat was under power, going with or against the wind, the occupants would be "fine." Tr. 286–88. However, as to Mr. Struble's suggestion that Respondents idly drifted for hours around in the RCA, Mr. Radon stated that would not be "normal[]" and he would not know why anybody would do it in those weather conditions as the boat would "get a little bit unstable, uncomfortable." Tr. 286–87. He explained that if you were under power "you're using the stability of the [length] instead of [the] width because you have 29 feet of [length] to use the stability . . . and if you're quartered with it then you're using the width." Tr. 287. That way you would be "much more comfortable and stable and safe." Tr. 288. Mr. Radon agreed with Mr. Robinson's claim as to how he operated his boat, just putting the throttle up "one click" so "you just get it so you have steerage. Once you give it a little throttle then the autopilot can steer the boat and keep it straight." Tr. 293.

Further, as to the claim that Respondents stayed and fished in one small area of a deep canyon in the RCA, Mr. Radon opined that in the seas around San Miguel Island "[i]t's pretty close to impossible to stay in one spot." Tr. 289, 291. The "wind it blows you off pretty quick." Tr. 291. He said he has tried on occasion to fish and stay on one spot, and found "it's almost impossible to stay in one spot. I mean it's literally almost impossible . . . in those kinds of seas it is impossible, I mean you just can't do it in my experience." Tr. 289, 291. At best he suggested that if the boat's "speed was close to equal to what the force was trying to push you back then you could . . . keep within 100 or 200 yards maybe." Tr. 292. He said he "can't imagine" staying within about two and a half meters. Tr. 292. Even as winds died down during the day, he said "you still have residual swells from the past 12 hours that will still keep pushing you around." Tr. 292.

Most significantly, Mr. Radon testified with regard to the accuracy of the VMS speed data reports, stating the speed in the boat over water and speed on ground "are totally two different speeds." Tr. 294. He explained that in a boat "you could be going 4 knots over a current and still read 1 knot over the ground" or less "if you're going against a 5 knot current and the wind too and the swell. Sometimes you have to go pretty hard just to barely creep along." Tr. 294–95. Thus, he suggested that the VMS reports as to Respondents' speed may not have reflected how fast the boat was actually intending to go, but rather its net speed against the current.

In addition to the foregoing testimony introduced live at hearing, the parties offered into the record Matthew Heasley's dual deposition testimony and affidavit. Jt. Ex. 19; Jt. Ex. 21; Jt. Ex. 22. Mr. Heasley is the Operations Manager at Faria Watchdog, Inc., the maker of the VMS system on the Risa Lynn. Jt. Ex. 19 at 10, 17. Mr. Heasley confirmed the testimony given by Agent Struble regarding the general method of operation for the system and stated that the data being gathered on an hourly basis is that of the vessel's location, speed, and heading as of five seconds before transmission. Jt. Ex. 21 at 13. In terms of location, he said the Faria system was more accurate than the 100-yard minimum accuracy standard NMFS requires of such systems. Jt. Ex. 19 at 19, 42.

As to speed, Mr. Heasley explained that the figure reported as the vessel's "speed" is truncated after the decimal point, not rounded, so speeds up to 0.9 knots are reported as zero. Jt. Ex. 21 at 15–17, 29–30; Jt. Ex. 22 at 2. Further, he stated that the system reports a "course over ground" value. Jt. Ex. 21 at 14; Jt. Ex. 22 at 2. This means that if a vessel's engine is operating and it is being propelled forward at 5 knots against a 4 knot current, the speed reported by the system would be 1 knot. Jt. Ex. 21 at 15, 28. Alternatively, if the boat's engine is idling and current is carrying it 4 knots per hour, the system would still report a speed of 4 knots. Jt. Ex. 21 at 31; Jt. Ex. 19 at 80. He opined that if the system retrieved a zero speed reading for a boat on the ocean when there was a substantial current, one knows the boat was under power at the time, and could have been be traveling up to 0.9 knots. Jt. Ex. 21 at 31–33.

In terms of heading, Mr. Heasley suggested that the degree reported is the direction that the boat is going at the moment the data was gathered. Jt. Ex. 19 at 38, 43; Jt. Ex. 21 at 12, 19. Thus, the heading does not indicate if the boat is going in forward or reverse. Jt. Ex. 21 at 19. Further, the decimal for heading is also truncated, not rounded, so a heading of up to 0.9 degrees would be reported as zero. Jt. Ex. 22 at 2. Zero is also the default value for a vessel that is idle. Jt. Ex. 21 at 21–22. Thus, a zero heading report could mean the vessel was going "true north"

(0.0°), almost true north (up to 0.9°), or not moving (no course over ground), and from the heading data alone one would not tell which was true. Jt. Ex. 21 at 20–23, 30–31; Jt. Ex. 22 at 2.

Further, Mr. Heasley averred that the chart the Agency created by drawing straight track lines in chronological order from one VMS hourly data report to another for the vessel on May 17, 2010, does not provide any information at all regarding where the vessel went or how fast it moved within the intervening hours. In such periods of time, the Risa Lynn could have turned around and went the other way, and then turned around again. Jt. Ex. 19 at 76. It could have gone right, left, sped up, slowed down or stopped. Jt. Ex. 19 at 76–77, 87–89, 92. Further, he implicitly acknowledged that the chart was misleading in that to connect the dots in chronological order the chart reflected lines that, on occasion, depicted the vessel on a heading different from that reported for the point by the VMS data for the particular point in time. Jt. Ex. 19 at 91–93, 96–98. Moreover, to the extent that the straight track lines on the chart showed the vessel as having travelled through or been portaged over the land that is San Miguel Island, they were also misleading. Jt. Ex. 19 at 77–78. In sum, he suggested that the "average" courses and speed data used by the Agency to create the chart was meaningless given that the vessel could have changed course and speed at any time. Jt. Ex. 19 at 98.

After considering all the evidence in the record, I find the Agency has not met its burden of proof regarding the violation. Specifically, I do not find sufficient evidence showing that it is "more likely than not" that Respondents failed to "continuously transit" through the RCA on May 17, 2010, as alleged by the Agency.

First, while the VMS readings did report both the vessel's heading and speed as "0" on three hourly occasions while located within the RCA on May 17, 2010, the evidence adduced at hearing indicates that such readings are not definitive proof that the vessel was, in fact, stopped or stationary at those times. Rather, the testimony given by Mr. Heasley, Mr. Albert, and Agent Struble was that while a "0" heading report could be indicative of a vessel not moving at all, such as when it is tied up at a dock, it could equally indicate that at that particular five-second transmission interval the vessel was traveling in the direction of "true north" or close thereto (0°–0.9°), which would be about the general direction the vessel would be headed in if Respondents were transiting back from their fishing grounds to San Miguel Island for cover as they allege. Tr. 194, 203–04, 269; Jt. Ex. 14a. It is recognized that "true north" is not the exact direction from Respondents' fishing spot to the Island, that the direction is really "northeast"; however, Mr. Robinson testified without contradiction, and consistent with the evidence as to the rough waters around the Island, that even using autopilot to maintain a constant course, the system is correcting constantly and the course of the vessel can vary 10 to 15 degrees as a result of the wind and the current.[23] Tr. 269, 275; Jt. Ex. 14a. Thus, it would be possible for the VMS in a

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[23] In addition to the report from the weather station situated on Santa Rosa Island, the channel island east of San Miguel, the parties also introduced in to the record a weather report from NOAA Buoy Station 46054, which is situated in the waters of Santa Barbara Channel. Jt. Ex. 10. That weather report indicated that at 6:50 a.m., 8:50 a.m., and 9:50 a.m. (almost the exact times Respondent was supposedly found by the VMS reports to be stopped in place) the winds out on the water blowing at 14.8, 14.3 and 12.1 miles per hour, respectively, a moderate breeze consistent with the Buoy Report. Jt. Ex. 9 at 2; Jt. Ex. 10 at 2; *see also* Tr. 109–10.

five-second interval to read the vessel's heading as true north or close thereto while it was generally transiting in a northeast direction back to the Island at 8:57 a.m. and 9:57 a.m., as alleged by Mr. Robinson. Further, with regard to the "0" heading reading at 6:57 a.m., when the vessel was purportedly headed in the opposite direction (southwest) out to the Island, Mr. Heasley testified that the heading does not reflect if a vessel is moving in forward or reverse. Thus at that time, if the vessel had been slowed to "one click" as Mr. Robinson alleged in anticipation of shortly reaching his fishing location, with the winds and currents pushing against in a northeasterly direction as the evidence indicates, it could have been read by the VMS to have no heading or a true north or close to true north heading for a five-second interval. *See* Jt. Ex. 10.

Similarly, in terms of speed, Mr. Heasley indicated that the VMS speed reading is that of the "course over ground," meaning that it is the speed of the vessel relative to the fluid in which it is traveling, i.e. the boat speed as affected by the water currents, or net speed. Thus, the "0" speed reading at 6:57 a.m. might reflect the vessel was not moving, but could equally reflect that Respondents were traveling "under power," even at a significant intended rate of speed, but against an almost equal opposing current, resulting in a net speed of less than 1 knot per hour. Jt. Ex. 21 at 31–33. Alternatively, with regard to the 8:57 a.m. and 9:57 a.m. VMS reports, such a "0" reading could reflect that Respondents were merely transiting back very slowly to the safety of the Island, as they have alleged. As acknowledged by Agent Struble at hearing, the relevant regulatory provision does not contain any minimum speed in regard to vessel's transiting the RCA. Tr. 88–89. Therefore, as long as Respondents were not stopped, but moving, even very, very slowly, under power, they would not be in violation.

Second, contrary to the Agency's claims, the evidence persuasively suggests that it is "impossible" for a small vessel such as Respondents' to be stopped or stationary in the waters around San Miguel Island for any meaningful period of time. All the testimony at hearing agreed with Agent Struble's statement that no one "in their right mind would deliberately turn off their engine while they're at sea in a boat like that. They're going to leave their engine idling at minimum." Tr. 116. Thus, the issue was whether even an idling vessel could remain stationary in the water around San Miguel. At hearing, Agent Struble, the Agency's lead witness in support of its theory that Respondents' vessel could be stationary, admitted he had never actually been out in a small boat to San Miguel Island. Tr. 81–82. In contrast, the Agent acknowledged that Mr. Radon has "an incredible amount of experience at sea. He's a very respected individual as far as I know in the community and he's had a long career building boats." Tr. 81–82, 124–25. Based upon his personal actual extensive experience in small vessels around San Miguel Island, Mr. Radon credibly testified at hearing that in the seas around the Island it is normally "impossible" to stay in one spot, due to the winds. Tr. 289, 291. Further, the evidence shows that there was a significant level of wind blowing on the waters that day. The May 17, 2010 report of Buoy 46054, which like Respondents' vessel at the time was out at sea to the west of Santa Barbara, indicates that at 6:50 a.m., 8:50 a.m., and 9:50 a.m. (almost the exact times Respondent was supposedly found by the VMS reports to be stopped in place), the wind was blowing at 14.8, 14.3 and 12.1 miles per hour respectively.[24] Jt. Ex. 10 at 2.

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[24] The NOAA Buoy Station report erroneously indicates the date of the report as May 17, *2011* and the degree of wind direction for May 17, 2011 as "999." Jt. Ex. 10 at 2. While there was

The significant wave height was 3.1 feet. *Id.* Even Agent Struble, who downplayed the weather, had advised Respondents during their interview that given the "usual sea conditions" in the area, maintaining a quarter-mile buffer from the RCA might not be enough to ensure their vessel did not cross over the boundary line. Tr. 48; Jt. Ex. 1 at 10. Thus, the evidence suggests it was unlikely, if not impossible, for Respondents' vessel to have been stopped or stationary for any meaningful period of time as the Agency alleges.

Third, while the VMS hourly report taken at 9:57 a.m. located the vessel in the RCA "a little bit to the left of the 8:57 a.m. point, those readings by themselves do not sufficiently establish that the vessel was "drifting" or remained in essentially the same location in the intervening hour. As indicated above, based upon the wind data subsequently obtained, upon cross-examination at hearing, Agent Struble essentially recanted the assertion in his report that the vessel was "drifting," and the Agency's other witness, Mr. Albert, explicitly testified at hearing that he did not see evidence of drifting. Tr. 218–19. Further, at hearing, Agent Struble acknowledged that Respondents' fishing area is just beyond the RCA, and four and a half to six and a quarter miles from anchoring points such as Point Bennett near San Miguel Island. Tr. 152–56. He estimated that it would take Respondents thirty minutes or less to travel from their fishing spot through the RCA to the Island cove at 15 knots per hour, and that they could go from cove back and forth to their fishing spot in an hour. Tr. 154. Thus, instead of remaining stationary in the RCA, in the intervening hour between 8:57 a.m. and 9:57 a.m., as Agent Struble acknowledged was "possible," Respondents could well have traveled closer to the Island and back out "continuously transiting" through the RCA and heading to their fishing spot, as they claim. Tr. 121, 131–32. Using autopilot to steer them in both directions would make it more likely they would have taken the same path and potentially hit about the same point in the water on each trip.

Fourth, the Agency has failed to offer a viable reason for Respondents to be stopped or stationary in the RCA. The purpose of the regulation is to prevent unlawful fishing in the RCA. Tr. 84–85; Jt. Ex. 13 at 2. The uncontroverted evidence of record is that on the day in question Respondents had only one set of longline fishing gear on their boat. Tr. 236–37, 148–50. The VMS data indicates that at 7:57 a.m. Respondents had passed through the RCA on the backside of the Island and were at their fishing grounds, heading back due east to San Miguel Island at 5 knots. Jt. Ex. 4; Tr. 134. There is no evidence in the record indicating that Respondents did not, in fact, set their fishing gear in their normal fishing spot beyond the RCA. Thus, they had no gear available to them to set in the RCA before or after that point. Moreover, while Agent Struble testified that there was a 200-fathom deep canyon in the area where the VMS reports found Respondents in the RCA, and that Respondents were near a 300-fathom line, Respondents testified they were fishing in depths greater than that and the landing records are consistent with Respondents' testimony. Tr. 158; Jt. Ex. 3 at 1. As Agent Struble acknowledged at hearing, the

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testimony at hearing that the date was a typographical error, it is uncertain as to the meaning of such directional degree reporting other than the absence of data. Tr. 126; Jt. Ex. 10 at 2. The report of the winds by the Buoy Station out in the Channel, where the vessel was, are deemed more reflective of the actual winds faced by the Risa Lynn on the day than those recorded by the station situated inland on Santa Rosa Island.

evidence is open to a world of activities Respondents could possibly have been doing in the RCA that day, but it does not support that fishing was more likely than not one of them. Tr. 104.

Fifth, the alternative explanations offered by Respondents for the VMS data reports are credible and reasonable. At hearing, as explanation for the VMS reports finding them in the RCA at 8:57 a.m. and 9:57 a.m. at 0 speed/0 heading, Respondents claimed that in an effort to monitor their fishing gear, they slowly but repeatedly traversed the RCA on an hourly basis, going from their fishing spot to a position of safety closer to San Miguel Island. Tr. 269, 280. Significantly, such explanation was consistent with what Agent Struble said his knowledge was of the common practices of fishermen in the area. Specifically, Agent Struble testified that "there's typically two basic scenarios. They either go back to the island and wait it out for several hours or they stay . . . in kind of the greater vicinity." Tr. 164. He suggested the choice was between "maintaining the safer ride, the smoother ride [near the island] versus sometimes being blown [on the ocean]," noting that the latter option was "going to be not a pleasant experience." Tr. 164. He also testified that he is aware of "a cove on the island that's a common spot . . . where they go in and anchor if they're going in to get out of the weather while their gear soaks," which is only four and one half miles away from Respondents' fishing spot. Tr. 151–53. Further, on cross examination Agent Struble agreed that it was reasonable and possible that after setting their gear Respondents went toward the Island for safety and that is consistent with what Mr. Robinson told him during his initial interview. Tr. 98, 121–22, 131–32.

As to the 6:57 a.m. VMS report finding Respondents in the RCA at 0 speed/0 heading on May 17, 2010, Mr. Robinson said he likely throttled down at that point as he was only about five minutes away from his fishing spot and "might [have] need[ed] time to get things squared away so that I can just go up and make my set and not have to bob around out there." Tr. 279. As previously discussed, it is plausible that this VMS report could have reflected the action of winds and currents pushing against the vessel. *See infra* at 26–27. However, upon his initial interview with Agent Struble, albeit ten months after the day in question, Mr. Robinson thought he may have briefly stopped to check or secure his gear. Tr. 140. While stopping in the RCA even briefly would technically be in violation of the requirement to continuously transit because the regulation provides no exception, both Mr. Albert and Agent Struble correctly noted that common sense and safety-related choices must play into a determination of whether a violation occurred. Tr. 83–86, 210–11, 215–16. Moreover, while perhaps it would have been better practice in such an event for Respondents to have called in to report their momentary violative action, as Mr. Albert suggested, their failure to do so is not itself a violation. Tr. 217.

Sixth, in his discussion of the alleged violation at hearing, Agent Struble seemed at points to be under the erroneous impression that the regulation required Respondents to maintain a "constant speed." For example, he testified "I believe . . . the regulations state maintain a constant course of speed so that we know what those [VMS] points mean." Tr. 93. Further, under cross-examination, in response to an inquiry as to whether Respondents were limited or prohibited from being in the RCA, Agent Struble responded: "Not if he's transiting through and maintaining a constant course and speed under power," and "In this case the RCA is approximately two miles wide so when you have speed of zero or less than one knot, it would take approximately two hours or more to cross the RCA at that constant speed." Tr. 90. In fact, maintaining a constant speed is not a regulatory requirement and, as Mr. Albert testified, Respondents could lawfully throttle up and down in RCA, changing their speed at will and not be in violation of the regulatory requirement so long as they were continuing to make way under power. Tr. 177–78, 209, 211. Moreover, there is no course limitation, and Respondents could travel laterally through the RCA if they so desired. Tr. 209. Thus, Agent Struble's suspicion of Respondents' activities and his opinion that Respondents' explanation for their conduct that day was reasonable seems influenced by an erroneous impression of the regulatory requirements.

Seventh, the nautical charts created by the Agency displaying straight track lines connecting the various hourly VMS data points and purportedly representing the "navigational acrobatics" of Respondents' constant course and continuous heading are misleading and do not provide a reliable basis for finding Respondents in violation. *See* Jt. Ex. 4 at 1–2; Agency Br. at 13–14. The evidence adduced at hearing consistently indicated that the VMS transmissions represent only five-second snap-shots of information, taken an hour apart, and no information regarding a vessel's activity in the intervening time is captured. Tr. 138–39, 214. As such, the "average" speed and course as stated by the system are only theoretical, resulting from a mathematical calculation performed in regard to two unrelated hourly data points. Tr. 214–15. Agent Struble and Mr. Albert both acknowledged at hearing, the chart tracks drawn in reliance on such data "just connect[] the dots," delineating one "possible course" out of many the vessel may have taken that day. Tr. 92, 132–33, 212. Moreover, Mr. Heasley delineated at least two specific instances where the course as drawn in reliance on such points was obviously erroneous, one where the chart reflected the vessel going in a direction opposite that reported by the VMS for the point and another which showed the vessel transiting directly through San Miguel Island. Jt. Ex. 19 at 76–78, 90–94, 171. Even Agent Struble admitted at hearing that a vessel could not go on a constant course in perfectly straight line as drawn on his plotting. Tr. 82–83. Thus, the Agency's charts do not accurately reflect Respondents' actual course of travel on the day or provide a basis for determining a violation occurred in this case.

In sum, it is certainly understandable that, based upon the VMS reports, Mr. Albert, Agent Struble, and NOAA enforcement would find the Respondents' activities on May 17, 2010 to be suspicious, especially in light of their past history and the fact that there was no evidence of further incursions into the RCA by Respondents after the March contact with Agent Struble. Tr. 102; Jt. Ex. 16 at 33–37. Further, this Tribunal recognizes the difficulty the Agency faces in enforcing the regulations, and its responsibility to protect the groundfish fishery generally. Tr. 144. However, this Tribunal nevertheless finds that the preponderance of the evidence does not establish that it is more likely than not Respondents were not continuously transiting the RCA on May 17, 2010.[25]

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[25] At hearing, Respondents raised two issues which are not addressed above. These concern the ten-month delay between the date of the alleged violation and the Agency's contact with Respondents in regard thereto, and the Agency's failure to increase the polling time to obtain more frequent VMS transmission reports on their vessel, both arguably hampering Respondents' access to evidence in their defense. Tr. 99–102; *see also* Jt. Ex. 19 at 63. The Agency witnesses provided credible explanations in response to both issues at hearing, and thus the issues are not deemed of significance here. Tr. 147–48, 205–07.

**ORDER**

Based upon the foregoing, Respondents **Jason Robinson** and **Shane William Robinson** are hereby found **NOT LIABLE** for the violation charged in this action.

**PLEASE TAKE NOTICE,** that this Initial Decision becomes effective as the final Agency action **60 days** after service on **August 29, 2013**, unless the undersigned grants a petition for reconsideration or the Administrator reviews the Initial Decision. 15 C.F.R. § 904.271(d).

**PLEASE TAKE FURTHER NOTICE,** that any petition for reconsideration of this Initial Decision must be filed within **20 days** after the Initial Decision is served. 15 C.F.R. § 904.272. Such petition must state the matter claimed to have been erroneously decided, and the alleged errors and relief sought must be specified with particularity. *Id.* Within **15 days** after a petition is filed, any other party to this proceeding may file an answer in support or in opposition. The undersigned will rule on any petition for reconsideration.

**PLEASE TAKE FURTHER NOTICE,** that any petition to have this Initial Decision reviewed by the NOAA Administrator must be filed with the Administrator within **30 days** after the date this Initial Decision is served and in accordance with the requirements set forth at 15 C.F.R. § 904.273. A copy of 15 C.F.R. §§ 904.271–273 is attached.

**SO ORDERED.**

Susan L. Biro
Chief Administrative Law Judge
U.S. Environmental Protection Agency

Dated: August 29, 2013
Washington, DC

In the Matter of Jason Robinson and Shane William Robinson, Respondents
Docket No. SW1002974, F/V Risa Lynn

CERTIFICATE OF SERVICE

I certify that the foregoing **Initial Decision And Order,** dated August 29, 2013, was sent this day in the following manner to the addressees listed below:

Maria Whiting-Beale
Maria Whiting-Beale
Staff Assistant

Dated: August 29, 2013

Original To:

Sybil Anderson
Headquarters Hearing Clerk
U.S. Environmental Protection Agency
Office of Administrative Law Judges
Mail Code 1900R
1200 Pennsylvania Aveneu, NW
Washington, DC 20460-2001

Copy by Regular Mail And E-Mail To:

Paul A. Ortiz, Enforcement Attorney
Office of the General Counsel for Enforcement
and Litigation, Southwest Region
501 W. Ocean Boulevard, Suite 4470
Long Beach, CA 90802
paul.ortiz@noaa.gov
julia.caracoza@noaa.gov

Robert L. Brace
Hollister & Brace
1126 Santa Barbara Street
Santa Barbara, CA 93101
rlbrace@hbsb.com

Copy By UPS To:

Administrator
National Oceanic & Atmospheric Administration
Department of Commerce
Room 5128
14th Street and Constitution Avenue, NW
Washington, DC 20230

Assistant General Counsel
for Enforcement and Litigation
National Oceanic & Atmospheric Administration
1315 East West Highway
SSMC3-15424
Silver Spring, MD 20910

Agenda Item G.1.b
Supplemental NMFS Report
September 2013

# Draft Rulemaking Plan for 2013

## *Groundfish and Halibut*

In addition to a list of groundfish and halibut rules that have already been completed over 2013, NMFS is providing a list of rulemakings that are in progress over the remainder of 2013. To start 2013, NMFS prioritized completion of harvest specifications and response to litigation, which caused some of other rulemakings to be delayed.

Completed rules:

1. Reconsideration of Allocation of Whiting (RAW 2), Proposed Rule (1/2/2013)
2. 2013-2014 Harvest Specifications and Management Measures Final Rule (1/3/2013)
3. Reconsideration of Allocation of Whiting (RAW 1), Extension of Emergency Rule (1/17/2013)
4. Trawl Cost Recovery, Proposed Rule (2/1/2013)
5. Tribal Whiting Fishery, Proposed Rule (3/5/2013)
6. Pacific Halibut Catch Sharing Plan, Final Rule (3/15/2013)
7. Reconsideration of Allocation of Whiting (RAW 2), Final Rule (3/28/2013)
8. Inseason Action (5/6/2013)
9. Tribal and Non-Tribal Whiting Fishery, Final Rule (5/7/2013)
10. Pacific Halibut Catch Sharing Plan, Correction (5/8/2013)
11. Trawl Program Improvement and Enhancement (PIE 2), Proposed Rule (7/19/2013)
12. Inseason Action (8/13/2013)

In Progress:

| | |
|---|---|
| **1. Chafing Gear Rule**<br>Timing: Proposed rule – fall 2013<br>Final rule – early 2014<br>Effective – late April/early May 2014<br>Includes: changes to chafing gear requirements<br>Sectors affected: limited entry (LE) trawl (IFQ/MS/C/P) | **5. Trawl RCA Rule** **(Rockfish Conservation Area)**<br>Timing: Proposed Rule – September 2013<br>Final rule – Fall 2013<br>Effective – ~November 1, 2013<br>Includes: changes to trawl RCA<br>Sectors affected: LE trawl (IFQ) |
| **2. Observer/Catch Monitor Rule**<br>Timing: Proposed rule – fall 2013<br>Final rule – November 2013<br>Effective – January 1, 2014<br>Includes: permitting for new observer providers, observer safety, minor revisions<br>Sectors affected: LE trawl (IFQ/MS/C/P) | **6. Seabird Rule**<br>Timing: Proposed Rule – fall 2013<br>Final rule – 2014<br>Effective – 2014<br>Includes: mandatory streamer lines<br>Sectors affected: LE and open access (OA) fixed gear |
| **3. PIE 2 Rule** **(program improvement and enhancement)**<br>Timing: Final rule – November 2013<br>Effective – January 1, 2014, except ban on QP transfer removed by 12/15/2013<br>Includes: QS trading, remove December ban on QP transfer, change opt-out requirements, revise first receiver site license requirements, eliminate double filing of coop reports, exempt certain lenders from control rules<br>Sectors affected: LE trawl (IFQ/MS/C/P) and LE fixed gear | **7. Pacific Halibut Catch Sharing Plan, 2014**<br>Timing: Proposed Rule – Dec 2013<br>Final rule – Mar 2014<br>Effective – spring 2014<br>Includes: changes to commercial and recreational halibut fisheries for Area 2A<br>Sectors affected: LE and OA fixed gear |
| **4. Cost Recovery**<br>Timing: Final rule – October 2013<br>Effective – January 1, 2014<br>Includes: industry fee to offset NMFS cost of management, data collection, enforcement<br>Sectors affected: LE trawl (IFQ/MS/C/P) | |

Pending Actions (in the near future):

1. Amendment 24, 2015/2016 specifications – improved specifications and management measures process
2. Stock complexes
3. Adaptive management program (IFQ Fishery)
4. Permit Rule – Registering a limited entry trawl and limited entry fixed gear permit to a vessel at same time, consider sablefish-endorsed limited entry fixed gear ownership issues
5. Trawl gear issues – broad trawl RCA changes, multiple gears onboard, year-round season for midwater non-whiting trawl, transiting multiple management areas
6. Whiting season date change
7. Risk pool exemption from control rules (IFQ Fishery)
8. Electronic monitoring
9. VMS/declaration changes

Science, Service, Stewardship

Agenda Item G.1.c
Supplemental NWFSC PowerPoint
September 2013

# Groundfish Science Report

John Stein and Michelle McClure
Northwest Fisheries Science Center

September 13, 2013

NOAA FISHERIES SERVICE

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

NOAA FISHERIES SERVICE

# Overview

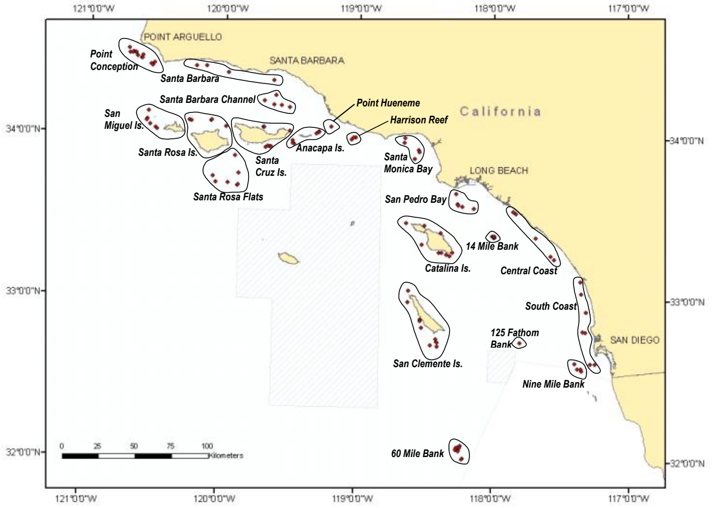
- Survey Updates
- Bycatch reduction studies
- Economic data collection
- Seabird avoidance study
- Recently published papers

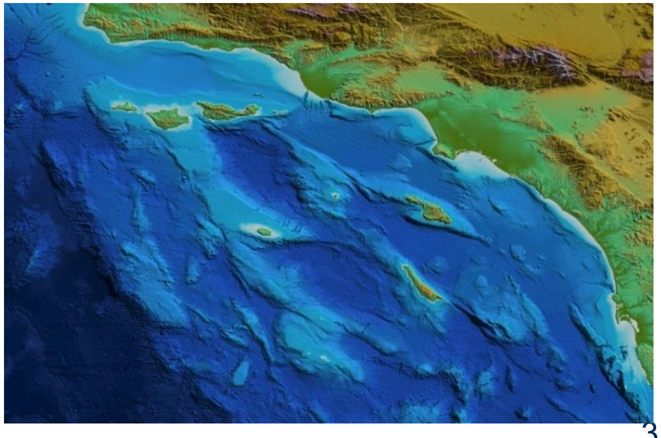
NOAA FISHERIES SERVICE

# Southern California Shelf Rockfish Hook and Line Survey

## 2013 Survey

- 10th year in survey time series
- Scheduled Dates: Sept. 16 – 28, 2013
- 27 sea-days
- 121 stations scheduled for sampling
- Vessels: F/V Aggressor, F/V Mirage, and F/V Toronado
- Third chartered vessel added in response to 2012 Peer review
- Expanding camera sled operations for habitat classification at all survey sites
- Collecting maturity samples from 11 species - NWFSC: bocaccio, vermilion/sunset, greenspotted, cowcod, and canary; and SWFSC: chilipepper, squarespot, rosy, yellowtail, swordspine, and speckled



NOAA
FISHERIES
SERVICE

# 2013 West Coast Groundfish Bottom Trawl Survey

## Pass 1: Report

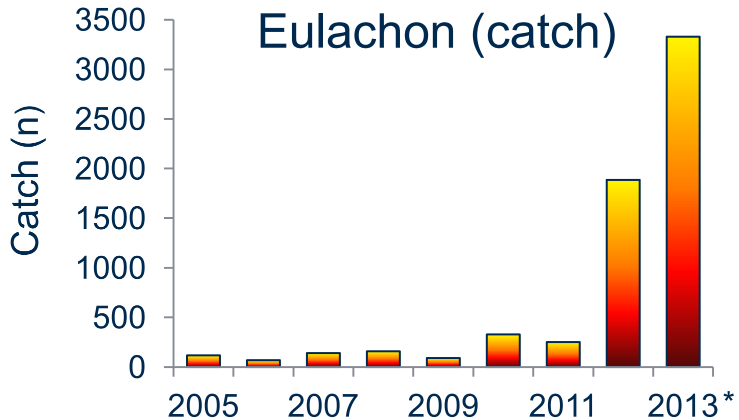
Pass 1: May 20-July 30

F/V Last Straw,
F/V Noah's Ark

Stations:
376 planned (usually 376)
~376 completed by July 30

Days-at-sea:
94 planned (usually 94)
94 completed by July 30

2,937 eulachon: Pass 1




* Survey still in progress

## Pass 2: Report

Pass 2: Aug. 19-Oct. 29

F/V Excalibur

Stations:
188 planned (usually 376)
~40 completed by Sept. 5

Days-at-sea:
47 planned (usually 94)
10 completed by Sept. 5

356 eulachon Pass 2 to date

Science, Service, Stewardship

# 2013 Joint Pacific Hake and Sardine Integrated Acoustic-Trawl Survey

NOAA FISHERIES SERVICE

NOAA FISHERIES SERVICE

**NOAA Ship *Bell M. Shimada*** - June 6 to August 27, 2013

- 98 Transects
- 76 Trawls

**CCGS *W.E. Ricker (WER)*** - August 20 to September 16, 2013

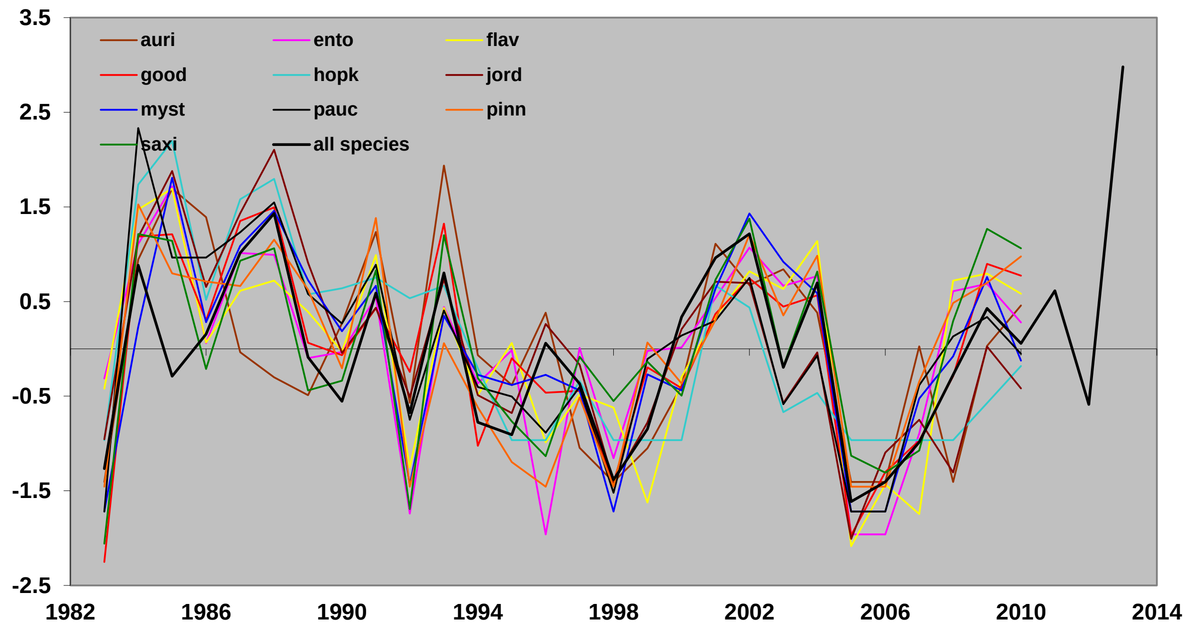
- 43 Proposed Transects
- *WER* Survey Ops currently underway,
  actual number of trawls and transects unknown

**Analysis of Survey Data Underway**

NOAA FISHERIES SERVICE

# Rockfish recruitment and ecosystem assessment survey (May-July, 2013)

- **Cool conditions, strong upwelling, high productivity**
- **Record numbers of juvenile rockfish - highest in 31 years**
- **High catches of krill, market squid, other YOY groundfish**




Science, Service, Stewardship

# 2013 Bycatch Reduction Research Projects

Waldo Wakefield, Mark Lomeli,
and Dave Colpo (PSMFC)
with Pacific Coast Fishing Industry

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# Three Field Projects
# Completed June - August 2013

- **Further testing of Pacific halibut flexible sorting grid excluders in the bottom trawl fishery**
  - June 2013 aboard *F/V Miss Sue*

- **Investigate light stimulus to enhance Chinook salmon escapement in the Pacific hake fishery**
  - June 2013 aboard *F/V Miss Sue*

- **Development and testing of industry-designed rockfish excluder in the Pacific hake fishery**
  - Year 2, August 2013 aboard *F/V Perseverance*

# Testing Two Pacific Halibut Excluders Aboard *F/V Miss Sue* (NWFSC/PSMFC Design & Industry Design)

NOAA FISHERIES SERVICE

# 2013 Halibut Excluders Aboard *F/V Miss Sue*

| | % Retention for selected species Vertical Flexible Grid 1.75" X 8" "slots" (NWFSC/PSMFC design) | % Retention for selected species Horizontal Flexible Grid 5.5"X 6" "rectangles" (Industry design) |
|---|---|---|
| Pacific halibut | 6% by weight | 21% by weight |
| | 12% by numbers | 27% by numbers |
| Dover sole | 89 | 99 |
| Petrale sole | 92 | 97 |
| English sole | 88 | 97 |
| Arrowtooth flounder | 75 | 93 |
| Sablefish | 7 | 90 |
| Lingcod | 1 | 92 |
| Canary rockfish | 4 | 100 |
| Shortspined thornyhead | - | 97 |
| Other roundfishes | 30 | 96 |

# Testing two Pacific Halibut Excluders Aboard *F/V Miss Sue*

(Catch and exclusion by the NWFSC/PSMFC Design)

Retained in Codend

Retained in Recapture Bag (Excluded)

NOAA FISHERIES SERVICE

# Fish Excluder Test

(Mouse over image to see player controls)

NOAA FISHERIES SERVICE

# Pacific Hake Midwater Trawl Fishery: *Rockfish Excluder Research*

- Started with a 2012 collaborative workshop held between gear researchers and hake fishing industry participants to design an excluder for testing

  Following the workshop, a flexible sorting grid rockfish excluder was developed and manufactured via Foulweather Trawl
- *Gear Testing / Sea Trials:*
  - ✓ testing occurred aboard the *F/V Perseverance* under “normal” fishing conditions in both 2012 and 2013
  - ✓ Excluder effective at excluding rockfishes, Pacific halibut and salmon, however, further research and development needed to resolve clogging issues that occur during encounters with extremely high volumes of hake

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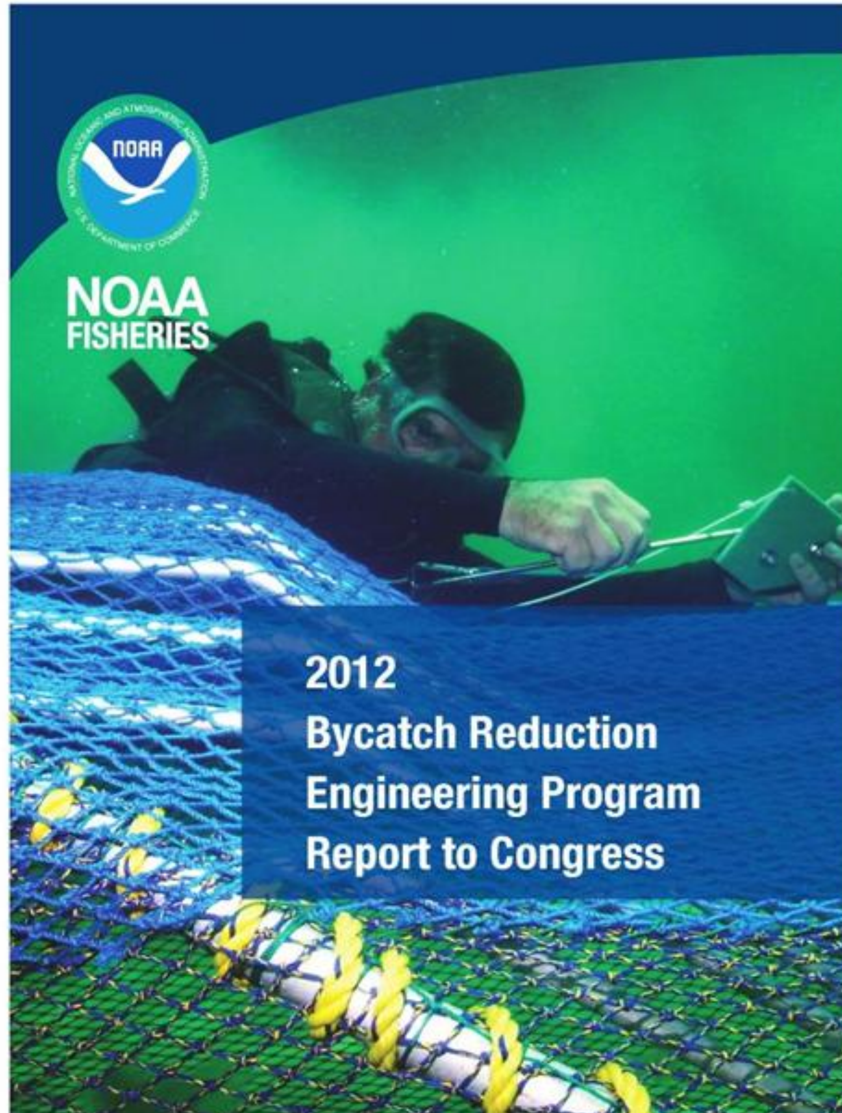
# NOAA NMFS National Bycatch Reduction Engineering Program

Available online at http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm



Science, Service, Stewardship

# 2013 Economic Data Collection Projects

NOAA
FISHERIES
SERVICE

# Economic Data Collection

## Open Access Voluntary Cost-Earning Survey

- Collects cost-earnings data from the vessel owners that (i) had at least $1,000 of landings on the West Coast during 2012, (ii) made at least one trip during 2012 targeting groundfish, salmon, crab, or shrimp and (iii) did not have a limited entry groundfish permit.
- Fielding began in July and will continue through October.

## Economic Data Collection (EDC) for Catch Share

- 2012 data was due September 1st.
- Responses to date.

| | Complete | Incomplete | Not received |
|---|---|---|---|
| First Receiver and Shorebased Processor | 25 | 3 | 27 |
| Catcher Processor | 9 | 0 | 0 |
| Catcher Vessel | 116 | 8 | 33 |
| Mothership | 6 | 0 | 0 |

Science, Service, Stewardship

# Seabird bycatch avoidance research in the sablefish longline fleet

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## Seabird bycatch avoidance research in the sablefish longline fleet

- WA Sea Grant research
- Test/fine tune seabird bycatch mitigation for the West Coast sablefish longline fleet
- Need vessels 55 feet and over to host research in 2013a
  - $400/day subsidy for host vessels.
- Research on vessels over 55 feet must occur this year before Streamer Line Regulation goes into effect or else an EFP or similar regulatory exemption would be required.

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# Design and conduct research to reduce seabird bycatch in West Coast longline fisheries

**Goal**: Refine and develop practical and safe tools to reduce seabird bycatch in West Coast longline fisheries in collaboration with the fishing industry with special attention to smaller vessels (< 55 ft.) and those vessels using combinations of weights and floats on the groundline.

**Three phases**

1) obtain information on fishing gear and practices
2) recruit cooperators (vessels owners/captains)
3) field test mitigation technologies to minimize seabird bycatch. Focus will be on streamer lines and line weighting.

**Regulations**

— Final action Nov. 2013 Council meeting requiring vessels ≥ 55 ft. to use streamer lines (per BiOp). This constrains research after end of 2013.

— Regulations for vessels < 55 ft. will be based on outcome of this research, as will final regulations for vessels ≥ 55 ft.

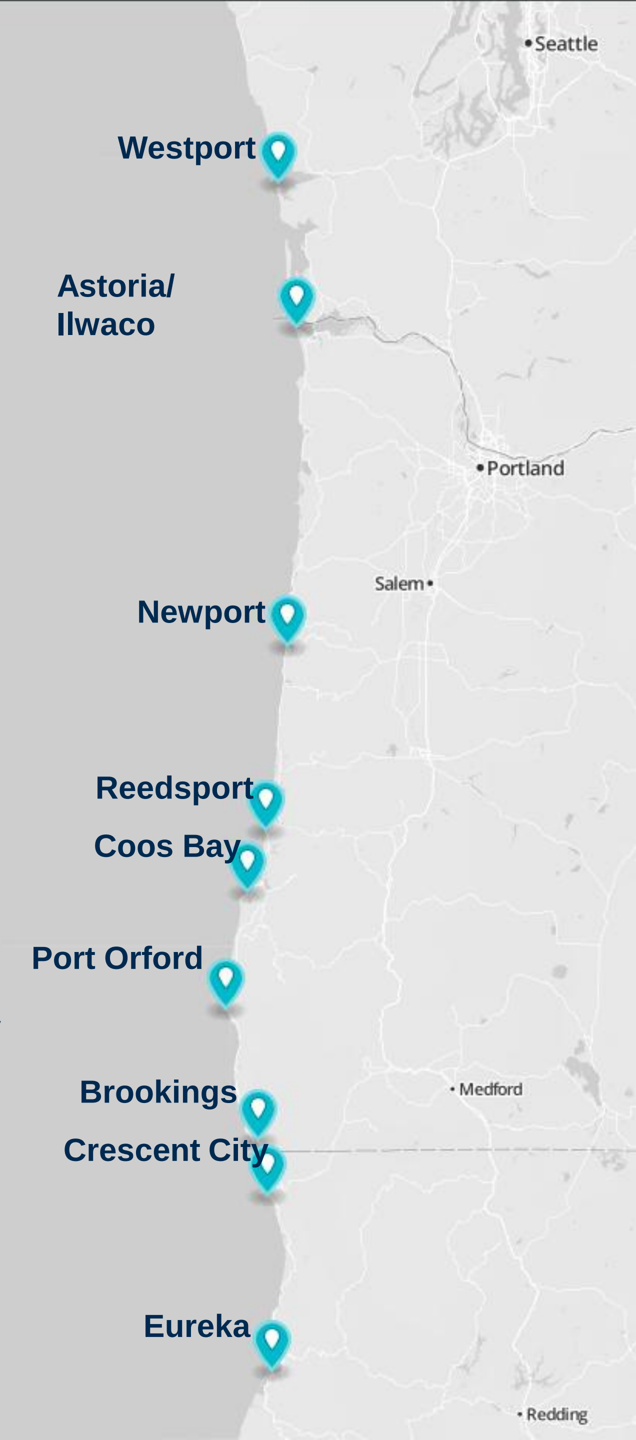
# Progress to Date

## Augmented Capacity
- Packard Foundation grant
- NFWF grant to OSU collaborators

## Engaged fishery stakeholders in 9 ports
- Characterizing gear and practices
- Identifying key players in each port
- Recruiting vessel owners to host research

## Field work
- Refined methods and protocols
- 2013 research on vessels ≥ 55 ft. (Sept. - Oct.).
- 2014 research on vessels < 55 ft.
- Sink rate data being collected by WCGOP

## Related Activities
- Facilitating production and distribution of free streamer lines to the West Coast fleet (w/NW Regional Office)
- Consulting with NW Region on pending seabird avoidance regulations (≥ 55 ft. ) for the West Coast
- Published paper on albatross-WC groundfish fishery overlap



Science, Service, Stewardship

# Recently Published

## A perspective on steepness, reference points, and stock assessment

Marc Mangel, Alec D. MacCall, Jon Brodziak, E.J. Dick,
Robyn E. Forrest, Roxanna Pourzand, and Stephen Ralston

*Canadian Journal of Fisheries and Aquatic Sciences* 70: 930–940

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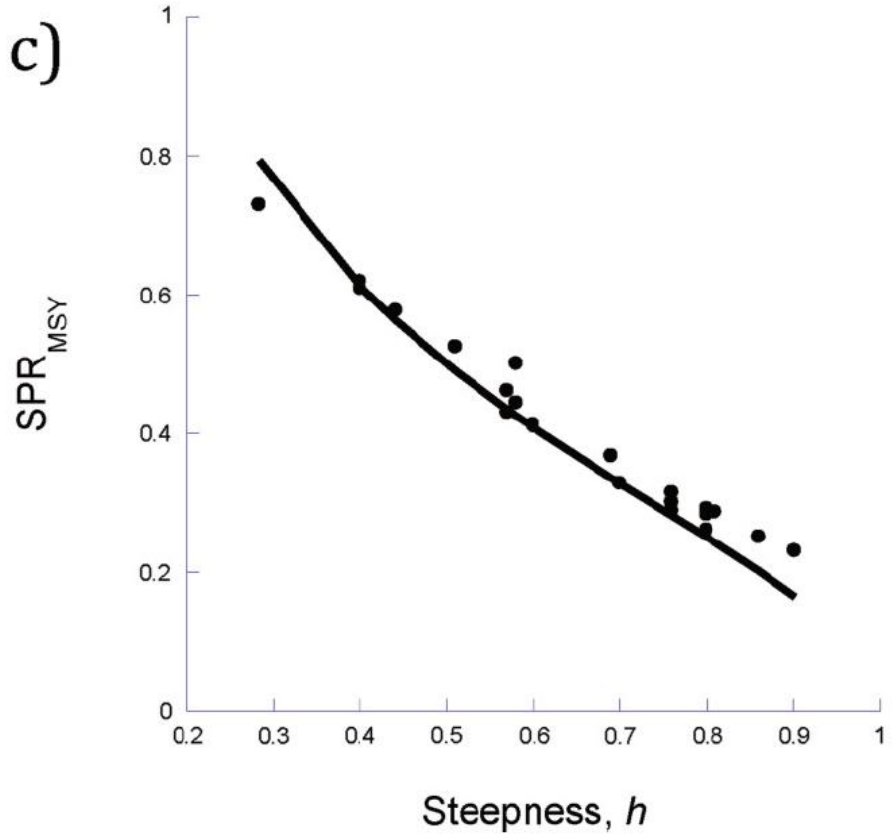
Figure shows SPR@ MSY as a function of steepness and for selected West Coast groundfish assessments.

- Demonstrates that key reference points are fixed when steepness and other life history parameters are fixed in stock assessments that use a Beverton–Holt stock–recruitment relationship, such that most point estimates or posterior samples do not address full extent of uncertainty.
- Recommendations for addressing these constraints include a greater emphasis on estimating, rather than fixing, steepness and natural mortality, as well as considering more complex stock-recruitment functions.



Science, Service, Stewardship

# Direct Estimation of Disturbance Rates of Benthic Macroinvertebrates from Contact with Standard and Modified Ocean Shrimp (Pandalus jordani) Trawl Footropes

Robert W. Hannah, Mark J. M. Lomeli, and Stephen A. Jones

*Journal of Shellfish Research, 32(2):551-557. 2013*

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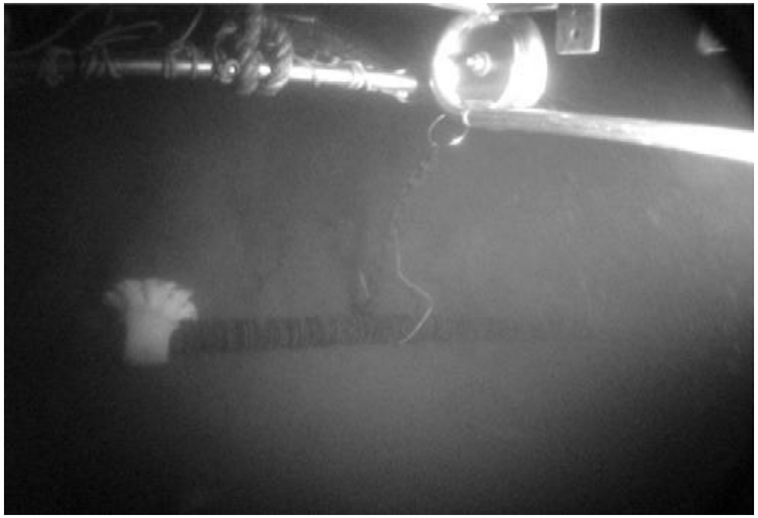
# Highlights of Study of Standard and Modified Ocean Shrimp Trawl Footropes

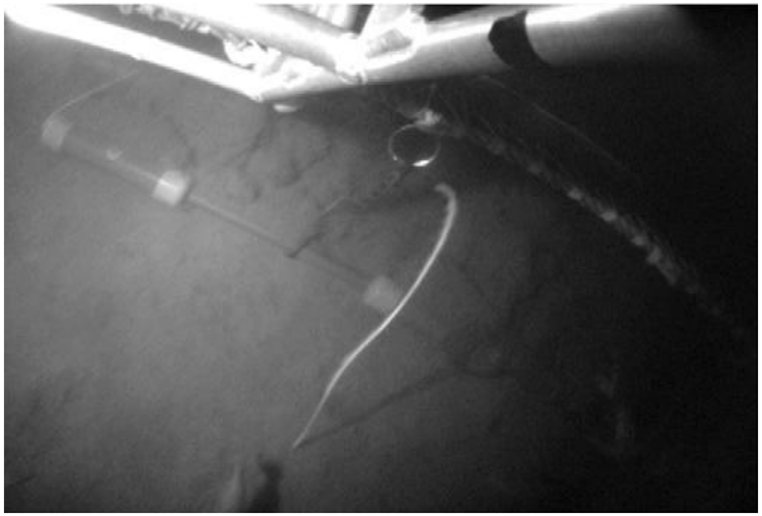
*(continued)*

- Constructing shrimp trawl groundlines from smoother materials and with modifications to elevate or eliminate portions of the groundline have the potential to reduce trawl-induced disturbance rates of benthic macroinvertebrates.

Common footrope in ocean shrimp fishery contacting a sea anemone



PVC pipe-covered groundline approaching a sea whip



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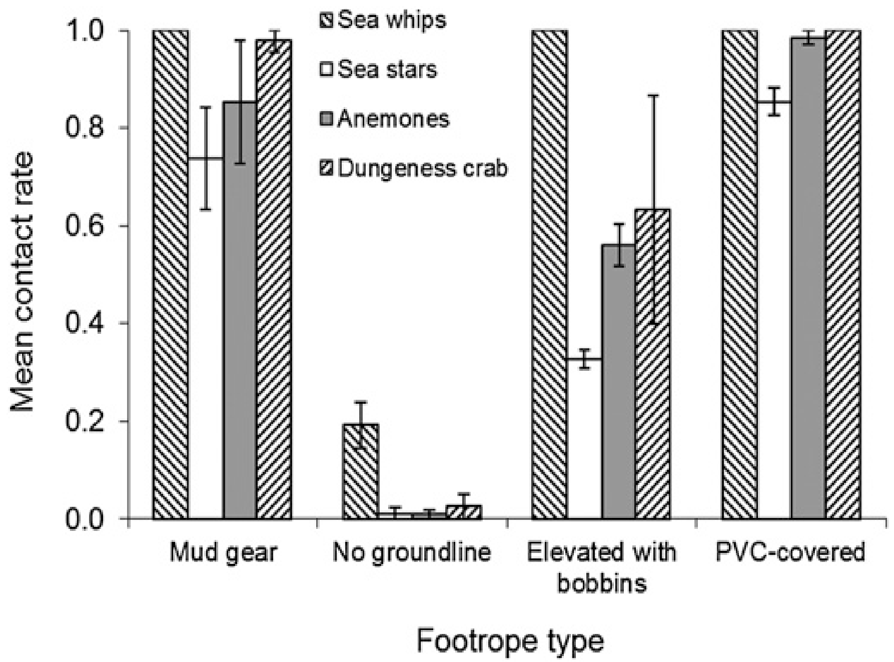
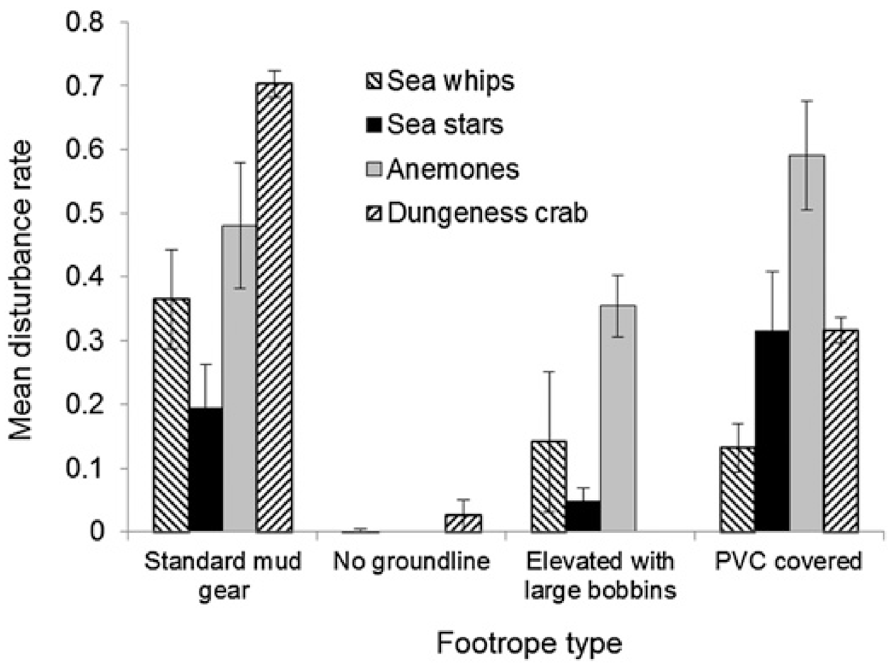
## Mean Contact Rates




## Mean Disturbance Rates



# GROUNDFISH ADVISORY SUBPANEL REPORT ON NATIONAL MARINE FISHERIES SERVICE REPORT: VESSEL MONITORING SYSTEMS

The Groundfish Advisory Subpanel (GAP) received a report from Mr. Dayna Matthews on a vessel monitoring systems (VMS) case relating to the Rockfish Conservation Area (RCA) for which a final decision and order was made on Aug. 29, 2013.

Mr. Matthews reviewed the case and its judicial review. Two of the main points of the case were the continuous transit language and the ping rate, which is currently one ping rate per hour, for which NMFS Office of Law Enforcement is proposing changes.

Some of the National Marine Fisheries Service (NMFS) Office of Law Enforcement (OLE) options suggestions include changing the RCA lines to polygons, increasing the ping rate to every 15 minutes (four times an hour) or using electronic logbooks.

While changing the RCA lines in various configurations would likely work for trawl vessels, this option would not work for fixed-gear vessels.

In the long-term, electronic logbooks may work, but this is an issue that has been in the works for years and there is no timeline for immediate implementation.

Increasing the ping rate will have financial consequences for all vessels, smaller vessels in particular. As an example, we've included the VMS service plans from one of the VMS manufacturers, Skymate. A small, open-access fixed-gear vessel that has the basic plan (Silver) of $21.99 a month likely would be burdened with a higher-cost plan, the Gold ($38.99 per month) or Platinum ($73.99 per month), which would allow for more pings per hour. Over a year, the cost increases could be considerable. Additionally, some vessel operators may have to purchase different equipment if their existing VMS is incapable of working within any new NMFS specifications.

Any VMS changes would have national implications and therefore bears greater scrutiny from other councils as well.

The GAP discussed alternatives such as testing a ping rate of two pings per hour, changing the declaration rules so that ping rates are increased only near sensitive areas, requesting the ping rate not be increased while the VMS equipment is in "sleep mode" (e.g., when the boat is tied to the dock). These were just some of the GAP's recommendations and we believe this issue requires further analysis rather than just an immediate change in the ping rates.

PFMC
09/13/13

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# Products

### SkyMate VMS Package

Designed for commercial fishermen with NMFS tracking requirements. Includes a SkyMate satellite communicator with an internal 12 channel GPS receiver with NEMA input capabilities, the SkyMate approved premium commercial grade 48” fiberglass VHF band antenna, a marine grade GPS antenna with 30’ of LMR coax cable for the VHF and GPS antennas, a GPS data cable, and a 8V 3.2 A-hr. sealed reserve battery. The package also includes the VMS user guide, power cables, a serial-to-USB adapter, a message indicator light, a serial data cable, and SkyMate PC software. This Package is not currently type approved for the Reefish Program(Amendment 18A).

View Product Image

**$1599.00**

### Specifications

| | |
|---|---|
| Frequency band | VHF |
| Transmit frequency | 148-150 Mhz |
| Receive frequency | 137-138 Mhz |
| Antenna impedance | 50 Ohms |
| Input voltage | 12-24 V DC |
| Transmit current | 2.5 A (1% duty cycle) |
| Receive current | 170 milliamps |
| Data interface | DB9 Female RS232 level |
| Satellite network | ORBCOMM |
| Operating conditions | 40-185 degree F |
| Humidity | 95% |
| Length | 7.08 in (180 mm) |
| Width | 4.06 in (104 mm) |
| Height | 1.42 in (30 mm) |
| Weight | 24.9 oz (800 grams) |
| GPS | 12 channel |

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# Service Plans

SkyMate offers you the flexibility to change your service plan month-to-month based on your fishing activity. *

### Platinum Plan

Send or receive 50,000 characters per month for just $73.99. Additional data costs only $1.40 per 1000 characters.

### Gold Plan

Send or receive 20,000 characters per month for just $38.99. Additional data costs only $1.90 per 1000 characters.

### Silver Plan

Send or receive 8,000 characters per month for just $21.99. Additional data costs only $2.25 per 1000 characters.

SkyMate suggests the following plans based on your reporting requirements. Each position report equals 20 characters.

| Reporting Interval | Reports Per Day | Characters/Month | Lowest Cost Plan | Lowest Plan with Messaging |
|---|---|---|---|---|
| Hourly | 24 | 14,400 | Silver | Gold |
| Every 30 Minutes | 48 | 28,800 | Gold | Platinum |

*$149 one time fee charged upon activation.

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Recreational Boating | Sport Fishing | Commercial Fishing | Workboats & Fleets

# SABLEFISH PERMIT STACKING PROGRAM REVIEW

The limited entry fixed gear (longline and fishpot) sablefish permit stacking program is a type of catch share program, was developed as Amendment 14 to the groundfish fishery management plan (FMP), and was first implemented for the latter part of the 2001 fishery. Under the permit stacking program, each limited entry permit endorsed for fixed gear sablefish is assigned to one of three tiers. The permit's tier level determines the poundage of sablefish which can be landed by that permit each year while participating in the primary sablefish fishery. Up to three permits can be stacked cumulatively onto a single vessel, allowing that vessel to land up to three tier limits in a single season. The program also included other provisions including a prohibition on the ownership of permits by corporations, a permit owner-on-board requirement, a limit on the number of permits any individual or entity (individually and collectively) can own or hold, and a prohibition on at-sea processing. A grandfather clause was provided for each of these provisions, allowing the continuation of situations in place prior to Council action.

The reauthorization of the Magnuson-Stevens Act (MSA), signed into law in 2007, included provisions which required periodic review for catch share programs:

> (c) REQUIREMENTS FOR LIMITED ACCESS PRIVILEGES.— (1) IN GENERAL.— Any limited access privilege program to harvest fish submitted by a Council or approved by the Secretary under this section shall—... (G) include provisions for the regular monitoring and review by the Council and the Secretary of the operations of the program, including determining progress in meeting the goals of the program and this Act, and any necessary modification of the program to meet those goals, with a formal and detailed review 5 years after the implementation of the program and thereafter to coincide with scheduled Council review of the relevant fishery management plan (but no less frequently than once every 7 years)." MSA 303A(c)(1)(G)

Applicability of 303A to pre-existing and recently-approved programs was addressed in MSA 303A(i)(1)(B). A program review of the sablefish requirements is consistent with the requirement for periodic reviews of limited access privilege programs.

This agenda item has been scheduled to begin in 2013, and dedicated funding has been provided to conduct this review. Included in the Council advance briefing materials are four documents: (1) a draft calendar for the review process (Agenda Item G.2.a, Attachment 1); (2) a draft advisory body structure, should the Council wish to establish such (Agenda Item G.2.a, Attachment 2); (3) a draft outline for the review document (Agenda Item G.2.a, Attachment 3); and (4) NOAA catch share performance indicators on the Pacific Coast sablefish permit stacking program (Agenda Item G.2.a, Attachment 4).

This process is intended to provide a review of the program and allow public input regarding potential changes. The draft schedule and document outline anticipate that the issues identified in the review and through public input will be summarized in a final report. Upon accepting the final report, the Council would select and prioritize identified issues for action, or consider these issues as part of its overall prioritization of new groundfish management measures scheduled for June 2014 (Agenda Item G.7, Attachment 4).

At this time, there are at least two issues that have been identified for possible listing and description in the program review. First, since shortly after the implementation of the sablefish permit stacking program, the Council has had on its workload list reconsideration of the sablefish stacking program's limits on the way the limit on the number of permits that may be owned and/or held by an individual or entity is specified. Second, under 303A of the MSA this program is subject to cost recovery and it is anticipated that this would be included in any subsequent rulemaking following the program review. The draft schedule provided here anticipates that these and other issues identified during the review would be prioritized for action at the end of the review process.

**Council Action:**

1. **Provide guidance on a calendar for the review process.**
2. **Provide guidance on the establishment of a specialized advisory body or bodies.**
3. **Provide guidance on content for the review.**

Reference Materials:

1. Agenda Item G.2.a, Attachment 1: Draft Sablefish Permit Stacking Review Calendar.
2. Agenda Item G.2.a, Attachment 2: Possible Advisory Body Structure and Composition.
3. Agenda Item G.2.a, Attachment 3: Draft Outline For The Pacific Coast Groundfish Limited Entry Fixed Gear Sablefish Permit Stacking Program Review.
4. Agenda item G.2.a, Attachment 4: NOAA Catch Share Performance Indicator Series: Pacific Coast Sablefish Permit Stacking Program.

Agenda Order:

a. Agenda Item Overview — Jim Seger
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Provide Guidance on Calendar, Process, and Content of Program Review.

PFMC
08/21/13

Agenda Item G.2.a
Attachment 1
September 2013

# DRAFT SABLEFISH PERMIT STACKING REVIEW CALENDAR

| | Council's Review Activity |
|---|---|
| September | • Approve calendar for review process<br>• Decide on need for and composition of advisory body(ies).<br>• Provide guidance on report outline and content, including identification of an initial list of issues for particular attention in the review. |
| November | • Provide further guidance on report content, including finalizing issues for particular attention in the review. |
| Winter 13/14 | • Develop draft program review document<br>• Hold advisory body review of preliminary draft program review document. |
| April | • Adopt draft program review document for public review. |
| June | • Adopt final program review document.<br>• Prioritize issues identified for possible Council action and adopt calendar for consideration. |

# POSSIBLE ADVISORY BODY STRUCTURE AND COMPOSITION

***Strawman*** Charge for Advisory Body: Review preliminary report on sablefish permit stacking program review and provide comments to drafters along with guidance on areas for further examination.

***Strawman*** Advisory Body Composition

| Seat | |
|---|---|
| Chair (potentially one of the below seats) | |
| Groundfish Management Team (GMT) Representative (State/Tribe) | |
| NMFS Sustainable Fisheries Division | |
| Enforcement Representative (State) | |
| Enforcement Representative (Federal) | |
| Pacific States Marine Fisheries Commission Representative (Data System) | |
| Longline Fisherman | |
| Longline Fisherman | |
| Pot Fisherman | |
| Pot Fisherman | |
| Conservation Representative | |
| Processor Representative | |

Agenda Items G.2.a
Attachment 3
September 2013

DRAFT OUTLINE FOR THE PACIFIC COAST GROUNDFISH LIMITED ENTRY FIXED GEAR SABLEFISH PERMIT STACKING PROGRAM REVIEW

# 1 Need for a Program Review

Twelve years have elapsed since implementation of the Sablefish Permit Stacking Program, a type of individual fishing quota (IFQ) program. A review would evaluate whether the program is functioning as originally intended in the goals and objectives of Amendment 14 to the Pacific coast groundfish fishery management plan (FMP), the overall FMP, and the Magnuson-Stevens Fishery Conservation and Management Act (MSA). A review would also identify any potential modifications or improvements to the program. A program review is consistent with the requirements in 303A of the MSA, to have periodic reviews of limited access privilege programs (LAPPs).

## 1.1 Relevant Groundfish Policy and Regulatory Changes Since Implementation

Since the implementation of the fixed gear sablefish permit stacking program, numerous regulatory changes have taken place within the Pacific coast groundfish fishery. Chief among these changes was implementation of groundfish conservation areas (i.e. Ecologically Important Habitat Closed Areas and Rockfish Conservation Areas) and the rationalization of the trawl fishery. Due to the large numbers of transfers occurring between the limited entry fixed gear (LEFG) sablefish fishery and the rationalized trawl fishery, development of the rationalized trawl fishery is further discussed in this section.

Trawl rationalization involved two closely related and interlinked decisions. The first was the specification of the management system used to rationalize the trawl fishery, Amendment 20 to the FMP. Amendment 20 involved the consideration of harvest control tools such as IFQs and harvester co-ops. The second decision involved determining the proportion of the available catch that would be allocated to the trawl versus the non-trawl fishery. This decision was addressed as Amendment 21 to the FMP.

## 1.2 Potential Issues this Review May Address

The following is a bulleted list of specific issues that have been identified for discussion, and potential inclusion in this program review:

- Identify primary ports where sablefish landings (both primary season landings and landings made in the daily trip limit (DTL) fishery) are occurring;
- Analyze how much stacking is occurring overall, as well as by port, and by vessel;
- Review use of different permit types and gear types;
- Analyze length of harvest period during the sablefish primary season vs. DTLs;

- Formulate and propose method(s) to improve catch accounting between the sablefish primary fishery and LEFG sablefish DTL fishery within the same year, such as moving to an e-fish ticket system;
- Analyze cross-over between this program and the trawl rationalized fishery;
- Address the MSA requirement for cost recovery;
- Analyze opportunities for new entrants (considering, for example, the high cost of a Tier 1 permit);
- Reconsider the limits on the number of permits that may be owned and/or held by an individual or entity;
- Review owner-on-board requirement;
- Review fish ticket requirements to ensure permit/tier documentation; and
- Review/analyze downstream effects to catch accounting, observer monitoring, and enforcement efficacy of allowing a fixed gear permit and a trawl permit to be registered to the same vessel at the same time (please note that the Council has already taken action on this item, but because this has potential implications for both the trawl rationalized fishery and LEFG fleet, further analysis on this issue will be included in this review).

# 2 Background

## 2.1 Pre-Permit Stacking Management History

Sablefish (*Anoplopoma fimbria*), also known as "black cod," is one of the most valuable species in the Groundfish fishery off Washington, Oregon, and California. Because of its high ex-vessel value per pound, sablefish is a desirable target species for many West Coast fisheries and gear groups. The Pacific Fishery Management Council (Council) has made several sablefish allocation decisions over the 15 years prior to implementation of Amendment 14 in order to divide this desirable resource among different sectors of the fishery.

In 1987, an allocation of sablefish was established between trawl (52 percent) and non-trawl gear (48 percent) groups. This allocation was later adjusted to 58 percent and 42 percent. Industry representatives of vessels participating in the non-trawl sablefish fisheries expressed their desire that the fishery be managed on a seasonal basis (as opposed to the year-round policy the Council pursued for most sectors of the groundfish fishery). The pursuit of seasonal management for the non-trawl segment of the sablefish fishery was a key decision that, when combined with a decline in sablefish abundance, ultimately impacted safety, efficiency, and allocational issues that the permit stacking program was meant to address.

The vast majority of the trawl and non-trawl sablefish harvest was placed under a license limitation program in 1994 (Amendment 6). Of the non-tribal commercial optimum yield of sablefish, 90.6 percent was allocated to the limited entry fishery and 9.4 percent was allocated to the open access fishery. The limited entry sablefish allocation was then allocated 58 percent to the limited entry trawl sector and 42 percent to the limited entry non-trawl (fixed gear) sector.

Management for the fixed gear fleet was, and continues to be divided at the 36º N. lat. line with separate annual catch limits (ACLs) for the northern and southern fisheries. While the coastwide trawl fishery took sablefish as part of its year-round cumulative trip limit fisheries, the northern fixed gear fleet landed 85 percent of its allocation in a directed sablefish season, and 15 percent of its allocation in DTL fisheries. The southern fixed gear fleet landed all of its allowed harvest in DTL fisheries. The directed season north of 36º N. lat. had become increasingly tense over the years, as vessel capacity and competition for landings increased and amounts of fish available for harvest decreased. Through 1996, the directed (or "primary") season was managed as an open competition derby ("derby"). Derby duration shortened each year, until the fishery was just five days long in 1996.

Concern for the safety of participants in the sablefish derby led the Council to develop Amendment 9 to the FMP. In 1997, National Marine Fisheries Service (NMFS) implemented Amendment 9, the sablefish endorsement program. Limited entry permit holders were eligible for sablefish endorsements based on their permit history. Permits without sufficient sablefish landings history were not endorsed for future participation in the primary season, but could still be used in the DTL fisheries.

Even with the sablefish endorsement, the fishery season remained short (nine days in 1997). In order to lengthen the season, equal limits were imposed on all qualified participants (sablefish endorsement holders). However, the season still had to be limited to keep the fishery from being classified as an individual quota (IQ) program. A fishery with a limited class of participants each with an amount of fish they are allowed to harvest is an IQ. In its 1996 re-authorization of the MSA, Congress had included a moratorium on implementing new IQ programs through October 1, 2000. The moratorium was interpreted to cover any program that would allow a vessel ample time and opportunity to catch a limit allocated specifically to that vessel. The moratorium forced the Council to manage the primary season to a short duration that prevented many participants from fully taking their vessel-specific limits (a "modified derby"). To further assure that the cumulative limits would not be categorized as an IQ program, regulations were established to set a maximum season length of 10 days. Equal cumulative limits were viewed by the Council as being extraordinarily reallocative in nature, but for 1997, equal limits were the only option available to lengthen the season and to begin to address safety issues.

The inequitable allocation system created by the equal cumulative limits was partially resolved with a "three-tier" system, which was established by regulatory amendment for 1998 and beyond. Under this "three-tier" system, sablefish endorsement holders were ranked into three different tiers based on their permit histories, with the lowest tier (Tier 3) having the lowest qualification requirements. Annual management of the three-tier cumulative limit system required that the allocation for this fishery be divided such that there were three different cumulative limits for the different tiers. While somewhat more equitable than the cumulative limit program, the three-tier system still required some fishermen to make large cutbacks in their harvest levels while allowing others to expand. The system provided little flexibility to operators to determine the manner in which their sablefish catch is harvested or to scale their harvest upward to match their pre-existing levels of capital investment. This lack of flexibility undoubtedly reduced efficiency, resulting in a lower net value for harvest.

Even under the three-tier system, the fishery still had to be managed as a modified derby, and the seasons were still too short (between 6-9 days) to allow fishermen to operate with care and safety. Short derby seasons are believed to result in accidents due to fatigue, and financial pressure to fish and transit under unsafe conditions.

The MSA moratorium on new IQ programs expired on October 1, 2000. On December 21, 2000, Public Law 106-553, an appropriations bill for NOAA, contained a continuation of the IQ moratorium through October 1, 2002 and an exception to that moratorium for a permit stacking program in the West Coast fixed gear sablefish fishery. On August 2, 2001, Amendment 14 implemented a permit stacking program, in which up to three sablefish-endorsed permits could be registered for use with a single vessel and that vessel could then have access to the primary season sablefish cumulative limits associated with each of those permits. Most importantly, the exception to the IQ moratorium for the fixed gear sablefish fishery as implemented through Amendment 14 allowed longer seasons (April through October), so that each vessel could fish against its limits at its own speed.

Portions of Amendment 14 were implemented for the 2001 primary sablefish season. The extended sablefish season was fully implemented in 2002. In 2006, NMFS implemented additional regulations for Amendment 14. In the future, NMFS will implement a permit stacking program fee system as required by the MSA.

Stages of Implementation

- Beginning in 2001, NMFS implemented the initial permit stacking provisions (66 FR 41152, August 7, 2001). The following provisions were put in place in 2001:
    - (1) up to 3 sablefish-endorsed permits may be registered for use with a single vessel;
    - (2) the limited entry, primary sablefish season is from August 15 - October 31, 2001;
    - (3) a vessel may fish for sablefish during the primary season with any of the gears specified on at least one of the limited entry sablefish-endorsed permits registered for use with that vessel;
    - (4) no person may own or hold more than 3 sablefish-endorsed limited entry permits unless that person owned more than 3 permits as of November 1, 2000;
    - (5) no partnership or corporation may own a sablefish-endorsed limited entry permit unless that partnership or corporation owned a permit as of November 1, 2000;
    - (6) cumulative limits for species other than sablefish and for the sablefish daily trip limit fishery remain per vessel limits and are not affected by permit stacking; and
    - (7) the limited entry daily trip limit fishery for sablefish is open during the primary season for vessels not participating in the primary season.

- Beginning in 2002, NMFS extended the fishing season to April 1 - October 31 as part of the Pacific Coast groundfish final specifications and management measures (67 FR 10490; March 7, 2002).

- Beginning in 2006, NMFS implemented further permit stacking regulations that include the following provisions (71 FR 10614, March 2, 2006):
  - (1) permit owners and permit holders are required to document their ownership interests in their permits to ensure that no person holds or has ownership interest in more than 3 permits;
  - (2) an owner-on-board requirement for permit owners who did not own sablefish-endorsed permits as of November 1, 2000;
  - (3) an opportunity for permit owners to add a spouse as co-owner;
  - (4) vessels that do not meet minimum frozen sablefish historic landing requirements are not allowed to process sablefish at sea;
  - (5) permit transferors are required to certify sablefish landings during mid-season transfers; and
  - (6) a definition of the term "base permit."

### 2.2 Permit Stacking Program Goals and Objectives

The legal basis for Amendment 14 is the Groundfish FMP approved by the Secretary of Commerce under the authority provided by the MSA.

Permit stacking and its accompanying regulatory provisions were expected to help the Council address objectives related to National Standards 4 (fair and equitable allocation), 5 (consider efficiency), 6 (take into account variations and contingencies), 8 (take communities into account), 9 (minimize bycatch and bycatch mortality), and 10 (promote safety). Specifically, it was expected to affect achievement of Groundfish FMP Goals 2 (maximize the value of the resource as a whole) and 3 (achieve maximum biological yield) through impacts related to Objectives 4 (achieve greatest net benefit), 9 (reduce wastage), 11 (equitable sharing of conservation burden, minimize bycatch or bycatch mortality), 12 (minimize gear conflicts), and 13 (accomplish changes with minimum disruption).

Key objectives of Amendment 14 and the permit stacking program were further defined as follows:

- <u>Rationalize the fleet and promote efficiency</u>. Capacity reduction is one of the key elements of the strategic plan. The strategic plan generally approaches capacity reduction by reducing the number of fishing vessels. This reduction does not of itself imply the rationalization of the fleet or increased efficiency. It is possible that the most efficient fixed gear sablefish harvest could involve a greater number of vessels taking sablefish as bycatch in other fisheries. However, given the high degree of overcapitalization in the fishery, it is believed that a reduction in capacity will generally move the fishery toward greater efficiency, addressing National Standard 5 and FMP Objective 6.
- <u>Maintain or direct benefits toward fishing communities</u>. This objective relates to National Standard 8 on fishing communities, and FMP Objective 17.
- <u>Prevent excessive concentration of harvest privileges</u>. This objective relates to National Standard 4 on allocation, National Standard 8 on fishing communities, and FMP Objective 16.

- Mitigate the reallocational effects of recent policies (3-tier system and equal limits). This objective relates to National Standard 4 on allocation and FMP Objectives 13 on equitable allocation and 15 on minimizing disruption.
- Promote equity. This objective relates to National Standard 4 on allocation and FMP Objective 13 on equitable sharing.
- Resolve or prevent new allocation issues from arising. This objective relates to National Standard 4 on allocation and FMP Objectives 13 on equitable sharing and 15 on minimizing disruption.
- Promote safety. This objective relates to National Standard 10 and FMP Objective 18 on safety.
- Improve product quality and value. This objective relates to National Standard 5 on efficiency and FMP Objective 6 on net national benefits.
- Take action without creating substantial new disruptive effects. This objective relates to FMP Objective 15 on minimizing disruption.
- Create a program that will readily transition to a multimonth IQ program. This objective relates to capacity reduction recommendations in the strategic plan. Where individual quotas are transferable and divisible they address National Standard 6 by providing the fleet with substantial flexibility to respond to changing conditions in the fishery and National Standard 5 by taking efficiency into account. FMP Objective 6 is also addressed.

The stacking program was intended to modify the economic and social impacts of the fishery management system in order to attain a more favorable result with respect to the entire suite of standards, goals, and objectives for management of the groundfish fishery.

### 2.3 Description of the Current Permit Stacking Program

The current permit stacking program, or sablefish primary fishery, occurs north of 36º N. lat., where vessels registered to at least one limited entry permit, with either a gear endorsement for longline or trap (or pot) gear, and an endorsement for sablefish, fish a specified tier limit. Such vessels are eligible to fish in the DTL fishery before the primary season (i.e., January through March) and after their aggregate tier limit on the vessel has been harvested, or the season has ended, whichever comes first. This transition between fisheries often occurs during the sablefish primary season. Under the permit stacking program, each fixed gear sablefish endorsed limited entry permit is assigned to one of three tiers. The permit's tier level determines the poundage of sablefish which can be landed by that permit each season while participating in the primary sablefish fishery. For sablefish endorsed, limited entry permits, the Regional Administrator will biennially or annually announce the size of the cumulative trip limit for each of the three tiers associated with the sablefish endorsement such that the ratio of limits between the tiers is approximately 1:1.75:3.85 for Tier 3:Tier 2:Tier 1, respectively. Up to three permits can be stacked onto a single vessel, allowing that vessel to land up to the sum of the three tier limits in aggregate.

The program also includes other provisions, including a prohibition on the ownership of permits by corporations or other business entities, a permit owner-on-board requirement, a limit on the number of permits any individual or entity (individually and collectively) can own or hold, and a prohibition on at-sea processing. A grandfather clause was provided for each of these provisions, allowing the continuation of situations in place prior to Council action. For non-grandfathered permits, the owner must be on board the vessel during the primary season when that permit's tier amount is being fished. If landings from a trip will be attributed to multiple tiers, then all permit owners of those tiered permits being fished must be onboard. However, there are medical and death exemptions from this requirement.

Currently there are 164 sablefish endorsed permits of which 131 are endorsed for longline only; 27 are trap/pot endorsed only, and 6 have two gear endorsements. The number of permits by tier levels is as follows: Tier 1 -28 permits; Tier 2 – 42 permits, and Tier 3 – 94 permits. As of August 2013, approximately 40 vessels have stacked permits (either tier 2 or 3).

**Further sections of this review may be structured as follows:**

**3 Program Performance and Review**
- **3.1 Overview of Materials Available for Program Review**
- **3.2 Biological Outcomes**
- **3.3 Socioeconomic Outcomes**
- **3.4 Community Impacts**
- **3.5 Safety at Sea**
- **3.6 Management Costs and Cost Recovery**
- **3.7 Enforcement**

**4 Research Needs**
- **4.1 Biological**
- **4.2 Socioeconomic**
- **4.3 Community**

**5 Recommendations for Moving Forward**

**6 Review Summary and Conclusions**

**7 References**

PFMC
08/21/13

# NOAA Catch Share Performance Indicator Series

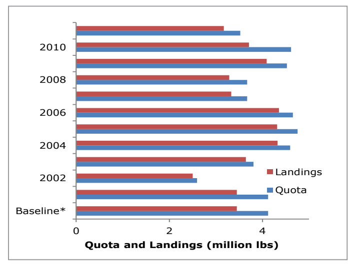
## Pacific

### Pacific Coast Sablefish Permit Stacking Program

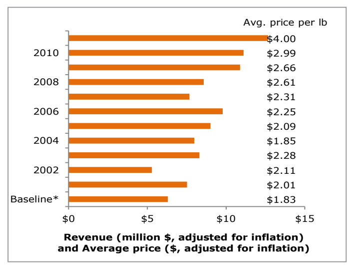
**NOAA Fisheries** has developed standard indicators to measure the economic performance of individual U.S. catch share programs over time. To calculate these metrics catch, effort, landings, revenue, share accumulation and cost recovery data are used.

**Management History:** Overcapacity in the Pacific sablefish fishery during the 1990's led to derby fishing, seasons as short as five days long, market gluts, and compromised safety at sea. As a first step in controlling the derby, the Pacific Fishery Management Council implemented a system in which each permit is assigned a maximum harvest level. With the end of the Magnuson-Stevens Act moratorium on new individual quota systems, the Council was able to extend the season length to seven months, effectively making the individual permit's maximum harvest level into defacto quotas. In the same action, the Council allowed the "stacking" (combining) of up to three sablefish permits, making the fishery more economical.

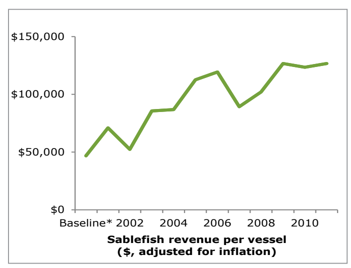
**Objectives:** The Pacific Coast Sablefish Permit Stacking Program (Program) was developed by the Pacific Fisheries Management Council as Amendment 14 to the Pacific Groundfish Fishery Management Plan. The catch share program manages 85% of the sablefish allocated to the limited entry groundfish fixed gear fishery, which is about 30% of all commercially harvested sablefish on the West Coast. The Program aims to improve economic efficiency, increase benefits for fishing communities, promote equity, mitigate reallocation effects of previous harvest regulations, promote safety, and improve product quality and value.




**Key Management Events:** Under the Program, each permit is associated with an individual quota (based upon a vessel's historical catch), and owners may register more than one sablefish endorsed permit (and associated quota) to their vessel. This stacking allows the number of overall vessels participating in the fishery to decline without reducing the total quota allocation. Amendment 14 to the Fishery Management Plan prohibited permit ownership by corporations and partnerships, and included an owner-on-board requirement, introduced in order to preserve the owner-operator nature of the fleet.




Quota allocated to the Program was reduced by 37% in 2002 when compared to the previous year. Quota was subsequently increased (by 47%) the following year and followed an upward trend until 2006. In 2006 and 2007, the quota was again reduced by 2% and 21% when compared to the previous years, respectively. Sablefish quota increased for the following three years and was reduced in 2011 by 24%, relative to 2010. These reductions in quota were implemented to manage Pacific Coast Sablefish stocks and would have occurred regardless of whether the catch share program was implemented.




**Performance Trends:** The fishery opens on April 1 and ends on October 31 of the same year. Information is shown for 2001 onwards; however, the Permit Stacking Program was only partially implemented in 2001 therefore this was an incomplete fishing year. Amounts reported are based on sablefish harvested in the primary limited entry groundfish fixed gear fishery and do not include sablefish harvested in the daily fishery component of the limited entry fixed gear fishery. Revenue and pricing information are presented in real terms (adjusted for inflation with the GDP 2010 index).

Economic efficiency, as measured by revenue per vessel, improved significantly under the Program. Revenue per vessel in 2011 is 165% greater than in the Baseline Period*. The Program was also successful in reducing capacity, with the number of vessels active in 2011 26% less than in the Baseline Period*. The number of entities holding shares also declined over the course of the Program, from 154 in 2001 to 114 in 2011. The Program also ended derby fishing, with season length increasing from five days a year to over 200 days annually.

*Baseline Period refers to the average of three years prior to implementation of the Pacific Coast Sablefish Permit Stacking Program (1998 - 2000).

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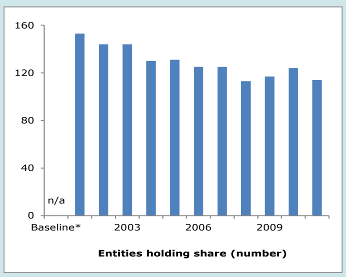
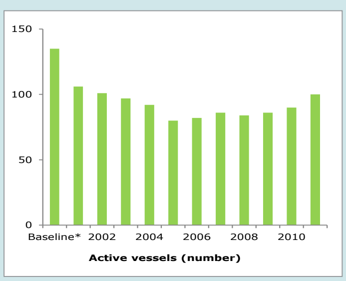
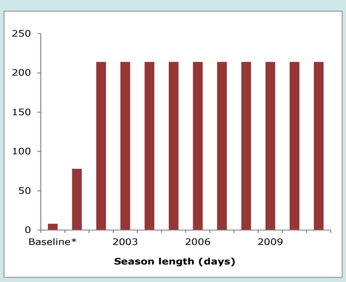



**For more information contact:**

Ayeisha Brinson
*ayeisha.brinson@noaa.gov*

Eric Thunberg
*eric.thunberg@noaa.gov*

**Cost Recovery Fees:** The Magnuson-Stevens Act authorizes the Secretary to adopt regulations implementing a cost recovery program to recover the actual cost of managing and enforcing limited access privilege programs.

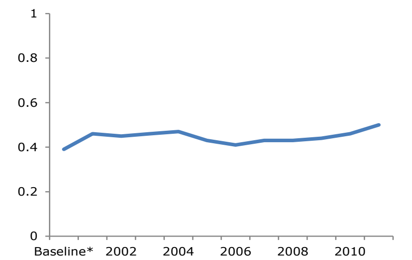
Cost recovery provisions have not yet been implemented in this Program. The Council is working to incorporate cost recovery provisions in the future.

**Share Caps:** The purpose of excessive share caps is to prevent individuals from controlling production and prices, as well as to achieve management objectives, per the Magnuson-Stevens Act and the National Standards.

There is no explicit share cap for sablefish. Sablefish is allocated to permit holders based on three different tier levels, and no vessel may hold more than three permits. Given the limit associated with each permit, the implicit share cap for any one vessel is 4.2%.

**Revenue Distribution:** The Gini coefficient measures the evenness of a distribution. Here, it measures the distribution of revenue among entities holding shares in the Pacific Coast Sablefish Permit Stacking Program. A value of 0 indicates that all shareholders earn the same amount of revenue, while a value of 1 indicates that one shareholder earns all of the revenue.

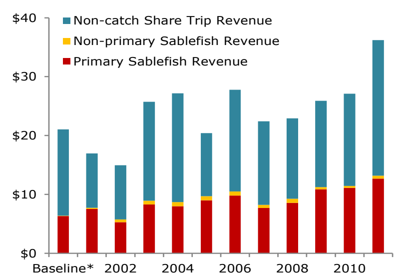
The Gini coefficient calculated for the Pacific Coast Permit Stacking Program was 0.39 in the Baseline Period* and 0.46 in 2001. It subsequently increased to 0.50 in 2011.



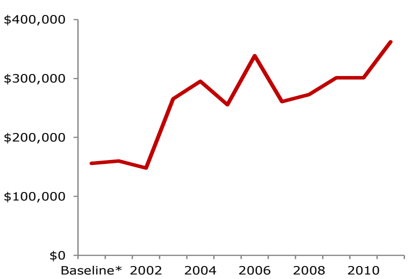

Revenue distribution among entities holding shares in the Pacific Sablefish Permit Stacking Program (Gini coefficient**)

**0 = perfect equality; 1 = perfect inequality

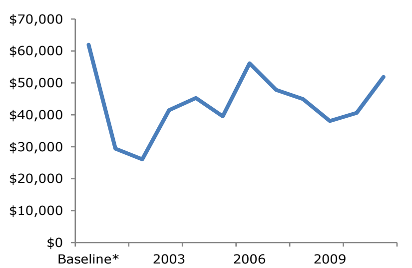
**Total Revenue:** Vessels participating in the Program generate revenue on primary sablefish trips from both sablefish and non-sablefish landings. In addition, these same vessels also participate in other fisheries (including non-catch share programs), and this revenue contributes to their total revenue. Over the course of the catch share program history, total revenue was lowest in 2002 at $14.9 million and greatest in 2011 at $36.2 million, amounting to a more than 72% increase when compared to the Baseline Period*. Total revenue increased in all but four years between the Baseline Period* and 2011. Declines in two of those years (2002 and 2007) coincided with declines in the quota allocated to the catch share program and catch share species revenue, as well as declines in the non-catch share trip revenue. In 2005, the decline in total revenue came from a decrease in non-catch share trip revenue. The 2001 total revenue decline coincided with a substantial decline in non-catch share trip revenue.




Total revenue (million $, adjusted for inflation)




Total revenue per vessel ($, adjusted for inflation)




Total revenue per trip ($, adjusted for inflation)

**Total revenue per vessel and total revenue per trip:** Total revenue per vessel increased in all years except for 2002, 2005, 2007, and 2010. Declines in catch share quota coincided with falling catch share revenues in 2002 and 2007 (see above); whereas, the decline in total revenue per vessel in 2005 coincided with a decline in non-catch share trip revenue. The 2010 decline in total revenue per vessel is most likely due to an increase in the number of active vessels participating in the Permit Stacking Program. In 2011, total revenue per trip was $52,000, a 16% decline over the Baseline Period* value.

**Catch Limits:** Following implementation of the catch share program, catch limits have not been exceeded in the Pacific Coast Sablefish Permit Stacking Program.

For more detailed information on the Pacific Coast Sablefish Permit Stacking Program, please visit: http://www.nwr.noaa.gov/fisheries/management/sablefish.html

More fact sheets can be found at: http://www.st.nmfs.noaa.gov/economics/fisheries/commercial/catch-share-program/fact-sheets/index

For more information on catch share programs: http://www.nmfs.noaa.gov/sfa/domes_fish/catchshare/index.htm

*Baseline Period refers to the average of three years prior to implementation of the Pacific Coast Sablefish Permit Stacking Program (1998 - 2000).

**Agenda Item G.2.a**
**Supplemental Agenda Item Overview PowerPoint**
**September 2013**

# Sablefish Permit Stacking Program Review

Agenda Item G.2

# Council Action

- Calendar for the review process.
- Specialized advisory body(ies)
- Content for the review.

# The Permit Stacking Program

- Each sablefish limited entry pot & longline permit qualified for an allocation tier.
  - Tier 1 gets the most, Tier 3 the least
- Up to 3 permits can be stacked.
- Three permit control limit.
  - Part ownership in a permit counts as one.
  - Part ownership of a permitted vessel counts as one.
- Corporate ownership is not allowed
- Permit owner(s) must be on board
- Grandfather exceptions

# Draft Calendar
# G.2.a Attachment 1

- Sept – calendar, advisory body, content
- Nov – content (indicators and list of concerns)
- Winter – document development and advisory meeting
- Apr – adopt draft for public comment
- Jun – adopt final review document and plan

# Draft Charge and Seats
# G.2.a Attachment 2

- Review preliminary report on sablefish permit stacking program review and provide comments to drafters along with guidance on areas for further examination.

| Managers | Constituents |
|---|---|
| GMT – State | Longline |
| GMT – Fed | Longline |
| EC – State | Pot |
| EC – Fed | Pot |
| PSMFC | Conservation |
| | Processor |

# Document Outline

1. Need for Program Review
    1.1 Changes since program implementation
    1.2 Potential Issues
2. Background
    2.1 Pre-Permit Stacking Management History
    2.2 Permit Stacking Program Goals and Objectives
    2.3 Description of the Current Program
3. Program Performance and Review (pg. 7)
4. Research Needs
5. Recommendations for Moving Forward
6. Review Summary and Conclusions

# Council Action

1. Provide guidance on a calendar for the review process.
2. Provide guidance on the establishment of a specialized advisory body or bodies.
3. Provide guidance on content for the review.

# ENFORCEMENT CONSULTANTS REPORT ON SABLEFISH PERMIT STACKING PROGRAM REVIEW

For the Enforcement Consultants (EC), our number one concern for this fishery is catch accounting. Under the current system, when a sablefish fixed gear tier delivery is made, the delivery by regulation is recorded on a state fish ticket. One to three tiers may be delivered and recorded on this one trip ticket. If not specified by the operator, the delivery is apportioned to the individual tiers (up to 3) by an even split until the tiers are reduced to a point where they are equal to or less than the daily-trip limits (DTL). All of this tabulation is done by the state agency(s) and then sent to Pacific States Marine Fisheries Commission (PSMFC) for entry into Pacific Fishery Information Network (PacFIN).

Although on the surface this may appear to be an adequate monitoring and accounting process, the EC sees numerous problems with this process. Our primary concern is that the opportunity for underreporting is extremely high, yet we have little information to support this fear, primarily because we have little access to data which is often times severely outdated. This creates a situation where at sea boarding or dockside inspection can do little besides checking the permit status, but has no real time information on the actual status of the tier(s) being fished.

There is no state regulatory requirement for the tier permit number to be listed on the state fish ticket. Since inception of the tier program, there has been a voluntary request made to the state agencies to list the federal permit number on the state ticket. To the extent the voluntary request is working is a matter of conjecture and, for us, a concern as well. Regardless, a state mandate requiring the Federal permit be listed on the state fish ticket would be a substantial improvement over the current reporting structure.

The EC believes the timeliness of data and access to the PACFIN data could be greatly improved through a Federal requirement that all tier deliveries be recorded on an Electronic (E) Fish Ticket. The E Fish Ticket program is now in its fifth year of implementation. Since inception of trawl rationalization, over 8,000 individual fishing quota (IFQ) trawl deliveries have been made with 96 percent of the tickets reconciled and in the data base within 48 hours. Contrast this with the paper system that can take weeks to months.

As envisioned, the tier permit(s) would be “loaded” with the appropriate pounds within an established corresponding vessel account. When deliveries are made, the operator would be required by rule to designate which of their tiers said pounds should be applied too. As with the corresponding IFQ data access that is currently enjoyed by all interested parties, the operator, tier owner, science centers, state and federal managers and enforcement would have access to tier delivery information, with no time lag or guessing whether the delivery is a tier delivery, under whose permit, or is in fact not a tier delivery but a DTL delivery.

The PSMFC E Fish Ticket already has the appropriate fields and drop down boxed to accommodate this fishery. The EC believes this proposal represents a vast improvement in catch accounting, and is in fact necessary to ensure compliance is this highly valued, highly regarded fishery.

Regarding the matter of EC participation in a possible advisory body composition, the EC supports the inclusion of one state enforcement representative and one federal enforcement representative.

Recommendations:

1. A state (preferred) or Federal requirement that the federal permit number be listed on the state fish ticket
2. A federal requirement that all tier deliveries be recorded on an E Fish Ticket.
3. Advisory Body Composition: include one state enforcement representative and one Federal enforcement representative.

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# GROUNDFISH ADVISORY SUBPANEL REPORT ON SABLEFISH PERMIT STACKING PROGRAM

The Groundfish Advisory Subpanel (GAP) heard a presentation from Ms. Ariel Jacobs, NMFS, and Mr. Jim Seger, PFMC, regarding a review of the sablefish permit stacking program.

The Council briefing book materials regarding the history and development of the program were very well done and helpful, particularly for GAP members who were not participants in the process.

The GAP recommends that NMFS prioritize and proceed forward now, in an expedited manner, with two previously approved management issues pertaining to fixed gear sablefish tier program

1) Allow trawl permit and fixed gear permits on the same vessel at the same time as approved by the Council in April 2012 (take action under G.9).

2) Address ownership and control issue of permits as previously recommended by GAP and addressed by the Council.

With regard to any other actions pertaining to sablefish tier permit program, the message is: “If it’s not broken, don’t fix it.” Fixed gear representatives noted that with the exceptions above, the industry has been satisfied with the program and has not proposed other changes to the program.

If the Council is going to proceed forward with a program review as set forth in Agenda Item G.2., the GAP recommends:

1. Industry representation on committee should be expanded to include at least 6-8 tier permit holders to include representation from different tier levels, states and gear types.

2. That the focus of the review be primarily on whether the program has met its objectives and goals as defined by national standards.

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Agenda Item G.2.b
Supplemental GMT Report
September 2013

# THE GROUNDFISH MANAGEMENT TEAM REPORT ON CONSIDERATION OF THE SABLEFISH PERMIT STACKING PROGRAM REVIEW

The Groundfish Management Team (GMT) would like to thank Mr. Jim Seger and Ms. Ariel Jacobs for their presentation on this agenda item. Given the team's workload at this meeting and given that this program review is in its initial planning stage, we kept our discussion and comments brief, with the understanding that future opportunities for input would be available.

One major topic of discussion was the possible scope of the review. That scope could conceivably range widely in both the amount of detail and the number of issues considered, and in turn, the amount of analysis and Council time that it could take. The Council may be concerned with the workload and this review's overlap with the current 2015-2016 and beyond harvest specifications and management measures cycle.

With such program reviews, the first step involves revisiting the stated goals and objectives of the program and evaluating whether they have been met. Completing this step would involve analysis of available information on the fishery performance since the start of the program. We understand there are resources available to help conduct such analysis.

The second step would be to identify whether modifications to the program, including revisions to the goals and objectives, are needed. It is at this step where the Council might consider how much to take on and set priorities and schedules for considering changes to the program. This two-step approach is what we understand as being contemplated in the draft calendar (Agenda Item G.2.a, Attachment 1). The draft calendar proposes that the preliminary list of changes and improvements to the sablefish permit stacking program be considered in June 2014, which is also when other groundfish management measures are considered for the changes to management measures that occur outside the harvest specifications and management measures process. The GMT thought Section 1.2 of Agenda Item G.2.a, Attachment 3 was a very good start at a list of what the analysis could consider.

On that note, we continue to support moving toward better integration of the various groundfish agenda items for analysis and workload planning. By considering all these items together, priorities can be set with full consideration of the scope of work that the Council, its advisory bodies, and cooperating agencies may be undertaking simultaneously.

Lastly, on the advisory body composition proposed in Agenda Item G.2.a, Attachment 3, some on the GMT recommend including three state seats in addition to or in lieu of one GMT seat. The reason is that the states play a key role in tracking landings and each state's system is different. It may be difficult for one GMT member to adequately represent each states' fish ticket considerations.

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# APPROVE STOCK ASSESSMENTS

The Pacific Fishery Management Council (Council) process for setting groundfish harvest levels and other specifications depends on periodic assessments of the status of groundfish stocks and a report from an established assessment review body or, in the Council parlance, a Stock Assessment Review (STAR) Panel. The Scientific and Statistical Committee (SSC) reviews this information and makes a recommendation relative to the standards of 1) the best available science, and 2) soundness for use in groundfish fishery management decision-making by the Council. The Council then approves the new assessments and relevant analyses used to set groundfish harvest levels and other specifications for the following biennial management period.

Six groundfish species (aurora rockfish, rougheye rockfish, shortspine thornyhead, longspine thornyhead, cowcod, and Pacific sanddab) were assessed with full assessments, which were reviewed in stock assessment review (STAR) panels this summer. The executive summaries of these assessments are provided in the briefing book and **the assessments in their entirety are available on the September 2013 briefing book CD and website (electronic only).** The STAR panel reports for these assessments are also provided in the briefing book.

The Council should consider the assessments and STAR panel reports, as well as the advice of the Scientific and Statistical Committee, other advisory bodies, and the public before adopting the new stock assessments for use in groundfish management in 2015 and beyond.

**Council Action:**

**Adopt those stock assessments recommended by the SSC.**

Reference Materials:

1. Agenda Item G.3.a, Attachment 1: Stock Assessment of Aurora Rockfish in 2013 (full stock assessment available electronically only).
2. Agenda Item G.3.a, Attachment 2: Stock Assessment Review (STAR) Panel Report for Aurora Rockfish.
3. Agenda Item G.3.a, Attachment 3: The Status of Rougheye Rockfish (*Sebastes aleutianus*) and Blackspotted Rockfish (*S. melanostictus*) as a Complex Along the U.S. West Coast in 2013 (full stock assessment available electronically only).
4. Agenda Item G.3.a, Attachment 4: Stock Assessment Review (STAR) Panel Report for Rougheye (and Blackspotted) Rockfish.
5. Agenda Item G.3.a, Attachment 5: Stock Assessment of Shortspine Thornyhead in 2013 (full stock assessment available electronically only).
6. Agenda Item G.3.a, Attachment 6: Shortspine Thornyhead Stock Assessment Review (STAR) Panel Report.
7. Agenda Item G.3.a, Attachment 7: Stock Assessment and Status of Longspine Thornyhead (*Sebastolobus altivelis*) off California, Oregon and Washington in 2013 (full stock assessment available electronically only).

8. Agenda Item G.3.a, Attachment 8: Longspine Thornyhead Stock Assessment Review (STAR) Panel Report.
9. Agenda Item G.3.a, Attachment 9: Status and Productivity of Cowcod, *Sebastes levis*, in the Southern California Bight, 2013 (full stock assessment available electronically only).
10. Agenda Item G.3.a, Attachment 10: Cowcod Stock Assessment Review (STAR) Panel Report.
11. Agenda Item G.3.a, Attachment 11: Status of the U.S. Pacific Sanddab Resource in 2013 (full stock assessment available electronically only).
12. Agenda Item G.3.a, Attachment 12: Pacific Sanddab Stock Assessment Review (STAR) Panel Report.

Agenda Order:

a. Agenda Item Overview — John DeVore
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt Final Stock Assessments for Rougheye, Aurora, Shortspine Thornyhead, Longspine Thornyhead, and Cowcod Rockfishes, and Pacific Sanddab

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08/22/13

Agenda Item G.3.a
Attachment 1 (Full Version, Electronic Only)
September 2013

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# Stock Assessment of Aurora Rockfish in 2013

by

Owen S. Hamel[1]
Jason M. Cope[1]
Sean Matson[2]

[1]Northwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

[2]Northwest Regional Office
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
7600 Sand Point Way Northeast
Seattle, WA 98115

DRAFT SAFE
08/8/2013

## Table of Contents

# Executive Summary

## Stock

Aurora rockfish (*Sebastes aurora*) occur from the Queen Charlotte Islands (British Columbia, Canada) south to mid-Baja California (Mexico), but are most common in US waters from northern Oregon to southern California. They are deep-dwelling, occurring from 200 to 700 meters, with the median depth increasing to the south. They are most abundant from 350 to 550 m in the north and 400 to 600 m in the south. While there are areas of greater abundance, the population appears continuous over the entire coast. There is no clear point for stock delineation. For the purposes of this assessment, the population of Aurora rockfish is treated as a single stock from the U.S.-Mexico border to the U.S.-Canada border.

## Catches

The fishery removals in the assessment are divided among two fleets, which include a domestic fishery ("twl" in the figures, since this is dominated by the trawl fleet) and a "full-retention" fishery ("nodisc" in the figures) including the historical foreign Pacific ocean perch (POP) and current at-sea Pacific hake fisheries. The domestic commercial fisheries have historically reported landed catch only, even though a portion of the aurora catch was discarded at sea. The foreign POP fishery, on the other hand, was known not to discard fish based on fish size or species, while the at-sea hake fishery reports total catch, including both retained and discarded fish. In order to account for differences in discarding practices and catch reporting, and most importantly avoid inflating aurora removals in POP and at-sea hake fisheries, landings by the domestic fleet and catch in foreign POP and at-sea hake fisheries were separated.

Landings of aurora rockfish were reconstructed from 1916 forward, and the assessment assumes zero catch and equilibrium unfished biomass in 1915. The reconstructed time series of aurora rockfish landings by the domestic trawl fishery and removals by the full-retention fleet are presented in Table ES-1 and shown in Figure ES-1.

**Table ES-1: Recent aurora rockfish landings (mt) by fleets used in the assessment.**

| Year | Domestic | | | Full Retention | | Total |
|---|---|---|---|---|---|---|
| | CA | OR | WA | Foreign | Hake | |
| 2003 | 50.357 | 5.32 | 0.931 | 0 | 0 | 56.62 |
| 2004 | 61.395 | 7.775 | 0.49 | 0 | 0.02 | 69.68 |
| 2005 | 39.654 | 3.353 | 0.242 | 0 | 0.03 | 43.28 |
| 2006 | 28.081 | 5.287 | 0.017 | 0 | 0 | 33.39 |
| 2007 | 29.737 | 7.797 | 0.222 | 0 | 0.01 | 37.76 |
| 2008 | 10.891 | 7.606 | 0.212 | 0 | 0 | 18.71 |
| 2009 | 15.494 | 7.905 | 0.31 | 0 | 0 | 23.7 |
| 2010 | 19.432 | 4.237 | 0.252 | 0 | 0.03 | 23.94 |
| 2011 | 9.823 | 12.411 | 2.32 | 0 | 0.1 | 24.66 |
| 2012 | 25.791 | 9.499 | 1.566 | 0 | 0.02 | 36.87 |

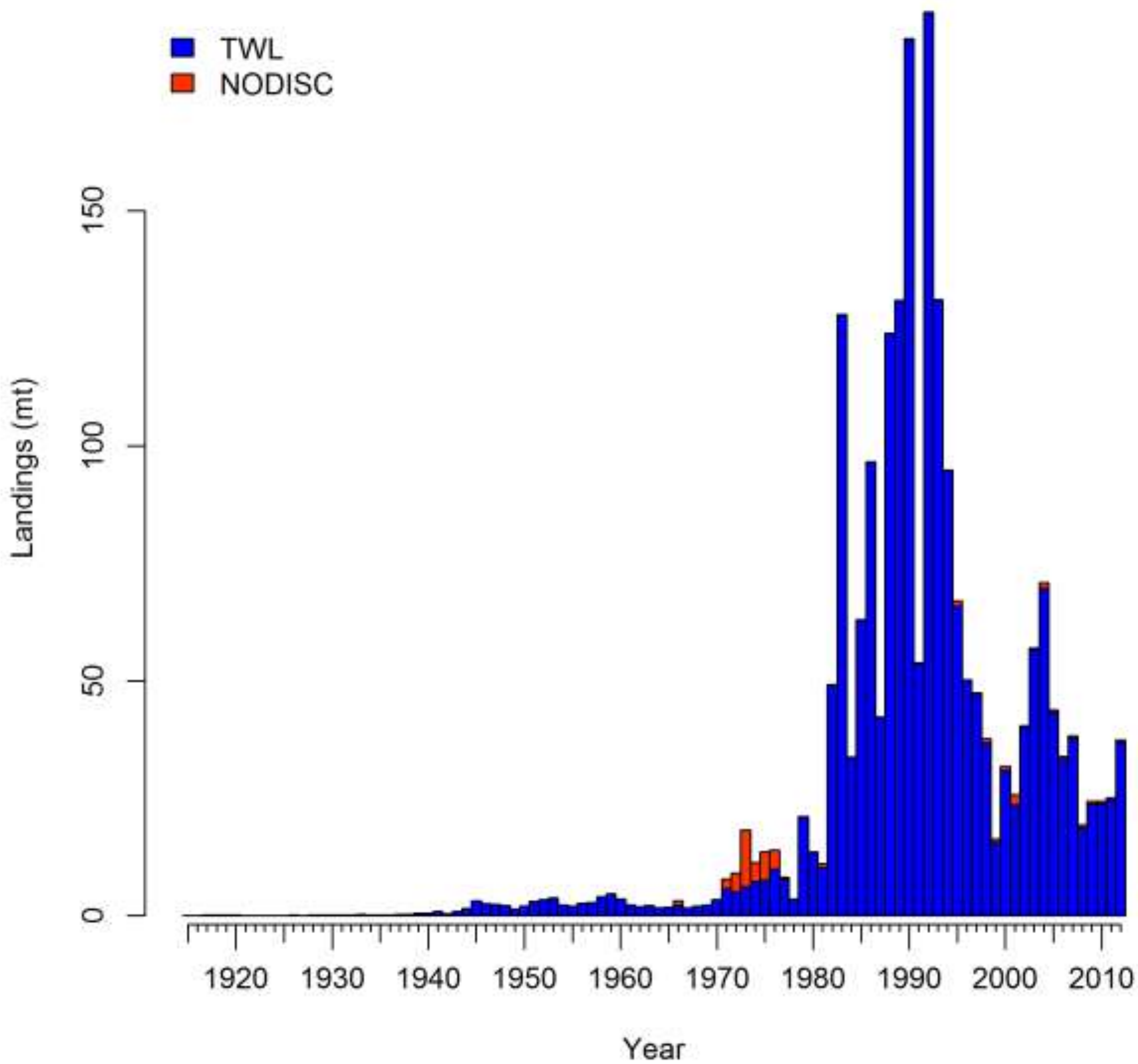


**Figure ES-1: Aurora rockfish landings history between 1916 and 2012 by fleet (TWL = domestic fleet, including trawl and non-trawl landings; NODISC=Foreign and at-sea hake and research catch).**

## Data and assessment

Aurora rockfish has not previously been assessed using category 1 assessment methods. The previous estimate of OFL values came from a category 3 assessment using Depletion-based Stock Reduction Analysis (DB-SRA) conducted by Dick and MacCall (2010).

The current stock assessment uses Stock Synthesis (SS) *(v3.24o*, R. Methot), which is an integrated length-age structured model. Landings have been reconstructed beginning in in 1916. The assessment includes fishery length composition data for the domestic fleet starting in 1978. Conditional age-at length data for the domestic fleet are included for 2003, 2008 and 2009. Estimates of discard rates are used from the Pikitch study for the years 1985-87, and from the West Coast Groundfish Observer Program

(WCGOP) from 2002-2011. Associated length compositions and mean weights from the WCGOP are also included in the assessment.

Survey data include abundance indices from the NMFS Triennial shelf survey for 1995, 1998, 2001 and 2004; The AFSC slope survey for 1997, 1999, 2000 and 2001; the NWFSC slope survey for 1999-2002; and the NWFSC shelf-slope survey from 2003-2012. Associated length composition data were available for all but the NWFSC slope survey, and age data were available and included in the model as conditional age-at-length data for the NWFSC shelf-slope survey for 2003, 2005, 2007, and 2009-2012.

A parsimonious model with adequate flexibility to fit the data was selected as the base model. Stock-recruitment steepness and natural mortality rates are fixed at the mean and median of their priors, respectively, while growth parameters are estimated separately for females and males.

Fishery selectivity is modeled as being asymptotic, as exploratory models allowing dome-shaped fishery selectivity estimated it to be asymptotic. Domestic fishery retention is modeled as an asymptotic curve, with the asymptote estimated in time blocks to fit the observed discard rates and length compositions. In particular, a single block is assumed though 1998, with slightly higher discard assumed in a block from 1999-2001. "Blocks" of individual years are used from 2002-2010 to allow for fit to the WCGOP data, and 2011-2012 (and forecast) discard rates are blocked together assuming more stability following the advent of Catch Shares and full observer coverage (and based upon the 2011 data).

The AFSC triennial shelf, AFSC slope and NWFSC shelf- slope surveys are modeled has having dome-shaped selectivity, each of which are estimated individually. The NWFSC slope survey is assumed to have the same selectivity as the NWFSC shelf-slope survey, as aurora do not occur in the depths not included in the earlier slope survey (30-100 fathoms), though they do in the latitudinal expansion south of Point Conception, and no length data were taken for aurora for those early years.

The base model converged and fits the data well given its highly variable nature. Runs with starting parameter values jittered from the base model were run to verify convergence. All of the parameters estimated within the base model are estimated at reasonable values.

## Stock biomass

In this assessment, aurora rockfish are assumed to have a proportional egg-to-spawning biomass relationship. Unfished spawning biomass (as a proxy of egg production) is estimated to be 2626 mt (95% CI: 1165-4087; CV = 28.4%; Table ES-5; Figure ES-2), with spawning biomass at the beginning of 2013 estimated to be 1673 mt (95% CI: 348-2998; CV = 40.4%; Table ES-2; Figure ES-2). The stock's status (depletion) is estimated to be at 64% of the unfished level in 2013 (Table ES-2; Figure ES-4).

Spawning biomass was steady until the 1980s, when the rapid increase in trawl catch of aurora caused a significant decline from unfished levels, which continued through the early 2000s. Since the mid-2000s, spawning biomass has remained stable, at levels slightly above 1650 mt (Table ES-2).

**Table ES-2: Recent trend in beginning of the year biomass and depletion**

| Year | Spawning Biomass (mt) | ~95% confidence interval | Estimated depletion | ~95% confidence interval |
|---|---|---|---|---|
| 2004 | 1760 | (478-3043) | 0.67 | (0.54-0.8) |
| 2005 | 1727 | (445-3010) | 0.66 | (0.52-0.79) |
| 2006 | 1710 | (427-2994) | 0.65 | (0.51-0.79) |
| 2007 | 1695 | (409-2980) | 0.65 | (0.5-0.79) |
| 2008 | 1681 | (392-2969) | 0.64 | (0.5-0.78) |
| 2009 | 1672 | (378-2965) | 0.64 | (0.49-0.78) |
| 2010 | 1659 | (359-2960) | 0.63 | (0.48-0.78) |
| 2011 | 1660 | (352-2968) | 0.63 | (0.48-0.79) |
| 2012 | 1669 | (353-2985) | 0.64 | (0.48-0.79) |
| 2013 | 1673 | (348-2998) | 0.64 | (0.48-0.79) |

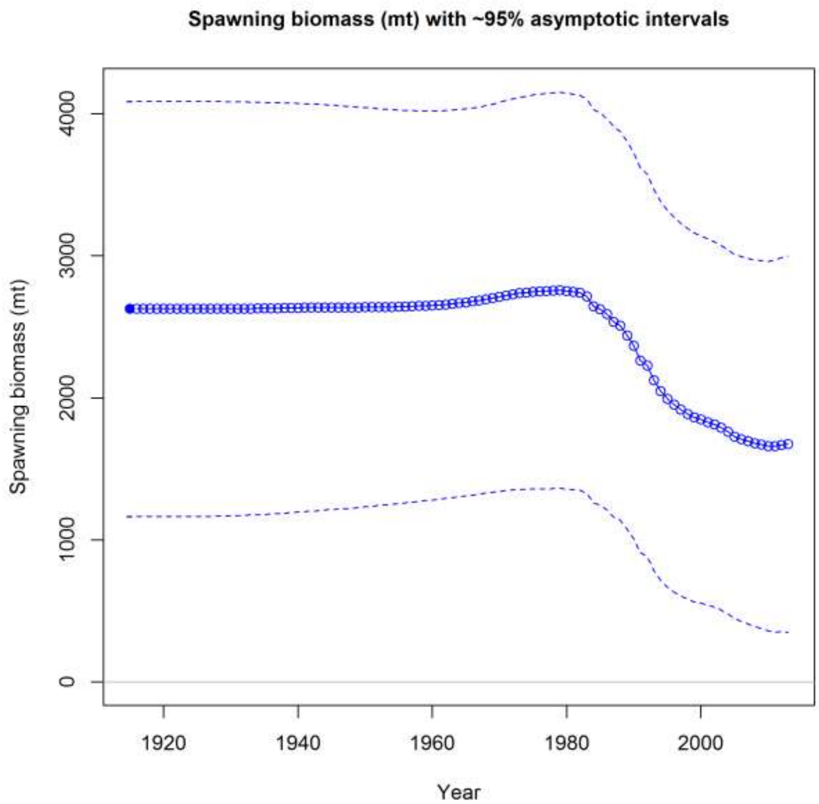


**Figure ES-3: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for aurora rockfish.**

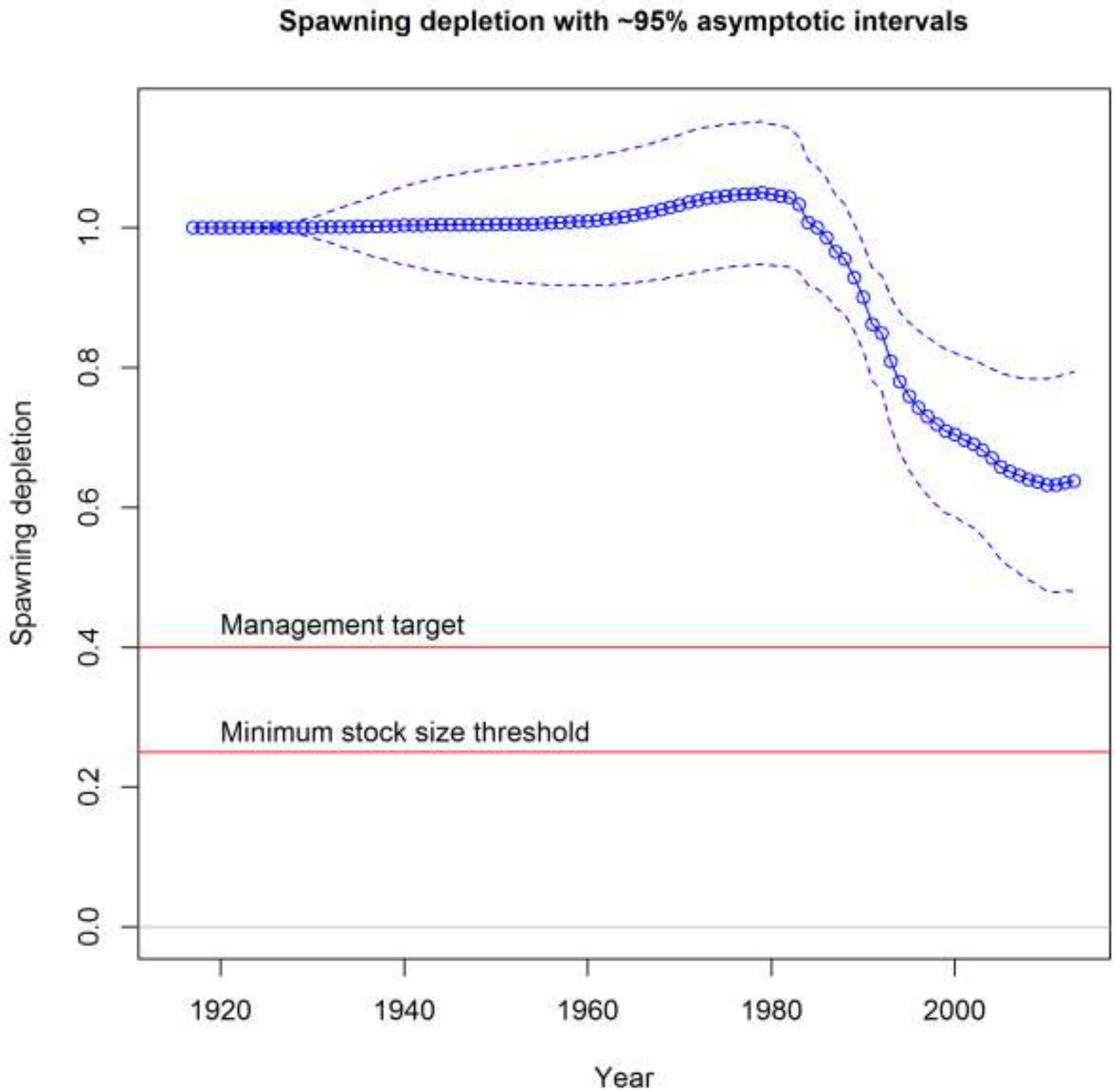


**Figure ES-4. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the aurora rockfish base case assessment model.**

## Recruitment

The aurora rockfish base case assumed a Beverton-Holt stock recruitment relationship parameterized with the steepness parameter. Steepness was fixed to the mean of the most recent rockfish steepness prior ($h$ = 0.779; Thorson, 2013). The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$). Recruitment deviations were estimated from 1916 (the beginning of the modeling period), with a ramp towards bias correction beginning in 1962, full-bias adjustment beginning in 1970 and ending in 2008, and a ramping back down to no bias correction in 2012. Two of the largest contemporary recruitment events are found in 1999 and 2007 (Table ES-3; Figure ES-4). Despite the inclusion of estimated ageing error, discerning individual year classes remains difficult and significant correlation exists between the estimated strength of adjacent year classes which may be primarily due to ageing error rather than actual correlation in recruitment strength.

**Table ES-3: Recent recruitment**

| Year | Estimated recruitment (1,000's) | ~95% confidence interval |
|---|---|---|
| 2004 | 638 | (40-1236) |
| 2005 | 1093 | (100-2085) |
| 2006 | 1130 | (35-2226) |
| 2007 | 1798 | (191-3406) |
| 2008 | 1328 | (32-2624) |
| 2009 | 1157 | (85-2229) |
| 2010 | 711 | (0-1425) |
| 2011 | 719 | (0-1486) |
| 2012 | 736 | (0-1569) |
| 2013 | 736 | (0-1570) |

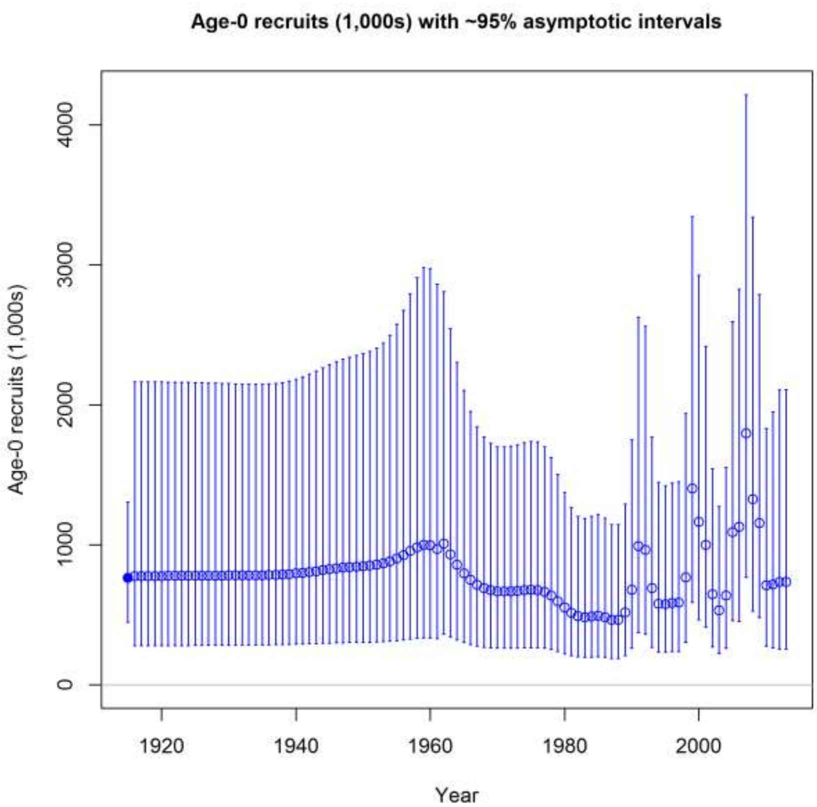


**Figure ES-4: Recruitment time series for the base model of aurora rockfish.**

## Exploitation status

Previous estimates of sustainable aurora rockfish removals (via catch-only methods) compared to actual removals indicated possibly elevated overfishing risks. The aurora base-case model provides an improved basis for evaluating the stock's exploitation history. The current model estimates that exploitation of aurora rockfish has actually been relatively low, with total catch estimated to have exceeded the current management harvest-rate limits in only 2 years, during the early peak in trawl catch (1990 and 1992) (Figure ES-5 and Figure ES-6). Recent levels of removals have remained moderate (Table ES-4). There seems to be very low risk that current removals are causing overfishing.

Biomass status also is estimated to be well above target levels (Figure ES-6). The target reference point for rockfish spawning biomass is 40% of unfished conditions. The current estimate of aurora rockfish depletion is 64%, with the lowest ever estimated depletion from the base case at 63%.

**Table ES-4. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate (catch divided by exploitable biomass)**

| Year | Estimated 1-SPR (%) | ~95% confidence interval | Exploitation rate | ~95% confidence interval |
|---|---|---|---|---|
| 2003 | 45% | (0-1.32) | 0.0205 | (0.01-0.0359) |
| 2004 | 48% | (0-1.43) | 0.0235 | (0.01-0.0411) |
| 2005 | 37% | (0-1.08) | 0.0151 | (0-0.0267) |
| 2006 | 38% | (0-1.11) | 0.0157 | (0-0.0287) |
| 2007 | 38% | (0-1.13) | 0.0161 | (0-0.0291) |
| 2008 | 36% | (0-1.06) | 0.0146 | (0-0.0291) |
| 2009 | 42% | (0-1.24) | 0.0186 | (0-0.0375) |
| 2010 | 30% | (0-0.9) | 0.0117 | (0-0.0215) |
| 2011 | 23% | (0-0.67) | 0.0079 | (0-0.0143) |
| 2012 | 31% | (0-0.91) | 0.0118 | (0-0.0212) |

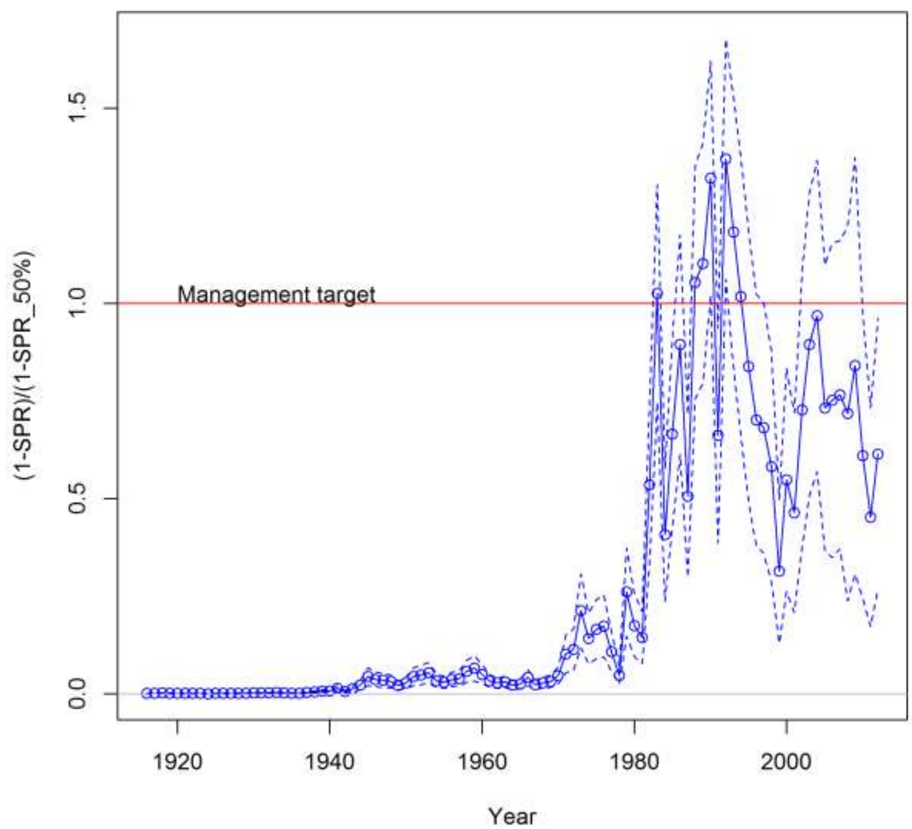


**Figure ES-5. Time series of estimated relative spawning potential ratio (1-SPR/1-SPRTarget=0.50) for the aurora rockfish base-case model (round points) with ~95% intervals (dashed lines). Values of relative SPR above 1.0 (100% in the table above) reflect harvests in excess of the current overfishing proxy.**

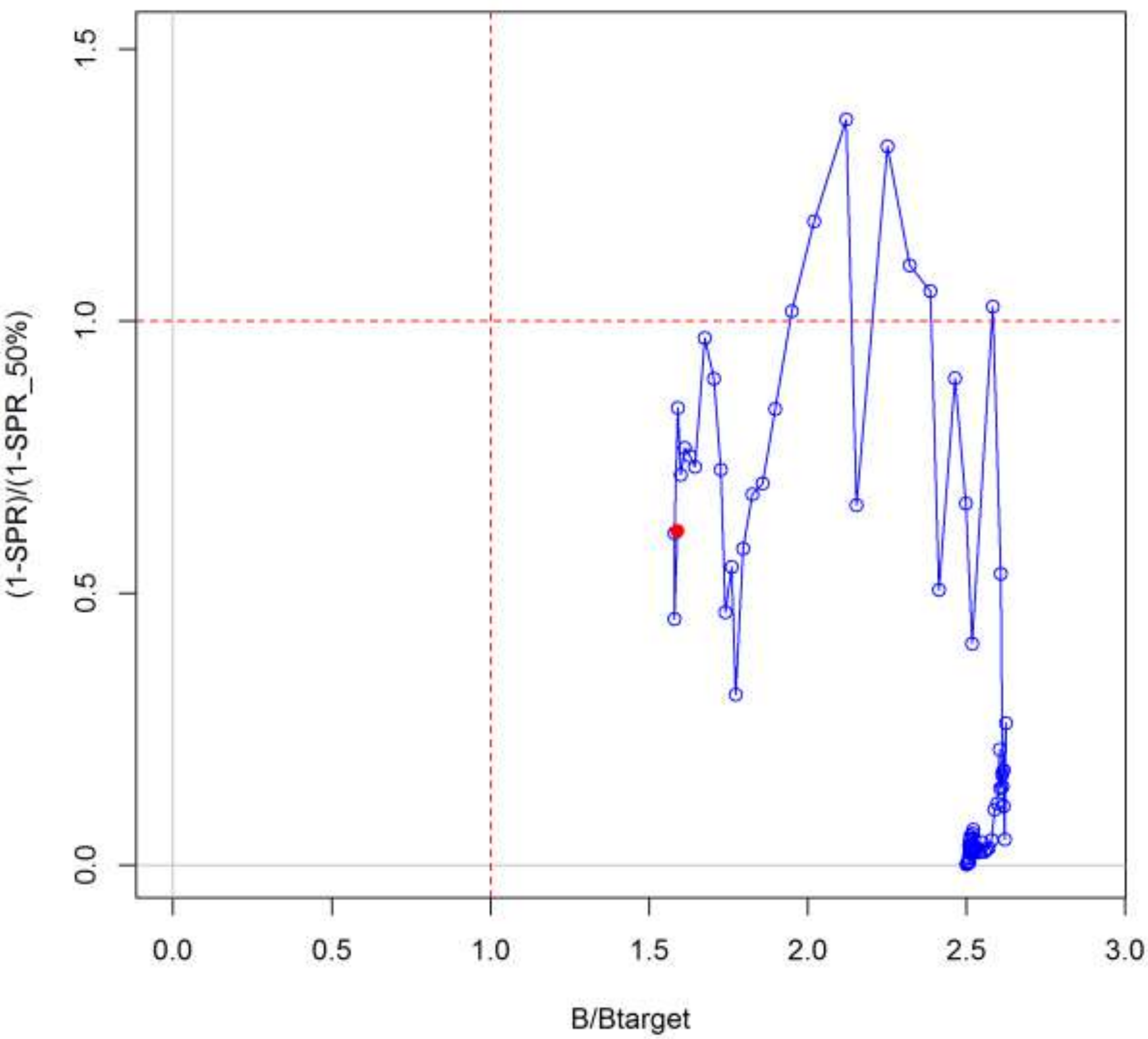


**Figure ES-6. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the aurora rockfish base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2012.**

## Ecosystem considerations

Aurora rockfish co-occurs with many prominent groundfish targets such as Dover sole, sablefish, thornyheads and hake (Figure 2), though it is most often reported with catch of splitnose rockfish. Aurora rockfish contribute to the overall California Current ecosystem as both predators of crustaceans and small fishes, and as prey to larger fishes, marine mammals, and large squid. Juvenile aurora rockfishes are preyed on by salmon, birds, and other fishes (Love 2011).

Several aspects of aurora rockfish population biology are affected by the ecosystem. The recruitment of many species of rockfish appears to have been high in 1999, suggesting that environmental conditions influence the spawning success and survival of larvae and juvenile rockfish, including aurora rockfish. The mechanism behind this observation is not well understood, but zooplankton abundance, changes in water temperature and currents, distribution of prey and predators, and amounts and timing of upwelling are all possible linkages. Changes in the environment may also directly influence age-at-maturity, fecundity, growth, and survival, which can affect stock status determination and its susceptibility to fishing. Thompson and Hannah (2010) found variations in growth corresponding to individual years based upon dendrochronological techniques and otoliths, and found a correlation between observed growth anomalies in otoliths and sea levels in individual years. Such results are intriguing, but insufficient for parameterizing population models. No other studies known to us have quantified any ecosystem level effects in aurora rockfish. Ecosystem considerations therefore were not explicitly included in this assessment.

## Reference points

Reference points and quantities for the aurora rockfish base case model are provided in Table ES-5.

**Table ES-5. Summary of reference points and management quantities for the base case model.**

| Quantity | Estimate | ~95% Confidence Interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 2626 | (1165-4087) |
| Unfished age 0+ biomass (mt) | 6109 | (2737-9481) |
| Unfished recruitment (R0) | 766 | (349-1182) |
| Spawning Biomass (2013) | 1673 | (348-2998) |
| SD of log Spawning Biomass (2013) | 0.39 | --- |
| Depletion (2013) | 0.64 | (0.48-0.79) |
| ***Reference points based on $SB_{40\%}$*** | | |
| Proxy spawning biomass ($B40_{\%}$) | 1050 | (466-1635) |
| SPR resulting in $B40_{\%}$ ($SPR_{B40\%}$) | 0.44 | (0.44-0.44) |
| Exploitation rate resulting in $B40_{\%}$ | 0.0304 | (0.0271-0.0337) |
| Yield with $SPR_{B40\%}$ at $B40_{\%}$ (mt) | 72 | (33-112) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 1213 | (538-1888) |
| $SPR_{proxy}$ | 50% | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.0248 | (0.0222-0.0274) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 67 | (31-104) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 648 | (283-1012) |
| $SPR_{MSY}$ | 0.30 | (0.2963-0.3039) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.0510 | (0.0442-0.0578) |
| *MSY* (mt) | 79 | (36-122) |

## Management performance

Stock-specific OFLs/ABCs (Table ES-6) were not historically set for aurora rockfish, though the reauthorized Magnuson-Stevens Act of 2006 required OFLs for all species in a management plan. The first of the OFLs were calculated in 2010 for the 2011-2012 management cycle. Aurora rockfish are not managed to their component OFL contributions to the minor slope rockfish complex, but past total removals have exceeded the current OFL component values in several years, suggesting the potential of chronic overfishing of aurora rockfish.

**Table ES-6. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.**

| Year | OFL contribution (mt) | ACL contribution (mt) | Commercial Landings (mt) | Estimated Total Catch (mt) |
|---|---|---|---|---|
| 2003 | NA | NA | 56.62 | 76.25 |
| 2004 | NA | NA | 69.68 | 85.88 |
| 2005 | NA | NA | 43.28 | 54.65 |
| 2006 | NA | NA | 33.39 | 56.55 |
| 2007 | NA | NA | 37.76 | 57.89 |
| 2008 | NA | NA | 18.71 | 52.46 |
| 2009 | NA | NA | 23.7 | 66.43 |
| 2010 | NA | NA | 23.94 | 41.74 |
| 2011 | 47 | NA | 24.66 | 28.59 |
| 2012 | 47 | NA | 36.87 | 42.71 |

## Unresolved problems and major uncertainties

Natural mortality: The aurora rockfish assessment is very sensitive to the values chosen for the female and male natural mortality coefficients. Natural mortality is always a very problematic parameter for stock assessments, but with very long-lived species such as aurora rockfish, the presence of very old individuals in composition data can provide strong information regarding the implausibility of large values for $M$. Future assessments of this stock would greatly benefit from an increase in the number of conditional age-at-length observations and a validation of the ageing method.

Calculating effective sample size: The pre-STAR panel model calculated effective sample size by iteratively reweighting the different data sources. Although this reweighting approach has become a standard feature of most US West Coast assessments, Francis (2011) provided compelling evidence that this standard approach results in questionable residual patterns. The Francis approach to reweighting, in contrast, greatly reduced these “bad” residual patterns. The STAR Panel endorsed the use of the Francis, however it remains to be determined whether the Francis approach is the “best” general approach for deriving reweighting factors.

Recruitment: The assessment model produced a strange pattern of historical recruitments in which an extended period of positive deviations (roughly for the years 1940-1965) was followed by an extended period of negative deviations (roughly 1966-1987). Possible causes for this unusual pattern are likely related to one or more structural limitations in the model, which created systematic departures from an equilibrium age composition. Attempts were made to uncover the mechanism(s) that might be responsible, but the exact cause(s) remain unknown. These structural limitations in the assessment model remain a source of uncertainty that should be explored more fully the next time this stock is assessed.

Decision table states of nature: How to adequate quantify and balance uncertainty when constructing the decision table was a major topic of discussion during the STAR Panel. This is an ongoing challenge for most assessment, so future stock assessments and STAR Panels would likely benefit if they were provided with more detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

## Harvest projections and decision table

The base model was projected with catches in 2013 and 2014 determined from a recent 5-year average and catches from 2015–2024 based on the predicted allowable biological catch (ABC) using a SPR proxy of 50% ($F_{50\%}$), and P*-based buffer of 0.952 and the 40-10 rule. The buffer is based upon a P* of 0.45 and a $\sigma$ of 0.39. This is the calculated standard deviation in log space of the 2013 spawning biomass based upon the CV in real space of 0.404, via the equation:

$$SD = \sqrt{\ln\left(1 + CV^2\right)}$$

The value of 0.39 is used as it is larger than the default value of 0.36 for category 1 stocks. While the ABCs nearly double from 2015 onward compared to the average catch, the spawning biomass stays relatively stable (Table ES-7). To observe stock status across important uncertainty considerations, a decision table was developed showing projections from 2015–2024 under ABC catches for three states of nature (defined by natural mortality *M*) and with catches streams based on the ABCs from each state of nature (Table ES-8). The most conservative scenario (low *M*, catch stream based on high *M*) indicates the stock will be at the target biomass in 2024. The least conservative scenario (high *M*, catch stream based on low *M*) indicates the population will climb to around 80% of initial conditions. All scenarios using the base case value of M indicate the population will be above the reference point in all years.

**Table ES-7. Projection of potential OFL, landings, and catch, summary biomass (age-5 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2013 and 2014 (average of the past 5 years (2008-2012), and catches at the ABC from 2013 onward. The OFL in years later than 2014 is the calculated total catch determined by $F_{SPR50\%}$. ABC values are calculated using $\sigma_{SB}$=0.39 and P*=0.45.**

| Year | Predicted OFL/contribution (mt) | ABC Catch (mt) | Landings (mt) | Age 0+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 41 | 46.38 | 40.45 | 4,366 | 1,673 | 63.7% |
| 2014 | 41 | 46.38 | 40.29 | 4,403 | 1,678 | 63.9% |
| 2015 | 91.67 | 87.33 | 75.55 | 4,439 | 1,685 | 64.2% |
| 2016 | 91.77 | 87.42 | 75.37 | 4,434 | 1,678 | 63.9% |
| 2017 | 91.90 | 87.55 | 75.34 | 4,427 | 1,674 | 63.7% |
| 2018 | 92.02 | 87.67 | 75.43 | 4,418 | 1,672 | 63.7% |
| 2019 | 92.08 | 87.73 | 75.61 | 4,406 | 1,673 | 63.7% |
| 2020 | 92.06 | 87.71 | 75.80 | 4,391 | 1,675 | 63.8% |
| 2021 | 91.95 | 87.60 | 75.96 | 4,374 | 1,676 | 63.8% |
| 2022 | 91.74 | 87.40 | 76.05 | 4,354 | 1,678 | 63.9% |
| 2023 | 91.44 | 87.11 | 76.04 | 4,333 | 1,678 | 63.9% |
| 2024 | 91.06 | 86.75 | 75.94 | 4,309 | 1,676 | 63.8% |

**Table ES-8. Summary table of 12-year projections showing results for 2015-2024 for alternate states of nature based on the axis of uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels from those states of nature. The average 5-year catch (2008-2012) of 46.4 mt is assumed for 2013 and 2014. ABCs are based upon the assumption that P*=0.45 and a σ of 0.39 which reflects the model uncertainty about the spawning biomass estimate in 2013 (Table ES-9).**

| | | | **State of nature** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low<br>$M_{female} = 0.033$ | | Base case<br>$M_{female} = 0.035$ | | High<br>$M_{female} = 0.037$ | |
| **Relative probability of ln(SB_2013)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| ABC catches from "Low" state of nature | 2015 | 54.3 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 54.6 | 1087 | 0.540 | 1692 | 0.644 | 2691 | 0.739 |
| | 2017 | 54.9 | 1089 | 0.541 | 1701 | 0.648 | 2713 | 0.745 |
| | 2018 | 55.2 | 1092 | 0.543 | 1713 | 0.652 | 2739 | 0.752 |
| | 2019 | 55.5 | 1097 | 0.546 | 1728 | 0.658 | 2768 | 0.760 |
| | 2020 | 55.7 | 1103 | 0.548 | 1743 | 0.664 | 2798 | 0.768 |
| | 2021 | 55.9 | 1109 | 0.551 | 1758 | 0.670 | 2829 | 0.777 |
| | 2022 | 56.0 | 1115 | 0.554 | 1773 | 0.675 | 2857 | 0.784 |
| | 2023 | 56.1 | 1120 | 0.557 | 1786 | 0.680 | 2884 | 0.792 |
| | 2024 | 56.1 | 1124 | 0.559 | 1798 | 0.685 | 2907 | 0.798 |
| Base Case ABC catches | 2015 | 87.3 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 87.4 | 1073 | 0.534 | 1678 | 0.639 | 2677 | 0.735 |
| | 2017 | 87.6 | 1061 | 0.528 | 1674 | 0.637 | 2686 | 0.737 |
| | 2018 | 87.7 | 1051 | 0.523 | 1672 | 0.637 | 2698 | 0.741 |
| | 2019 | 87.7 | 1043 | 0.519 | 1673 | 0.637 | 2713 | 0.745 |
| | 2020 | 87.7 | 1035 | 0.515 | 1675 | 0.638 | 2730 | 0.750 |
| | 2021 | 87.6 | 1028 | 0.511 | 1676 | 0.638 | 2747 | 0.754 |
| | 2022 | 87.4 | 1020 | 0.507 | 1678 | 0.639 | 2763 | 0.759 |
| | 2023 | 87.1 | 1012 | 0.503 | 1678 | 0.639 | 2777 | 0.762 |
| | 2024 | 86.8 | 1002 | 0.498 | 1676 | 0.638 | 2787 | 0.765 |
| ABC catches from "High" state of nature | 2015 | 145.7 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 145.3 | 1049 | 0.522 | 1654 | 0.630 | 2653 | 0.728 |
| | 2017 | 145.0 | 1013 | 0.504 | 1625 | 0.619 | 2637 | 0.724 |
| | 2018 | 144.7 | 980 | 0.487 | 1600 | 0.609 | 2626 | 0.721 |
| | 2019 | 144.2 | 948 | 0.471 | 1577 | 0.600 | 2618 | 0.719 |
| | 2020 | 143.7 | 917 | 0.456 | 1555 | 0.592 | 2611 | 0.717 |
| | 2021 | 143.0 | 886 | 0.440 | 1533 | 0.584 | 2605 | 0.715 |
| | 2022 | 142.2 | 855 | 0.425 | 1511 | 0.575 | 2598 | 0.713 |
| | 2023 | 141.2 | 824 | 0.409 | 1488 | 0.567 | 2589 | 0.711 |
| | 2024 | 140.2 | 792 | 0.394 | 1464 | 0.558 | 2578 | 0.708 |

**Table ES-9. Aurora rockfish base case results summary.**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 57 | 70 | 43 | 33 | 38 | 19 | 24 | 24 | 25 | 37 | NA |
| Estimated Total catch (mt) | 77 | 85 | 54 | 48 | 53 | 48 | 52 | 41 | 29 | 43 | NA |
| OFL contribution(mt) | | | | | | | | | 47 | 47 | 41 |
| ACL contribution(mt) | | | | | | | | | | | |
| 1-SPR | 0.45 | 0.48 | 0.37 | 0.38 | 0.38 | 0.36 | 0.42 | 0.30 | 0.23 | 0.31 | NA |
| Exploitation rate | 0.0205 | 0.0235 | 0.0151 | 0.0157 | 0.0161 | 0.0146 | 0.0186 | 0.0117 | 0.0079 | 0.0118 | NA |
| Age 0+ biomass (mt) | 4313 | 4274 | 4233 | 4225 | 4225 | 4224 | 4237 | 4240 | 4275 | 4326 | 4366 |
| Spawning Biomass | 1791 | 1760 | 1727 | 1710 | 1695 | 1681 | 1672 | 1659 | 1660 | 1669 | 1673 |
| ~95% Confidence Interval | (507-3074) | (478-3043) | (445-3010) | (427-2994) | (409-2980) | (392-2969) | (378-2965) | (359-2960) | (352-2968) | (353-2985) | (348-2998) |
| Recruitment | 534 | 638 | 1093 | 1130 | 1798 | 1328 | 1157 | 711 | 719 | 736 | 736 |
| ~95% Confidence Interval | (46-1022) | (40-1236) | (100-2085) | (35-2226) | (191-3406) | (32-2624) | (85-2229) | (0-1425) | (0-1486) | (0-1569) | (0-1570) |
| Depletion (%) | 0.68 | 0.67 | 0.66 | 0.65 | 0.65 | 0.64 | 0.64 | 0.63 | 0.63 | 0.64 | 0.64 |
| ~95% Confidence Interval | (0.56-0.81) | (0.54-0.8) | (0.52-0.79) | (0.51-0.79) | (0.5-0.79) | (0.5-0.78) | (0.49-0.78) | (0.48-0.78) | (0.48-0.79) | (0.48-0.79) | (0.48-0.79) |

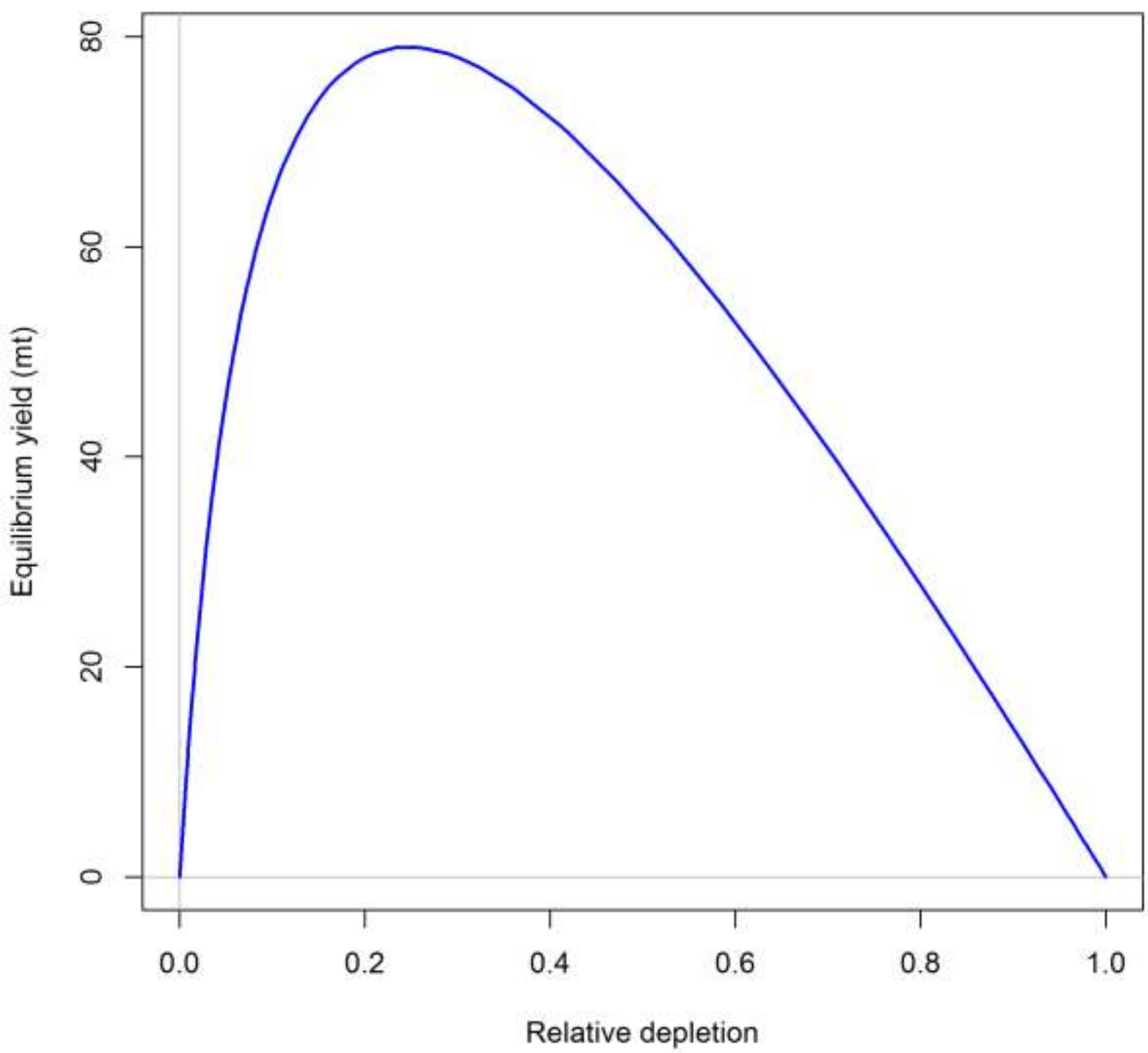


**Figure ES-7. Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the aurora rockfish base case model. Values are based on 2010 fishery selectivity and distribution with steepness fixed at 0.779. The depletion is relative to unfished spawning biomass.**

## Research and data needs

The following research could improve the ability of future stock assessments to determine the current status and productivity of the aurora rockfish population:

1) This was the first year in which aurora rockfish otoliths were read to develop age data. There was insufficient time to read all of the otoliths or even cover all of the years for which aurora rockfish otoliths were collected from the fisheries or surveys. Additional age data could provide additional information for the model to estimate such parameters as natural mortality and recruitment deviations. Additionally, validation methods, such as the bomb radiocarbon chronometer, could be used to validate the ages and ageing method for aurora rockfish.
2) The base model does not use newly available information of female maturity collected within the NWFSC shelf-slope survey in 2012. This new information includes data on mass atresia (a form of skipped spawning), at far greater numbers than that reported in Thompson and Hannah (2010). More data on aurora rockfish maturity will be collected this year on the NWFSC shelf-slope survey, which could confirm the information on mass atresia or indicate variability between years. This information could better inform the maturity curves used in the assessment
3) The base model assumes spawning output is proportional to spawning biomass. For many rockfish species, fecundity has been shown to have a non-linear relationship with female weight. Determining this relationship for aurora rockfish would improve the estimation of spawning output and depletion.
4) Improve the meta-analysis for steepness. This would include consideration of fixed and estimated parameters, assumptions, and the quality of the information on maturity and fecundity in the component assessments, as well as correlations in recruitments among assessments due to environmental drivers.
5) The application of the GLMM software elicited many unresolved questions. Continued research and articulation of that model and the options available (e.g. extreme catch events) will greatly benefit both STAT application and STAR Panel understanding of the model and its advantages.
6) Further research on the most appropriate method for data-weighting is greatly needed. Simulation testing and comparison of standard and new (Francis 2011) methods would benefit future assessments of this and other stocks.
7) Development of information on the spatial structure of the stock, including genetic analysis, investigation of differences in and size at maturity, and information on aurora rockfish off of Canada and Mexico.
8) The development of additional indices could provide further information to anchor the assessment. While direct adult biomass indices are unlikely to surface, there may be some possibility to develop a larval abundance index from the CalCOFI data set. This index reflects a measure of spawning biomass.

# 1 Introduction

## 1.1 Basic Information

Aurora rockfish (*Sebastes aurora*) are encountered between the Queen Charlotte Islands (British Columbia, Canada) south to mid-Baja California (Mexico). Off of the United States, they are common from northern Oregon to southern California, and are most abundant in the area around Point Conception, California (Figure 1 to Figure 2). They occur at depths from 200 to 700 fathoms, with the median depth increasing to the south, such that they are most abundant from 350 to 550 m in the north and 400 to 600 m in the south.

While there are areas of greater abundance off of northern Oregon and especially off of Point Conception, California, the population appears continuous over the entire coast, so that there is no clear point for stock delineation. Survey catches exhibit a continuous distribution along the entire coast, though with areas of higher and lower abundances along the coast (Figure 1). For the purposes of this assessment, the population of Aurora rockfish is treated as a single stock from the U.S.-Mexican border to the U.S.-Canada border.

## 1.2 Life History

Aurora rockfish is a long lived rockfish species, with maximum observed age of 125 years based upon otoliths aged for this assessment. This is slightly greater than the maximum of 118 years seen by Thompson and Hannah (2010) and consistent with a maximum age greater than 75 as reported by Love et al. (2002). As with many rockfish species, aurora rockfish exhibit both spatially varying and sexually dimorphic growth, with females reaching a slightly larger size than males. Off of Oregon, females reached an asymptotic length of 36.9 cm, while males reached only 33.6 cm (Thompson and Hannah 2010). Asymptotic size and size at age decreases with latitude, and since the bulk of the stock is south of Oregon, the average asymptotic lengths are quite a bit lower than those reported above.

Thompson and Hannah (2010) found the age at 50% maturity for female aurora rockfish to be 12.56 years and the length at 50% maturity to be 25.54 cm. Maturity data collected coastwide during the 2012 NWFSC trawl survey found similar values, though with more evidence of atresia in older and larger fish than observed in the Thomson and Hannah study.

Aurora rockfish larvae have been collected off of California in months ranging from November to August, with abundance peaking in May and June, corresponding to the observation of females with developed embryos from March to May off of California and in May in Oregon (Love et al. 2002). Thompson and Hannah (2010) also found that parturition peaked in May off of Oregon. Auroras settle on the bottom when they reach a length of about 3.3 cm (Love et al. 2002).

Aurora rockfish display ontogenetic movement, with smaller fish found in shallower waters (below 400-450 m). They are distributed over both hard and soft substrates (Love et al. 2002)

## 1.3 Ecosystem Considerations

Aurora rockfish co-occurs with many prominent groundfish targets such as Dover sole, sablefish, thornyheads and hake (Figure 2), though are most reported in the catch of splitnose rockfish. Aurora rockfish contributes to the overall California Current ecosystem as both predator or crustaceans and small fishes, and as prey to larger fishes, marine mammals, and large squid. Juvenile aurora rockfishes are preyed on by salmon, birds, and other fishes (Love 2011).

Several aspects of aurora rockfish population biology are affected by the ecosystem. The recruitment of many species of rockfish appears to be high in 1999, suggesting that environmental conditions influence the spawning success and survival of larvae and juvenile rockfish, including aurora rockfish. The mechanism behind this observation is not well understood, but zooplankton abundance, changes in water temperature and currents, distribution of prey and predators, and amount and timing of upwelling are all possible linkages. Changes in the environment may also directly influence age-at-maturity, fecundity, growth, and survival, which can affect stock status determination and its susceptibility to fishing. Thompson and Hannah (2010) found variations in growth corresponding to individual years based upon dendrochronological techniques and otoliths, and found a correlation between observed growth anomaly in otoliths and sea level in individual years. Such results are intriguing, but insufficient for parameterizing population models. No other studies known to us have quantified any ecosystem level effects in aurora rockfish. Ecosystem considerations therefore were not explicitly included in this assessment.

## 1.4 Fishery History

Groundfish trawls are the primary gear type that has been used to catch aurora rockfish. The use of trawls off the west coast of the United States dates to the late 1800s, though there was little fishery expansion until the availability of the otter trawl and the diesel engine in the mid-1920s (Douglas 1998). Trawl fisheries mainly were conducted on the shelf and became more established during World War II when demand increased for groundfish. Mink farms were also major destination of groundfish removals in the 1940s and 1950s (Jones and Harry 1960). Foreign fleets began fishing for rockfish, including deeper waters of the slope, in the mid-1960s, with declining participation until the 200-mile EEZ was implemented in 1977 (Rogers 2003). Peaks in the foreign catch have typically been seen in the mid-1960s for rockfishes, but for aurora rockfish, the largest catches were taken in the early 1970s. Foreign fishing was limited in the northern regions by 1970, shifting effort southward and more into aurora rockfish habitat. After 1977, domestic landings of rockfish increased rapidly until about 1990. Subsequent declines in rockfish landings were driven by declining biomass levels and implementation of new, more restrictive management practices, particularly between 1997 and 2002.

Documented and estimated removals of aurora rockfish do not reach consistently large levels until the 1980s (Table 1). Aurora rockfish are and have been historically most commonly taken from central California to Oregon, tightly coupled with the splitnose rockfish. The term "rosefish" was often used to describe either splitnose or aurora rockfish and has been used as a reporting category in California since 1982. Aurora rockfish remains largely a non-targeted member of the slope rockfish complex.

## 1.5 Management History

Aurora rockfish, being a relatively minor component of groundfish fisheries, has not had the species-specific attention other rockfishes have been afforded over the last 30 years. Most of its management has come in the form of indirect effects from either co-occurring species (such as splitnose) or from effort or catch reductions targeted at species complexes (Appendix 1).

Limits on select rockfishes, which included the co-occurring species splitnose, were established in 1982. The first imposed catch limits on a coastwide *Sebastes* complex (aurora being one of the 50 rockfishes in the complex) were instituted in 1983. This complex was divided into two management areas north and south of 43º00' N (separating the Eureka and Columbia INPFC areas) in 1994. Ongoing concern that shelf and slope rockfishes may be undergoing overfishing led the attempt by Rogers et al. (1996) to describe the status of most rockfishes contained in the *Sebastes* complex. Aurora rockfish information content was low, so only estimates of exploitation rates were provided, indicating the stock was undergoing very high exploitation rates relative to biomass estimates in both management areas.

The *Sebastes* complex was subsequently divided into nearshore, shelf, and slope complexes effective in the year 2000, and the dividing line between the northern and southern management areas was shifted to

40º10' N. latitude. Aurora rockfish has since been managed under trip limits for minor slope rockfish complex in both north and south management areas.

## 1.6 Management Performance

While stock-specific OFLs/ABCs were not set historically for aurora rockfish, the reauthorized Magnuson-Stevens Act of 2006 required that all species within a Fishery Management Plan be covered by an OFL. The first of the OFL contributions for minor species that were not calculated using a simple average-catch metric were estimated using DB-SRA in 2010 for the 2011-2012 management cycle. Figure 3 compares the aurora rockfish contribution to the 2012 minor slope rockfish OFLs in each management area to estimated total removals of aurora, over 2003-2011. Several years in both areas indicate removals are higher than the 2012 OFL, a strong indicator that aurora rockfish needed further scientific advice on current stock status and other management indicators, hence the recommendation that a full stock assessment be performed.

While the effects of the Rockfish Conservation Areas (RCAs) are often evaluated for their effects on fishery selectivity, aurora rockfish are found almost entirely deeper than the most seaward depth lines used during the history of the RCAs (366 m).

# 2 Assessment

## 2.1 Data

The aurora rockfish data used in the assessment are summarized

Figure 4. These data include the following fishery-dependent and fishery-independent sources.

1) Commercial landings from 1916-2012.
2) Fishery length compositions from the domestic fleet (1978-2012).
3) Fishery conditional age-at-length data from the domestic fleet (2003, 2008, 2009).
4) Estimates of discard length frequencies, mean weight, and fraction discarded in the fishery obtained from the West Coast Groundfish Observer Program (WCGOP) and the study by Pikitch et al (1988).
5) Fishery independent data including bottom trawl survey-based indices of abundance and biological data (age and length) from NWFSC shelf /slope survey (2003-2012); NMFS Triennial shelf survey (1995-2004); AFSC slope survey (1997, 1999, 2000, 2001); and NWFSC slope survey (1999-2002). Associated length composition data were available and used for all but the NWFSC slope survey, and age data were available and used for the NWFSC shelf-slope survey for 2003, 2005, 2007, and 2009-2012.
6) Estimates of maturity, length-weight relationships and ageing error from various sources.

A description of each of the specific data sources, including both fishery-dependent and fishery-independent sources is presented below.

### 2.1.1 Ageing methods

All ages used in this assessment were read by the Cooperative Ageing Project (CAP) in Newport Oregon for the express purpose of being included in this assessment. Due to time limitations only 7 years of survey age data and 3 years of commercial age data were available. Otoliths were read using the break-and-burn (BB) method.

#### *2.1.1.1 Ageing error*
Ageing of otoliths is an imperfect measure of the true age of a fish. Incorrect ageing of fish, if ignored, can potentially lead to bias and imprecision in stock assessment derived outputs. Ageing error (both bias and imprecision) is therefore quantified and included in the assessment so as to include such uncertainty in derived assessment quantities. A total of 896 double-read aurora rockfish ages were provided by CAP. Ageing error, for use in interpreting age-composition data, was estimated using the approach of Punt et al. (2008). This approach estimates the underlying true-age distribution of a sample and requires the assumption that at least one age reader is unbiased. Reader 1 is assumed unbiased in explored models. Functional forms of the bias of reader 2 (unbiased, linear or curvilinear) and precision of readers 1 and 2 (constant CV, curvilinear standard deviation, or curvilinear CV) were also considered (Table 8). In all consideration, the form of the precision function was assumed the same for reader 1 and reader 2. Model selection was based on AIC corrected for small sample size (AICc), which converges to AIC when sample sizes are large. The data strongly supported curvilinear bias in reader 2 and curvilinear standard deviation of precision for readers 1 and 2 (Table 8; Figure 5). The choice of minus and plus ages was also explored, but showed very little sensitivity.

### 2.1.2 Fishery-dependent data
The fishery removals in the assessment are divided among two fleets, which include a domestic fishery ("twl" in figures, as this is dominated by the trawl fishery) and a "full-retention" fishery ("nodisc" in the figures) including the historical foreign Pacific ocean perch (POP), current at-sea Pacific hake fisheries and research catch. The domestic commercial fisheries have historically reported landed catch only, even though a portion of the aurora catch was and is discarded at sea. The foreign POP fishery, on the other hand, was known not to discard fish based on fish size or species, while the at-sea hake fishery reports total catch, including both retained and discarded fish. In order to account for differences in discarding practices and catch reporting, and most importantly avoid inflating aurora removals in POP and at-sea hake fisheries, landings in the domestic trawl fleet and catch in foreign POP and at-sea hake fisheries were treated separately in the model.

Landings of aurora rockfish were reconstructed from 1916 forward, and the assessment assumes a zero catch and equilibrium unfished biomass in 1915. The reconstructed time series of aurora rockfish landings by the domestic fishery and removals by the full-retention fleet are presented in Table 1 and Figure 6.

#### *2.1.2.1 Domestic commercial landings*
Estimates of recent commercial landings of aurora rockfish (between 1981 and 2012) were obtained from the Pacific Fisheries Information Network (PacFIN), a regional fisheries database maintained by the Pacific States Marine Fisheries Commission (PSMFC) that serves as a clearinghouse for fishery-dependent information, in cooperation with state agencies on the West Coast and NOAA Fisheries (www.pacfin.com). Landings data were extracted for each gear type on May 17, 2013 and then combined into the fishing fleets used in the assessment. A few records of aurora rockfish recreational catches (for 1984, 1986-1988 and 1994) were reported in the Recreational Fisheries Information Network (RecFIN) (www.recfin.org), another project of PSMFC. Those few records were added to the domestic fishery landings.

Time series of historical (pre-1981) landings were reconstructed by gear group (trawl and non-trawl) for each state separately, and then combined to produce annual coastwide estimates for the domestic fleet. The methods used to reconstruct historical landings for each state are described below.

##### 2.1.2.1.1 Washington

Historically, rockfish landings in Washington were reported on fish tickets in two mixed-species complexes: "Pacific Ocean Perch" and "Other Rockfish" (Tagart and Kimura 1982). In 1966, the

Washington Department of Fish and Wildlife (WDFW) initiated a sampling program to estimate landings of each rockfish species within these mixed-species complexes. Tagart and Kimura (1982) described the methodology employed in calculating rockfish landings by species, based on data collected by the WDFW sampling program, and Tagart (1985) provided time series of rockfish landings by year between 1963 and 1980. There were no records of aurora rockfish in these early Washington landings (Tagart, 1985); therefore, no Washington aurora landings were included into time series of domestic landings prior to the PacFIN era (Table 1).

##### 2.1.2.1.2 Oregon

Records of aurora rockfish trawl landings in Oregon go back to the late 1960s, although non-trawl landings were reported earlier (Table 1). Similar to Washington, aurora rockfish were historically landed in Oregon in mixed species market categories, primarily within "Pacific Ocean Perch" and "Unspecified Rockfish". A small portion of rockfish landed in Oregon between 1942 and the early 1980s were also landed in the "Animal Food" category (also called "Mink Food" or "Miscellaneous" by some sources). This portion of catch went to feed mink for the fur trade. Mink food consisted mainly of red meat until World War II, when horsemeat became increasingly difficult and expensive to obtain. During this period, there was an abundance of fillet carcasses, which were used as a protein source for mink. When the demand exceeded the supply, whole fish were specifically targeted to supplement the carcasses (Niska, 1969).

A time series of Oregon historical landings of aurora rockfish through 1986 was provided by the Oregon Department of Fish and Wildlife (ODFW), which in collaboration with the National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC), conducted a reconstruction of historical groundfish landings in Oregon (Karnowski et al., 2012). Karnowski et al. (2012) provide a detailed description of methods used in calculating rockfish landings by species. A variety of data sources were used to reconstruct historical landings of rockfish market categories, including Oregon Department of Fish and Wildlife's Pounds and Value reports derived from the Oregon fish ticket line data (1969-1986), Fisheries Statistics of the United States (1927-1977), Fisheries Statistics of Oregon (Cleaver, 1951; Smith, 1956), Reports of the Technical Sub-Committee of the International Trawl Fishery Committee (now the Canada-U.S. Groundfish Committee) (1942-1975) and many others.

To inform species compositions of rockfish within different market categories, the ODFW has routinely sampled species compositions of multi-species rockfish categories from commercial bottom trawl landings since 1963. Rockfish landings by species, which were estimated based on data collected by the ODFW sampling program, have been summarized in several ODFW reports, including Niska (1976), Barss and Niska (1978) and Douglas (1998). The latter publication by Douglas (1998) was an expansion and improvement on earlier publications (Niska, 1976; Barss and Niska, 1978). These sources were also used by Karnowski et al. (2012) in reconstructing historical landings of aurora rockfish in Oregon. The reconstructed landings of aurora rockfish in Oregon are presented in Table 1.

##### 2.1.2.1.3 California

A time series of California landings of aurora rockfish during the most recent "historical" period (between 1969 and 1980) were available from the California Cooperative Groundfish Survey (CalCOM) database.

Earlier landing records (between 1916 and 1968) were recently reconstructed by the NMFS's Southwest Fisheries Science Center (SWFSC) (Ralston et al., 2010). The reconstructed landings of aurora rockfish in California are presented in Table 1.

#### 2.1.2.2 Discard in the Domestic fisheries

Two sources of information on discard were used for this assessment.

Pikitch et al. (1988) conducted a study from 1985 to 1987, which included the at-sea collection of retained and discard catch data from commercial vessels off of Oregon and Washington. Vessels using bottom, mid-water, or shrimp gear participated in the study on a voluntary basis. John Wallace re-analyzed this data looking at discard rates of aurora rockfish relative to fish assemblages, and applied them to PacFIN data using both Rogers and Pikitch (1992) post-hoc assemblages and area to produce estimates of discard rates (and CVs).

Since 2002, the West Coast Groundfish Observer Program (WCGOP) has collected discard information for limited entry trawl and fixed gear fleets off of the U.S. west coast. Observer coverage averaged about 20% from 2002-2010, expanding to 100% under management of the ITQ (catch share) fishery, which began in 2011. More limited observer coverage exists for the California halibut trawl, the nearshore fixed gear and the pink shrimp trawl fisheries. The Groundfish Mortality Reports (formerly "Total Mortality Reports") produced by the WCGOP incorporates landed and estimates of discarded catch for each year. The WCGOP can also produce estimates of discard rates for each species, but for species caught in stock complexes, such as aurora rockfish, discard estimates of an individual species are relative to total groundfish and not the individual species. For this reason we used the Groundfish Mortality Report estimates of discard for the trawl and non-trawl fleets from 2002-2011 (the 2012 values were not yet available). The values from the Groundfish Mortality Reports do not have associated coefficients of variation or other measures of uncertainty, therefore values consistent with other stocks were assumed.

The WCGOP also has collected length-composition and average-weight data for discarded fish, and these are included to provide information on relative retention at size as well as additional data for estimating discard rates.

#### 2.1.2.3 Catch in the foreign POP fishery

Between 1966 and 1976, foreign trawl fleets from the former Soviet Union, Japan, Poland, Bulgaria and East Germany came to the Northeast Pacific Ocean to target large aggregations of Pacific Ocean perch over high-relief rocky outcrops (Love et al., 2002). Using very large vessels (often called factory trawlers), foreign fleets, particularly the Soviets, had the capacity to operate independently, by processing and freezing their own catch. Support vessels, such as refrigerated transports, oil tankers, and supply ships permitted these large stern trawlers to operate at sea for extended periods of time.

Rogers (2003) estimated removals of POP and other species caught within this foreign POP fishery, including removals of aurora rockfish. In the assessment, we used removals of aurora rockfish catch in the foreign POP fishery between 1966 and 1976 as estimated by Rogers (Rogers, 2003).

#### 2.1.2.4 Catch in the at-sea Pacific hake fishery

A very small amount of aurora rockfish has also been taken as bycatch in the at-sea Pacific hake fishery. The at-sea Pacific hake fishery dates back to the 1960s when foreign vessels participated. In the 1980s, the fishery evolved into a joint venture with U.S. catcher vessels delivering to foreign processing vessels. By 1991, foreign vessels were no longer allowed to fish in U.S. waters, the Pacific hake fishery became completely domesticated, allowing only U.S. vessels to catch and process fish.

The At-Sea Hake Observer Program (A-SHOP) monitors the at-sea hake processing vessels and collects total catch and bycatch data. Since the 1970s, observers were deployed onto foreign fishing vessels that were catching Pacific hake. After 1991, observers continued to be deployed aboard U.S. flagged catcher-processor and mothership vessels.

The annual amounts of aurora rockfish bycatch in the at-sea hake fishery, collected by A-SHOP, were obtained from the North Pacific Database Program (NORPAC). Since 1991, virtually 100% of hauls in the at-sea hake fishery have been sampled for catch and species composition, and the total catch (retained and discarded) has been estimated for both targeted and bycatch species from each haul. To derive the total amount of aurora rockfish bycatch by year, we simply summed the estimated catch in every haul within each year. Prior to 1991 (during the foreign fishery and joint venture), not every haul was sampled. For these years, NORPAC used an expansion factor (one for each year), a ratio of total hauls to sampled hauls. These year-specific expansion factors were used to estimate the total amount of aurora rockfish caught by multiplying the amount of total catch in sampled hauls by the expansion factor. The removals of aurora in the at-sea hake fishery between 1977 and 2012 are presented in Table 1.

#### 2.1.2.5 Fishery biological data

Biological information on domestic commercial landings was obtained from PacFIN (extracted on May 31, 2013). The fishery biological data included sex, length and age of individual fish (amount of data available varied by year and state). These biological data were used to generate length- and age-frequency distributions by sex, which were then used in the assessment to describe selectivity of the domestic trawl and non-trawl fleets. For a portion of length samples, sex information was not available. We used these samples to generate length compositions for unsexed fish and included these compositions in the model, along with those for sexed fish. The summary of sampling efforts, which includes the number of sampled trips and fish by year (for sexed and unsexed fish separately) is provided in Table 4 and Table 5. No biological information was available for aurora removals in foreign POP and at-sea hake fisheries.

##### 2.1.2.5.1 Length composition data

###### *2.1.2.5.1.1 Fishery length compositions*

Length-composition data from commercial fisheries were compiled into 16 length bins, ranging from 8 to 38 cm. Most of the length data from PacFIN were reported for females and males separately; therefore length-frequency distributions of aurora rockfish in commercial landings were generated by year and sex. Length compositions for unsexed fish were also included, in addition to the sex-specific compositions.

Overall biological sampling effort has varied among the three states, and the proportion of fish from sampled trips that are measured has been highly variable. To account for non-proportional sampling of aurora rockfish among trips and states, and to generate length frequency distributions that would be more representative of coastwide species landings, the observed length-composition data were expanded using the following algorithm:

1. Length-composition data were acquired at the trip level, along with year, state, and sex information;
2. For each trip, raw length observations were scaled up to represent aurora rockfish landings for the entire trip:
    a. An expansion factor was calculated by dividing the total weight of trip landings by the total weight of aurora rockfish sampled for length within the same trip;
    b. The observed raw length-composition data within each trip were multiplied by the expansion factor and then summed up by state.
3. The expanded and summed lengths in each state were then expanded again to account for differences in species landings among states:
    a. The expansion factor was computed by dividing the total weight of state landings of aurora rockfish by the total weight of aurora rockfish in trips sampled for length within this state;

b. The length frequency distributions for each state (from step 2 of this algorithm) were multiplied by the expansion factor (from step 3.a) and then summed to determine the coastwide sex-specific, length-frequency distributions by year.

Length-frequencies distributions were developed for the period between 1978 and 2012. We only used randomly collected samples. The initial input sample sizes for length-frequency distributions of aurora landings by year for California and for Oregon and Washington combined were calculated as a function of the number of trips and number of fish sampled, using the method developed by Stewart and Miller (pers. com.):

$$N_{input} = N_{trips} + 0.138N_{fish} \qquad \text{where } \frac{N_{fish}}{N_{trips}} < 44$$

$$N_{input} = 7.06N_{trips} \qquad \text{where } \frac{N_{fish}}{N_{trips}} \geq 44$$

The method was developed based on analysis of the input and model-derived effective sample sizes from west coast groundfish stock assessments. A step-wise linear regression was used to estimate the increase in effective sample size per sample, based on fish-per-sample and the maximum effective sample size for large numbers of individual fish.

##### *2.1.2.5.1.2 Discard length compositions*

Length compositions of discarded fish were recorded at the tow level by WCGOP observers on board commercial vessels, starting in 2002 for both the trawl and fixed-gear fleets. Length compositions of sampled discarded aurora rockfish were scaled up to the estimated number of discarded aurora in each tow, and then these were summed across observed tows for each year. Sample size was calculated using a modification of Stewart and Miller for survey tows, recognizing that observed discards are less random than surveys.

$$N_{input} = (N_{tows} + 0.0707N_{fish})^{0.9} \qquad \text{where } \frac{N_{fish}}{N_{tows}} < 55$$

$$N_{input} = (4.89N_{tows})^{0.9} \qquad \text{where } \frac{N_{fish}}{N_{tows}} \geq 55$$

#### 2.1.2.5.2 Average weight data for discards

The average weight of discarded fish was also provided by the WCGOP and included as another measure of the size of discarded aurora rockfish in the assessment.

#### 2.1.2.5.3 Age-composition data

Fishery age-composition data were available for the trawl fleet only, and only for the years 2003, 2008 and 2009. These age data were compiled into 61 age bins, ranging from age 0 to age 60 fish. Nearly 1,200 ages were available from commercial landings in these three years, as summarized in Table 4.

Age-composition data from the domestic fishery were assembled as conditional distributions of ages at length, by year and sex. The conditional-ages-at-length approach uses an age-length matrix, in which columns correspond to ages and rows to length bins. The distribution of ages in each column then is treated as a separate age composition conditioned on the corresponding length bin (row). The conditional-ages-at-length approach has been used in most recent stock assessments on the West Coast of the United States, since it has several advantages over the use of marginal age-frequency distributions. Age structures are usually collected from individuals that have also been measured for length. If the standard age compositions are used along with length frequency distributions in the assessment, the information on sex ratio and year-class strength are double-counted, since the same fish are contributing to likelihood components that are assumed to be independent. The use of conditional age distributions within each length bin allows avoiding such double-counting without having to downweight both the age and length data. Also, the use of conditional ages-at-length distributions allows the reliable estimation of growth parameters within the assessment model.

Each aged fish was treated as an independent sample of age-at-length. The number of ages within each length bin was used as the initial input sample size for conditional ages–at-length distributions.

### 2.1.3 Fishery-independent data

#### *2.1.3.1 Surveys*

Four fishery-independent groundfish trawl surveys were considered for abundance index development: 1) The Triennial shelf (1977-2004) survey (conducted by the Alaska and Northwest Fisheries Science Centers), the Alaska Fisheries Science Center (AFSC) slope (1997, 1999-2001) survey, and the Northwest Fisheries Science Center (NWFSC) slope survey (1999-2002) and shelf-slope trawl survey (2003-present). Though each survey uses trawl gear to sample groundfishes, the gear specifications, latitudinal and depth distributions, and survey design differs (Cope and Haltuch 2012).

The sampling design of the Triennial groundfish survey employed randomly-selected trawling stations, along each affixed array of latitudinal line transects and was conducted every 3 years from 1977 to 2004. Sampling time, depth, and latitude changed in 1995, with later surveys starting earlier in the year and sampling greater depths (Cope and Haltuch 2012). The deeper sampling is reflected in the fact that aurora rockfish is almost completely absent in this survey before 1995, but present in 17-19% of tows from then on (Table 6; Figure 7). Only years 1995 and onward are considered for survey index development.

The AFSC slope survey has been conducted periodically and without spatial consistency since 1984, but only since 1997 has the survey provided a dependable measure of depths from 183 to 1280 m throughout the area north of 34.5ºN (Table 6). This survey also utilized a fixed-transect design. Frequency of occurrence of aurora rockfish fluctuated from 16% to 21% (Table 6), with an overall occurrence rate of 18% (Figure 8).

The Northwest Fisheries Science Center began conducting a slope trawl survey in 1998, however minimal data were collected for rockfish until 1999. Surveys conducted during 1999-2002 were similar in design to the AFSC slope surveys, in that they continued the line-transect survey design over a slope depth range (183-1,280 m), with no coverage south of Point Conception. However, the new survey differed in the type of vessels and gear used, and trawl duration. The sample coverage was also limited, constraining strata consideration (Figure 9). In 2003, the survey was completely redesigned, switching to a random stratified design and including a wider range of depths (55-1,280m; referred to as the "shelf-slope" survey) and extending to the Mexican border. More samples also allowed for finer stratification options (Figure 10). Relative frequency of occurrence of aurora rockfishes was generally higher in the slope survey (Table 6).

#### *2.1.3.2 Survey abundance indices*

Delta-Generalized Linear Mixed Models (delta-GLMMs) were compared to design-based expanded swept-area estimates of abundance. Delta-GLMMs are preferred over the design-based estimates because the approach models both probability of positives and the magnitude of positive tows while allowing for different factors such as vessel and strata effects to be considered in a holistic modeling environment that propagates the uncertainty through all considered processes. The Bayesian implementation of this approach follows that of Thorson and Ward (2013). Lognormal and gamma errors structures were considered for the positive tows, including the option to model extreme catch events (ECEs), defined as hauls with extraordinarily large catches, as a mixture distribution (Thorson et al. 2011). The ECE models were considered exploratory and not considered in model selection. Model convergence was evaluated using the effective sample size of all estimated parameters (typically >500 of more than 1000 kept samples would indicate convergence), while model goodness-of-fit was evaluated using Bayesian Q-Q plots. Deviance was used to choose between the lognormal and gamma error structures.

Stratification for each survey was determined by first considering observations with the design-based strata. Any additional strata within the design strata required at least 5 positive occurrences. Design strata can be broken up into finer strata, but combining strata of differential sampling effort could create bias, thus combining strata was limited to cases where additional samples could be added with small increases in depth beyond a certain strata boundary. Design depth strata considered were 55-183 m,183-366 m, and 366-500m; and 55-183 m, 183-549m, and 549-1280m for the AFCS triennial and NWFSC annual surveys, respectively. There were no specific latitudinal design strata for the AFSC triennial survey, but the NWFSC had one latitudinal effort break at 34.5º N lat. (near Pt. Conception). Final design strata used in the GLMMs for those stocks are shown in Figure 7 to Figure 10. Year-strata effects were assumed fixed with no interactions for both the binomial and positives models. The AFSC surveys assume no vessel effects, while the NWFSC surveys assumed random vessel effects.

Model comparisons and selection are shown in Figure 11 to Figure 14. The gamma error structure was chosen over lognormal based on the deviance criterion in three of the four comparisons, but gamma was used for all surveys for consistency with the design based estimates and lack of reasoning to select lognormal over gamma from just one survey (Figure 15 to Figure 18). All chosen models demonstrated good effective sample sizes and acceptable Q-Q plots (Figure 19). Final index time series used in the base case models are given in Table 7.

#### *2.1.3.3 Survey Length Composition Data*

Length-composition data collected by the surveys were used to derive length frequency distributions by survey, year and sex. A summary of sampling efforts in all surveys are summarized in Table 9. Length composition data were compiled into 16 length bins, ranging from under 10 cm to 38 cm and larger, with 2-cm bins intermediate. The observed length compositions were expanded to account for differences in relative sampling among tows as well as biomass indices for each spatial stratum. To generate coast-wide length frequency distributions the following algorithm was used:

1. For a specific year and survey, length data by sex were acquired at the tow level;
2. For each tow, the raw length observations were expanded to represent the entire tow:
    a. An expansion factor was calculated by dividing the total weight of aurora within a tow by the total weight of aurora in a tow measured for length;
    b. The observed length frequencies were multiplied by the corresponding expansion factor and then summed up within a spatial stratum.
3. The expanded and summed length frequencies in each spatial stratum were normalized and then weighted to account for differences in the year-specific indices among the spatial strata:
    a. The weighted and summed length frequencies were divided by their sum so that the resultant frequency vector summed to 1.0;
    b. These normalized length frequency compositions within each stratum multiplied by the proportion of the year specific numerical index within that stratum (i.e. the stratum index divided by the total index).

Spatial strata used to generate annual length frequency distributions were consistent with the strata used to compute survey abundance indices (Table 10; Figure 6 to Figure 10). The coast-wide length frequency distributions of female and male aurora rockfish by survey, year and sex are shown in Figure 35 to Figure 46.

The initial input sample sizes for the survey length frequency distribution data for each stratum were calculated as a function of both the number of fish and number of tows sampled using the method developed by Stewart and Miller (NWFSC, pers.com.):

$$N_{input} = N_{tows} + 0.0707N_{fish} \qquad \text{where} \quad \frac{N_{fish}}{N_{tows}} < 55$$

$$N_{input} = 4.89N_{tows} \qquad \text{where} \quad \frac{N_{fish}}{N_{tows}} \geq 55$$

The total input N was then calculated via the following equation which accounts for the difference in relative index (I) in each stratum and the relative effective sample size in each stratum, under the assumption of a binomial distribution within each cell of the length composition:

$$N_{total} = \frac{1}{\sum_{stratum=1}^{n} \frac{I_{stratum}^2}{N_{stratum}}}$$

#### *2.1.3.4 Age-composition data*

Age composition data were available for the NWFSC shelf/slope survey only, and only for the years 2003, 2005, 2007, and 2009-2012. A summary of age data available for the assessment is presented in Table 4 and Table 9. Age composition data from the surveys were compiled as conditional distributions of ages at length by survey, year and sex, as with the fishery data (Section 2.1.2.5.3). Each age was considered an independent observation of age at length, and thus the raw observed age at length data were used as the conditional data and the number of fish in each aged length bin was used as the input sample size. Conditional ages at length compositions generated and used in the assessment are shown in Figure 87 to Figure 90.

### 2.1.4 Priors for informing parameter values

A prior for natural mortality was developed based upon Hoenig's (1983) method and the method of developing priors from one or more meta-analytical methods developed by Hamel, which has been used in multiple west coast groundfish stock assessments. A prior for steepness (the Thorson-Dorn prior) was calculated using previous stock assessments for the 2013 stock assessment cycle and reviewed at a SSC groundfish subcommittee meeting in March, 2013.

## 2.2 Model

### 2.2.1 Modeling Software

This assessment uses the Stock Synthesis modeling framework developed by Dr. Richard Methot (NMFS, NWFSC). The most recent version (SSv3.24o, distributed on April 10, 2013) was used, since it included improvements in the output statistics for producing assessment results and several corrections to older versions.

### 2.2.2 General Model Specifications

This assessment focuses on the population of aurora rockfish that occurs in coastal waters of the western United States, off Washington, Oregon and California. The population within this area is treated as a single coastwide stock, given the lack of data suggesting the presence of multiple stocks. The modeling period begins in 1916, assuming that in 1915 the stock was in an unfished equilibrium condition.

Fishery removals are divided among two fleets: 1) the domestic fishery (including trawl as well as hook-and-line, pot, setnet and other gears), and 2) the full-retention foreign POP and at-sea Pacific hake fisheries (along with the minimal research catch). As described earlier, the domestic and full-retention fleets are treated separately to account for difference in handling and reporting the discards. The domestic fishery is associated with a particular amount of catch discarded at sea. The foreign POP fishery is known not to discard fish (based on their size or species), while the at-sea hake fishery, which is managed under maximized retention regulations. The time series of discards, therefore, are estimated for the domestic fleet, and no discard is assumed for the full-retention fleet.

Historical landings for the domestic trawl and non-trawl fisheries were reconstructed by state, and then combined into the coastwide fleet. Selectivity and retention parameters are estimated for the domestic fleet, while selectivity of the full retention fleet is mirrored to that of the domestic fishery. The Triennial, AFSC slope and NWFSC surveys are treated as separate fleets with independently estimated selectivity and catchability parameters reflecting differences in depth and latitudinal coverage, design and methods. Since no length or age data are available for the NWFSC slope survey, the selectivity of that survey is mirrored to that of the NWFSC shelf-slope survey which used the same general methodology (except for selection of survey trawls) and also covers the entire depth range of the species. Given the difference in latitudinal range, catchability was estimated independently for the NWFSC slope and NWFSC shelf-slope surveys.

No seasons are used to structure removals or biological predictions; data collection is assumed to be relatively continuous throughout the year. Fishery removals in the model occur instantaneously at the mid-point of each year and recruitment on the 1st of January

The base model is sex-specific model and the sex-ratio at birth is assumed to be 1:1. Growth of aurora rockfish is assumed to follow the von Bertalanffy growth model, and separate growth parameters are estimated for females and males, except for the CV of length-at-age (Table 11). Females and males also have separate weight-at-length parameters.

Recruitment dynamics are assumed to be governed by a Beverton-Holt stock-recruit function (Table 11). ‘Main’ recruitment deviations were estimated for modeled years that had information about recruitment, between 1962 and 2011 (as determined from the bias-correction ramp). We additionally estimated ‘early’ deviations between 1916 and 1959 so that age-structure for the first year with length composition data (1978) would deviate from the stable age-structure that is consistent with estimated variability in recruitment

The length composition data are summarized into 16 2-cm bins, ranging between 8 cm (representing fish under 10 cm) and 38+ cm (Appendix B). Population length bins are defined at a finer, 1-cm scale. The age data are summarized into 61 bins, ranging being age 0 and age 60+. Age data beyond age 60 comprise less than 15% of all the age data available for the assessment and ageing error is large for fish that old. For the internal population dynamics, ages 0-80 are individually tracked, with the accumulator age of 80 determining when the ‘plus-group’ calculations are applied. This accumulator age is selected since little growth is predicted to occur at and beyond this and so that, given the ageing error associated with fish in this plus group, the model would not expect fish in the 80+ group to have age estimates below age 60. The model does not allow growth to continue in the plus-group.

One round of iterative re-weighting was used in the assessment to achieve consistency between the input sample sizes and the effective sample sizes for length and age composition samples based on model fit.

This reduces the potential for particular data sources to have a disproportionate effect on total model fit. Additional down-weighting of compositional data were undertaken using Francis' method (Francis 2011; Table 10).

### 2.2.3 Estimated and Fixed Parameters

In the assessment, there are parameters of three types, including life history parameters, stock-recruitment parameters and selectivity and retention parameters. These parameters were either fixed or estimated within the model. Reasonable bounds were specified for all estimated parameters. A full list of all parameters used in the assessment is provided in Table 11 and Table 12.

#### *2.2.3.1 Life History Parameters*

Life history parameters that were fixed in the base model included weight-at-length parameters (Figure 20) for females and males, female maturity-at-length (Figure 21) and fecundity-at-length (Figure 22), and natural mortality (*M*) for females and males (Table 11). These parameters were either derived from data or obtained from the literature, as described in Section 1.2.

The von Bertalanffy growth function (von Bertalanffy 1938) was used to model the relationship between length and age in aurora rockfish. This is the most widely applied somatic growth model in fisheries (Haddon 2001), and has been commonly used to model growth in rockfish species (e.g  Love et al. 2002) and several west coast stock assessments).

Female aurora rockfish were reported to reach larger sizes than males; therefore, time-invariant growth was modeled for each sex separately. The Stock Synthesis modeling framework uses the following version of the von Bertalanffy function:

$$L_A = L_\infty + (L_1 - L_\infty)e^{-k(A-A_1)}$$

Where asymptotic length, $L_\infty$, is calculated as:

$$L_\infty = L_1 + (L_2 - L_1)\ /(1 - e^{-k(A_2-A)})$$

In these equations, $L_A$ is length (cm) at age $A$, $k$ is the growth coefficient, $L_\propto$ is asymptotic length, and $L_1$ and $L_2$ are the sizes associated with a minimum $A_1$ and maximum $A_2$ reference ages.
Ages $A_1$ and $A_2$ were set to be 1 and 40 years, respectively. Female parameters $L_1$, $L_2$, growth coefficient $k$ and CV associated with $L_1$ and $L_2$ estimates were estimated in the model. The male $L_1$, $L_2$ and growth coefficient $k$ were estimated in the model while CV associated with $L_1$ and $L_2$ were set to be identical to those of for females.

Natural mortality rates were set at the median of the prior derived from Hoenig's method: 0.0350 for females and 0.0371 for males (Table 11).

#### *2.2.3.2 Stock recruit Parameters*

Recruitment dynamics are assumed in the assessment to be governed by a Beverton-Holt stock-recruit function. This relationship is parameterized to include two estimated quantities: the log of unexploited equilibrium recruitment ($R_0$) and steepness ($h$) (Table 11).

In this assessment the log of $R_0$ was estimated, while $h$ was fixed at its prior mean of 0.779. This prior was estimated using a likelihood profile approximation to a maximum marginal likelihood mixed-effect model for steepness from ten Tier-1 rockfish species off the U.S. West Coast (Pacific Ocean perch, bocaccio, canary, chilipepper, black, darkblotched, gopher, splitnose, widow and yellowtail rockfish). Both northern and southern assessments of black rockfish were used, although the log-likelihood for each was given a 0.5 weighting, to ensure that the together these two assessments had an equal weighting to the other species. This likelihood profile model is intended to synthesize observation-level data from assessed species, while avoiding the use of model output and thus improving upon previous meta-analyses (Dorn, 2002; Forrest et al., 2010). This methodology has been simulation tested, and has been recommended by the PFMC' SSC for use in stock assessments.

We estimate lognormal deviations from the standard Beverton-Holt stock-recruit relationship for the period between 1916 and 2011. Deviations are penalized in the objective function, and the standard deviation of the penalty ($\sigma_R$) is specified as 0.5. This is a reasonable, but fairly low value. Methot and Taylor (2011) suggested that $\sigma_R^2$ could be tuned to match the sum of the variance of the estimate recruitment deviations and the square of the average standard error of these estimates. Applying this method to the estimated values and their uncertainty for the base model provided a value of 0.518, which was seen as similar enough to the assumed value of $\sigma_R = 0.5$ that no additional tuning was applied. Recruitment deviations are also bias-corrected following Methot and Taylor (2011), by providing a proportion of the total bias correction for year $y$ that varies depending upon how informative the data are about $r_y$. Specifically, we used R4SS (Taylor et al. 2012) to estimate a five-parameter bias-correction ramp (Figure 23).

#### *2.2.3.3 Selectivity Parameters*

Gear selectivity parameters used in this assessment were specified as a function of size with no direct dependence upon age (Table 12). Separate size-based selectivity curves were fit to each fishery fleet and survey for which length composition data were available.

Logistic selectivity curves were used for all three fisheries, with the full retention fleet mirrored to the domestic trawl fleet. The logistic curve has two parameters: 1) The length at 50% selectivity, and 2) the width of the curve.

Separate retention curves were estimated for the domestic trawl fleet and the non-trawl fleet.  Retention curves are defined as a logistic function of size. These curves are described by four parameters: 1) inflection, 2) slope, 3) asymptotic retention, and 4) male offset to inflection. Male offset to retention was fixed at 0 (i.e. no male offset was applied). Asymptotic retention was set as a time-varying quantity with blocks from 1999-2001, individual years from 2002-2010, and 2011-2012 as a time block. Discard rates were fit to match the observed amount of discard between 2002 and 2011. The time-varying parameters were set via use of time blocks.

The selectivity curves for all the surveys were estimated to be dome-shaped and modeled with double-normal selectivity. The double-normal selectivity curve has six parameters, including: 1) peak, which is the length at which selectivity is first fully selected, 2) width of the plateau on the top, 3) width of the ascending part of the curve, 4) width of the descending part of the curve, 5) selectivity at the first size bin, and 6) selectivity at the last size bin.

### 2.2.4 Key assumptions and structural choices

The structure of the base model was selected to balance model realism and parsimony. While the model was able to estimate natural mortality, uncertainty about the historical selectivity of the fishery led to concern about the estimated natural mortality rates. The *a priori* information about natural mortality from Hoenig's (1983) method led to the natural mortality rate being set at 0.0350 for females and 0.0371 for males.

The domestic trawl fishery selectivity curve is estimated to be asymptotic even when given the opportunity to be a dome-shaped (i.e. a double-normal form). We have, therefore, chosen to specify that fishery selectivity is asymptotic, which is consistent with previous rockfish assessments for such a fishery.

### 2.2.5 Changes made during STAR panel Review

- The specification for the recruitment deviations was changed from having "simple" recruitment deviations (not forced to sum to zero) in the SS3 control file to having a standard "dev-vector". It is not clear how the "simple" deviations are constrained, nor has this option been tested or reviewed.
- The "Trawl" and "Non-Trawl" fleets were combined into a single Domestic fleet which is dominated by the Trawl fleet, and only Trawl compositional data is used to characterize this fleet. This was done due to the sparse Non-Trawl compositional data and concerns that the recent Non-Trawl data did not reflect the historical mix of fisheries in that data set.
- The iterative reweighting method was changed from just looking at the differences between the input and estimated effective sample sizes for each set of indices or compositional data to using the Francis (2011) method for compositional data which considers the deviation between observed and modeled mean length or age within each compositional data set.
- The natural mortality rates $M$ were set at the median of the prior distributions (0.035 for females and 0.0371 for males) rather than the mean of those lognormal distributions.

### 2.2.6 Base Model Results

A converged base model was found with appropriate gradient, covariance and Hessian properties. Additional exploration to conclude the base model was not settling on a local likelihood minimum was conducted by jittering staring values for all parameters at two jitter values (0.1 and 0.5) 100 times each (Figure 24). These jitter runs confirm the base case likelihood minimum over a large exploration of likelihood space.

#### *2.2.6.1 Life history parameters*

The list of the all the parameters used in the assessment model and their values (either fixed or estimated) is provided in Table 11 and Table 12. The life history parameters estimated within the model are reasonable and consistent with what we know about the species. Both sexes follow the same trajectory in their growth, but with females reaching larger sizes (Figure 25). Figure 20 to Figure 22 show weight-at-length relationships by sex, female maturity-at-length, fecundity-at-length generated based on fixed parameters that were derived outside the model. Female fecundity and spawning output in the assessment are expressed in spawning biomass since no information on the relationship of fecundity and size specific to aurora rockfish was available.

#### *2.2.6.2 Discards*

The base model balances the information in the discard fraction or amount data with the length and mean weight data to estimate the shape of the retention curve and, in the case of the trawl fleet, a time-varying asymptote for retention reflecting changes in management measures.

The model does a reasonable job of fitting the length composition data for trawl discard, including balancing those data and the discard ratio data for 2006 and 2007, and matching the decline in average length of discards following the implementation of the catch shares fishery in 2011 (Figure 77 to Figure 82). There is some evidence in these length compositions for incoming year classes.

#### *2.2.6.3 Abundance Indices*
The base model did not indicate contradictions between the survey biomass indices and the estimated trends in selected biomass (Figure 31 to Figure 34). Fit to the all surveys was generally flat. This is not unexpected for the short time-series of the AFSC (Figure 32) and NWFSC slope (Figure 33) surveys. For the Triennial survey, which covers 10 years (1995-2004, though with only 4 indices across that time period) the model does not reflect the small but steady observed increase in the index (Figure 31). The NWFSC survey index is fairly flat, but the model estimates a small increase at the end of the time series (Figure 34). Estimating additional variation for these surveys was attempted, but estimated to be zero for all surveys.

#### *2.2.6.4 Length and age compositions*
The model fit to length and age frequency distributions, by year and aggregated across year, and Pearson residuals for the fits by fleet, year and sex are shown in Figure 35 to Figure 90. The quality of fit varies among years and fleets, which reflects the differences in quantity and quality of data. The Pearson residuals, which reflect the noise in the data both within and among years, did not exhibit any strong trends except for the non-trawl fleet for which the small sample size precluded more complex modeling (Figure 47 to Figure 58). Effective samples sizes varied from input sample sizes, but due to the reweighting scheme (primarily the Francis reweighting) the final input sample sizes were generally well below the estimated effective sample sizes (Figure 59 to Figure 70).

Plots of observed and expected length compositions for the domestic landings aggregated across all years (Figure 72, Figure 74, and Figure 76) show acceptably good fits.

The survey length composition generally exhibits smaller average length than the fishery, and hence is more likely to pick out individual cohorts (Figure 83 to Figure 86). However, the variability in the discard rates over the past decade along with the variability of the length compositions makes it difficult to pick these out from Figure 36, Figure 38, and Figure 40.

The fits to conditional ages at length are shown in Figure 87 to Figure 90. These plots show that predicted average age at length is generally within predicted error bars around the observed average age at length, which provides support for the assumption that length at age is adequately approximated by the base model, as is necessary to model size at age internally within Stock Synthesis.

#### *2.2.6.5 Selectivity*

##### 2.2.6.5.1 Fisheries
Estimated selectivity and retention curves for the fisheries are shown in Figure 91 to Figure 96. Estimated parameter values are given in Table 12. The selectivity curve for the domestic and full retention fleets (which were assumed identical) is shifted towards larger aurora (Figure 91). The retention curves (Figure 92) fit the discard data reasonably well (Figure 27). The asymptote of the retention curve for the trawl fleet is varies to fit the early Pikitch discard data from 1985-1987 and the observer data from 2002-2011, though the fit to the estimated discard fraction is not quite as good for 2006 and 2007 (Figure 27) due to balancing fits to the corresponding length data (Figure 35 and Figure 51) and mean weight data (Figure 26). A single retention curve for the non-trawl fleet was estimated given the relatively small amount of catch and data for that fleet (Figure 91). Since landings and catch are dominated by the trawl fleet, and there is information on catch and discard amounts for the non-trawl fleet, the difficulty in accurately estimating the selectivity and retention functions for the non-trawl fleet has little overall impact on the assessment. A significant portion of the trawl (Figure 95) and full retention (Figure 96) fisheries includes immature individuals.

#### 2.2.6.5.2 Surveys

Estimated selectivity curves for surveys are shown in Figure 91 and parameter values are in Table 12. All surveys cover the core of the depth distribution of aurora (350-500m), with the slope and slope-shelf surveys covering the deeper end of their range as well. It appears that gear and vessel differences are more important than depth differences in selectivity, as the Triennial and the AFSC slope surveys have nearly identical estimates of dome-shaped selectivity, while the NWFSC surveys have peak selectivity at a larger size. Immature individuals are well sampled in all surveys (Figure 97 to Figure 100).

### *2.2.6.6 Derived outputs*

The deviations from the estimated stock-recruitment function have a very large uncertainty which is slightly reduced from the 1960s through the 2000s (Figure 101). Therefore, the relative bias adjustment was ramped to the maximum value during this period. Variable recruitment is evident in the 1990s and 2000s, though the ability to discern recruitment in individual years is still limited (Figure 102). The assumed model value for the recruitment variability parameter ($\sigma_R$) is sufficiently matched by the asymptotic error estimate of recruitment variability (Figure 103).

The estimated time series of total and summary biomass (which are the same in this model), spawning biomass, spawning depletion (relative to $B_0$), recruitment and fishing mortality are presented in Table 13 and Figure 104 to Figure 107. Trends in total and summary biomass, spawning biomass and spawning depletion track one another very closely. The summary and spawning biomass of aurora rockfish started to decline in the 1980s and 1990s. Between 1980 and 2000, the spawning output dropped from over 100% to under 70% of its unfished level. The spawning output continued to decrease, reaching its lowest estimated level of 63% of its unfished level in 2009. Since then, the spawning biomass has been slowly increasing. Currently, the spawning output is estimated to be 64% of its unfished level (Figure 105). Aurora rockfish seems neither to be overfished nor undergoing overfishing (Figure 108). The peak of the yield curve, given the high steepness curve, is well to the left of the assumed biomass target of 40% (Figure 109). Given the history of generally low exploitation rates (Figure 107) and high steepness, surplus production is high (
Figure 110).

## 2.2.7 Profiles, and sensitivity and retrospective analyses

Parameter uncertainty in the assessment is explicitly captured in the asymptotic confidence intervals estimated within the model and reported throughout this assessment for key parameters and management quantities. These intervals reflect the uncertainty in the model fits to the data sources in the assessment, but do not include the uncertainty associated with alternative model configurations and fixed parameters. To explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in model assumptions, a variety of sensitivity runs were performed.

### *2.2.7.1 Profiles*

Profiles were conducted across values of natural mortality $M$ and steepness $h$. These were conducted both with the assumed value of the other parameter or while estimating the other parameter. Thus four profiles were conducted: across $h$ with $M$ fixed (Table 14, Figure 111 to Figure 113), across $h$ with $M$ estimated for both males and females(Table 15, Figure 114 to Figure 116), across $M$ with $h$ fixed at 0.779 (Table 16, Figure 117 to Figure 119), and across $M$ while estimating $h$ (Table 17, Figure 120 to Figure 122).

The base case model (Table 14 and Figure 111) shows support for steepness values above 0.6, with low sensitivity to any of the derived outputs. All likelihood components converge on higher steepness values with little to no significantly contradictory behavior in any of the likelihood components (Figure 112 and Figure 113).

Allowing natural mortality to be estimated in the base case produces notable differences from the base case (Table 15 and Figure 114). While general sensitivity across steepness values remained low, the lower estimated of natural mortality greatly decreased both the scale ($R_0$ and biomass) and the status (depletion). Depletion was estimated to be near the target ($B_{40\%}$). It also greatly increased the analytically derived value of the survey catchability coefficients, arguably to values that seem unlikely for rockfishes. This demonstrates significant uncertainty in derived outputs when considering either assumed or data-driven natural mortality values. All likelihood components again converge on higher steepness values with little to no significantly contradictory behavior in any of the likelihood components (Figure 115 and Figure 116).

Shifting focus on holding steepness fixed and profiling across natural female mortality rates shows that a very small range of possible M values are supported by the data (Table 16 and Figure 117). Both Scale and status are very sensitive to assumed mortality rates, though all plausible depletion values are around or above the biomass target ($B_{40\%}$). A deeper look at the likelihood components demonstrates contradictory behavior in that the trawl survey length compositions are not well fit and the best fit likelihood values are at the least likely natural mortality values (Figure 118 and Figure 119). Age compositions and survey data were more consistent with the best fit natural mortality values (Figure 119). Estimating steepness profiled across female natural mortality does little to change this overall behavior in derived outputs (Table 17 and Figure 120) and likelihood components (Figure 121 and Figure 122).

#### *2.2.7.2 Sensitivity Analyses*

Sensitivity analyses were conducted to explore the sensitivity of the model to various assumptions. These included alternate runs with:

1) The natural mortality rates (*M*) for females and males either a) estimated or b) set at the mean of the prior.
2) A fecundity relationship with an exponent on weight similar to the average value estimated by Dick (2009).
3) Marginal ages used instead of conditional age-at-length for a) All age data, b) only fishery age data, or c) all age data and with *M* estimated.
4) Ageing error (CV) assumed to be a) half or b) twice of that assumed in the base model.
5) A selectivity block for fishery selectivity starting in 2011 to reflect the effect of catch shares.
6) Maturity curves based upon a) ages instead of lengths (from Thomson and Hannah, 2010) or b) the maturity data from the 2012 NWFSC survey.

Results of these sensitivity runs are summarized in Table 18. The model proved again to be most sensitive to the treatment of natural mortality.

#### *2.2.7.3 Retrospective analyses.*

Retrospective analyses were produced as if the assessment had been conducted in previous years but with only the years of data that would have been available in that terminal year and before. Retrospective runs were conducted every year back to an assessment year of 2008 (Figure 123 to Figure 127). There is a retrospective pattern which begins after removing the last two years of data, with the scale of the population and the uncertainty about the scale increasing. These removals have the greatest effect on the age and discard data and the NWFSC survey data. These patterns generally lead to higher biomass estimates and higher stock status (Figure 127), with lower exploitation rates (Figure 124). While recruitment deviations are little affected (Figure 125), the scale of recruitment changes after two years are removed and again in the last retrospective year (Figure 126). Estimates of initial recruitment become less certain (Figure 127).

### 2.2.8 Comparison to catch-only methods

Dick and MacCall (2010) applied the depletion-corrected stock reduction analysis (DB-SRA) to aurora rockfish to estimate OFLs in 2011 and 2013. These estimates (47 mt in 2011 and 2012) of OFL are well below the base case estimated yield at an SPR proxy for MSY of 50% (104 mt). Removal comparisons between the 2010 DB-SRA model and the current base case show little difference (Figure 128). A simple Stock Synthesis (SSS; Cope 2013), a catch-only approach similar to DB-SRA, was performed using the current total removals from the base case and same life history parameters. The depletion in year 2000 prior used in the SSS model was assumed a symmetric beta distributed with a mean of 0.3 and standard deviation of 0.2. These values follow the method of Cope et al. (2013) that use the Productivity-Susceptibility Analysis measure of vulnerability to predict depletion. A comparison of the results to the recent base case (Figure 129) illustrate that catch-only methods show a much lower spawning biomass and more highly depleted stock. The additional data (indices of abundance and length and age data) in the full assessment reduce the uncertainty in stock status, but increase the uncertainty in biomass scale.

# 3 Reference Points

A summary of reference points for the base model is provided in Table 19. Unfished spawning biomass (as a proxy of egg production) is estimated to be 2626 mt (95% CI: 1165-4087; CV = 28.4%) with spawning biomass at the beginning of 2013 estimated to be 1050 mt (95% CI: 466-1635; CV = 40.4%). The stock's status (depletion) is estimated to be at 64% of the unfished level in 2013.

A stock is declared overfished if the current spawning output is estimated to be below 25% of unfished level. The management target for aurora rockfish is defined as 40% of the unfished spawning output ($SB_{40\%}$), which is estimated by the model to be 1050 mt (95% confidence interval: 466-1,635 mt), which corresponds to an exploitation rate of 0.0304. This harvest rate provides an equilibrium yield of 72 mt at $SB_{40\%}$ (95% confidence interval: 33-112 mt). The exploitation rate corresponding to an SPR of 50% (the proxy $F_{MSY}$) is 0.0248, resulting in an equilibrium yield of 67 mt (95% confidence interval of 31-104 mt) at a biomass of 1213 mt (95% confidence interval of 538-1888 mt).

The assessment shows that the stock of aurora rockfish off the continental U.S. Pacific Coast is currently at 64% of its unexploited level. This is above the overfished threshold of $SB_{25\%}$ and the management target of $SB_{40\%}$ of unfished spawning output.

This assessment estimates that the 2012 SPR is 69%, while the SPR-based management fishing mortality target is 50%. For the last 18 years, the SPR has been above 50%, which means that overfishing of aurora rockfish has not been occurring (Figure 124). Historically, the aurora rockfish had been fished beyond the SPR-based target fishing rate in 1988-1990 and 1992-1994.

# 4 Harvest projections and decision tables

The base model was projected with catches in 2013 and 2014 determined from a recent 5-year average and catches from 2015–2024 based on the predicted allowable biological catch (ABC) using a SPR proxy of 50% ($F_{50\%}$), and P*-based buffer of 0.956 and the 40-10 rule. While the ABCs nearly double from 2015 onward compared to the average catch, the spawning biomass stays relatively stable (Table 20).

To observe stock status across important uncertainty considerations, a decision table was developed showing projections from 2015–2024 under ABC catches for three states of nature (defined by natural mortality *M*) and with catches streams based on the ABCs from each state of nature (Table 21). The base case demonstrated large sensitivity to the choice of *M*, which is why it was selected to define the decision table states of nature. The base model assumes *M* was fixed, so capturing the uncertainty in *M* was important, and there were two measures of this uncertainty available: 1) A prior on M (Table 11); 2) The post-model estimate of variance in *M*. The latter was available either using the asymptotic variance or through a likelihood profile. The second option was selected in order to not constrain the uncertainty to a normal distribution. The likelihood profile on *M* was used to parameterize a lognormal distribution of uncertainty. To combine uncertainty both in the prior on *M* and in the likelihood based post-model estimate of *M*, the two lognormal distributions were combined into a quasi-posterior distribution. It turns out that the prior contributes little to this combined value, thus the final measure of uncertainty in *M* is very similar to the likelihood profile estimator. This also happens to be very similar to the asymptotic variance estimator. The 12.5% and 87.5% quantiles of *M* were then used to define the lower and upper states of nature, with the median value for the base case value of *M*. The resultant spawning biomass in 2013 from the lower and upper states of nature model runs were very similar to the corresponding quantile values of spawning biomass based on the asymptotic variance. While this characterization of uncertainty in *M* looks to capture measurement and process uncertainty, it does not include model misspecification error.

The most conservative scenario (low *M*, catch stream based on high *M*) indicates the stock will be at the target biomass in 2024. The least conservative scenario (high *M*, catch stream based on low *M*) indicates the population will climb to around 80% of initial conditions. All scenarios using the base case value of M indicate the population will be above the reference point in all years.

# 5 Regional Management Considerations

This species is currently managed within the slope complexes, north and south of 40°10' latitude. This assessment is not spatially structured. There are indications, however, that life history parameters, particularly growth, might be varying with latitude. Analysis conducted within this assessment did not allow identification of specific areas with different growth parameters, but rather detected a continuous gradient along the coast, which is common for *Sebastes* species on the West Coast of the United States. The relative exploitation rate may be different in the north and south as well, as less than 20% of the NWFSC shelf-slope survey biomass indices are seen in the north, but far more than that percentage of catch has been taken from the north.

# 6 Future Research Recommendations

The following research could improve the ability of future stock assessments to determine the current status and productivity of the aurora rockfish population:

1) This was the first year in which aurora rockfish otoliths were read to develop age data. There was insufficient time to read all of the otoliths or even cover all of the years for which aurora rockfish otoliths were collected from the fisheries or surveys. Additional age data could provide additional information for the model to estimate such parameters as natural mortality and recruitment deviations. Additionally, validation methods, such as the bomb radiocarbon chronometer, could be used to validate the ages and ageing method for aurora rockfish.
2) The base model does not use newly available information of female maturity collected within the NWFSC shelf-slope survey in 2012. This new information includes data on mass atresia (a form of skipped spawning), at far greater numbers than that reported in Thompson and Hannah (2010). More data on aurora rockfish maturity will be collected this year on the NWFSC shelf-slope survey, which could confirm the information on mass atresia or indicate variability between years. This information could better inform the maturity curves used in the assessment
3) The base model assumes spawning output is proportional to spawning biomass. For many rockfish species, fecundity has been shown to have a non-linear relationship with female weight. Determining this relationship for aurora rockfish would improve the estimation of spawning output and depletion.

4) Improve the meta-analysis for steepness. This would include consideration of fixed and estimated parameters, assumptions, and the quality of the information on maturity and fecundity in the component assessments, as well as correlations in recruitments among assessments due to environmental drivers.
5) The application of the GLMM software elicited many unresolved questions. Continued research and articulation of that model and the options available (e.g. extreme catch events) will greatly benefit both STAT application and STAR Panel understanding of the model and its advantages.
6) Further research on the most appropriate method for data-weighting is greatly needed. Simulation testing and comparison of standard and new (Francis 2011) methods would benefit future assessments of this and other stocks.
7) Development of information on the spatial structure of the stock, including genetic analysis, investigation of differences in and size at maturity, and information on aurora rockfish off of Canada and Mexico.
8) The development of additional indices could provide further information to anchor the assessment. While direct adult biomass indices are unlikely to surface, there may be some possibility to develop a larval abundance index from the CalCOFI data set. This index reflects a measure of spawning biomass.

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# 8 Tables

## 8.1 Catches

**Table 1. Total landings (mt) of aurora rockfish for the domestic trawl and non-trawl fleets (provided here by state) and full-retention fleet (separated here as catch in foreign POP and in at-sea Pacific hake fisheries). The domestic fleet in the assessment model includes both the trawl and non-trawl fisheries.**

| Year | Trawl | | | Non-trawl | | | Catch in foreign POP fishery | Bycatch in at-sea hake fishery + research | Total |
|---|---|---|---|---|---|---|---|---|---|
| | CA | OR | WA | CA | OR | WA | | | |
| 1915 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1916 | 0.06 | 0 | 0 | 0.020 | 0.001 | 0 | 0 | 0 | 0.08 |
| 1917 | 0.09 | 0 | 0 | 0.033 | 0.001 | 0 | 0 | 0 | 0.12 |
| 1918 | 0.10 | 0 | 0 | 0.031 | 0.001 | 0 | 0 | 0 | 0.14 |
| 1919 | 0.07 | 0 | 0 | 0.018 | 0.001 | 0 | 0 | 0 | 0.09 |
| 1920 | 0.07 | 0 | 0 | 0.021 | 0.001 | 0 | 0 | 0 | 0.10 |
| 1921 | 0.06 | 0 | 0 | 0.018 | 0.001 | 0 | 0 | 0 | 0.08 |
| 1922 | 0.05 | 0 | 0 | 0.018 | 0.001 | 0 | 0 | 0 | 0.07 |
| 1923 | 0.05 | 0 | 0 | 0.022 | 0.001 | 0 | 0 | 0 | 0.08 |
| 1924 | 0.03 | 0 | 0 | 0.025 | 0.001 | 0 | 0 | 0 | 0.05 |
| 1925 | 0.03 | 0 | 0 | 0.028 | 0.001 | 0 | 0 | 0 | 0.06 |
| 1926 | 0.06 | 0 | 0 | 0.039 | 0.001 | 0 | 0 | 0 | 0.10 |
| 1927 | 0.07 | 0 | 0 | 0.012 | 0.001 | 0 | 0 | 0 | 0.08 |
| 1928 | 0.09 | 0 | 0 | 0.015 | 0.002 | 0 | 0 | 0 | 0.11 |
| 1929 | 0.11 | 0 | 0 | 0.013 | 0.003 | 0 | 0 | 0 | 0.13 |
| 1930 | 0.12 | 0 | 0 | 0.013 | 0.002 | 0 | 0 | 0 | 0.14 |
| 1931 | 0.12 | 0 | 0 | 0.025 | 0.002 | 0 | 0 | 0 | 0.14 |
| 1932 | 0.16 | 0 | 0 | 0.004 | 0.001 | 0 | 0 | 0 | 0.17 |
| 1933 | 0.22 | 0 | 0 | 0.014 | 0.001 | 0 | 0 | 0 | 0.23 |
| 1934 | 0.17 | 0 | 0 | 0.003 | 0.001 | 0 | 0 | 0 | 0.18 |
| 1935 | 0.13 | 0 | 0 | 0.003 | 0.001 | 0 | 0 | 0 | 0.13 |
| 1936 | 0.12 | 0 | 0 | 0.004 | 0.002 | 0 | 0 | 0 | 0.13 |
| 1937 | 0.21 | 0 | 0 | 0.004 | 0.002 | 0 | 0 | 0 | 0.22 |
| 1938 | 0.32 | 0 | 0 | 0.008 | 0.002 | 0 | 0 | 0 | 0.33 |
| 1939 | 0.47 | 0 | 0 | 0.016 | 0.001 | 0 | 0 | 0 | 0.48 |
| 1940 | 0.46 | 0 | 0 | 0.023 | 0.002 | 0 | 0 | 0 | 0.49 |
| 1941 | 0.90 | 0 | 0 | 0.060 | 0.004 | 0 | 0 | 0 | 0.96 |
| 1942 | 0.36 | 0 | 0 | 0.023 | 0.006 | 0 | 0 | 0 | 0.39 |
| 1943 | 0.85 | 0 | 0 | 0.010 | 0.016 | 0 | 0 | 0 | 0.87 |
| 1944 | 1.57 | 0 | 0 | 0 | 0.003 | 0 | 0 | 0 | 1.57 |
| 1945 | 3.11 | 0 | 0 | 0.001 | 0.001 | 0 | 0 | 0 | 3.11 |
| 1946 | 2.54 | 0 | 0 | 0.003 | 0.002 | 0 | 0 | 0 | 2.55 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1947 | 2.42 | 0 | 0 | 0.011 | 0.001 | 0 | 0 | 0 | 2.43 |
| 1948 | 2.18 | 0 | 0 | 0.018 | 0.002 | 0 | 0 | 0 | 2.20 |
| 1949 | 1.43 | 0 | 0 | 0.019 | 0.001 | 0 | 0 | 0 | 1.45 |
| 1950 | 1.98 | 0 | 0 | 0.014 | 0.001 | 0 | 0 | 0 | 1.99 |
| 1951 | 3.08 | 0 | 0 | 0.016 | 0.001 | 0 | 0 | 0 | 3.09 |
| 1952 | 3.38 | 0 | 0 | 0.013 | 0 | 0 | 0 | 0 | 3.39 |
| 1953 | 3.75 | 0 | 0 | 0.012 | 0 | 0 | 0 | 0 | 3.77 |
| 1954 | 2.32 | 0 | 0 | 0.011 | 0.001 | 0 | 0 | 0 | 2.33 |
| 1955 | 2.05 | 0 | 0 | 0.007 | 0 | 0 | 0 | 0 | 2.06 |
| 1956 | 2.58 | 0 | 0 | 0.011 | 0 | 0 | 0 | 0 | 2.59 |
| 1957 | 2.75 | 0 | 0 | 0.009 | 0.001 | 0 | 0 | 0 | 2.76 |
| 1958 | 4.07 | 0 | 0 | 0.005 | 0 | 0 | 0 | 0 | 4.08 |
| 1959 | 4.62 | 0 | 0 | 0.007 | 0 | 0 | 0 | 0 | 4.63 |
| 1960 | 3.51 | 0 | 0 | 0.008 | 0.004 | 0 | 0 | 0 | 3.52 |
| 1961 | 2.33 | 0 | 0 | 0.009 | 0.001 | 0 | 0 | 0 | 2.33 |
| 1962 | 1.95 | 0 | 0 | 0.006 | 0.001 | 0 | 0 | 0 | 1.96 |
| 1963 | 2.13 | 0 | 0 | 0.009 | 0 | 0 | 0 | 0 | 2.14 |
| 1964 | 1.31 | 0.13 | 0 | 0.007 | 0.166 | 0 | 0 | 0 | 1.61 |
| 1965 | 1.52 | 0.25 | 0 | 0.009 | 0 | 0 | 0 | 0 | 1.77 |
| 1966 | 1.45 | 0.64 | 0 | 0.016 | 0 | 0 | 1 | 0 | 3.11 |
| 1967 | 1.40 | 0.28 | 0 | 0.013 | 0.001 | 0 | 0 | 0 | 1.69 |
| 1968 | 1.19 | 0.83 | 0 | 0.011 | 0 | 0 | 0 | 0 | 2.03 |
| 1969 | 2.24 | 0.04 | 0 | 0.002 | 0.001 | 0 | 0 | 0 | 2.28 |
| 1970 | 2.64 | 0.74 | 0 | 0.001 | 0 | 0 | 0 | 0 | 3.38 |
| 1971 | 2.94 | 2.90 | 0 | 0.001 | 0 | 0 | 2 | 0 | 7.84 |
| 1972 | 3.38 | 1.62 | 0 | 0.003 | 0 | 0 | 4 | 0 | 9.00 |
| 1973 | 4.75 | 1.36 | 0 | 0.004 | 0.067 | 0 | 12 | 0 | 18.17 |
| 1974 | 4.75 | 2.26 | 0 | 0.013 | 0.224 | 0 | 4 | 0 | 11.25 |
| 1975 | 4.68 | 2.78 | 0 | 0.005 | 0.052 | 0 | 6 | 0 | 13.51 |
| 1976 | 5.80 | 4.11 | 0 | 0.013 | 0.025 | 0 | 4 | 0 | 13.95 |
| 1977 | 5.44 | 0.46 | 0 | 0.008 | 1.850 | 0 | 0 | 0.08 | 7.83 |
| 1978 | 0.11 | 3.27 | 0 | 0.058 | 0.047 | 0 | 0 | 0.01 | 3.49 |
| 1979 | 10.78 | 10.08 | 0 | 0.061 | 0.077 | 0 | 0 | 0.09 | 21.08 |
| 1980 | 4.65 | 8.72 | 0 | 0.049 | 0.040 | 0 | 0 | 0.13 | 13.59 |
| 1981 | 5.03 | 5.09 | 0 | 0.061 | 0.047 | 0 | 0 | 0.87 | 11.10 |
| 1982 | 30.17 | 18.87 | 0 | 0.084 | 0.040 | 0 | 0 | 0 | 49.17 |
| 1983 | 107.34 | 20.46 | 0 | 0.057 | 0.045 | 0 | 0 | 0 | 127.91 |
| 1984 | 22.94 | 9.54 | 0.47 | 0.685 | 0.017 | 0 | 0 | 0.04 | 33.69 |
| 1985 | 51.32 | 9.72 | 1.37 | 0.393 | 0.028 | 0 | 0 | 0.10 | 62.93 |
| 1986 | 77.02 | 15.66 | 0 | 2.690 | 0.119 | 0 | 0 | 0.13 | 95.62 |
| 1987 | 23.32 | 11.58 | 0.47 | 6.629 | 0.041 | 0 | 0 | 0.07 | 42.11 |
| 1988 | 79.04 | 25.66 | 2.45 | 10.351 | 6.248 | 0 | 0 | 0 | 123.75 |
| 1989 | 78.84 | 35.32 | 0 | 16.794 | 0 | 0 | 0 | 0 | 130.96 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 112.90 | 38.28 | 1.45 | 33.848 | 0 | 0 | 0 | 0.01 | 186.49 |
| 1991 | 13.63 | 28.86 | 1.06 | 10.025 | 0 | 0 | 0 | 0.05 | 53.62 |
| 1992 | 93.45 | 90.39 | 0.09 | 8.322 | 0 | 0 | 0 | 0 | 192.25 |
| 1993 | 97.57 | 32.30 | 0.10 | 0.928 | 0.097 | 0 | 0 | 0 | 131.00 |
| 1994 | 79.16 | 14.91 | 0.18 | 0.238 | 0.201 | 0 | 0 | 0 | 94.68 |
| 1995 | 57.83 | 6.73 | 0.50 | 0.838 | 0 | 0 | 0 | 0 | 65.90 |
| 1996 | 43.79 | 5.24 | 0.30 | 0.815 | 0 | 0 | 0 | 0 | 50.14 |
| 1997 | 36.81 | 6.77 | 0.39 | 2.964 | 0.026 | 0 | 0 | 0.07 | 47.03 |
| 1998 | 22.59 | 11.18 | 0.44 | 2.498 | 0.001 | 0 | 0 | 0 | 36.71 |
| 1999 | 8.95 | 6.43 | 0.15 | 0.029 | 0 | 0 | 0 | 0 | 15.56 |
| 2000 | 18.82 | 10.07 | 0.10 | 1.762 | 0.041 | 0.120 | 0 | 0.05 | 30.96 |
| 2001 | 16.95 | 6.15 | 0.07 | 0.341 | 0.121 | 0.010 | 0 | 0.10 | 23.74 |
| 2002 | 36.65 | 1.94 | 0.12 | 1.207 | 0 | 0.052 | 0 | 0.01 | 39.98 |
| 2003 | 48.12 | 5.32 | 0.30 | 2.237 | 0 | 0.631 | 0 | 0 | 56.62 |
| 2004 | 60.55 | 7.75 | 0.45 | 0.845 | 0.025 | 0.040 | 0 | 0.02 | 69.68 |
| 2005 | 39.28 | 3.35 | 0.04 | 0.374 | 0.003 | 0.202 | 0 | 0.03 | 43.28 |
| 2006 | 27.80 | 5.27 | 0.01 | 0.281 | 0.017 | 0.007 | 0 | 0 | 33.39 |
| 2007 | 29.53 | 7.79 | 0.18 | 0.207 | 0.007 | 0.042 | 0 | 0.01 | 37.76 |
| 2008 | 10.23 | 7.56 | 0.15 | 0.661 | 0.046 | 0.062 | 0 | 0 | 18.71 |
| 2009 | 8.38 | 7.87 | 0.28 | 7.114 | 0.035 | 0.030 | 0 | 0 | 23.70 |
| 2010 | 18.60 | 4.22 | 0.21 | 0.832 | 0.017 | 0.042 | 0 | 0.03 | 23.94 |
| 2011 | 9.45 | 12.37 | 2.27 | 0.373 | 0.041 | 0.050 | 0 | 0.10 | 24.66 |
| 2012 | 25.45 | 9.43 | 1.47 | 0.341 | 0.069 | 0.096 | 0 | 0.02 | 36.87 |

**Table 2. Recent trend in commercial landings (mt) relative to the management guidelines.**

| Year | OFL (mt) | ACL (mt) | Commercial Landings (mt) |
|---|---|---|---|
| 2003 | NA | NA | 56.62 |
| 2004 | NA | NA | 69.68 |
| 2005 | NA | NA | 43.28 |
| 2006 | NA | NA | 33.39 |
| 2007 | NA | NA | 37.76 |
| 2008 | NA | NA | 18.71 |
| 2009 | NA | NA | 23.7 |
| 2010 | NA | NA | 23.94 |
| 2011 | 47 | NA | 24.66 |
| 2012 | 47 | NA | 36.87 |

**Table 3. Recreational and research removals (mt) of aurora rockfish. In the model, recreational removals are added to landings of the non-trawl fleet and research removals are added to the catches of the full-retention fleet.**

| Year | Recreational removals | Research removals |
|---|---|---|
| 1977 | 0 | 0.381386 |
| 1978 | 0 | 0 |
| 1979 | 0 | 0 |
| 1980 | 0 | 0.000907 |
| 1981 | 0 | 0 |
| 1982 | 0 | 0 |
| 1983 | 0 | 0.008754 |
| 1984 | 0.036166936 | 0.086865 |
| 1985 | 0 | 0 |
| 1986 | 1.016227165 | 0.000227 |
| 1987 | 0.162257166 | 0 |
| 1988 | 0.131557383 | 0.02844 |
| 1989 | 0 | 0 |
| 1990 | 0 | 0.152679 |
| 1991 | 0 | 0.171413 |
| 1992 | 0 | 0.012158 |
| 1993 | 0 | 0.060875 |
| 1994 | 0.227651765 | 0 |
| 1995 | 0 | 1.134795 |
| 1996 | 0 | 0.08863 |
| 1997 | 0 | 0.405601 |
| 1998 | 0 | 0.999161 |
| 1999 | 0 | 0.717655 |
| 2000 | 0 | 0.806884 |
| 2001 | 0 | 2.007741 |

| | | |
|---|---|---|
| 2002 | 0 | 0.449 |
| 2003 | 0 | 0.4039 |
| 2004 | 0 | 1.20133 |
| 2005 | 0 | 0.51015 |
| 2006 | 0 | 0.49506 |
| 2007 | 0 | 0.53173 |
| 2008 | 0 | 0.571669 |
| 2009 | 0 | 0.605653 |
| 2010 | 0 | 0.462659 |
| 2011 | 0 | 0.436277 |
| 2012 | 0 | 0.50182 |

**Table 4. Summary of fishery sampling effort (number of trips fish sampled) used to create length and age compositions of the domestic trawl landings.**

| Year | Lengths from trawl landings | | | | Ages from trawl landings | |
|---|---|---|---|---|---|---|
| | Sexed fish | | Unsexed fish | | | |
| | # Trips | # Fish | # Trips | # Fish | # Trips | # Fish |
| 1978 | 1 | 17 | 0 | 0 | 0 | 0 |
| 1979 | 1 | 7 | 0 | 0 | 0 | 0 |
| 1980 | 7 | 34 | 1 | 1 | 0 | 0 |
| 1981 | 2 | 19 | 0 | 0 | 0 | 0 |
| 1982 | 22 | 90 | 0 | 0 | 0 | 0 |
| 1983 | 58 | 542 | 0 | 0 | 0 | 0 |
| 1984 | 37 | 415 | 0 | 0 | 0 | 0 |
| 1985 | 98 | 788 | 0 | 0 | 0 | 0 |
| 1986 | 58 | 573 | 0 | 0 | 0 | 0 |
| 1987 | 29 | 178 | 0 | 0 | 0 | 0 |
| 1988 | 30 | 212 | 1 | 2 | 0 | 0 |
| 1989 | 28 | 219 | 7 | 2 | 0 | 0 |
| 1990 | 18 | 184 | 2 | 43 | 0 | 0 |
| 1991 | 24 | 113 | 22 | 1 | 0 | 0 |
| 1992 | 8 | 94 | 58 | 264 | 0 | 0 |
| 1993 | 17 | 157 | 37 | 84 | 0 | 0 |
| 1994 | 19 | 343 | 98 | 73 | 0 | 0 |
| 1995 | 27 | 441 | 58 | 37 | 0 | 0 |
| 1996 | 20 | 421 | 29 | 28 | 0 | 0 |
| 1997 | 29 | 330 | 30 | 52 | 0 | 0 |
| 1998 | 32 | 246 | 28 | 21 | 0 | 0 |
| 1999 | 16 | 237 | 18 | 76 | 0 | 0 |
| 2000 | 27 | 248 | 24 | 3 | 0 | 0 |
| 2001 | 24 | 378 | 8 | 239 | 0 | 0 |
| 2002 | 49 | 1002 | 17 | 315 | 0 | 0 |
| 2003 | 42 | 773 | 19 | 582 | 21 | 481 |
| 2004 | 30 | 684 | 27 | 145 | 0 | 0 |
| 2005 | 34 | 890 | 20 | 268 | 0 | 0 |
| 2006 | 62 | 1070 | 29 | 583 | 0 | 0 |
| 2007 | 83 | 1524 | 32 | 182 | 0 | 0 |
| 2008 | 101 | 1744 | 16 | 131 | 55 | 382 |
| 2009 | 94 | 1615 | 27 | 189 | 53 | 323 |
| 2010 | 98 | 1376 | 24 | 120 | 0 | 0 |
| 2011 | 129 | 2822 | 49 | 677 | 0 | 0 |
| 2012 | 118 | 2376 | 42 | 501 | 0 | 0 |

**Table 5. Summary of fishery sampling effort (number of trips, hauls and fish sampled) used to create length compositions of the domestic non-trawl landings.**

| Year | Lengths from non-trawl landings | | | |
|---|---|---|---|---|
| | Sexed fish | | Unsexed fish | |
| | # Trips | # Fish | # Trips | # Fish |
| 1985 | 2 | 3 | 5 | 7 |
| 1986 | 1 | 1 | 1 | 1 |
| 1987 | 0 | 0 | 1 | 1 |
| 1988 | 3 | 3 | 1 | 1 |
| 1989 | 5 | 12 | 3 | 32 |
| 1990 | 18 | 98 | 18 | 161 |
| 1991 | 2 | 2 | 0 | 0 |
| 1992 | 3 | 11 | 0 | 0 |
| 1993 | 1 | 1 | 2 | 2 |
| 1994 | 0 | 0 | 3 | 5 |
| 1995 | 0 | 0 | 6 | 11 |
| 1996 | 0 | 0 | 40 | 332 |
| 1997 | 2 | 2 | 17 | 188 |
| 1998 | 0 | 0 | 3 | 43 |
| 1999 | 0 | 0 | 2 | 4 |
| 2000 | 5 | 33 | 8 | 47 |
| 2001 | 4 | 38 | 3 | 5 |
| 2002 | 6 | 49 | 5 | 8 |
| 2003 | 3 | 31 | 6 | 34 |
| 2004 | 8 | 19 | 0 | 0 |
| 2005 | 1 | 1 | 4 | 10 |
| 2006 | 1 | 1 | 2 | 22 |
| 2007 | 6 | 10 | 1 | 3 |
| 2008 | 5 | 8 | 8 | 21 |
| 2009 | 7 | 11 | 14 | 83 |
| 2010 | 12 | 19 | 16 | 44 |
| 2011 | 5 | 9 | 9 | 49 |
| 2012 | 5 | 33 | 7 | 26 |

## 8.2 Surveys and indices

**Table 6. Relative frequency of occurrence by survey and year for aurora rockfish. Gray cells indicate years used in developing indices of abundance. The NWFSC survey represents two surveys: 1) slope (1998-2002) and 2) shelf-slope (2003-2012).**

| | AFSC | | |
|---|---|---|---|
| Year | Triennial | Slope | NWFSC |
| 1980 | 0% | - | - |
| 1981 | - | - | - |
| 1982 | - | - | - |
| 1983 | 1% | - | - |
| 1984 | - | 16% | - |
| 1985 | - | - | - |
| 1986 | 0% | - | - |
| 1987 | - | - | - |
| 1988 | - | 21% | - |
| 1989 | 0% | - | - |
| 1990 | - | 19% | - |
| 1991 | - | 18% | - |
| 1992 | 0% | 9% | - |
| 1993 | - | 18% | - |
| 1994 | - | - | - |
| 1995 | 19% | 18% | - |
| 1996 | - | 15% | - |
| 1997 | - | 20% | - |
| 1998 | 19% | - | 0% |
| 1999 | - | 21% | 21% |
| 2000 | - | 16% | 17% |
| 2001 | 17% | 16% | 24% |
| 2002 | - | - | 23% |
| 2003 | - | - | 12% |
| 2004 | 17% | - | 12% |
| 2005 | - | - | 14% |
| 2006 | - | - | 14% |
| 2007 | - | - | 14% |
| 2008 | - | - | 17% |
| 2009 | - | - | 13% |
| 2010 | - | - | 13% |
| 2011 | - | - | 13% |
| 2012 | - | - | 14% |

**Table 7. Final design and model (GLMM)-based survey abundance indices for aurora rockfish.**

| | Triennial | | | AFSC slope | | | NWFSC slope | | | NWFSC shelf-slope | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Design | Model | Log SD | Design | Model | Log SD | Design | Model | log_SD | Design | Model | Log SD |
| 1995 | 1838 | 1866 | 0.17 | | | | | | | | | |
| 1996 | | | | | | | | | | | | |
| 1997 | | | | 2919 | 3009 | 0.26 | | | | | | |
| 1998 | 2025 | 2041 | 0.16 | | | | | | | | | |
| 1999 | | | | 2878 | 2982 | 0.27 | 1652 | 1685 | 0.22 | | | |
| 2000 | | | | 3310 | 3390 | 0.26 | 1876 | 1858 | 0.23 | | | |
| 2001 | 2337 | 2359 | 0.17 | 3138 | 3214 | 0.26 | 2390 | 2399 | 0.22 | | | |
| 2002 | | | | | | | 2212 | 2205 | 0.19 | | | |
| 2003 | | | | | | | | | | 4911 | 4962 | 0.32 |
| 2004 | 2516 | 2545 | 0.19 | | | | | | | 5715 | 5947 | 0.28 |
| 2005 | | | | | | | | | | 4566 | 4541 | 0.21 |
| 2006 | | | | | | | | | | 4365 | 4448 | 0.21 |
| 2007 | | | | | | | | | | 4860 | 4888 | 0.23 |
| 2008 | | | | | | | | | | 4250 | 4273 | 0.19 |
| 2009 | | | | | | | | | | 4678 | 4679 | 0.20 |
| 2010 | | | | | | | | | | 4008 | 4078 | 0.19 |
| 2011 | | | | | | | | | | 4132 | 4221 | 0.21 |
| 2012 | | | | | | | | | | 4443 | 4543 | 0.33 |

## 8.3 Ageing error

**Table 8. Ageing error models and resultant model selection (AICc) values for 12 models of bias and precision explored for aurora rockfish.**

| | Reader 1 | | Reader 2 | | Model selection | |
|---|---|---|---|---|---|---|
| Model | Bias | Precision | Bias | Precision | AICc | ΔAICc |
| 1 | 0 | 1 | 0 | 1 | 12155 | 242 |
| 2 | 0 | 2 | 0 | 2 | 11963 | 49 |
| 3 | 0 | 3 | 0 | 3 | 12051 | 138 |
| 4 | 0 | 1 | 1 | 1 | 12125 | 211 |
| 5 | 0 | 2 | 1 | 2 | 11946 | 33 |
| 6 | 0 | 3 | 1 | 3 | 11967 | 54 |
| 7 | 0 | 1 | 2 | 1 | 12091 | 178 |
| 8 | 0 | 2 | 2 | 2 | **11913** | 0 |
| 9 | 0 | 3 | 2 | 3 | 11936 | 23 |
| 10 | 0 | 1 | 3 | 1 | 55528 | 43615 |
| 11 | 0 | 2 | 3 | 2 | 41621 | 29708 |
| 12 | 0 | 3 | 3 | 3 | 55532 | 43619 |

## 8.4 Length compositions

**Table 9. Summary of survey sampling effort (number of tows and fish sampled) used to create length and age compositions from the surveys.**

| | Triennial lengths | | | AFSC slope lengths | | | NWFSC shelf-slope lengths | | | NWFSC shelf-slope ages | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | #Tows | #Fish | InputN | #Tows | #Fish | InputN | #Tows | #Fish | InputN | #Tows | #Fish | InputN |
| 1995 | 76 | 2361 | 238 | | | | | | | | | |
| 1996 | | | | | | | | | | | | |
| 1997 | | | | 37 | 1187 | 121 | | | | | | |
| 1998 | 88 | 3076 | 281 | | | | | | | | | |
| 1999 | | | | 42 | 1131 | 120 | | | | | | |
| 2000 | | | | 34 | 1412 | 106 | | | | | | |
| 2001 | 89 | 3296 | 277 | 34 | 958 | 102 | | | | | | |
| 2002 | | | | | | | | | | | | |
| 2003 | | | | | | | 63 | 1112 | 128.6 | 63 | 404 | * |
| 2004 | 66 | 2939 | 214 | | | | 51 | 1078 | 111.6 | | | |
| 2005 | | | | | | | 84 | 1671 | 191.8 | 82 | 428 | * |
| 2006 | | | | | | | 86 | 1715 | 169.0 | | | |
| 2007 | | | | | | | 86 | 1681 | 170.6 | 81 | 395 | * |
| 2008 | | | | | | | 113 | 1691 | 215.2 | | | |
| 2009 | | | | | | | 84 | 1889 | 159.9 | 79 | 403 | * |
| 2010 | | | | | | | 88 | 1631 | 194.2 | 79 | 487 | * |
| 2011 | | | | | | | 90 | 1498 | 178.0 | 86 | 502 | * |
| 2012 | | | | | | | 95 | 1670 | 174.8 | 85 | 407 | * |

**Table 10. Total multiplicative downweighting factors (when <1) used for length and conditional age compositional data based upon the two step iterative reweighting, with the second step using the Francis (2011) method.**

| | Domestic Fishery | Triennial Survey | AK Slope Survey | NWFSC Survey |
|---|---|---|---|---|
| Lengths | 0.15 | 0.33 | 0.37 | 0.67 |
| Conditional Ages | 0.31 | - | - | 1 |

## Model results

### 8.4.1 Base case

**Table 11. Biological parameterizations used in the aurora rockfish base case model. Male length CVs were set equal to the estimated female values.**

| | | | Prior | | | Estimated |
|---|---|---|---|---|---|---|
| Parameter | Bounds | Fixed value | Type | Mean | SD | value |
| Female | | | | | | |
| Natural mortality (M) | 0.001 to 2 | 0.04 | Log_Norm | -3.35 | 0.54 | |
| Length at age=1 | 1 to 11.82 | | Sym_Beta | 6.00 | 10.00 | 8.46 |
| Length at age=40 | 1 to 73.8 | | No prior | | | 30.67 |
| VBGF K | 0.01 to 1 | | No prior | | | 0.09 |
| Length CV at age=1 | 0.03 to 0.2 | | No prior | | | 0.12 |
| Length CV at age=40 | 0.03 to 0.2 | | No prior | | | 0.09 |
| Weight-Length a | -3 to 3 | 0.00001 | No prior | | | |
| Weight-Length b | -3 to 4 | 3.14 | No prior | | | |
| Length at 50% maturity | 1 to 1000 | 25.54 | No prior | | | |
| Maturity slope | -30 to 3 | -0.62 | No prior | | | |
| Eggs/kg | -3 to 3 | 1.00 | No prior | | | |
| Eggs/kg slope | -3 to 3 | 0.00 | No prior | | | |
| Male | | | | | | |
| Natural mortality (M) | 0.001 to 2 | 0.04 | Log_Norm | -3.30 | 0.54 | |
| Length at age=1 | 1 to 11.82 | | Sym_Beta | 6.00 | 10.00 | 8.58 |
| Length at age=40 | 1 to 73.8 | | No prior | | | 30.16 |
| VBGF K | 0.01 to 1 | | No prior | | | 0.09 |
| Length CV at age=1 | -1 to 1 | | No prior | | | 0.12 |
| Length CV at age=40 | -1 to 1 | | No prior | | | 0.09 |
| Weight-Length a | -3 to 3 | 0.00001 | No prior | | | |
| Weight-Length b | -3 to 4 | 3.15 | No prior | | | |
| Stock-recruit | | | | | | |
| $\ln(R_0)$ | 1 to 31 | | No prior | | | 7.17 |
| steepness (h) | 0.25 to 0.99 | 0.78 | Full_Beta | 0.78 | 0.15 | |
| $\sigma_R$ | 0 to 2 | 0.50 | No prior | | | |

**Table 12. Selectivity parameterizations used in the aurora rockfish base case model.**

| Parameter | Bounds | Fixed value | Prior | | | Estimated |
|---|---|---|---|---|---|---|
| | | | Type | Mean | SD | value |
| Trawl fleet | | | | | | |
| logisitic parameter 1 | 15 to 30 | | No prior | | | 22.99 |
| logisitic parameter 2 | 0.001 to 50 | | No prior | | | 7.22 |
| retention parameter 1 | 10 to 35 | | No prior | | | 24.34 |
| retention parameter 2 | 0.1 to 10 | | No prior | | | 1.22 |
| retention parameter 3 | 0.001 to 1 | | No prior | | | 0.96 |
| retention parameter 1999 | 0.001 to 1 | 0.9 | Normal | 0.9 | 99 | |
| retention parameter 2002 | 0.001 to 1 | | Normal | 0.8 | 99 | 0.78 |
| retention parameter 2003 | 0.001 to 1 | | Normal | 0.8 | 99 | 0.81 |
| retention parameter 2004 | 0.001 to 1 | | Normal | 0.9 | 99 | 0.92 |
| retention parameter 2005 | 0.001 to 1 | | Normal | 0.9 | 99 | 0.89 |
| retention parameter 2006 | 0.001 to 1 | | Normal | 0.7 | 99 | 0.78 |
| retention parameter 2007 | 0.001 to 1 | | Normal | 0.7 | 99 | 0.80 |
| retention parameter 2008 | 0.001 to 1 | | Normal | 0.5 | 99 | 0.43 |
| retention parameter 2009 | 0.001 to 1 | | Normal | 0.5 | 99 | 0.44 |
| retention parameter 2010 | 0.001 to 1 | | Normal | 0.7 | 99 | 0.66 |
| retention parameter 2011 | 0.001 to 1 | | Normal | 0.95 | 99 | 1.00 |
| Triennial survey | | | | | | |
| double-normal parameter 1 | 10 to 30 | | No prior | | | 23.54 |
| double-normal parameter 2 | -6 to 4 | | No prior | | | -2.67 |
| double-normal parameter 3 | -1 to 9 | | No prior | | | 3.66 |
| double-normal parameter 4 | -1 to 9 | | No prior | | | 2.80 |
| double-normal parameter 5 | -5 to 9 | -4.99 | No prior | | | |
| double-normal parameter 6 | -5 to 9 | | No prior | | | -0.65 |
| AFSC slope | | | | | | |
| double-normal parameter 1 | 10 to 30 | | No prior | | | 24.07 |
| double-normal parameter 2 | -6 to 4 | | No prior | | | -5.87 |
| double-normal parameter 3 | -1 to 9 | | No prior | | | 4.06 |
| double-normal parameter 4 | -1 to 9 | | No prior | | | 3.03 |
| double-normal parameter 5 | -5 to 9 | -4.99 | No prior | | | |
| double-normal parameter 6 | -5 to 9 | | No prior | | | -0.79 |
| NWFSC slope & shelf-slope | | | | | | |
| double-normal parameter 1 | 10 to 30 | | No prior | | | 27.94 |
| double-normal parameter 2 | -6 to 4 | | No prior | | | -5.32 |
| double-normal parameter 3 | -1 to 9 | | No prior | | | 4.34 |
| double-normal parameter 4 | -1 to 9 | | No prior | | | 1.95 |
| double-normal parameter 5 | -5 to 9 | -4.99 | No prior | | | |
| double-normal parameter 6 | -5 to 9 | | No prior | | | -0.84 |

**Table 13. Time series of total biomass, summary biomass, spawning output, stock status (depletion), recruitment, and exploitation rate estimated in the aurora rockfish base model.**

| Year | Total biomass (mt) | Summary biomass (mt) | Spawning biomass (mt) | Depletion (%) | Recruits (Age-0 in 1000s) | Exploitation rate |
|---|---|---|---|---|---|---|
| 1916 | 6109 | 6109 | 2626 | 100% | 777 | 0.0000 |
| 1917 | 6109 | 6109 | 2626 | 100% | 777 | 0.0000 |
| 1918 | 6109 | 6109 | 2626 | 100% | 778 | 0.0000 |
| 1919 | 6109 | 6109 | 2626 | 100% | 778 | 0.0000 |
| 1920 | 6110 | 6110 | 2626 | 100% | 778 | 0.0000 |
| 1921 | 6110 | 6110 | 2626 | 100% | 779 | 0.0000 |
| 1922 | 6111 | 6111 | 2626 | 100% | 779 | 0.0000 |
| 1923 | 6111 | 6111 | 2626 | 100% | 779 | 0.0000 |
| 1924 | 6112 | 6112 | 2626 | 100% | 780 | 0.0000 |
| 1925 | 6113 | 6113 | 2626 | 100% | 780 | 0.0000 |
| 1926 | 6115 | 6115 | 2626 | 100% | 780 | 0.0000 |
| 1927 | 6116 | 6116 | 2626 | 100% | 781 | 0.0000 |
| 1928 | 6118 | 6118 | 2626 | 100% | 781 | 0.0000 |
| 1929 | 6119 | 6119 | 2626 | 100% | 781 | 0.0000 |
| 1930 | 6121 | 6121 | 2627 | 100% | 781 | 0.0000 |
| 1931 | 6123 | 6123 | 2627 | 100% | 782 | 0.0000 |
| 1932 | 6125 | 6125 | 2628 | 100% | 782 | 0.0000 |
| 1933 | 6127 | 6127 | 2628 | 100% | 782 | 0.0000 |
| 1934 | 6129 | 6129 | 2629 | 100% | 783 | 0.0000 |
| 1935 | 6131 | 6131 | 2630 | 100% | 784 | 0.0000 |
| 1936 | 6134 | 6134 | 2630 | 100% | 785 | 0.0000 |
| 1937 | 6136 | 6136 | 2631 | 100% | 787 | 0.0000 |
| 1938 | 6138 | 6138 | 2632 | 100% | 789 | 0.0001 |
| 1939 | 6141 | 6141 | 2633 | 100% | 793 | 0.0001 |
| 1940 | 6143 | 6143 | 2634 | 100% | 797 | 0.0001 |
| 1941 | 6146 | 6146 | 2634 | 100% | 802 | 0.0002 |
| 1942 | 6148 | 6148 | 2635 | 100% | 807 | 0.0001 |
| 1943 | 6151 | 6151 | 2636 | 100% | 814 | 0.0002 |
| 1944 | 6153 | 6153 | 2637 | 100% | 820 | 0.0003 |
| 1945 | 6156 | 6156 | 2637 | 100% | 827 | 0.0006 |
| 1946 | 6157 | 6157 | 2637 | 100% | 833 | 0.0005 |
| 1947 | 6159 | 6159 | 2637 | 100% | 838 | 0.0004 |
| 1948 | 6162 | 6162 | 2637 | 100% | 842 | 0.0004 |
| 1949 | 6166 | 6166 | 2637 | 100% | 845 | 0.0003 |
| 1950 | 6172 | 6172 | 2638 | 100% | 848 | 0.0004 |

| Year | Total biomass (mt) | Summary biomass (mt) | Spawning biomass (mt) | Depletion (%) | Recruits (Age-0 in 1000s) | Exploitation rate |
|---|---|---|---|---|---|---|
| 1951 | 6177 | 6177 | 2639 | 100% | 852 | 0.0006 |
| 1952 | 6182 | 6182 | 2639 | 100% | 858 | 0.0006 |
| 1953 | 6187 | 6187 | 2639 | 100% | 868 | 0.0007 |
| 1954 | 6193 | 6193 | 2640 | 101% | 882 | 0.0004 |
| 1955 | 6201 | 6201 | 2641 | 101% | 902 | 0.0004 |
| 1956 | 6211 | 6211 | 2643 | 101% | 928 | 0.0005 |
| 1957 | 6221 | 6221 | 2645 | 101% | 957 | 0.0005 |
| 1958 | 6233 | 6233 | 2647 | 101% | 984 | 0.0007 |
| 1959 | 6245 | 6245 | 2648 | 101% | 1001 | 0.0008 |
| 1960 | 6257 | 6257 | 2650 | 101% | 998 | 0.0006 |
| 1961 | 6273 | 6273 | 2653 | 101% | 970 | 0.0004 |
| 1962 | 6292 | 6292 | 2657 | 101% | 1010 | 0.0004 |
| 1963 | 6312 | 6312 | 2661 | 101% | 932 | 0.0004 |
| 1964 | 6334 | 6334 | 2666 | 102% | 859 | 0.0003 |
| 1965 | 6357 | 6357 | 2672 | 102% | 797 | 0.0003 |
| 1966 | 6380 | 6380 | 2678 | 102% | 749 | 0.0005 |
| 1967 | 6401 | 6401 | 2685 | 102% | 715 | 0.0003 |
| 1968 | 6422 | 6422 | 2693 | 103% | 691 | 0.0004 |
| 1969 | 6440 | 6440 | 2701 | 103% | 676 | 0.0004 |
| 1970 | 6456 | 6456 | 2711 | 103% | 667 | 0.0006 |
| 1971 | 6467 | 6467 | 2720 | 104% | 667 | 0.0013 |
| 1972 | 6471 | 6471 | 2728 | 104% | 669 | 0.0015 |
| 1973 | 6470 | 6470 | 2736 | 104% | 672 | 0.0029 |
| 1974 | 6457 | 6457 | 2739 | 104% | 676 | 0.0019 |
| 1975 | 6448 | 6448 | 2745 | 105% | 679 | 0.0023 |
| 1976 | 6433 | 6433 | 2749 | 105% | 677 | 0.0024 |
| 1977 | 6415 | 6415 | 2751 | 105% | 666 | 0.0014 |
| 1978 | 6399 | 6399 | 2754 | 105% | 640 | 0.0006 |
| 1979 | 6386 | 6386 | 2757 | 105% | 599 | 0.0037 |

| Year | Total biomass (mt) | Summary biomass (mt) | Spawning biomass (mt) | Depletion (%) | Recruits (Age-0 in 1000s) | Exploitation rate |
|---|---|---|---|---|---|---|
| 1980 | 6351 | 6351 | 2750 | 105% | 553 | 0.0024 |
| 1981 | 6322 | 6322 | 2745 | 105% | 514 | 0.0020 |
| 1982 | 6293 | 6293 | 2740 | 104% | 491 | 0.0088 |
| 1983 | 6219 | 6219 | 2713 | 103% | 484 | 0.0231 |
| 1984 | 6058 | 6058 | 2646 | 101% | 489 | 0.0063 |
| 1985 | 5998 | 5998 | 2625 | 100% | 493 | 0.0118 |
| 1986 | 5904 | 5904 | 2589 | 99% | 483 | 0.0183 |
| 1987 | 5771 | 5771 | 2535 | 97% | 465 | 0.0082 |
| 1988 | 5698 | 5698 | 2508 | 95% | 466 | 0.0243 |
| 1989 | 5534 | 5534 | 2438 | 93% | 520 | 0.0265 |
| 1990 | 5364 | 5364 | 2365 | 90% | 679 | 0.0389 |
| 1991 | 5138 | 5138 | 2263 | 86% | 990 | 0.0117 |
| 1992 | 5060 | 5060 | 2229 | 85% | 965 | 0.0424 |
| 1993 | 4832 | 4832 | 2123 | 81% | 690 | 0.0303 |
| 1994 | 4678 | 4678 | 2049 | 78% | 581 | 0.0227 |
| 1995 | 4568 | 4568 | 1993 | 76% | 576 | 0.0164 |
| 1996 | 4494 | 4494 | 1951 | 74% | 587 | 0.0125 |
| 1997 | 4440 | 4440 | 1918 | 73% | 588 | 0.0120 |
| 1998 | 4394 | 4394 | 1887 | 72% | 767 | 0.0096 |
| 1999 | 4367 | 4367 | 1862 | 71% | 1403 | 0.0045 |
| 2000 | 4362 | 4362 | 1848 | 70% | 1166 | 0.0088 |
| 2001 | 4345 | 4345 | 1828 | 70% | 999 | 0.0072 |
| 2002 | 4338 | 4338 | 1814 | 69% | 648 | 0.0129 |
| 2003 | 4313 | 4313 | 1791 | 68% | 534 | 0.0177 |
| 2004 | 4274 | 4274 | 1760 | 67% | 638 | 0.0201 |
| 2005 | 4233 | 4233 | 1727 | 66% | 1093 | 0.0129 |
| 2006 | 4225 | 4225 | 1710 | 65% | 1130 | 0.0134 |
| 2007 | 4225 | 4225 | 1695 | 65% | 1798 | 0.0137 |
| 2008 | 4224 | 4224 | 1681 | 64% | 1328 | 0.0124 |
| 2009 | 4237 | 4237 | 1672 | 64% | 1157 | 0.0157 |
| 2010 | 4240 | 4240 | 1659 | 63% | 711 | 0.0098 |
| 2011 | 4275 | 4275 | 1660 | 63% | 719 | 0.0067 |
| 2012 | 4326 | 4326 | 1669 | 64% | 736 | 0.0099 |
| 2013 | 4366 | 4366 | 1673 | 64% | 736 | NA |

### 8.4.2 Profiles

**Table 14. Results from the steepness (highlighted in gray) profile of the base case model for aurora rockfish. The base case steepness value is 0.78.**

| Metrics | Profile values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | | | | | | | | | |
| h | 0.25 | 0.35 | 0.45 | 0.55 | 0.65 | 0.75 | 0.85 | 0.95 | 0.99 |
| M (female) | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| M (male) | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| $lnR_0$ | 6.70 | 6.67 | 6.66 | 6.65 | 6.64 | 6.64 | 6.64 | 6.64 | 6.64 |
| Derived outputs | | | | | | | | | |
| $SB_0$ | 2822 | 2723 | 2677 | 2653 | 2638 | 2628 | 2622 | 2617 | 2615 |
| $SB_{2013}$ | 1719 | 1686 | 1676 | 1673 | 1673 | 1673 | 1674 | 1675 | 1676 |
| Depletion | 0.61 | 0.62 | 0.63 | 0.63 | 0.63 | 0.64 | 0.64 | 0.64 | 0.64 |
| $F_{SPR}$ | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| $Yield_{SPR}$ | 0 | 10 | 41 | 54 | 62 | 66 | 69 | 72 | 72 |
| $SPR_{2012}$ | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 |
| Survey catchability (q) | | | | | | | | | |
| AKSHLF_q | 0.94 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| AKSLP_q | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.41 | 1.41 | 1.41 | 1.41 |
| NWSLP_q | 0.72 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.72 | 0.72 |
| NWFSC_q | 1.66 | 1.66 | 1.65 | 1.65 | 1.64 | 1.64 | 1.63 | 1.63 | 1.63 |
| Likelihood components | | | | | | | | | |
| Total likelihood | 2294.87 | 2281.14 | 2279.04 | 2277.78 | 2276.92 | 2276.29 | 2275.81 | 2275.49 | 2275.89 |
| survey_like_AKSHLF | -5.90 | -5.94 | -5.96 | -5.97 | -5.98 | -5.99 | -5.99 | -6.00 | -6.00 |
| survey_like_AKSLP | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 |
| survey_like_NWSLP | -5.32 | -5.33 | -5.33 | -5.33 | -5.33 | -5.34 | -5.34 | -5.34 | -5.34 |
| survey_like_NWFSC | -13.79 | -13.74 | -13.71 | -13.69 | -13.67 | -13.66 | -13.65 | -13.64 | -13.64 |
| Lt_like_TWL | 133.38 | 132.63 | 132.27 | 132.05 | 131.90 | 131.80 | 131.72 | 131.66 | 131.64 |
| Lt_like_AKSHLF | 12.12 | 12.15 | 12.17 | 12.18 | 12.19 | 12.19 | 12.20 | 12.20 | 12.20 |
| Lt_like_AKSLP | 6.81 | 6.82 | 6.82 | 6.82 | 6.83 | 6.83 | 6.83 | 6.83 | 6.83 |
| Lt_like_NWFSC | 32.32 | 31.90 | 31.69 | 31.56 | 31.48 | 31.42 | 31.38 | 31.35 | 31.33 |
| Age_like_TWL | 231.45 | 231.24 | 231.14 | 231.07 | 231.03 | 230.99 | 230.97 | 230.95 | 230.94 |
| Age_like_NWFSC | 1948.58 | 1948.34 | 1948.19 | 1948.08 | 1948.01 | 1947.95 | 1947.91 | 1947.87 | 1947.86 |
| Ct_like | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Recruitment penalty | -3.60 | -3.83 | -3.98 | -4.09 | -4.16 | -4.21 | -4.26 | -4.29 | -4.30 |
| Parameter penalty | 17.28 | 5.32 | 4.16 | 3.49 | 3.02 | 2.67 | 2.41 | 2.27 | 2.72 |
| Parameter bounds | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

**Table 15. Results from the steepness (highlighted in gray) profile of the base case model for aurora rockfish when female and male natural mortality are estimated. The base case steepness value is 0.78.**

| Metrics | Profile values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | | | | | | | | | |
| h | 0.25 | 0.35 | 0.45 | 0.55 | 0.65 | 0.75 | 0.85 | 0.95 | 0.99 |
| M (female) | 0.03835 | 0.03434 | 0.03333 | 0.03285 | 0.03256 | 0.03237 | 0.03223 | 0.03212 | 0.03208 |
| M (male) | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| $lnR_0$ | 11.32 | 6.50 | 6.31 | 6.24 | 6.21 | 6.19 | 6.17 | 6.16 | 6.16 |
| Derived outputs | | | | | | | | | |
| $SB_0$ | 245258 | 2369 | 2057 | 1963 | 1918 | 1892 | 1876 | 1865 | 1861 |
| $SB_{2013}$ | 225346 | 1354 | 1087 | 1014 | 983 | 967 | 958 | 953 | 951 |
| Depletion | 0.92 | 0.57 | 0.53 | 0.52 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| $F_{SPR}$ | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| $Yield_{SPR}$ | 0 | 9 | 30 | 38 | 42 | 44 | 46 | 47 | 48 |
| $SPR_{2012}$ | 1.00 | 0.64 | 0.57 | 0.55 | 0.54 | 0.54 | 0.54 | 0.53 | 0.53 |
| Survey catchability (q) | | | | | | | | | |
| AKSHLF_q | 0.01 | 1.14 | 1.37 | 1.45 | 1.49 | 1.51 | 1.52 | 1.52 | 1.53 |
| AKSLP_q | 0.01 | 1.72 | 2.06 | 2.18 | 2.23 | 2.26 | 2.28 | 2.29 | 2.29 |
| NWSLP_q | 0.01 | 0.88 | 1.05 | 1.11 | 1.14 | 1.16 | 1.17 | 1.17 | 1.18 |
| NWFSC_q | 0.01 | 2.03 | 2.48 | 2.63 | 2.70 | 2.73 | 2.75 | 2.76 | 2.77 |
| Likelihood components | | | | | | | | | |
| Total likelihood | 2294.49 | 2281.11 | 2278.87 | 2277.49 | 2276.54 | 2275.84 | 2275.31 | 2274.96 | 2275.34 |
| survey_like_AKSHLF | -6.30 | -5.84 | -5.76 | -5.75 | -5.75 | -5.76 | -5.76 | -5.77 | -5.77 |
| survey_like_AKSLP | -5.26 | -5.25 | -5.24 | -5.24 | -5.24 | -5.24 | -5.25 | -5.25 | -5.25 |
| survey_like_NWSLP | -5.38 | -5.32 | -5.30 | -5.30 | -5.30 | -5.30 | -5.30 | -5.31 | -5.31 |
| survey_like_NWFSC | -13.42 | -13.81 | -13.86 | -13.86 | -13.86 | -13.85 | -13.84 | -13.84 | -13.83 |
| Lt_like_TWL | 133.63 | 132.56 | 132.09 | 131.81 | 131.63 | 131.49 | 131.39 | 131.31 | 131.28 |
| Lt_like_AKSHLF | 12.18 | 12.15 | 12.15 | 12.16 | 12.18 | 12.18 | 12.19 | 12.20 | 12.20 |
| Lt_like_AKSLP | 6.79 | 6.79 | 6.79 | 6.79 | 6.79 | 6.79 | 6.79 | 6.79 | 6.79 |
| Lt_like_NWFSC | 32.59 | 31.90 | 31.58 | 31.40 | 31.29 | 31.21 | 31.16 | 31.11 | 31.10 |
| Age_like_TWL | 231.32 | 231.27 | 231.22 | 231.19 | 231.17 | 231.16 | 231.15 | 231.14 | 231.13 |
| Age_like_NWFSC | 1948.19 | 1948.31 | 1948.14 | 1948.00 | 1947.90 | 1947.83 | 1947.77 | 1947.72 | 1947.70 |
| Ct_like | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Recruitment penalty | -3.96 | -3.81 | -3.98 | -4.11 | -4.21 | -4.28 | -4.34 | -4.39 | -4.40 |
| Parameter penalty | 17.27 | 5.34 | 4.19 | 3.53 | 3.07 | 2.73 | 2.47 | 2.33 | 2.79 |
| Parameter bounds | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

**Table 16. Results from the female natural mortality (highlighted in gray) profile for aurora rockfish when male natural mortality is estimated. The base case female natural mortality value is 0.035.**

| Metrics | Profile values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | | | | | | | | | | |
| M (female) | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 |
| h | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| M (male) | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 |
| $lnR_0$ | 3.94 | 4.97 | 5.88 | 8.46 | 13.35 | 13.33 | 13.55 | 13.79 | 14.02 | 14.83 |
| Derived outputs | | | | | | | | | | |
| $SB_0$ | 1011 | 1155 | 1579 | 12884 | 1086920 | 740966 | 650542 | 592409 | 547091 | 853697 |
| $SB_{2013}$ | 42 | 163 | 577 | 11270 | 1011270 | 763460 | 690255 | 630884 | 574692 | 826542 |
| Depletion | 0.04 | 0.14 | 0.37 | 0.87 | 0.93 | 1.03 | 1.06 | 1.06 | 1.05 | 0.97 |
| $F_{SPR}$ | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.18 |
| $Yield_{SPR}$ | 8 | 17 | 35 | 379 | 42777 | 35217 | 37421 | 40786 | 44594 | 86115 |
| $SPR_{2012}$ | 0.01 | 0.08 | 0.38 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Survey catchability (q) | | | | | | | | | | |
| AKSHLF_q | 8.49 | 4.80 | 2.02 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AKSLP_q | 12.60 | 7.16 | 3.03 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NWSLP_q | 5.30 | 3.50 | 1.55 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NWFSC_q | 26.25 | 11.87 | 4.01 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Likelihood components | | | | | | | | | | |
| Total likelihood | 2387.18 | 2294.85 | 2276.86 | 2278.48 | 2293.28 | 2313.46 | 2329.01 | 2347.96 | 2371.20 | 2393.35 |
| survey_like_AKSHLF | -1.19 | -3.67 | -5.51 | -6.24 | -6.14 | -5.60 | -5.09 | -4.53 | -3.89 | -3.77 |
| survey_like_AKSLP | -5.09 | -5.18 | -5.24 | -5.26 | -5.25 | -5.22 | -5.18 | -5.14 | -5.09 | -5.08 |
| survey_like_NWSLP | -4.81 | -5.05 | -5.27 | -5.37 | -5.33 | -5.20 | -5.08 | -4.97 | -4.84 | -4.81 |
| survey_like_NWFSC | -6.87 | -13.33 | -14.04 | -13.40 | -13.30 | -13.63 | -13.80 | -13.93 | -14.03 | -13.94 |
| Lt_like_TWL | 136.80 | 130.32 | 132.03 | 132.18 | 130.54 | 130.06 | 129.67 | 129.61 | 130.13 | 132.56 |
| Lt_like_AKSHLF | 12.61 | 12.08 | 12.17 | 12.27 | 12.77 | 12.69 | 12.87 | 13.12 | 13.41 | 14.87 |
| Lt_like_AKSLP | 7.96 | 7.22 | 6.83 | 6.73 | 6.61 | 6.69 | 6.72 | 6.74 | 7.49 | 6.73 |
| Lt_like_NWFSC | 30.23 | 29.45 | 30.47 | 32.14 | 32.34 | 31.72 | 31.77 | 32.25 | 33.04 | 39.05 |
| Age_like_TWL | 242.66 | 234.68 | 231.42 | 230.81 | 230.18 | 229.90 | 229.94 | 230.59 | 232.20 | 230.57 |
| Age_like_NWFSC | 1969.72 | 1953.64 | 1946.45 | 1948.16 | 1952.97 | 1953.82 | 1956.06 | 1961.95 | 1970.11 | 1976.58 |
| Ct_like | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| Recruitment penalty | 44.90 | 3.61 | -4.44 | -3.07 | 7.25 | 27.07 | 39.12 | 49.24 | 58.74 | 64.90 |
| Parameter penalty | 7.97 | 4.05 | 2.83 | 2.64 | 3.58 | 4.08 | 4.89 | 5.85 | 6.71 | 8.42 |
| Parameter bounds | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |

**Table 17. Results from the female natural mortality (highlighted in gray) profile for aurora rockfish when male natural mortality and steepness are estimated. The base case female natural mortality value is 0.035.**

| Metrics | Profile values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | | | | | | | | | | |
| M (female) | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 |
| h | 0.99 | 0.98 | 0.97 | 0.96 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| M (male) | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 |
| $\ln R_0$ | 3.97 | 4.98 | 5.90 | 8.30 | 13.33 | 13.35 | 13.59 | 13.84 | 13.96 | 14.82 |
| Derived outputs | | | | | | | | | | |
| $SB_0$ | 1034 | 1161 | 1596 | 10929 | 1075620 | 757516 | 675775 | 620052 | 518013 | 847159 |
| $SB_{2013}$ | 50 | 182 | 606 | 9458 | 996775 | 761924 | 693560 | 635369 | 541297 | 792687 |
| Depletion | 0.05 | 0.16 | 0.38 | 0.87 | 0.93 | 1.01 | 1.03 | 1.02 | 1.04 | 0.94 |
| $F_{SPR}$ | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.17 |
| $Yield_{SPR}$ | 9 | 19 | 38 | 345 | 45422 | 38748 | 41869 | 45992 | 44955 | 91665 |
| $SPR_{2012}$ | 0.01 | 0.09 | 0.39 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Survey catchability (q) | | | | | | | | | | |
| AKSHLF_q | 8.08 | 4.58 | 1.96 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AKSLP_q | 12.01 | 6.85 | 2.94 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NWSLP_q | 5.12 | 3.37 | 1.51 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NWFSC_q | 24.03 | 10.97 | 3.85 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Likelihood components | | | | | | | | | | |
| Total likelihood | 2382.12 | 2293.16 | 2276.17 | 2277.95 | 2292.42 | 2312.16 | 2327.68 | 2346.62 | 2368.44 | 2390.61 |
| survey_like_AKSHLF | -1.55 | -3.92 | -5.57 | -6.23 | -6.14 | -5.61 | -5.10 | -4.54 | -3.81 | -3.73 |
| survey_like_AKSLP | -5.11 | -5.19 | -5.24 | -5.26 | -5.25 | -5.22 | -5.18 | -5.14 | -5.09 | -5.08 |
| survey_like_NWSLP | -4.84 | -5.08 | -5.28 | -5.37 | -5.33 | -5.20 | -5.09 | -4.97 | -4.83 | -4.80 |
| survey_like_NWFSC | -8.54 | -13.66 | -14.06 | -13.41 | -13.30 | -13.63 | -13.79 | -13.92 | -14.04 | -13.95 |
| Lt_like_TWL | 135.70 | 130.07 | 131.93 | 132.07 | 130.52 | 130.02 | 129.63 | 129.58 | 129.71 | 132.22 |
| Lt_like_AKSHLF | 12.73 | 12.13 | 12.19 | 12.28 | 12.76 | 12.70 | 12.89 | 13.14 | 13.33 | 14.76 |
| Lt_like_AKSLP | 7.98 | 7.20 | 6.82 | 6.73 | 6.61 | 6.70 | 6.72 | 6.74 | 6.76 | 6.74 |
| Lt_like_NWFSC | 30.31 | 29.44 | 30.46 | 32.08 | 32.30 | 31.70 | 31.78 | 32.29 | 32.86 | 38.69 |
| Age_like_TWL | 243.72 | 234.57 | 231.38 | 230.77 | 230.15 | 229.86 | 229.90 | 230.55 | 231.46 | 230.50 |
| Age_like_NWFSC | 1972.84 | 1953.41 | 1946.41 | 1948.13 | 1952.74 | 1953.67 | 1955.97 | 1961.87 | 1967.76 | 1975.25 |
| Ct_like | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| Recruitment penalty | 39.43 | 3.44 | -4.55 | -3.07 | 7.06 | 26.31 | 38.23 | 48.27 | 60.74 | 64.63 |
| Parameter penalty | 7.66 | 3.71 | 2.50 | 2.32 | 3.25 | 3.78 | 4.59 | 5.56 | 6.36 | 8.09 |
| Parameter bounds | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |

## 8.4.3 Sensitivities

**Table 18. Results from sensitivity runs on the base case model for aurora rockfish.**

| | | Sensitivity run | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Natural mortality | | | Marginal ages | | | Ageing error | | | Maturity | |
| Metrics | BC | Estiamted | Mean | 1.25 Fec | All | Fishery ages | All with est. *M* | x0.5 | x2 | CS sel blks | Age-based | Survey-data |
| Parameters | | | | | | | | | | | | |
| h | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| M (female) | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| M (male) | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| $\ln R_0$ | 6.64 | 6.18 | 10.17 | 6.64 | 7.30 | 6.89 | 6.49 | 6.63 | 6.60 | 6.72 | 6.64 | 6.64 |
| Derived outputs | | | | | | | | | | | | |
| $SB_0$ | 2626 | 1887 | 69590 | 2195 | 5082 | 3359 | 2530 | 2619 | 2506 | 2862 | 2883 | 2411 |
| $SB_{2013}$ | 1673 | 964 | 64082 | 1388 | 4026 | 2370 | 1625 | 1652 | 1550 | 1909 | 1879 | 1521 |
| Depletion | 0.64 | 0.51 | 0.92 | 0.63 | 0.79 | 0.71 | 0.64 | 0.63 | 0.62 | 0.67 | 0.65 | 0.63 |
| $F_{SPR}$ | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 |
| $Yield_{SPR}$ | 67 | 45 | 2046 | 66 | 139 | 86 | 65 | 67 | 63 | 72 | 69 | 66 |
| $SPR_{2012}$ | 0.69 | 0.54 | 0.99 | 0.69 | 0.85 | 0.76 | 0.69 | 0.69 | 0.67 | 0.72 | 0.70 | 0.69 |
| Survey catchability (q) | | | | | | | | | | | | |
| AKSHLF_q | 0.94 | 1.51 | 0.03 | 0.94 | 0.42 | 0.70 | 0.95 | 0.97 | 0.97 | 0.85 | 0.94 | 0.94 |
| AKSLP_q | 1.41 | 2.27 | 0.04 | 1.41 | 0.62 | 1.06 | 1.42 | 1.48 | 1.43 | 1.27 | 1.42 | 1.41 |
| NWSLP_q | 0.73 | 1.16 | 0.02 | 0.73 | 0.29 | 0.53 | 0.67 | 0.75 | 0.76 | 0.65 | 0.73 | 0.73 |
| NWFSC_q | 1.64 | 2.74 | 0.04 | 1.63 | 0.66 | 1.19 | 1.54 | 1.69 | 1.72 | 1.45 | 1.64 | 1.63 |
| Likelihood components | | | | | | | | | | | | |
| Total likelihood | 2276.13 | 2275.67 | 2279.06 | 2276.13 | 482.37 | 2088.60 | 481.64 | 2269.38 | 2357.46 | 2275.43 | 2276.11 | 2276.13 |
| survey_like_AKSHLF | -5.99 | -5.75677 | -6.26195 | -5.99 | -6.04 | -6.02 | -5.86 | -5.93 | -6.01 | -6.04 | -5.99 | -5.99 |
| survey_like_AKSLP | -5.25 | -5.24 | -5.26 | -5.25 | -5.25 | -5.25 | -5.24 | -5.25 | -5.25 | -5.25 | -5.25 | -5.25 |
| survey_like_NWSLP | -5.34 | -5.30 | -5.37 | -5.34 | -5.34 | -5.34 | -5.32 | -5.33 | -5.34 | -5.35 | -5.34 | -5.34 |
| survey_like_NWFSC | -13.65 | -13.85 | -13.37 | -13.65 | -13.62 | -13.62 | -13.77 | -13.66 | -13.72 | -13.62 | -13.65 | -13.65 |
| Lt_like_TWL | 131.77 | 131.46 | 132.32 | 131.78 | 129.15 | 132.42 | 128.96 | 132.01 | 131.56 | 130.40 | 131.76 | 131.77 |
| Lt_like_AKSHLF | 12.19 | 12.19 | 12.21 | 12.19 | 10.63 | 12.21 | 10.57 | 13.12 | 11.67 | 12.18 | 12.20 | 12.19 |
| Lt_like_AKSLP | 6.83 | 6.79 | 6.89 | 6.83 | 6.53 | 6.79 | 6.40 | 6.85 | 6.33 | 6.83 | 6.83 | 6.83 |
| Lt_like_NWFSC | 31.41 | 31.20 | 31.79 | 31.41 | 29.33 | 31.24 | 29.50 | 31.35 | 30.95 | 31.70 | 31.40 | 31.41 |
| Age_like_TWL | 230.99 | 231.15 | 230.87 | 230.99 | 45.12 | 44.38 | 45.33 | 230.52 | 235.32 | 231.07 | 230.98 | 230.99 |
| Age_like_NWFSC | 1947.94 | 1947.81 | 1948.47 | 1947.94 | 346.10 | 1946.90 | 345.53 | 1940.26 | 2029.86 | 1948.14 | 1947.93 | 1947.93 |
| Ct_like | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Recruitment penalty | -4.23 | -4.30 | -2.77 | -4.23 | -2.96 | -4.26 | -3.21 | -3.95 | -6.52 | -4.63 | -4.23 | -4.23 |
| Parameter penalty | 2.59 | 2.65 | 2.64 | 2.59 | 1.58 | 2.27 | 1.64 | 2.48 | 1.71 | 2.55 | 2.59 | 2.59 |
| Parameter bounds | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

### 8.4.4 Reference points

**Table 19. Summary of reference points for the base case model.**

| Quantity | Estimate | ~95% Confidence Interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 2626 | (1165-4087) |
| Unfished age 0+ biomass (mt) | 6109 | (2737-9481) |
| Unfished recruitment (R0) | 766 | (349-1182) |
| Depletion (2013) | 0.64 | (0.48-0.79) |
| ***Reference points based on $SB_{40\%}$*** | | |
| Proxy spawning biomass ($B40_{\%}$) | 1050 | (466-1635) |
| SPR resulting in $B40_{\%}$ ($SPR_{B40\%}$) | 0.44 | (0.44-0.44) |
| Exploitation rate resulting in $B40_{\%}$ | 0.0304 | (0.0271-0.0337) |
| Yield with $SPR_{B40\%}$ at $B40_{\%}$ (mt) | 72 | (33-112) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 1213 | (538-1888) |
| $SPR_{proxy}$ | 50% | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.0248 | (0.0222-0.0274) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 67 | (31-104) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 648 | (283-1012) |
| $SPR_{MSY}$ | 0.30 | (0.2963-0.3039) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.0510 | (0.0442-0.0578) |
| *MSY* (mt) | 79 | (36-122) |

### 8.4.5 Harvest projections

**Table 20. Projection of potential OFL, landings, and catch, summary biomass (age-5 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2013 and 2014 (average of the past 5 years (2008-2012), and catches at the ABC from 2013 onward. The OFL in years later than 2014 is the calculated total catch determined by $F_{SPR50\%}$. ABC values are calculated using $\sigma_{SB}$=0.39 and P*=0.45.**

| Year | Predicted OFL/contribution (mt) | ABC Catch (mt) | Landings (mt) | Age 0+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 41 | 46.38 | 40.45 | 4,366 | 1,673 | 63.7% |
| 2014 | 41 | 46.38 | 40.29 | 4,403 | 1,678 | 63.9% |
| 2015 | 91.67 | 87.33 | 75.55 | 4,439 | 1,685 | 64.2% |
| 2016 | 91.77 | 87.42 | 75.37 | 4,434 | 1,678 | 63.9% |
| 2017 | 91.90 | 87.55 | 75.34 | 4,427 | 1,674 | 63.7% |
| 2018 | 92.02 | 87.67 | 75.43 | 4,418 | 1,672 | 63.7% |
| 2019 | 92.08 | 87.73 | 75.61 | 4,406 | 1,673 | 63.7% |
| 2020 | 92.06 | 87.71 | 75.80 | 4,391 | 1,675 | 63.8% |
| 2021 | 91.95 | 87.60 | 75.96 | 4,374 | 1,676 | 63.8% |
| 2022 | 91.74 | 87.40 | 76.05 | 4,354 | 1,678 | 63.9% |
| 2023 | 91.44 | 87.11 | 76.04 | 4,333 | 1,678 | 63.9% |
| 2024 | 91.06 | 86.75 | 75.94 | 4,309 | 1,676 | 63.8% |

### 8.4.6 Decision Table

**Table 21 Summary table of 12-year projections showing results for 2015-2024 for alternate states of nature based on the axis of uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels from those states of nature. The average 5-year catch (2008-2012) of 46.4 mt is assumed for 2013 and 2014. ABCs are based upon the assumption that P*=0.45 and a σ of 0.39 which reflects the model uncertainty about the spawning biomass estimate in 2013.**

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low $M_{female}$ = 0.033 | | Base case $M_{female}$ = 0.035 | | High $M_{female}$ = 0.037 | |
| **Relative probability of ln(SB_2013)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| ABC catches from "Low" state of nature | 2015 | 54.3 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 54.6 | 1087 | 0.540 | 1692 | 0.644 | 2691 | 0.739 |
| | 2017 | 54.9 | 1089 | 0.541 | 1701 | 0.648 | 2713 | 0.745 |
| | 2018 | 55.2 | 1092 | 0.543 | 1713 | 0.652 | 2739 | 0.752 |
| | 2019 | 55.5 | 1097 | 0.546 | 1728 | 0.658 | 2768 | 0.760 |
| | 2020 | 55.7 | 1103 | 0.548 | 1743 | 0.664 | 2798 | 0.768 |
| | 2021 | 55.9 | 1109 | 0.551 | 1758 | 0.670 | 2829 | 0.777 |
| | 2022 | 56.0 | 1115 | 0.554 | 1773 | 0.675 | 2857 | 0.784 |
| | 2023 | 56.1 | 1120 | 0.557 | 1786 | 0.680 | 2884 | 0.792 |
| | 2024 | 56.1 | 1124 | 0.559 | 1798 | 0.685 | 2907 | 0.798 |
| Base Case ABC catches | 2015 | 87.3 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 87.4 | 1073 | 0.534 | 1678 | 0.639 | 2677 | 0.735 |
| | 2017 | 87.6 | 1061 | 0.528 | 1674 | 0.637 | 2686 | 0.737 |
| | 2018 | 87.7 | 1051 | 0.523 | 1672 | 0.637 | 2698 | 0.741 |
| | 2019 | 87.7 | 1043 | 0.519 | 1673 | 0.637 | 2713 | 0.745 |
| | 2020 | 87.7 | 1035 | 0.515 | 1675 | 0.638 | 2730 | 0.750 |
| | 2021 | 87.6 | 1028 | 0.511 | 1676 | 0.638 | 2747 | 0.754 |
| | 2022 | 87.4 | 1020 | 0.507 | 1678 | 0.639 | 2763 | 0.759 |
| | 2023 | 87.1 | 1012 | 0.503 | 1678 | 0.639 | 2777 | 0.762 |
| | 2024 | 86.8 | 1002 | 0.498 | 1676 | 0.638 | 2787 | 0.765 |
| ABC catches from "High" state of nature | 2015 | 145.7 | 1087 | 0.541 | 1685 | 0.642 | 2674 | 0.734 |
| | 2016 | 145.3 | 1049 | 0.522 | 1654 | 0.630 | 2653 | 0.728 |
| | 2017 | 145.0 | 1013 | 0.504 | 1625 | 0.619 | 2637 | 0.724 |
| | 2018 | 144.7 | 980 | 0.487 | 1600 | 0.609 | 2626 | 0.721 |
| | 2019 | 144.2 | 948 | 0.471 | 1577 | 0.600 | 2618 | 0.719 |
| | 2020 | 143.7 | 917 | 0.456 | 1555 | 0.592 | 2611 | 0.717 |
| | 2021 | 143.0 | 886 | 0.440 | 1533 | 0.584 | 2605 | 0.715 |
| | 2022 | 142.2 | 855 | 0.425 | 1511 | 0.575 | 2598 | 0.713 |
| | 2023 | 141.2 | 824 | 0.409 | 1488 | 0.567 | 2589 | 0.711 |
| | 2024 | 140.2 | 792 | 0.394 | 1464 | 0.558 | 2578 | 0.708 |

# 9 Figures

## 9.1 Ecology

**Figure 1. Occurrence and abundance of aurora rockfish found in the NWFSC annual survey (2003-2012) north of 40º10' N lat.**

The image part with relationship ID rId27 was not found in the file.

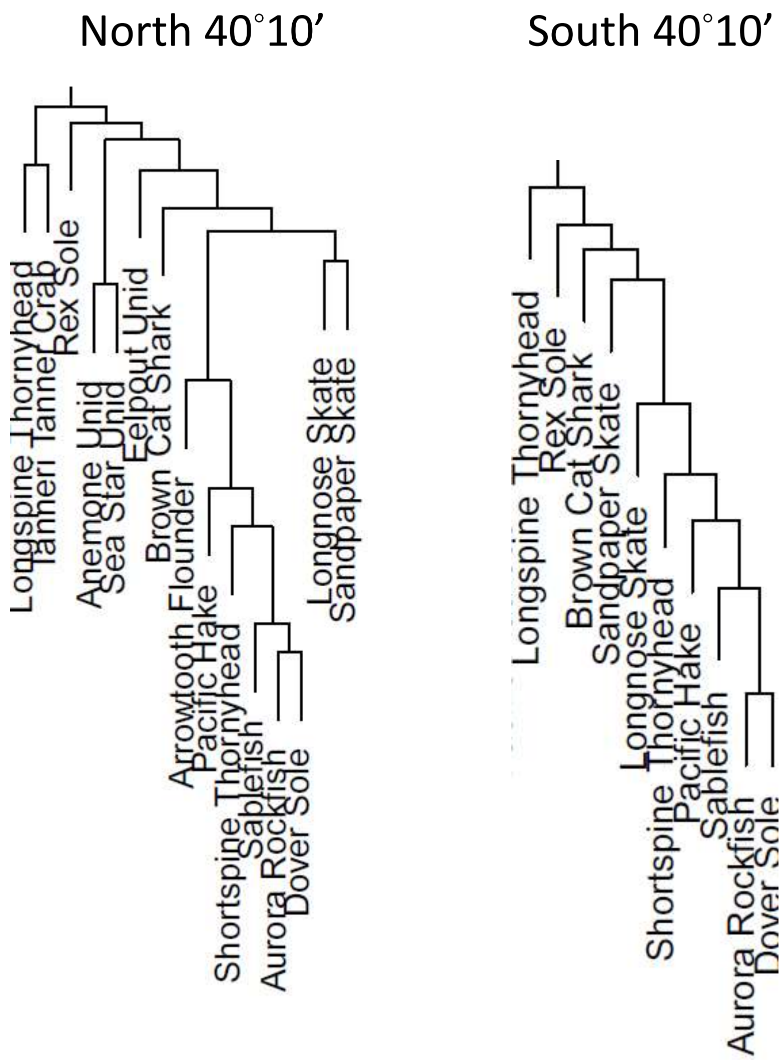



**Figure 2. Significant co-occurrence with other shelf-slope groundfishes of aurora rockfish in the NWFSC trawl survey north and south of Cape Mendocino (North-south management unit break).**

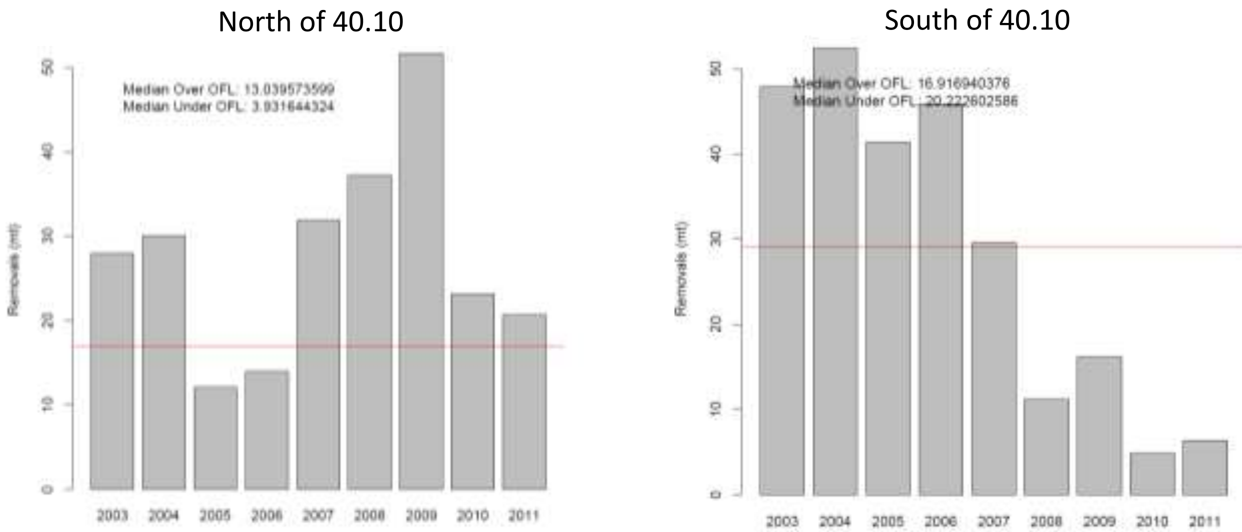



**Figure 3. Total removals of aurora rockfish north (left panel) and south (right panel) of 40.10 N. The red horizontal bar indicates the area-specific aurora rockfish 2012 OFL component to the overall minor slope rockfish complex. Median values above and below the OFL across all years are also reported.**

## 9.2 Data

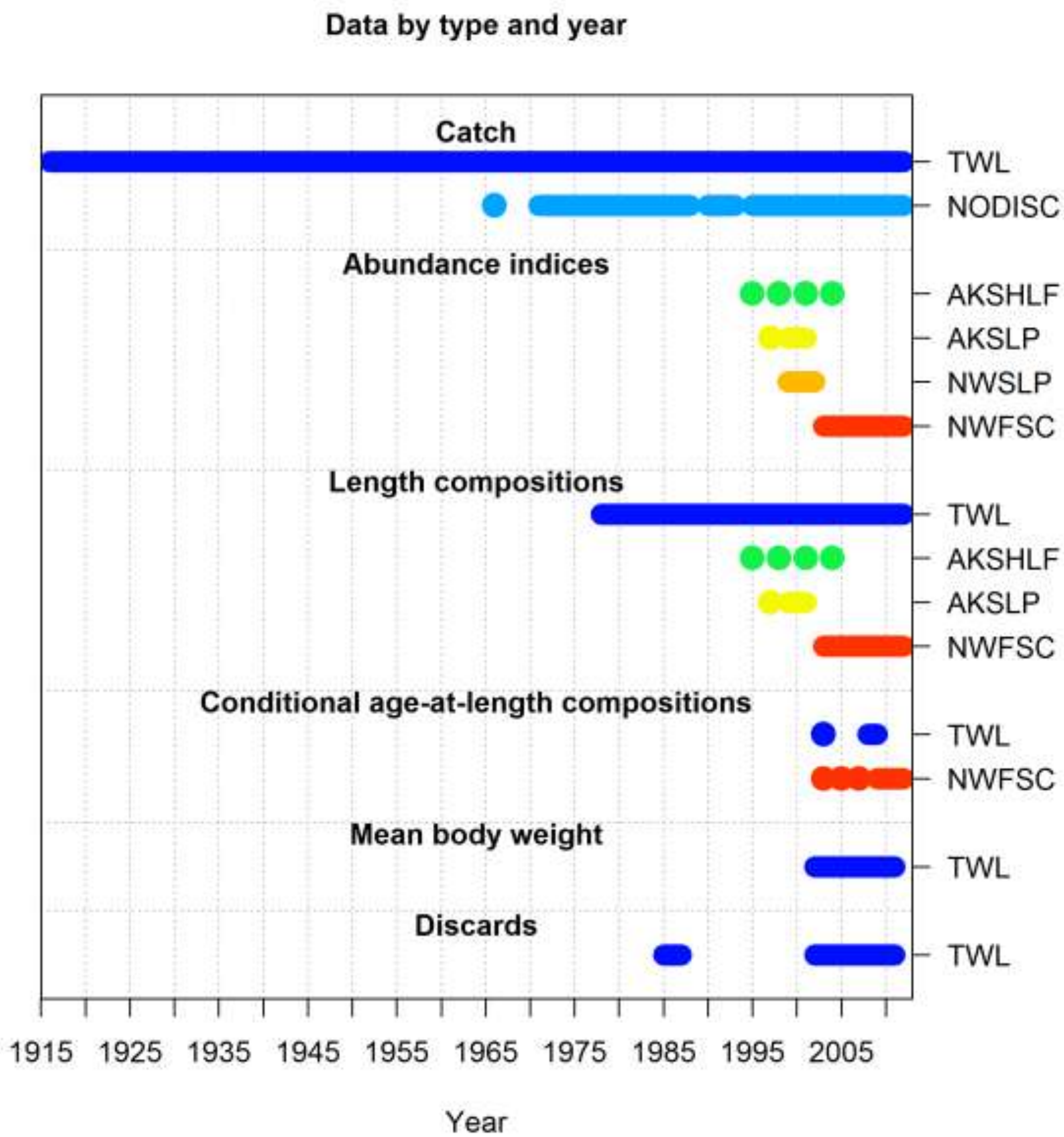



**Figure 4. Data types and coverage in the base case aurora rockfish model.**

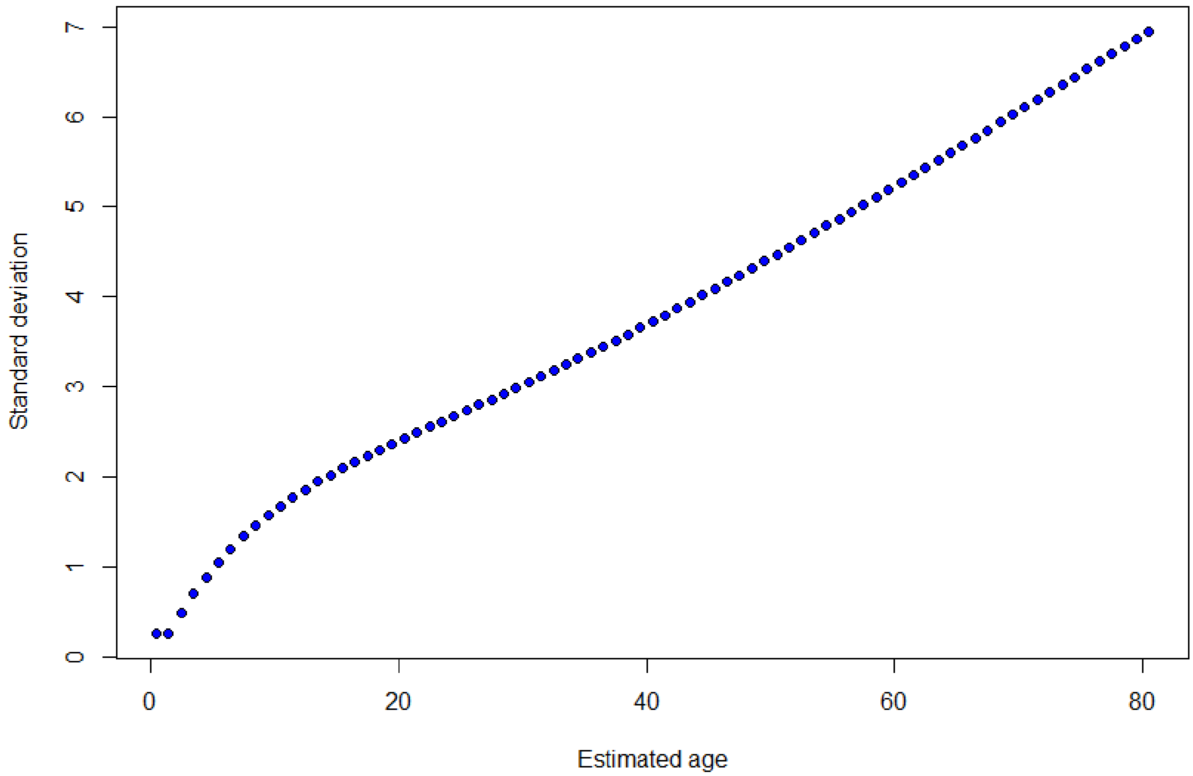



**Figure 5. Ageing error relationship used in the aurora rockfish base case assuming curvilinear bias for reader 2 and curvilinear standard deviations for both readers.**

### 9.2.1 Catches

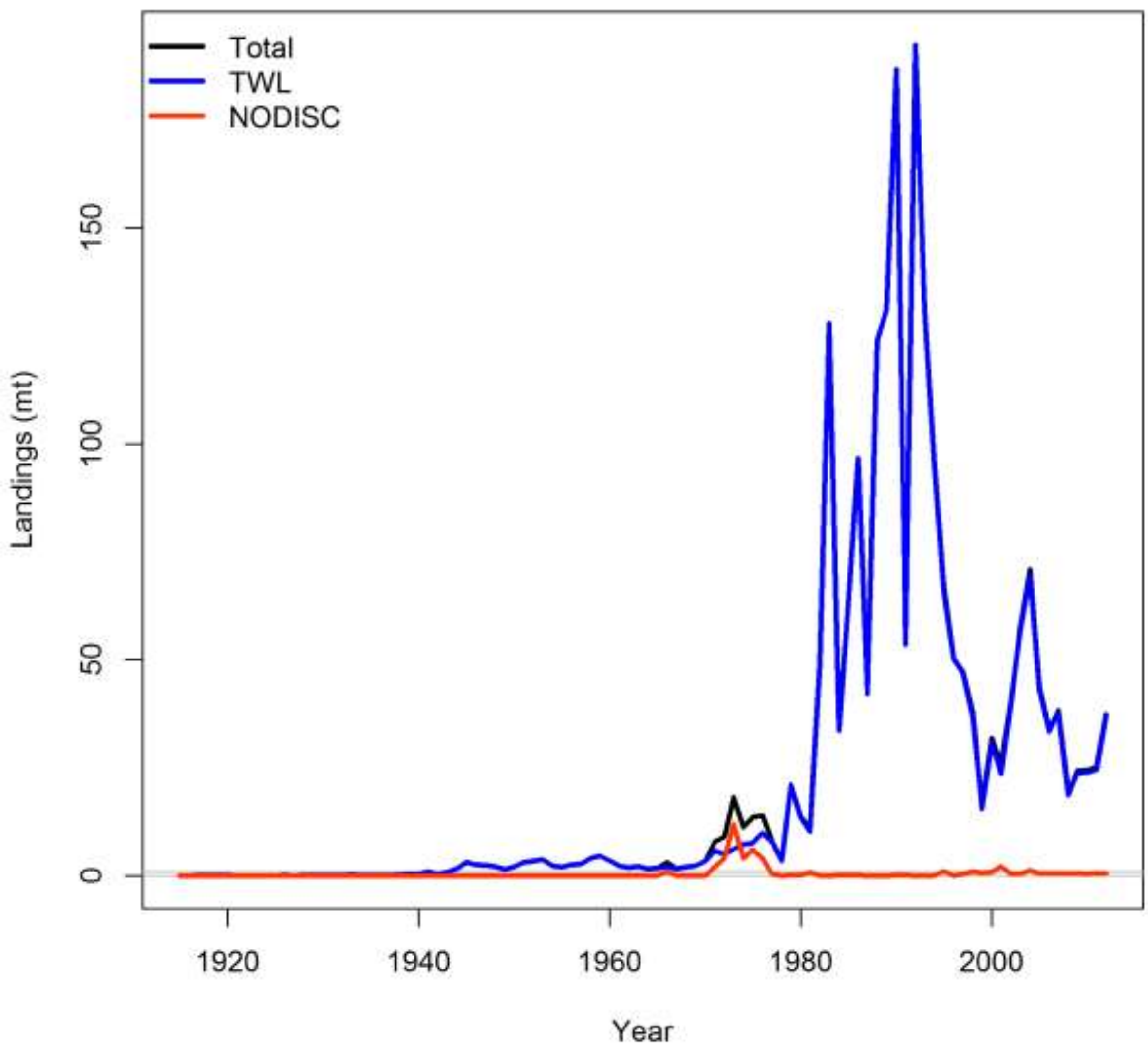



**Figure 6. Total and by sector aurora rockfish landings (1916-2012).**

### 9.2.2 Surveys

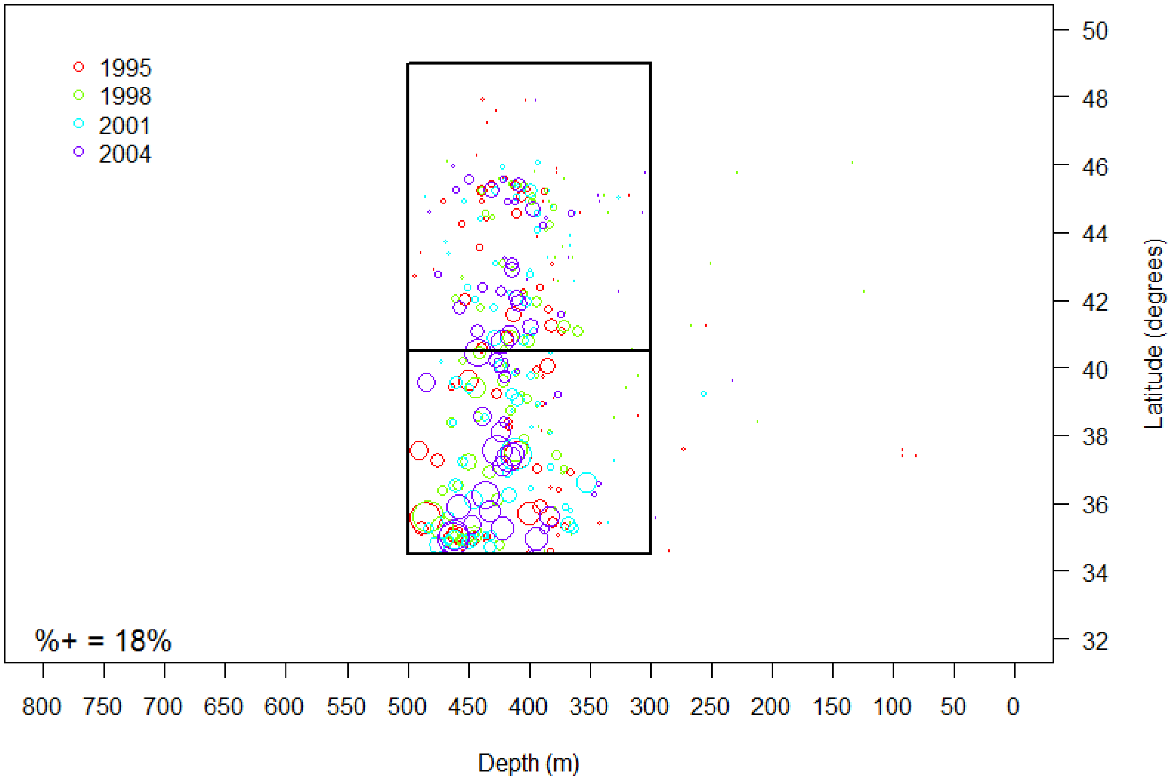



**Figure 7. Depth and latitudinal occurrence of aurora rockfish in the AFSC triennial survey by year. Circle size indicates magnitude of catch. Black lines indicate the strata used in the GLMMs. Number in lower right is the percentage of positive tows.**

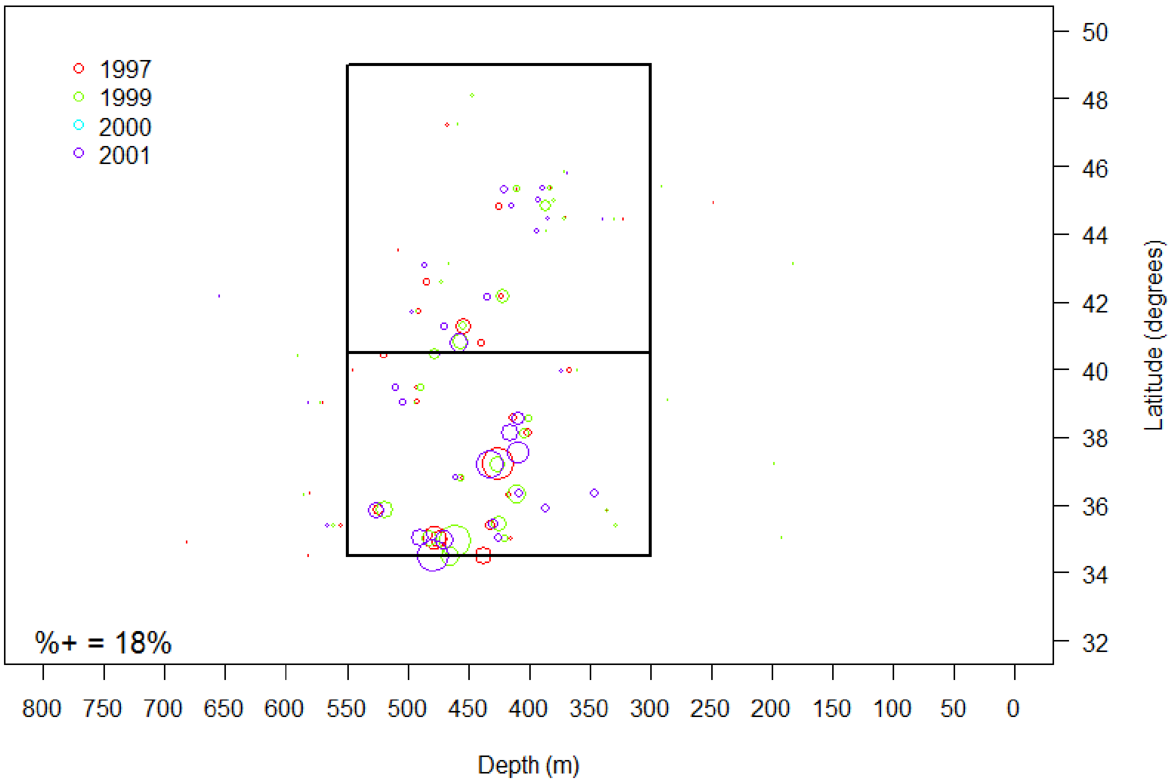



**Figure 8. Depth and latitudinal occurrence of aurora rockfish in the AFSC slope survey by year. Circle size indicates magnitude of catch. Black lines indicate the strata used in the GLMMs. Number in lower right is the percentage of positive tows.**

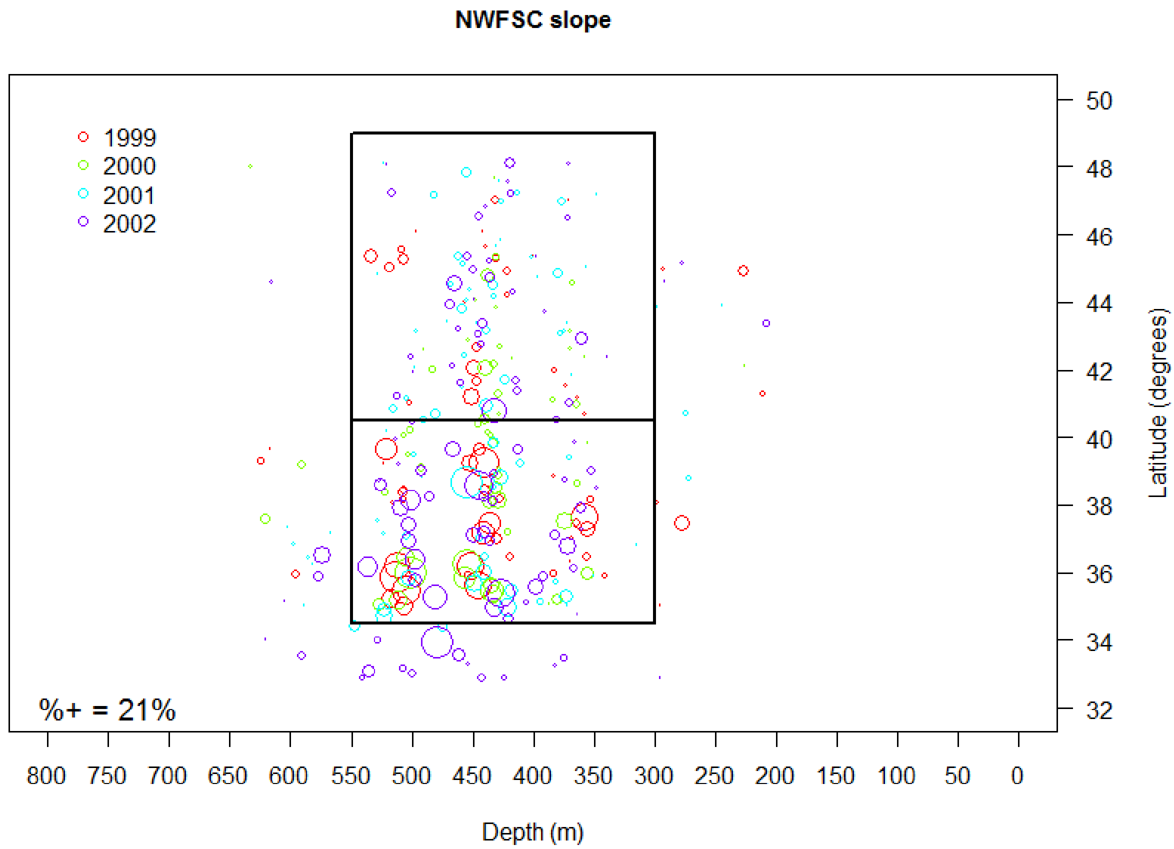



**Figure 9. Depth and latitudinal occurrence of aurora rockfish in the NWFSC slope survey by year. Circle size indicates magnitude of catch. Black lines indicate the strata used in the GLMMs. Number in lower right is the percentage of positive tows.**

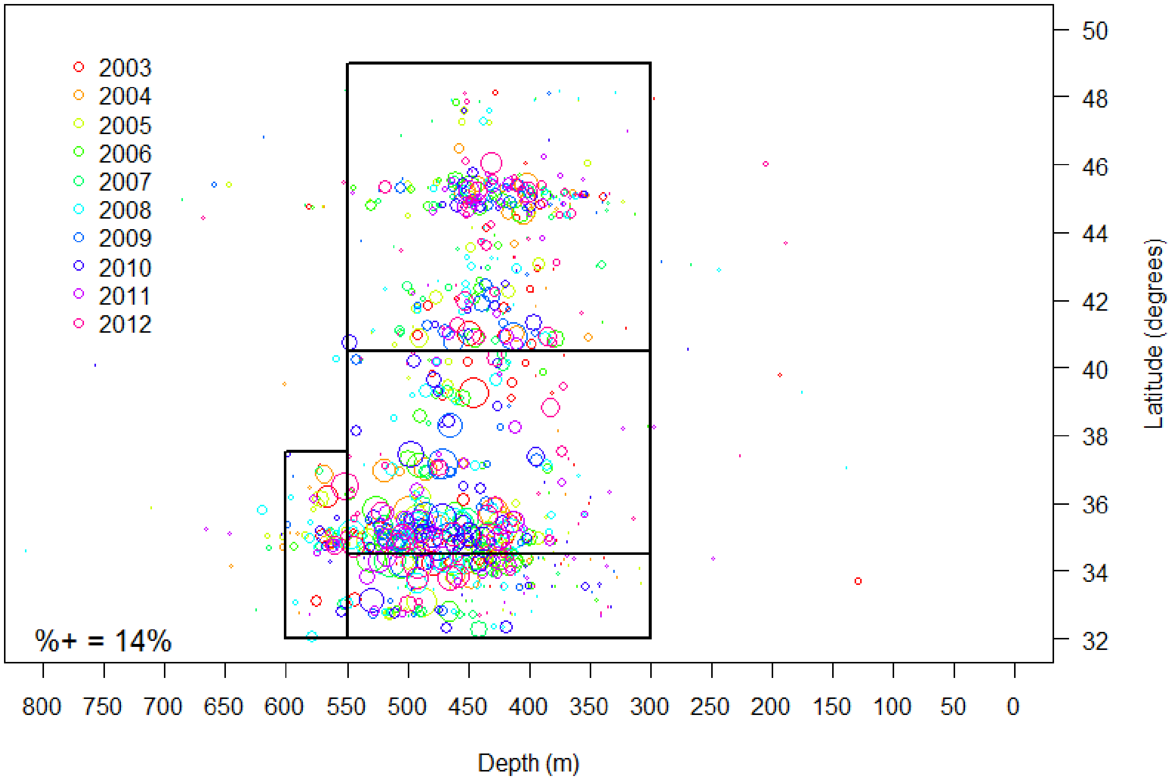



**Figure 10. Depth and latitudinal occurrence of aurora rockfish in the NWFSC shelf-slope survey by year. Circle size indicates magnitude of catch. Black lines indicate the strata used in the GLMMs. Number in lower right is the percentage of positive tows.**

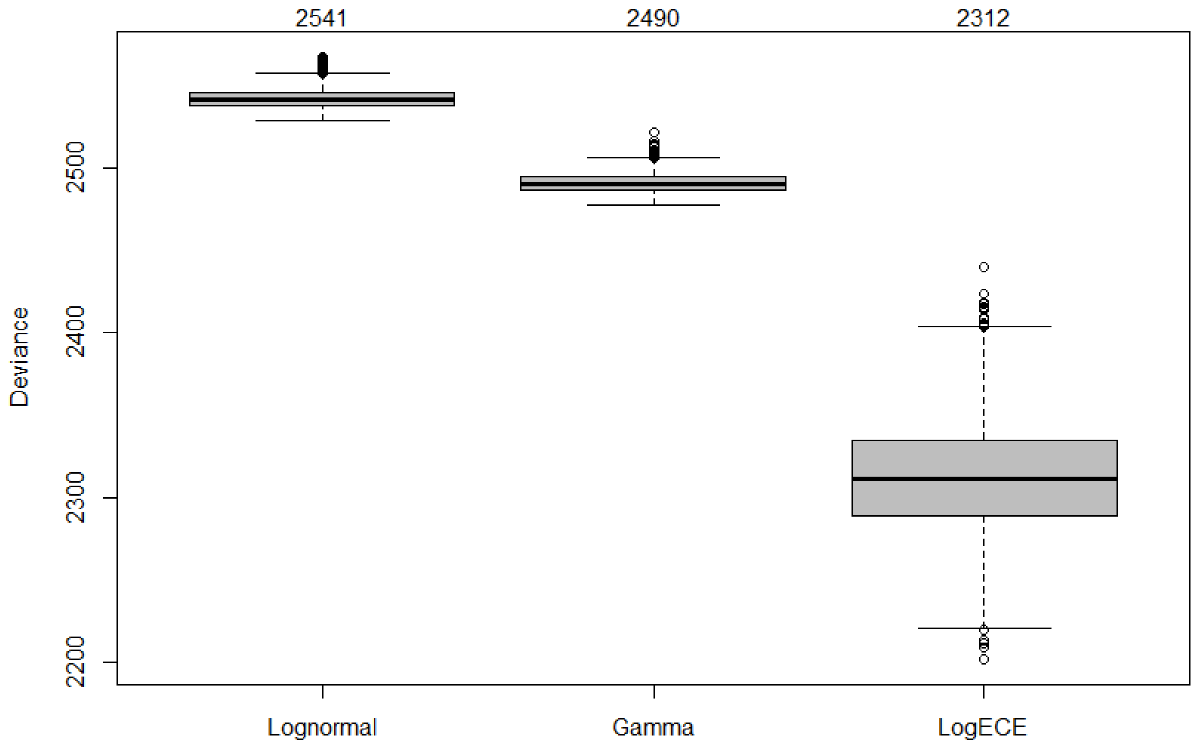



**Figure 11. Box plot of deviance for three error structures explored in the GLMM models for the AFSC triennial shelf survey (1995-2004). Black line: median. Box: interquartile range. Whiskers intervals: 95%. Median deviance is given above each box plot.**

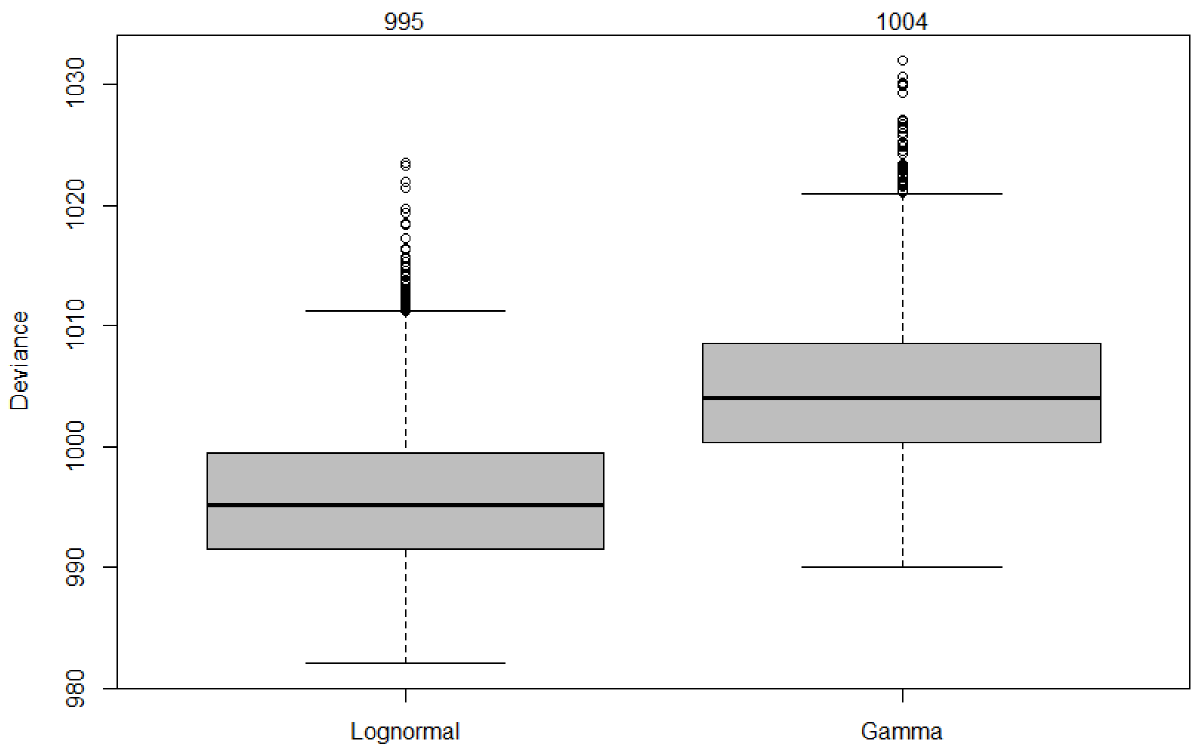



**Figure 12. Box plot of deviance for two error structures explored in the GLMM models for the AFSC slope survey (1997, 1999-2001). Black line: median. Box: interquartile range. Whiskers intervals: 95%. Median deviance is given above each box plot.**

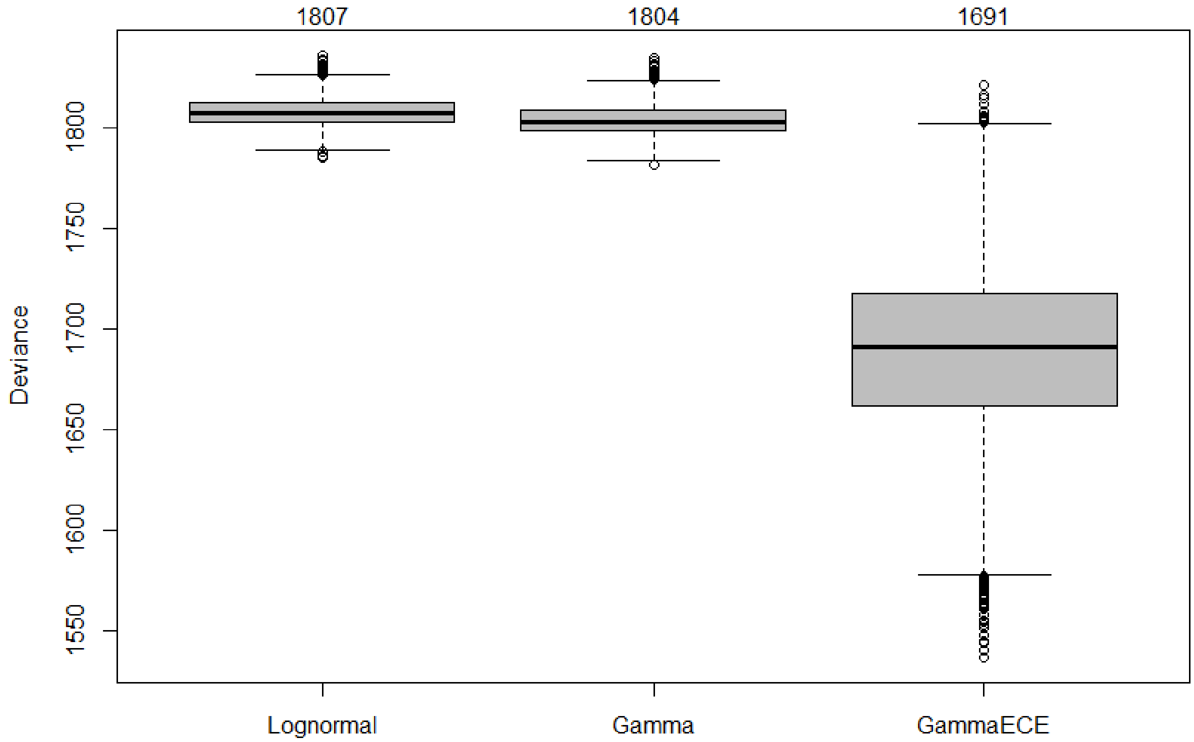



**Figure 13. Box plot of deviance for three error structures explored in the GLMM models for the NWFSC slope survey (1999-2002). Black line: median. Box: interquartile range. Whiskers intervals: 95%. Median deviance is given above each box plot.**

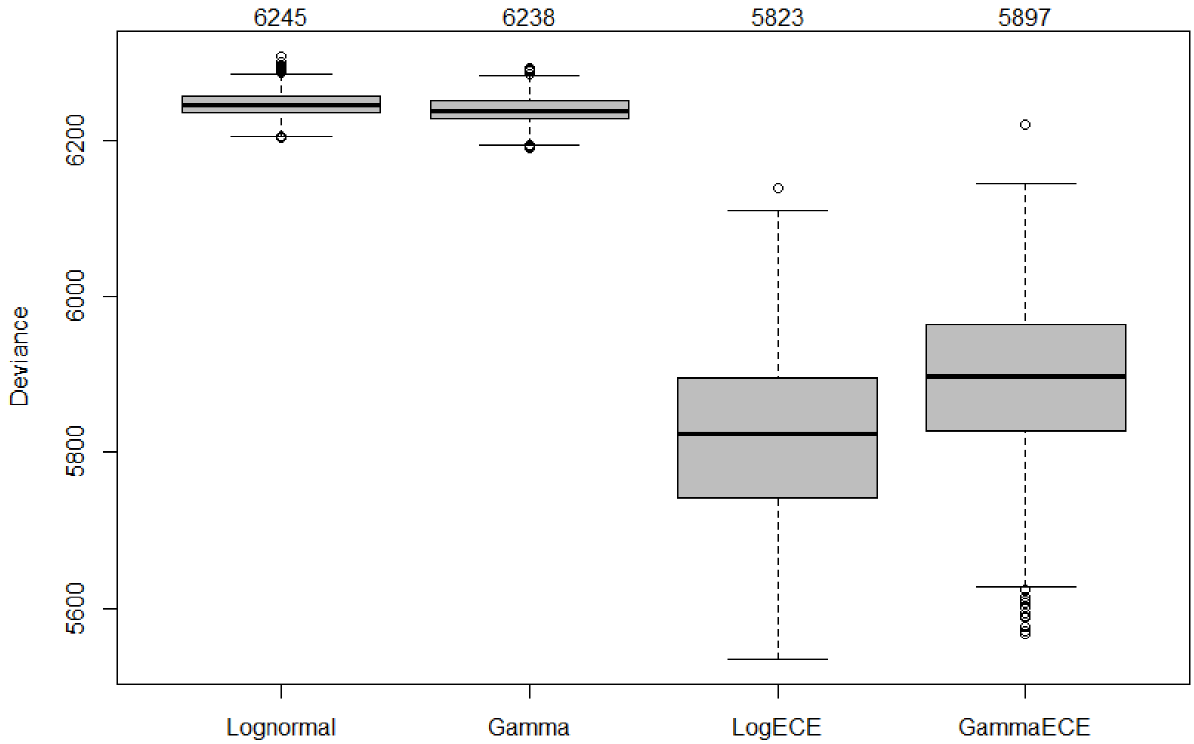



**Figure 14. Box plot of deviance for three error structures explored in the GLMM models for the NWFSC shelf-slope survey (2003-2012). Black line: median. Box: interquartile range. Whiskers intervals: 95%. Median deviance is given above each box plot.**

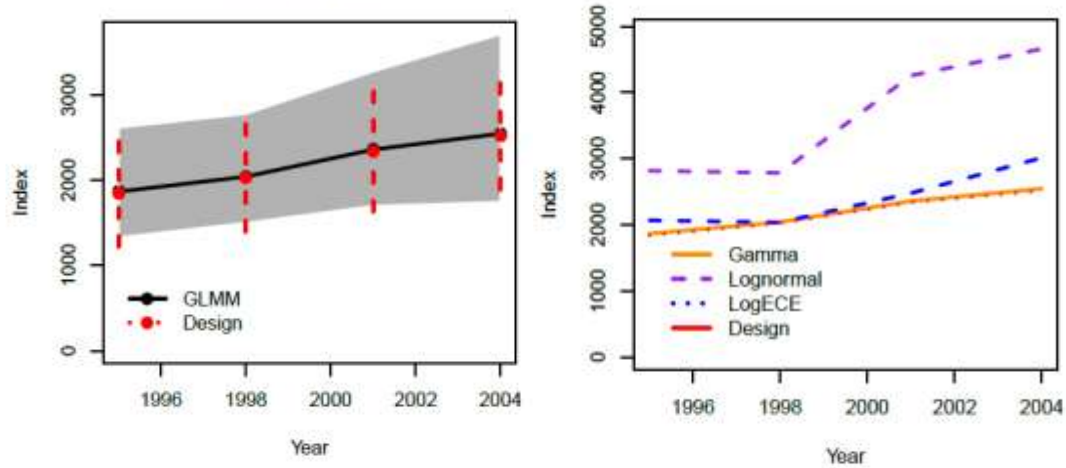



**Figure 15. GLMM fits for the AFSC triennial survey assuming the gamma error structure as the base model compared to the designed based estimates (top panel; gray area and red vertical lines are 95% credibility intervals for the GLMM and design, respectively) and the other error structure models (bottom panel).**

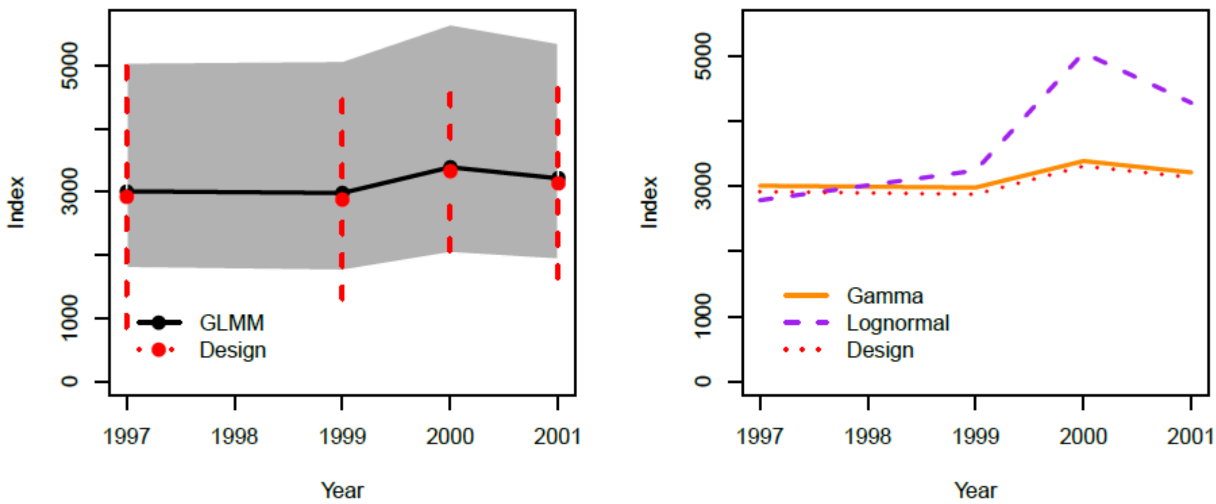



**Figure 16. GLMM fits for the AFSC slope survey assuming the gamma error structure as the base model compared to the designed based estimates (top panel; gray area and red vertical lines are 95% credibility intervals for the GLMM and design, respectively) and the other error structure models (bottom panel).**

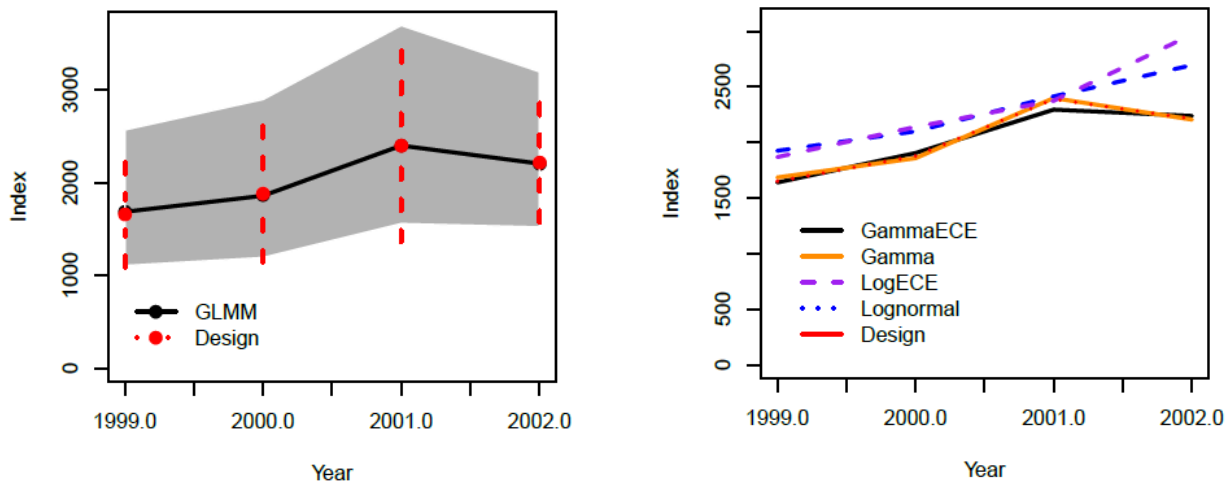



**Figure 17. GLMM fits for the NWFSC slope survey assuming the gamma error structure as the base model compared to the designed based estimates (top panel; gray area and red vertical lines are 95% credibility intervals for the GLMM and design, respectively) and the other error structure models (bottom panel).**

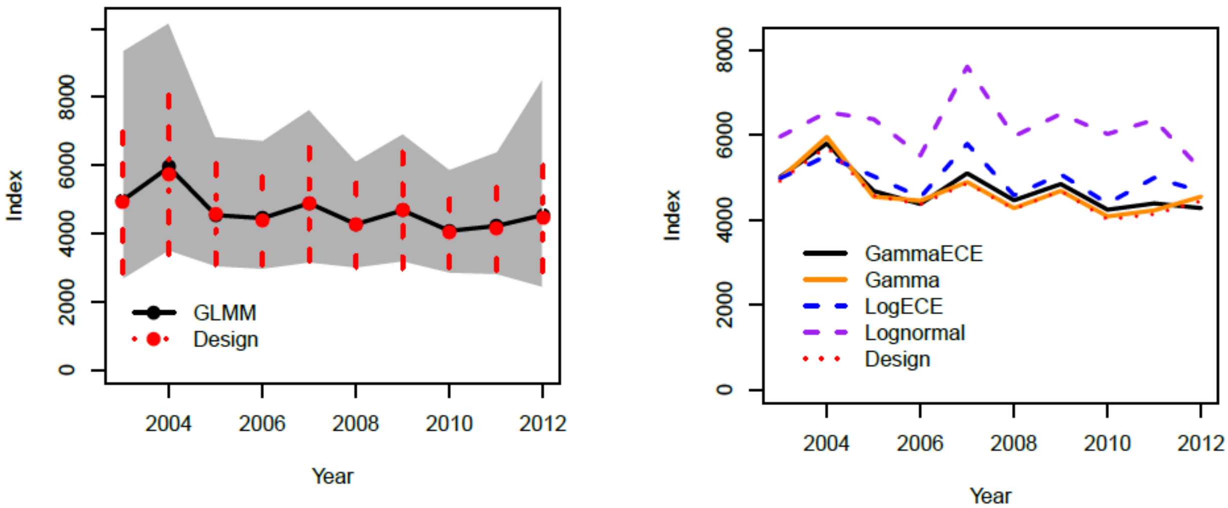



**Figure 18. GLMM fits for the NWFSC shelf-slope survey assuming the gamma error structure as the base model compared to the designed based estimates (top panel; gray area and red vertical lines are 95% credibility intervals for the GLMM and design, respectively) and the other error structure models (bottom panel).**

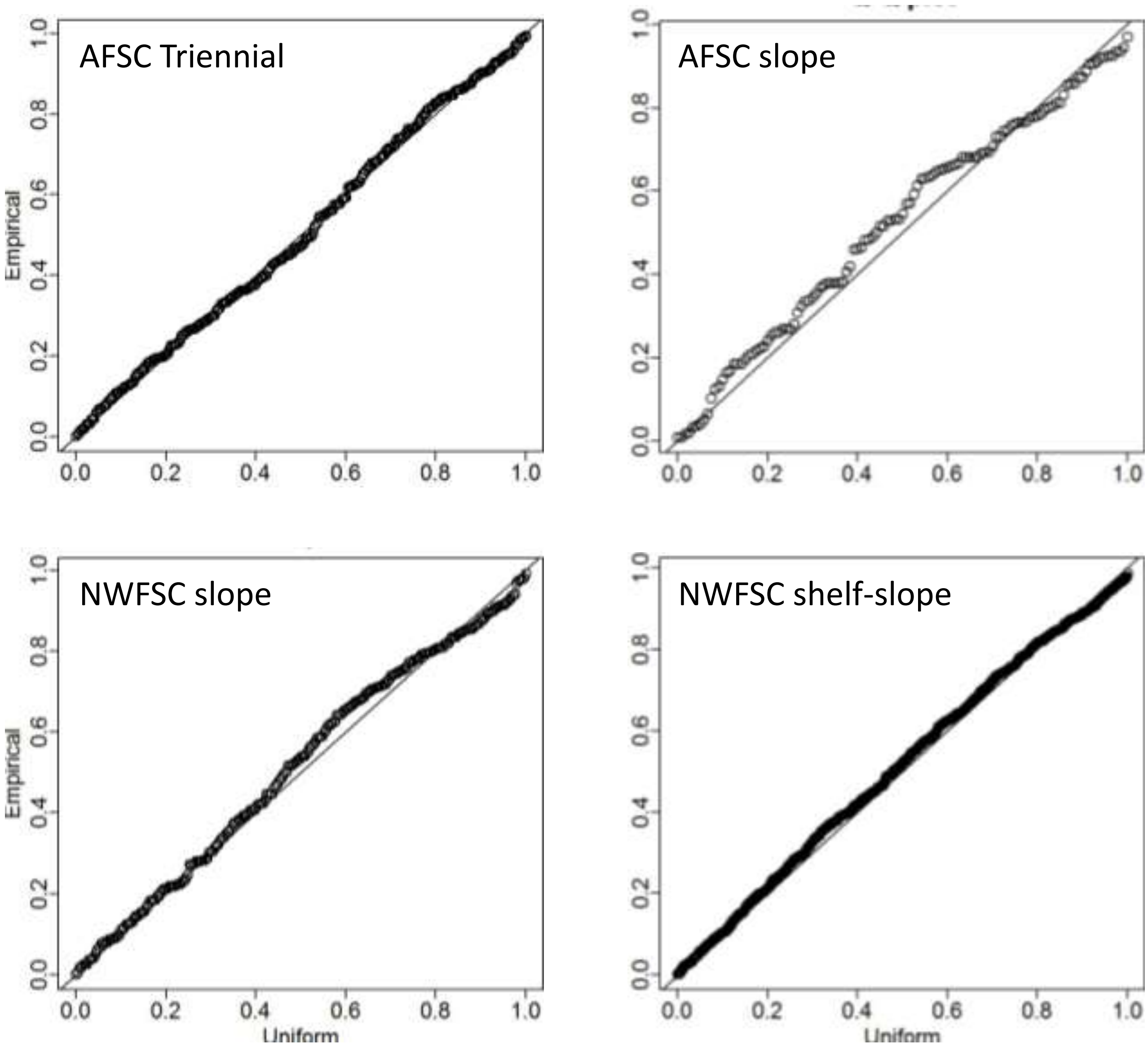



**Figure 19. Q-Q plots used to diagnose convergence of the Bayesian GLMM model for the each survey series.**

### 9.2.3 Life history parameters

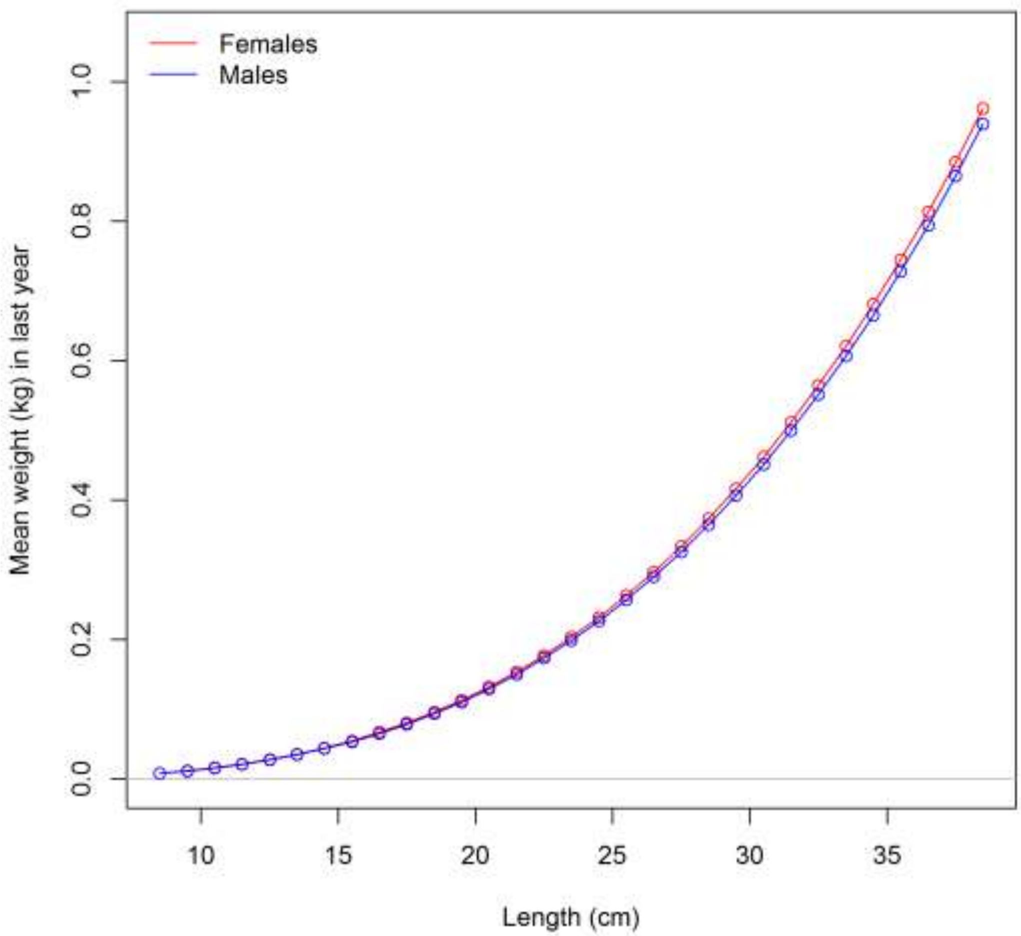



**Figure 20. Length-weight relationship for female and male aurora rockfish assumed in the base case model.**

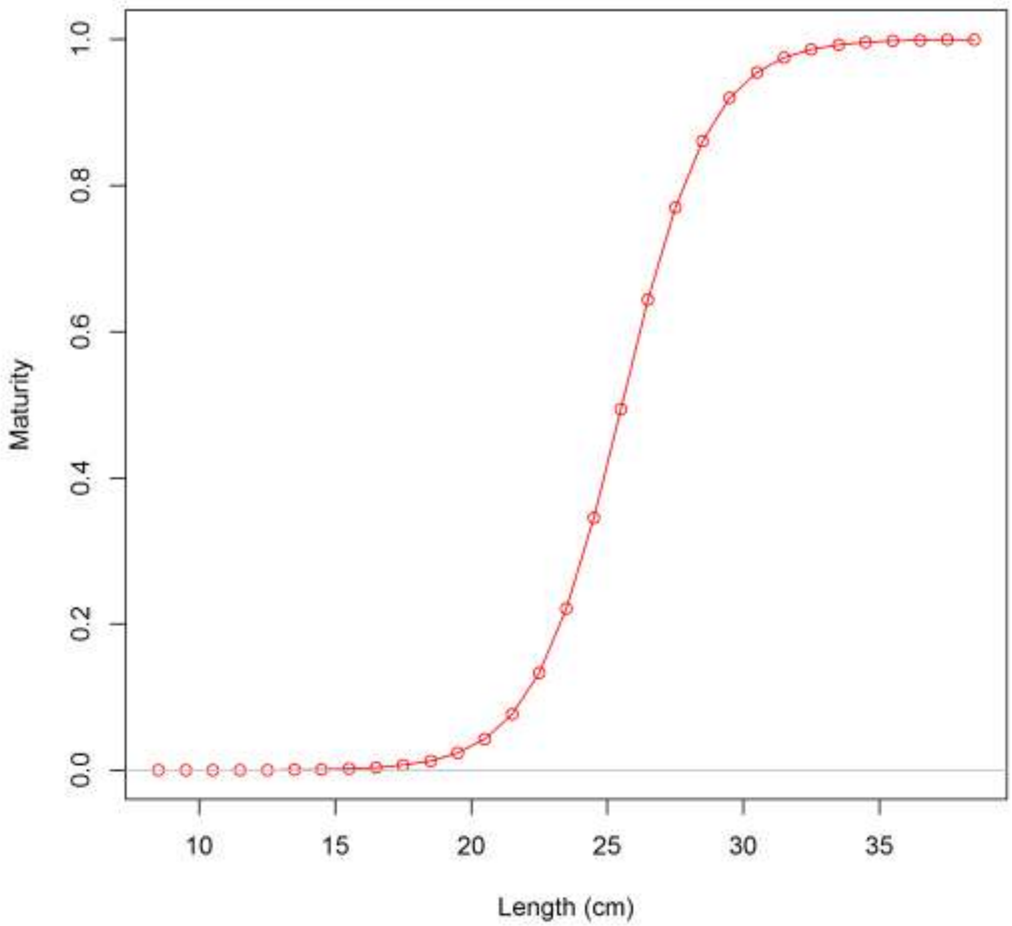



**Figure 21. Female maturity ogive used in the aurora rockfish base case model.**

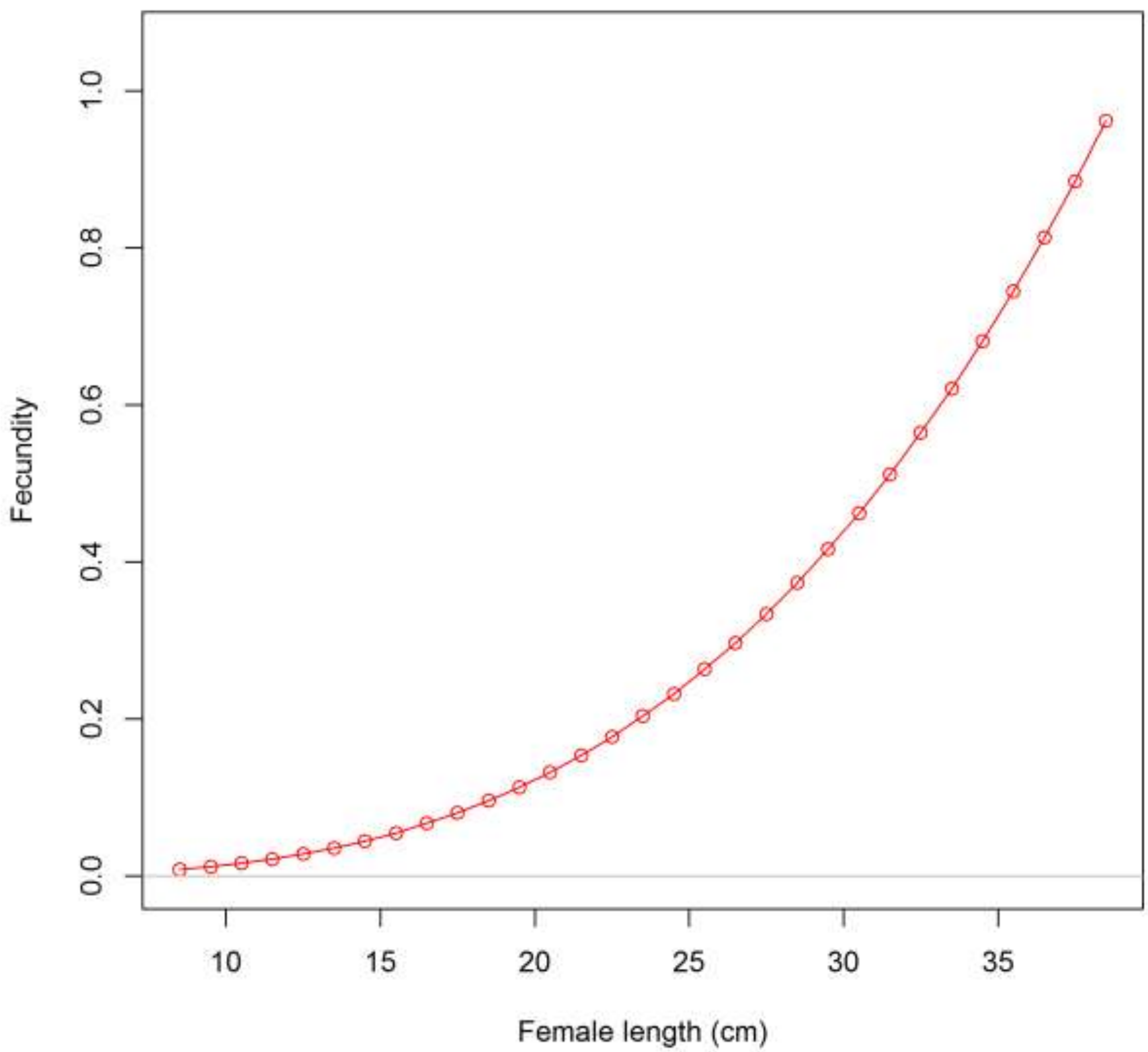



**Figure 22. Fecundity at length relationship assumed in the aurora rockfish base case model.**

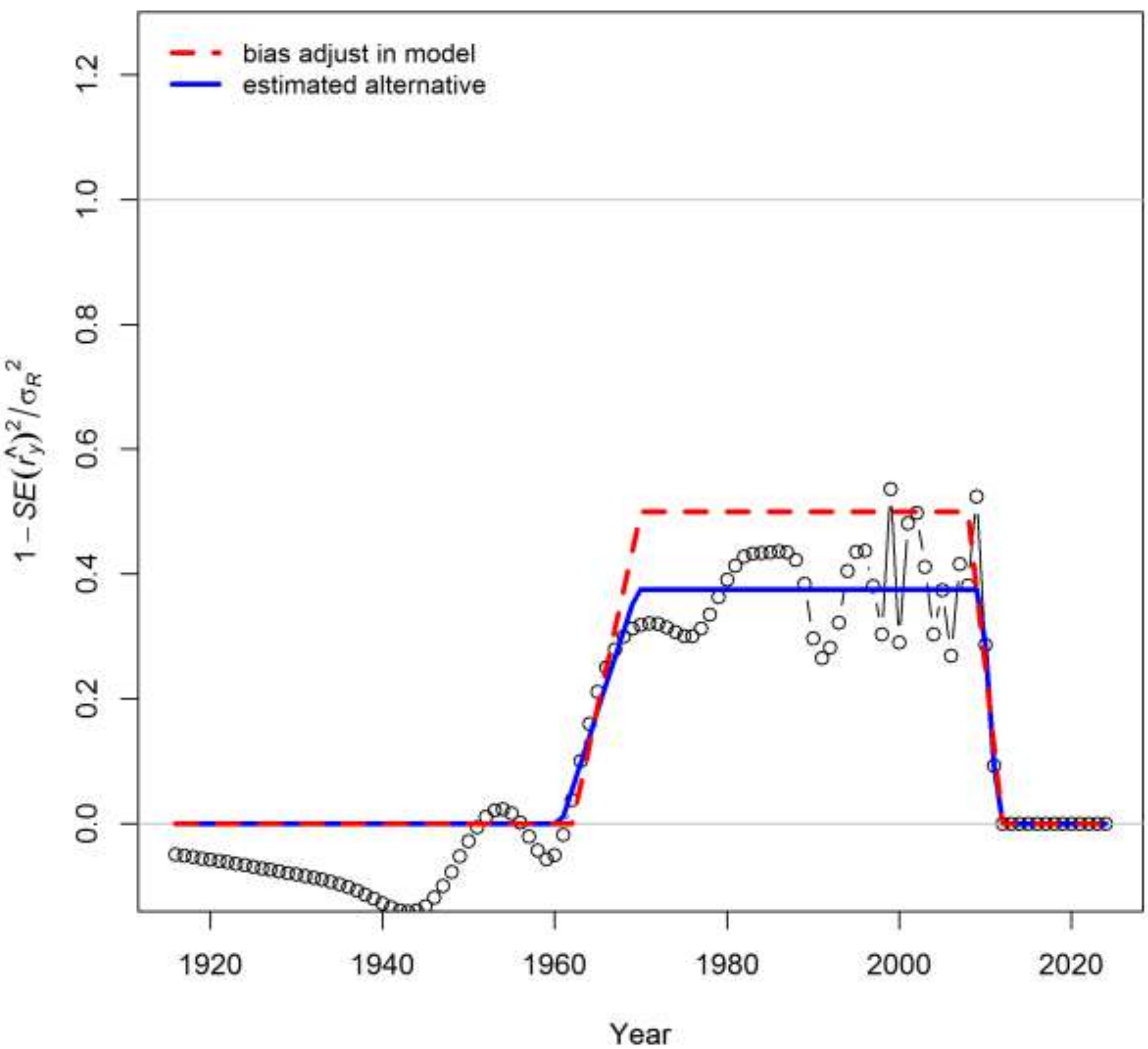



**Figure 23. Time series of the applied bias-adjustment in the aurora rockfish base case model.**

## 9.3 Model results

### 9.3.1 Base model

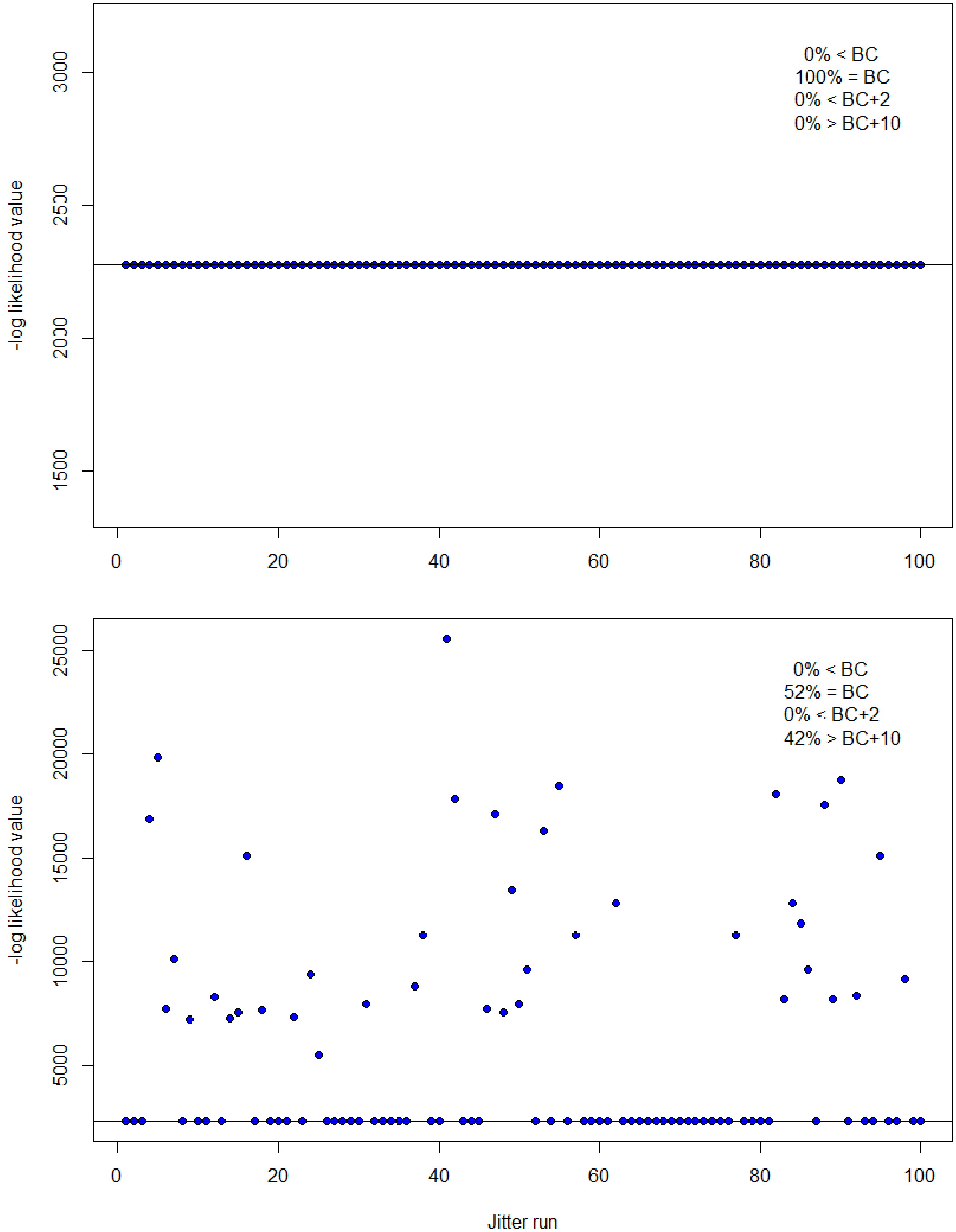



**Figure 24. Results from 100 jitter runs using jitter values of either 0.1 (top panel) or 0.5 (bottom panel). Results relative to the assumed base case (BC) model are given with each panel. The <2 indicates runs within,**

**but not equal to, the base case likelihood. The +10 indicates runs with likelihoods 10 or more units from the base case.**

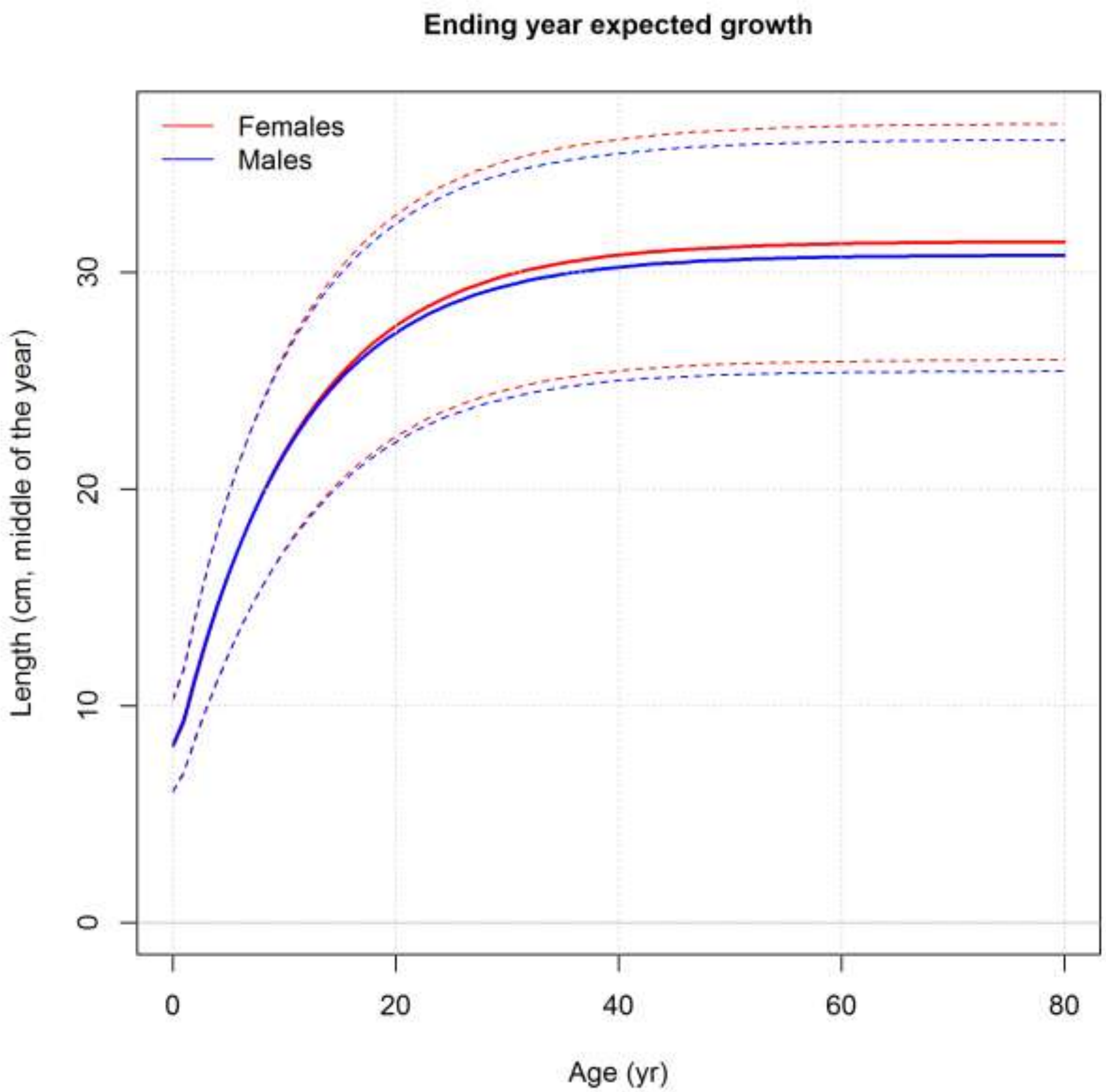



**Figure 25. Estimated age and growth relationship for females and males in the aurora rockfish base case model.**

*9.3.1.1 Removals and discards*

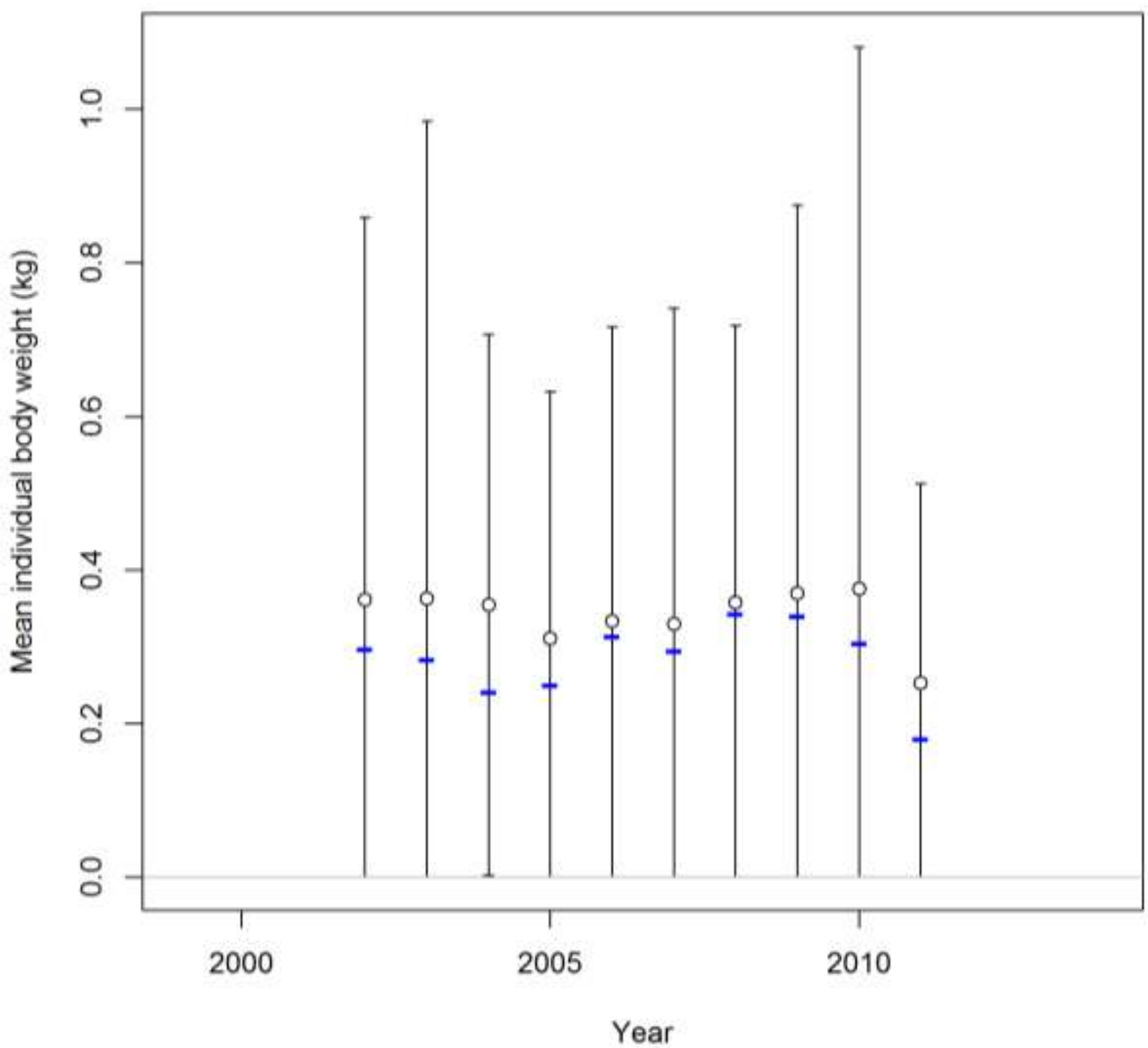



**Figure 26. Base case model fit to aurora rockfish mean individual body weight in the trawl fishery.**

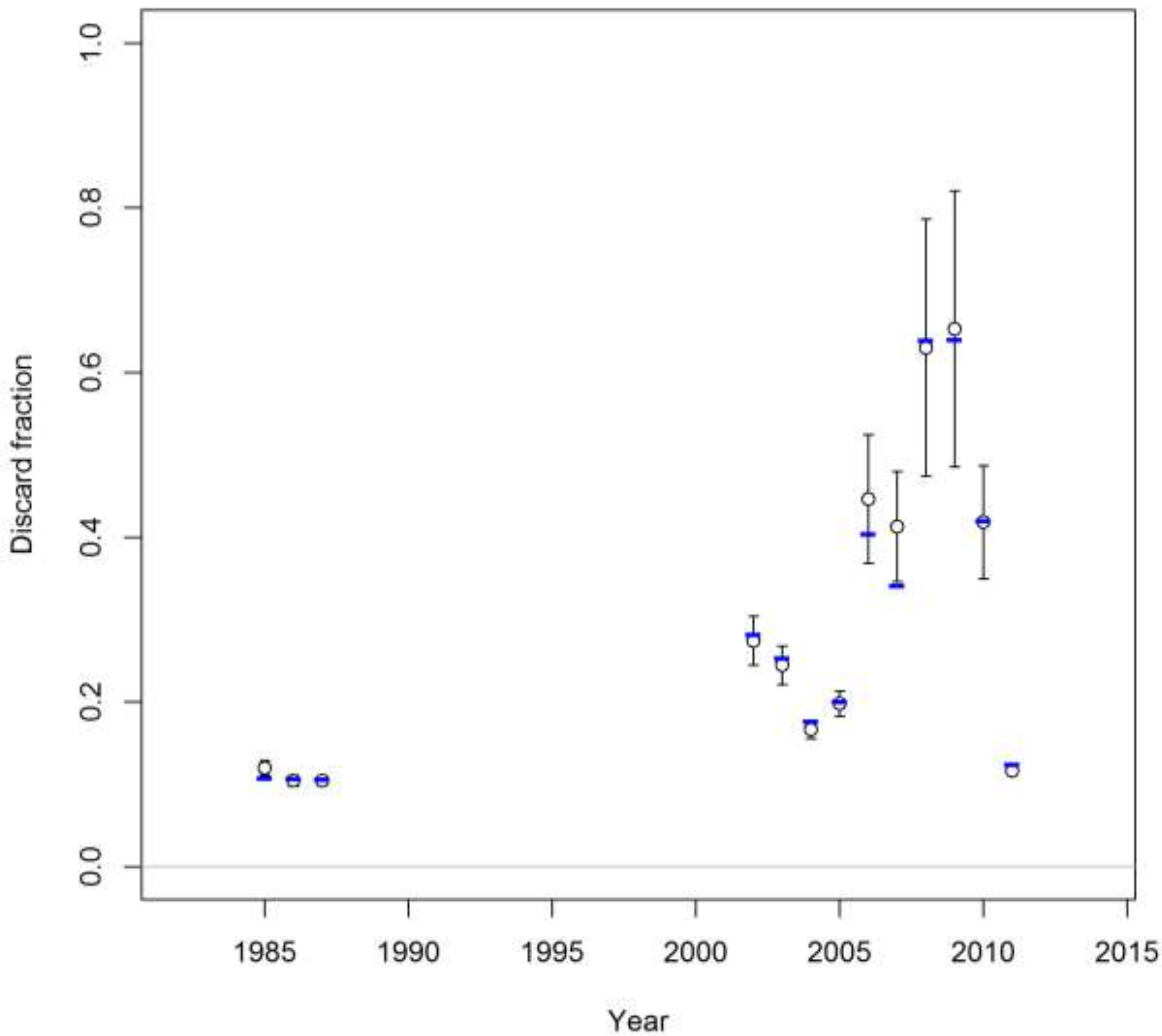



**Figure 27. Base case model fits to discard fractions in the domestic fleet.**

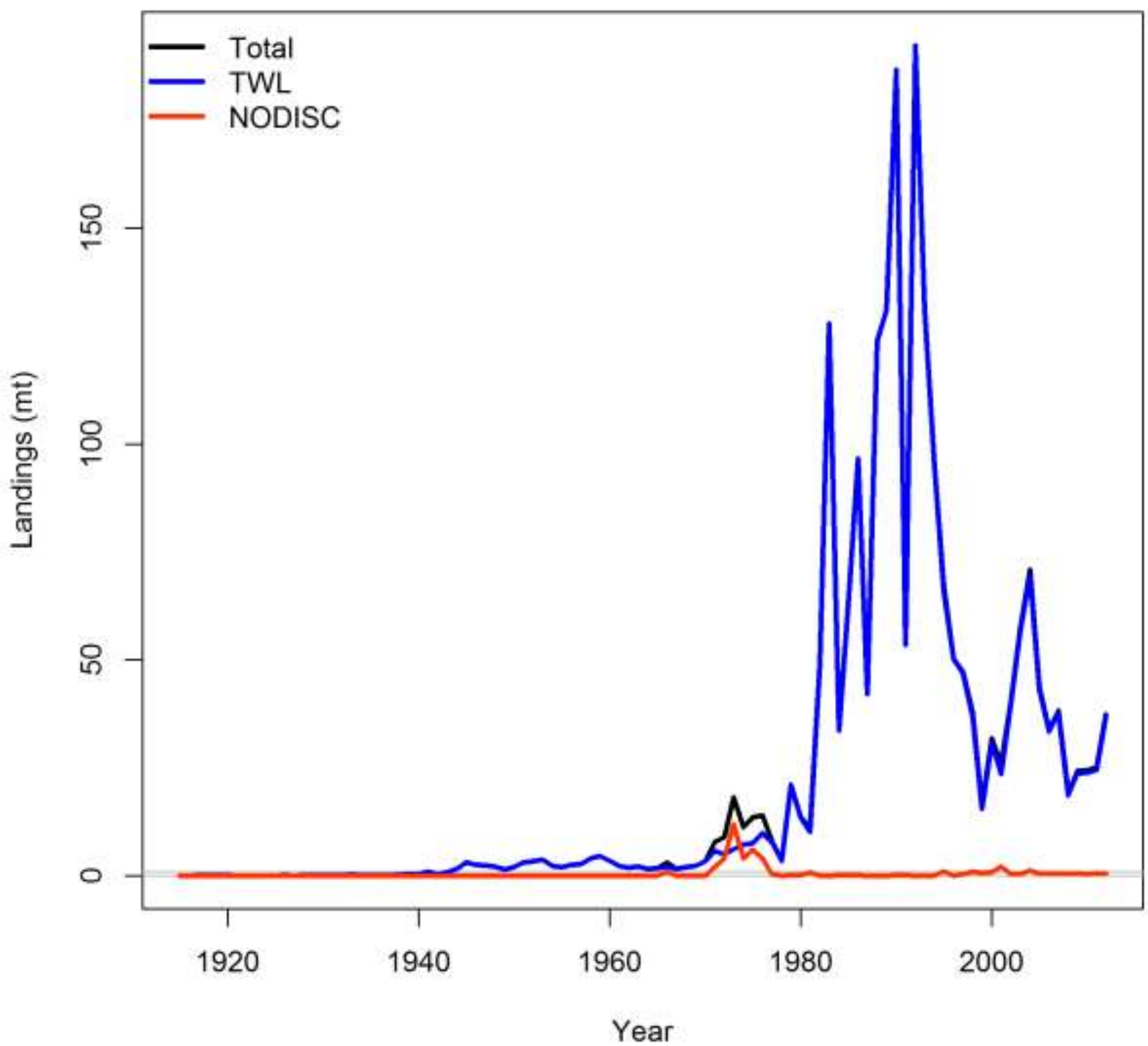



**Figure 28. Total and by sector aurora rockfish removals (1916-2012). TWL= trawl fleet. NODISC= catch and full retention fleet and research catch.**

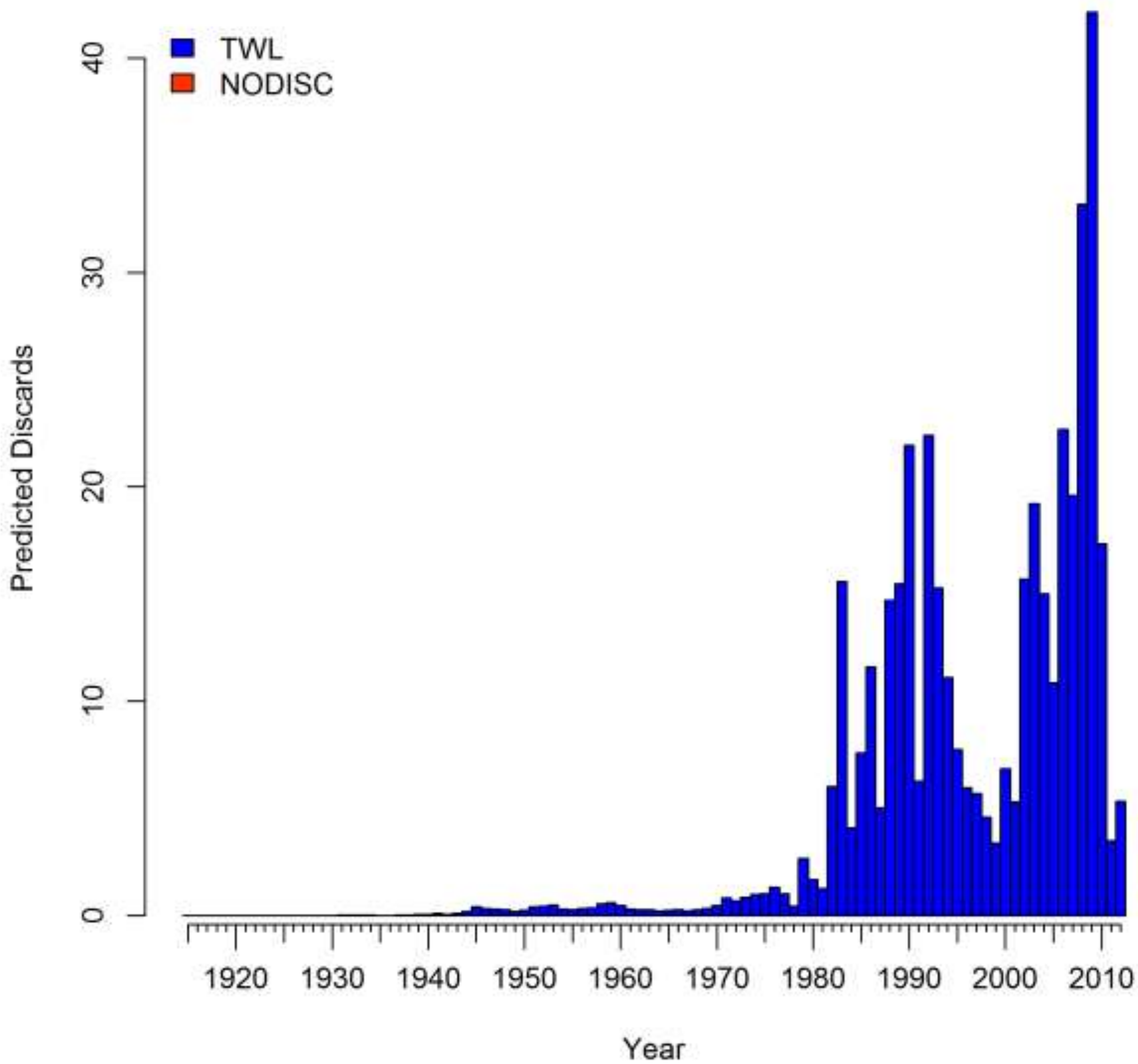



**Figure 29. Base case model predicted discards of aurora rockfish by sector. TWL= trawl fleet. NODISC= Bycatch and full retention fleet.**

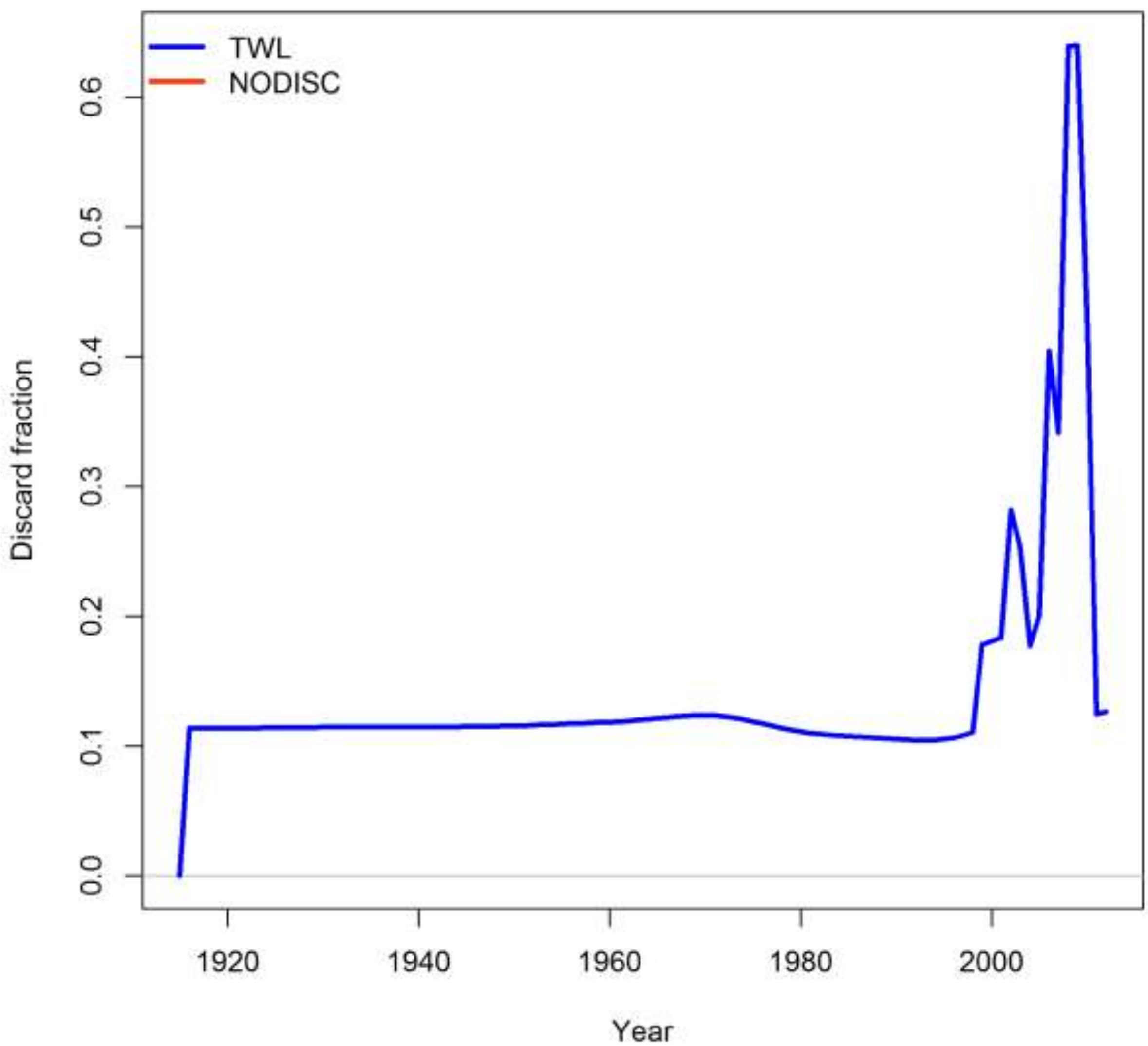



Figure 30. Discards fraction of aurora rockfish by sector used in the base case model. TWL= trawl fleet. NODISC= Bycatch and full retention fleet.

### *9.3.1.2 Abundance indices*

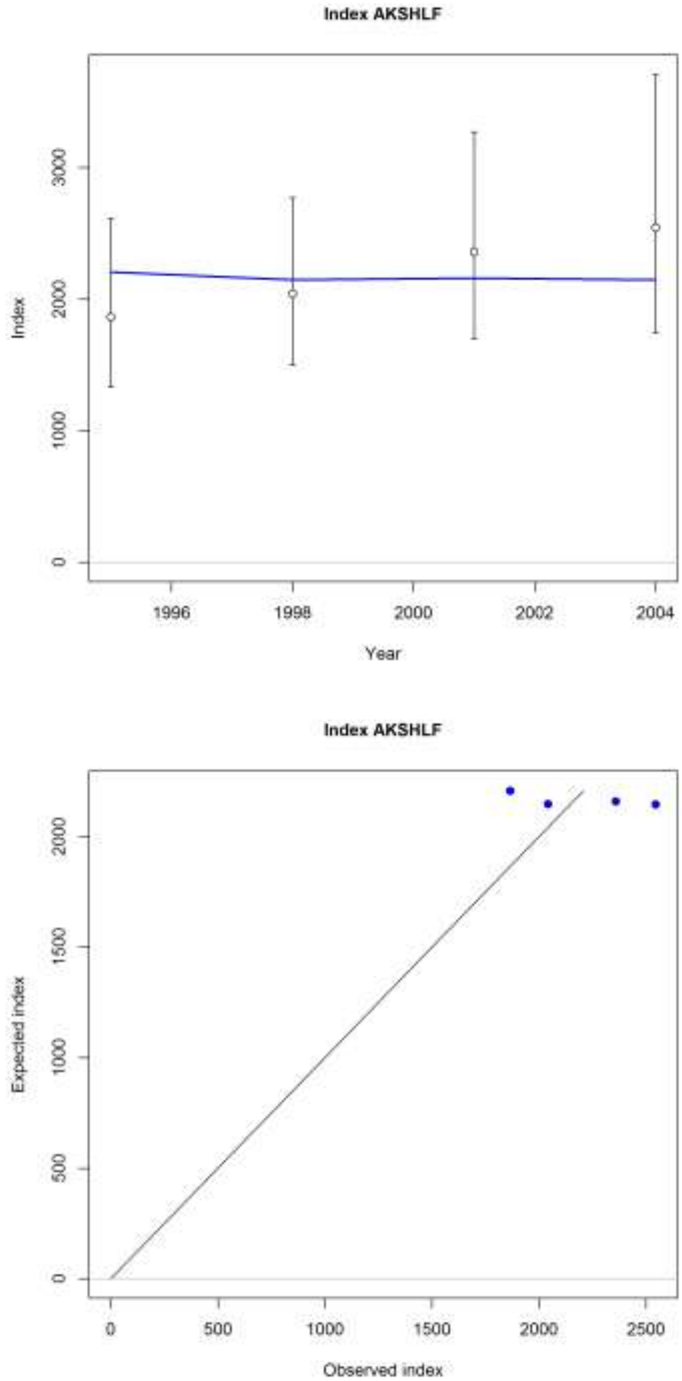



**Figure 31. Top panel: Base case model fit (solid blue line) to the AFSC triennial survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of said survey values.**

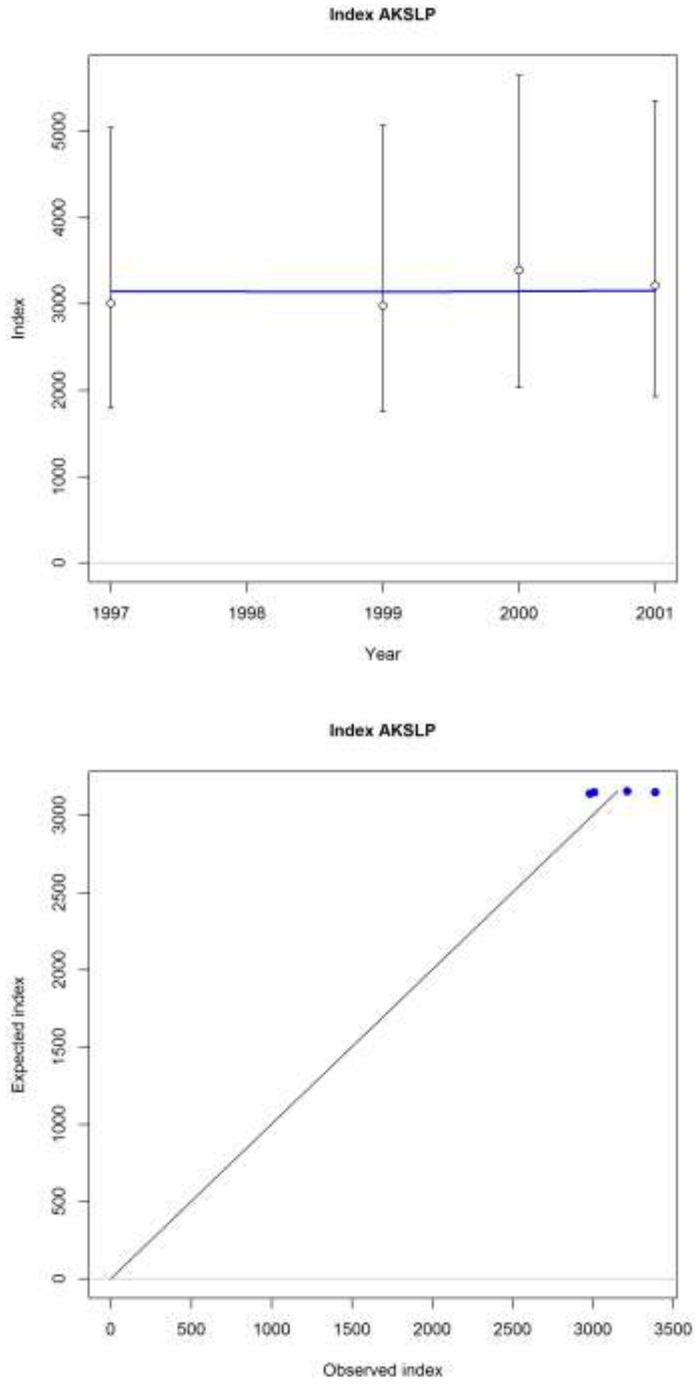
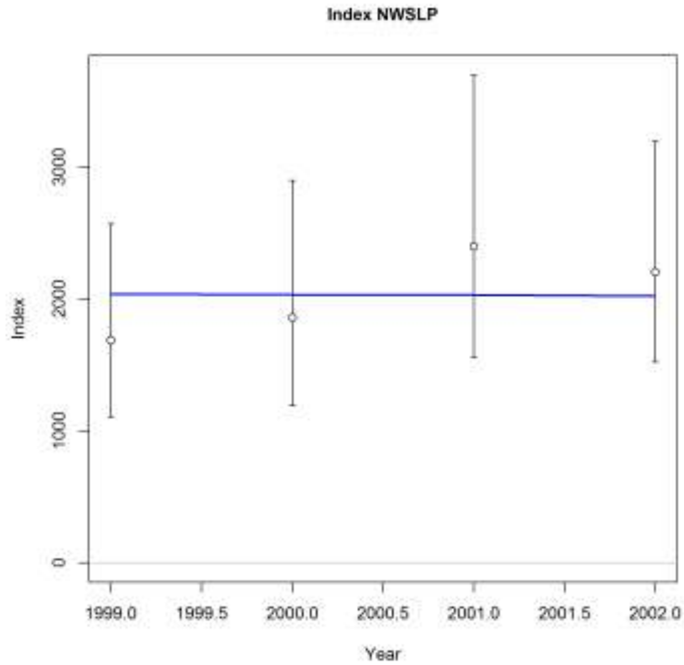



**Figure 32. Top panel: Base case model fit (solid blue line) to the AFSC slope survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of said survey values.**



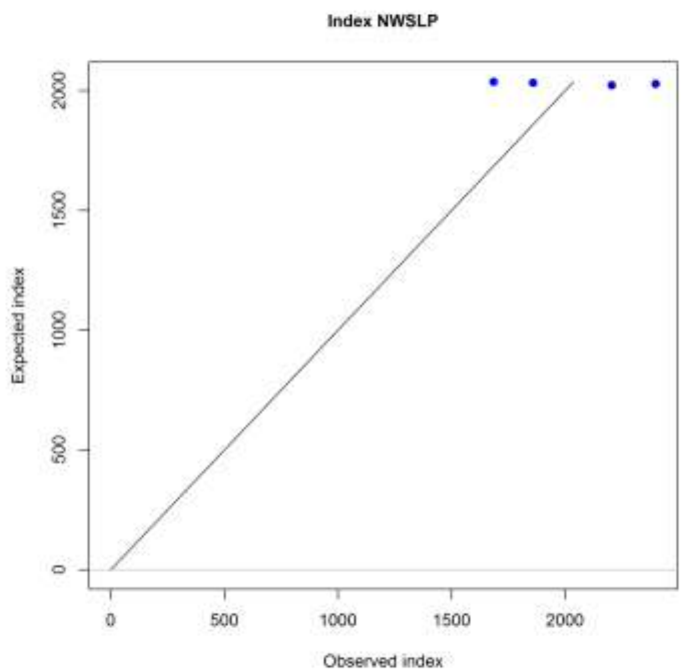




**Figure 33. Top panel: Base case model fit (solid blue line) to the NWFSC slope survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of said survey values.**

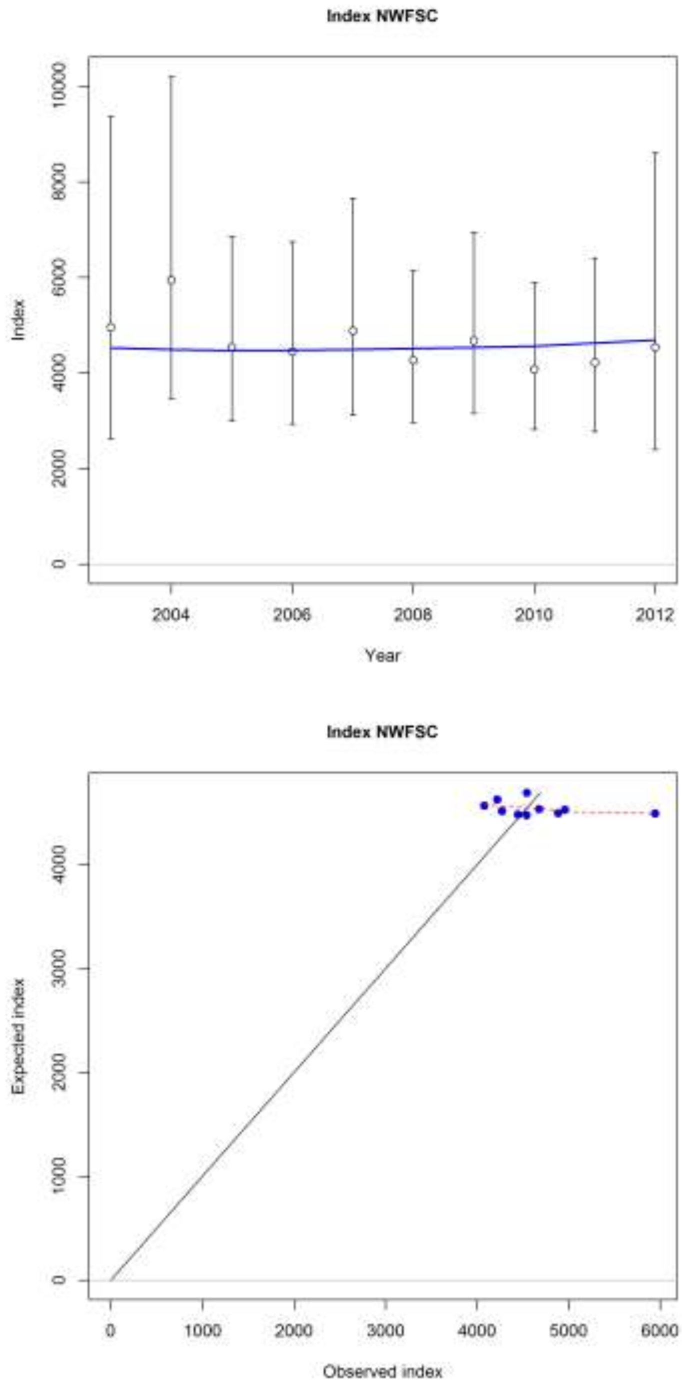



**Figure 34. Base case model fit (solid blue line) to the NWFSC shelf-slope survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of said survey values.**

### *9.3.1.3 Length compositions*

9.3.1.3.1 Fits

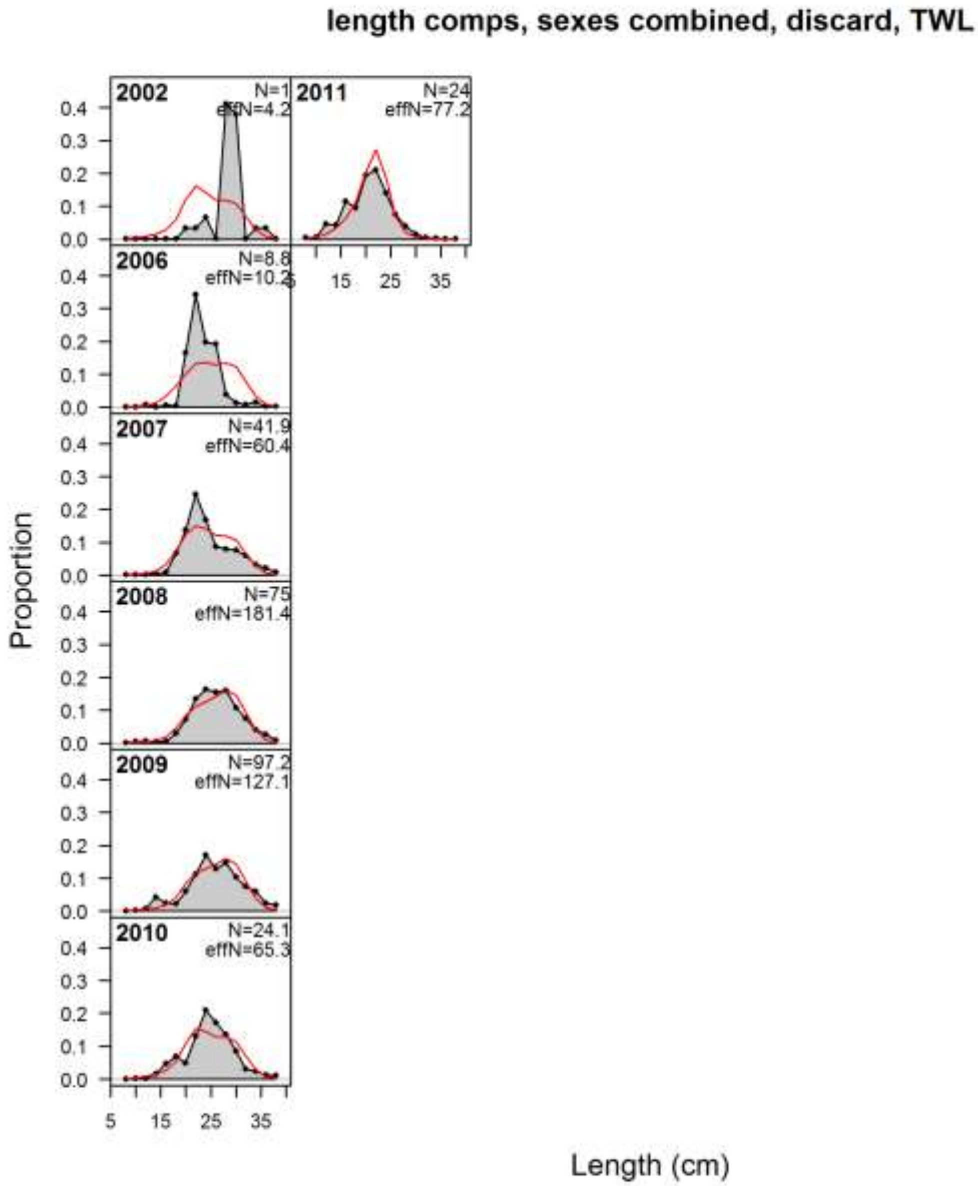



**Figure 35. Base case fits to the trawl fleet discard combined-sex length composition data for aurora rockfish.**

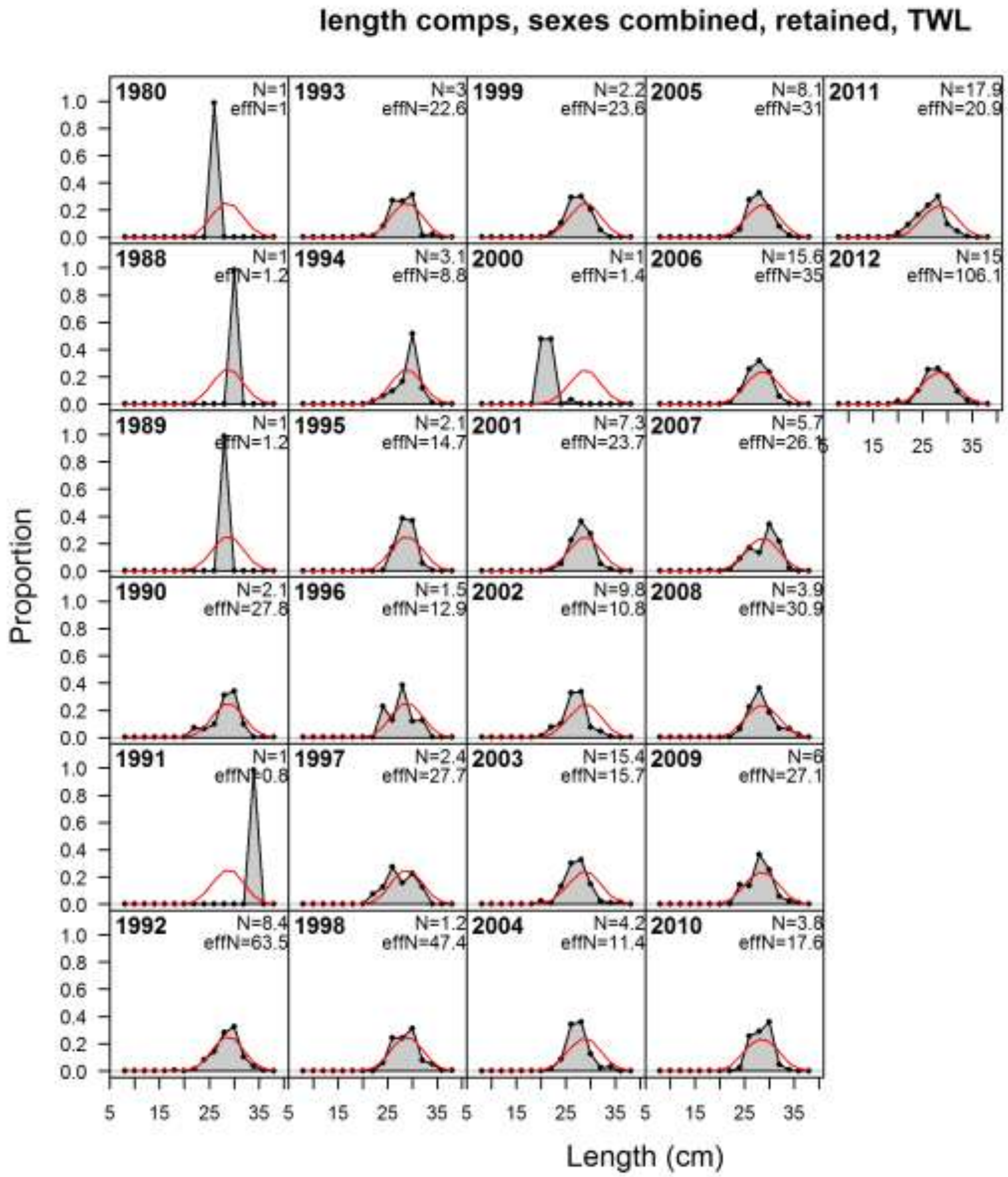



**Figure 36. Base case fits to the trawl fleet retained combined-sex length composition data for aurora rockfish.**

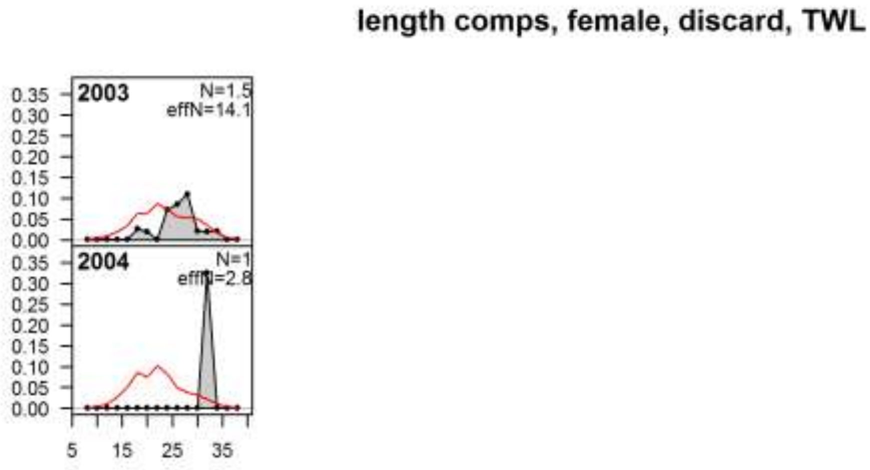



**Figure 37 Base case fits to the trawl fleet discard female length composition data for aurora rockfish.**

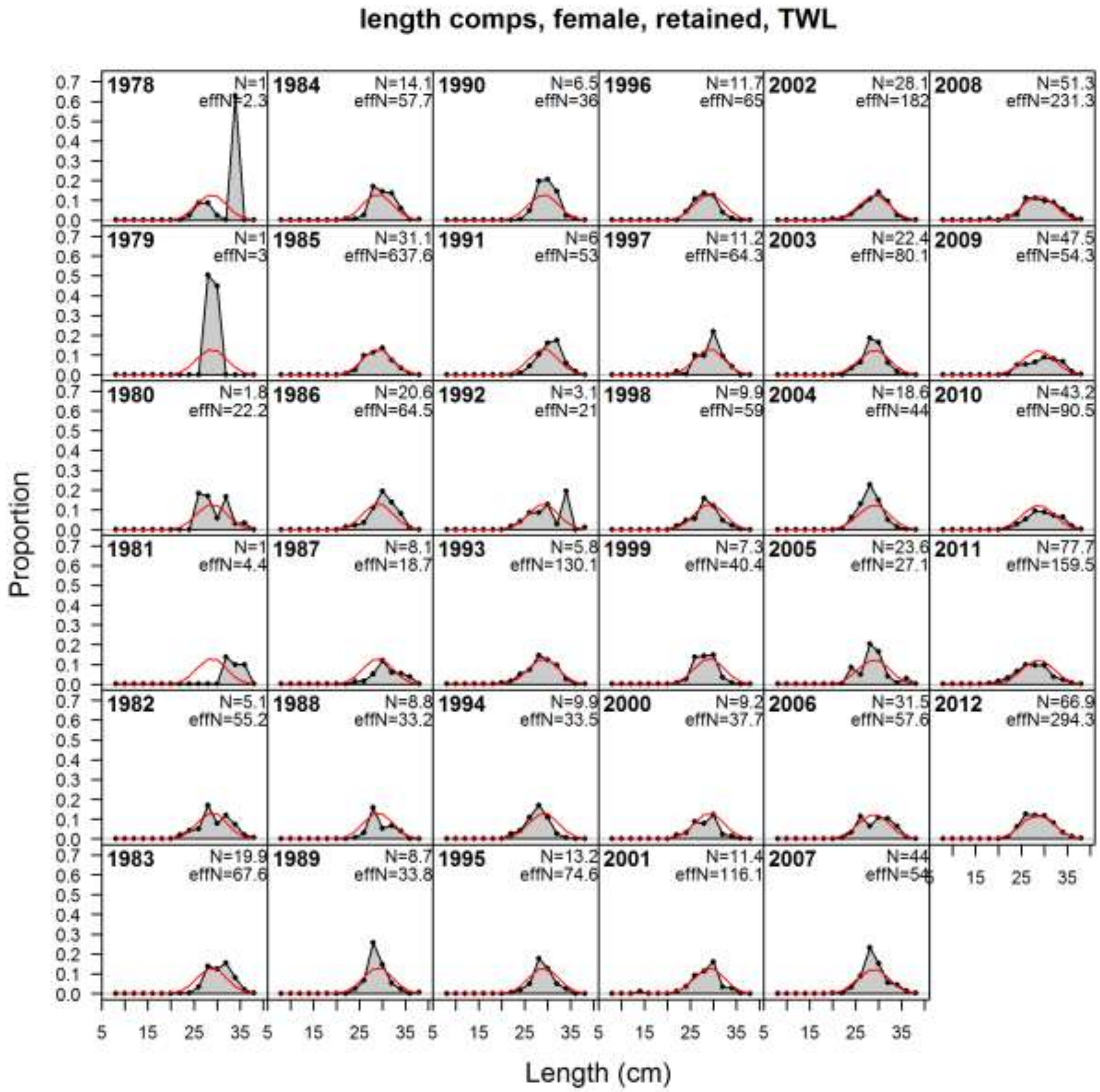



**Figure 38. Base case fits to the trawl fleet retained female length composition data for aurora rockfish.**

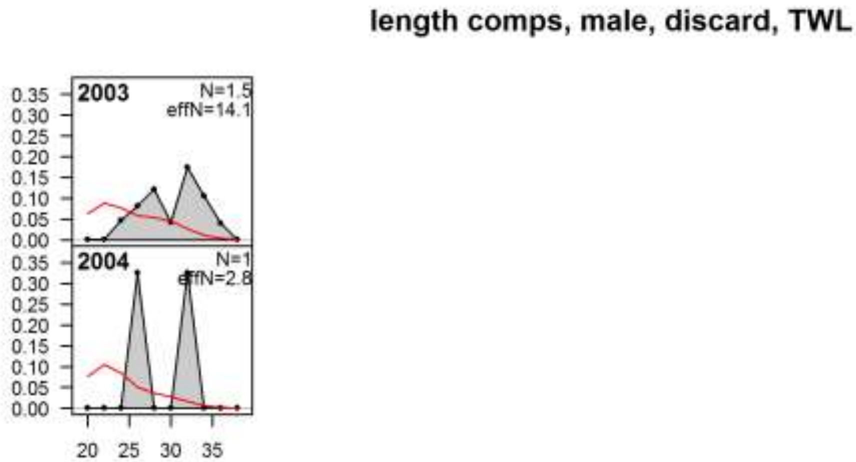



**Figure 39. Base case fits to the trawl fleet discard male length composition data for aurora rockfish.**

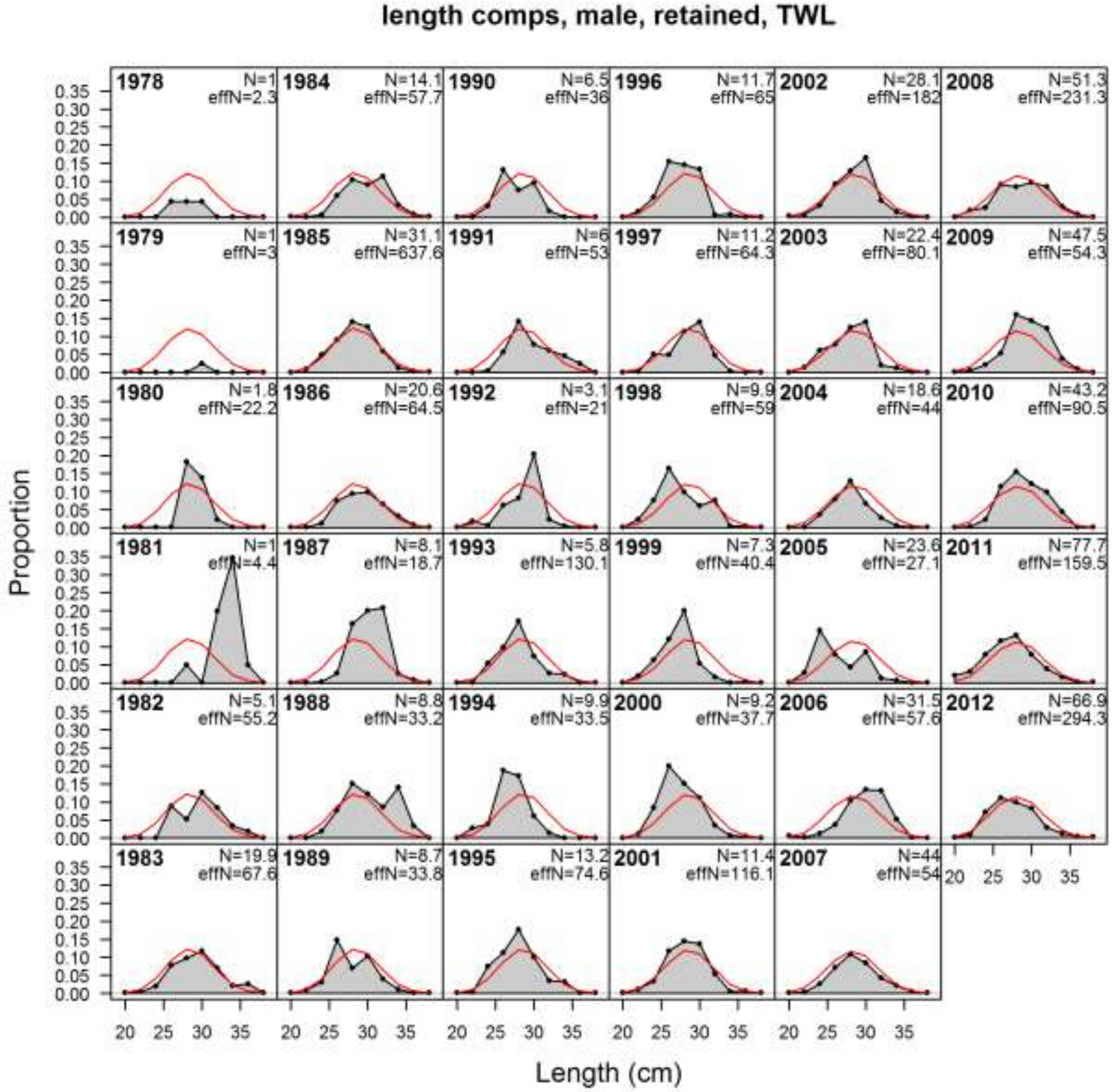



**Figure 40. Base case fits to the trawl fleet retained male length composition data for aurora rockfish.**

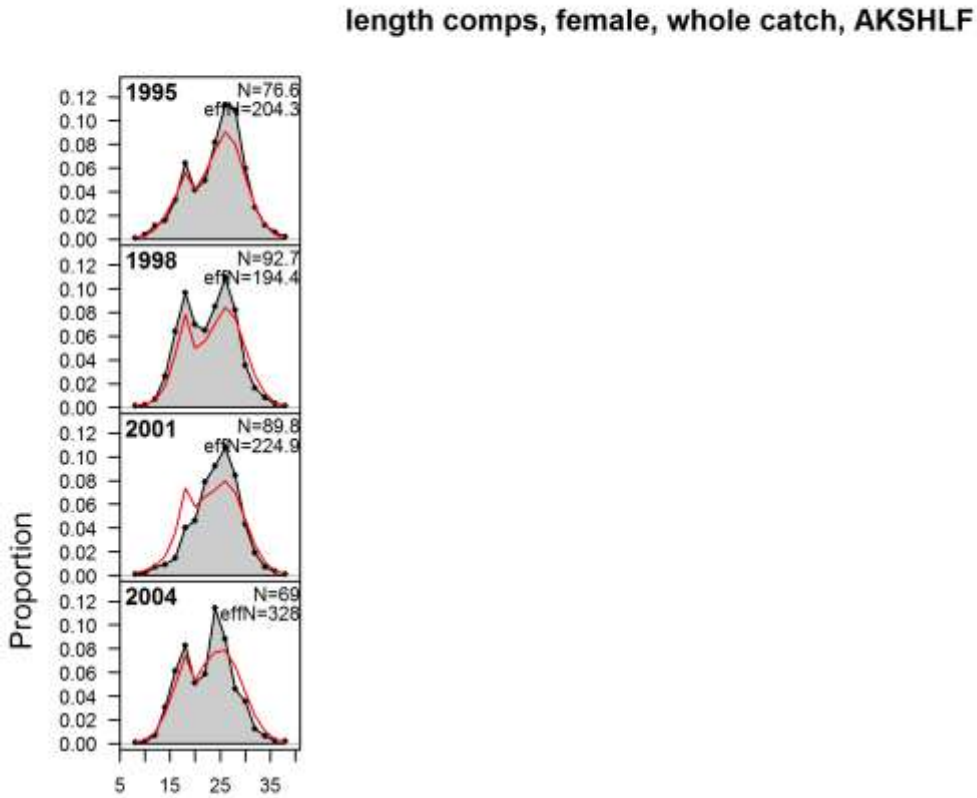



**Figure 41. Base case fits to the AFSC triennial survey female length composition data for aurora rockfish.**

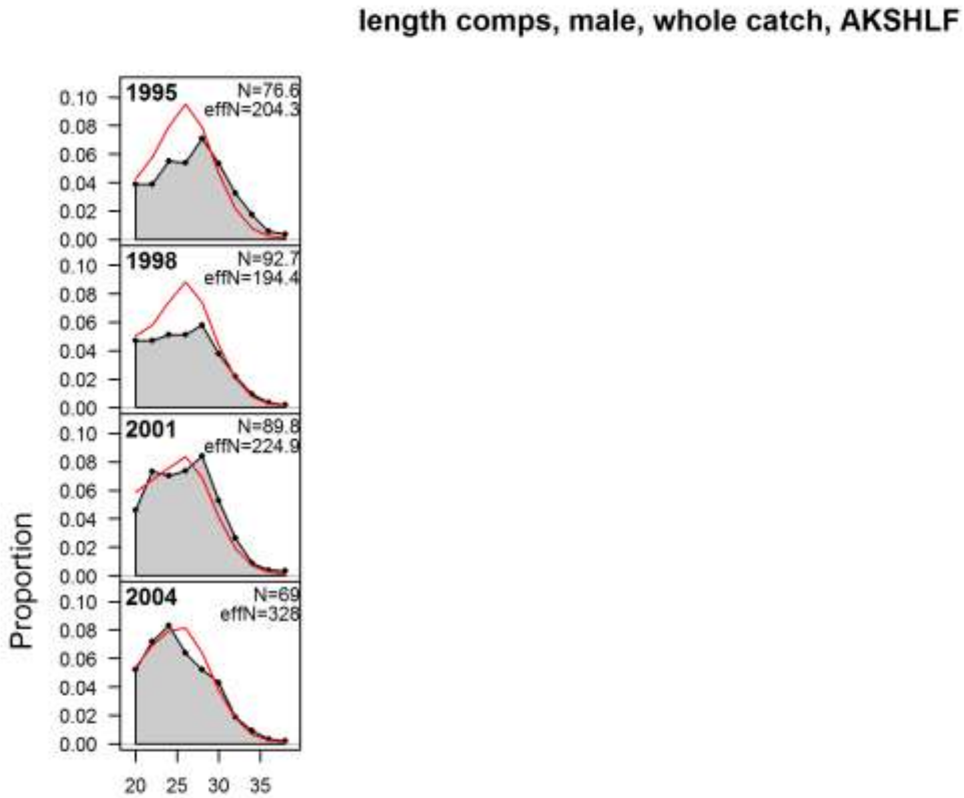



**Figure 42. Base case fits to the AFSC triennial survey male length composition data for aurora rockfish.**

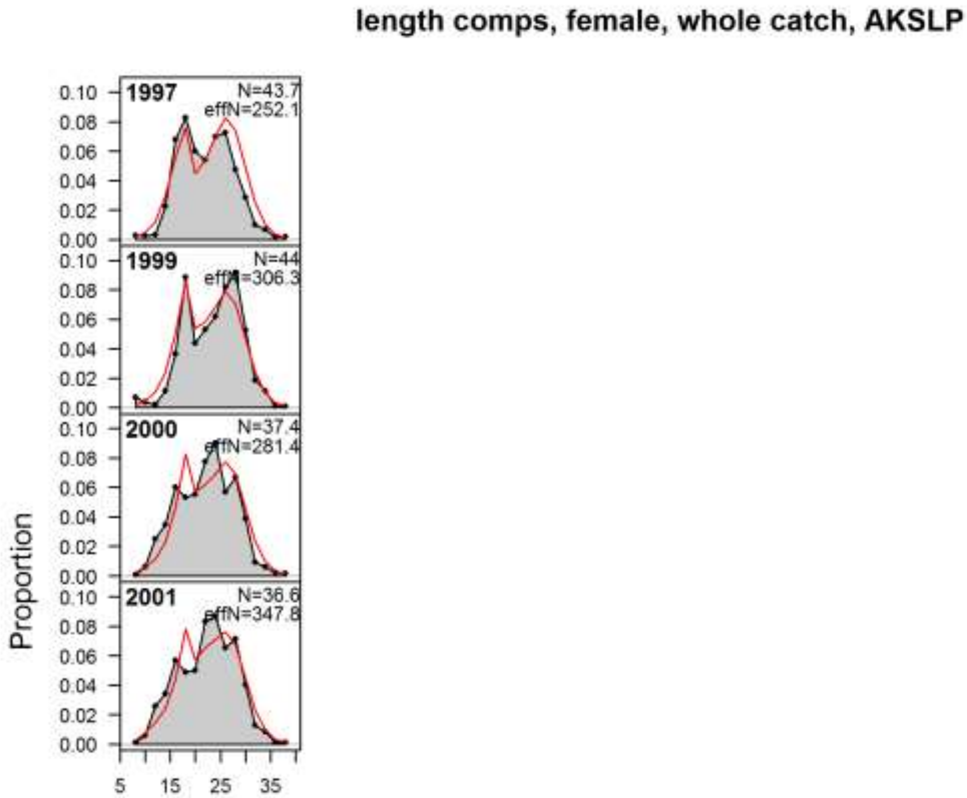



**Figure 43. Base case fits to the AFSC slope survey female length composition data for aurora rockfish.**

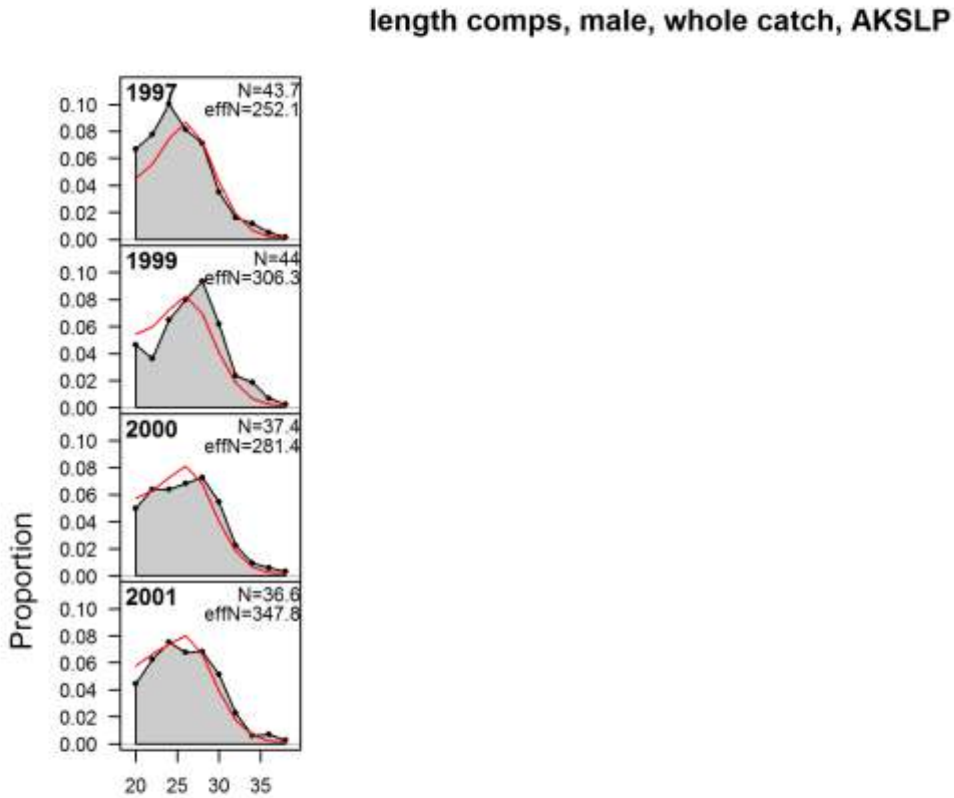



**Figure 44. Base case fits to the AFSC slope survey male length composition data for aurora rockfish.**

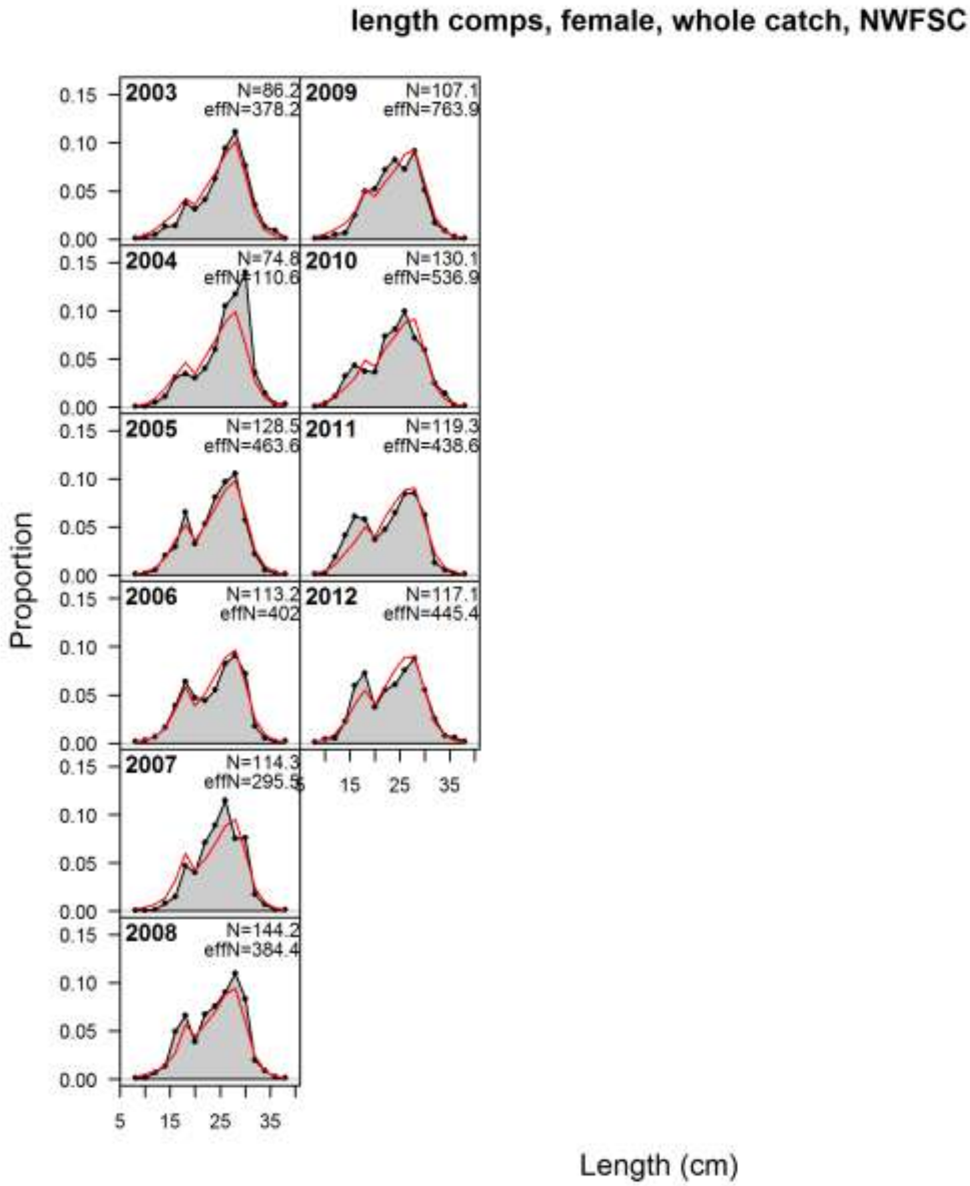



**Figure 45. Base case fits to the NWFSC shelf-slope survey female length composition data for aurora rockfish.**

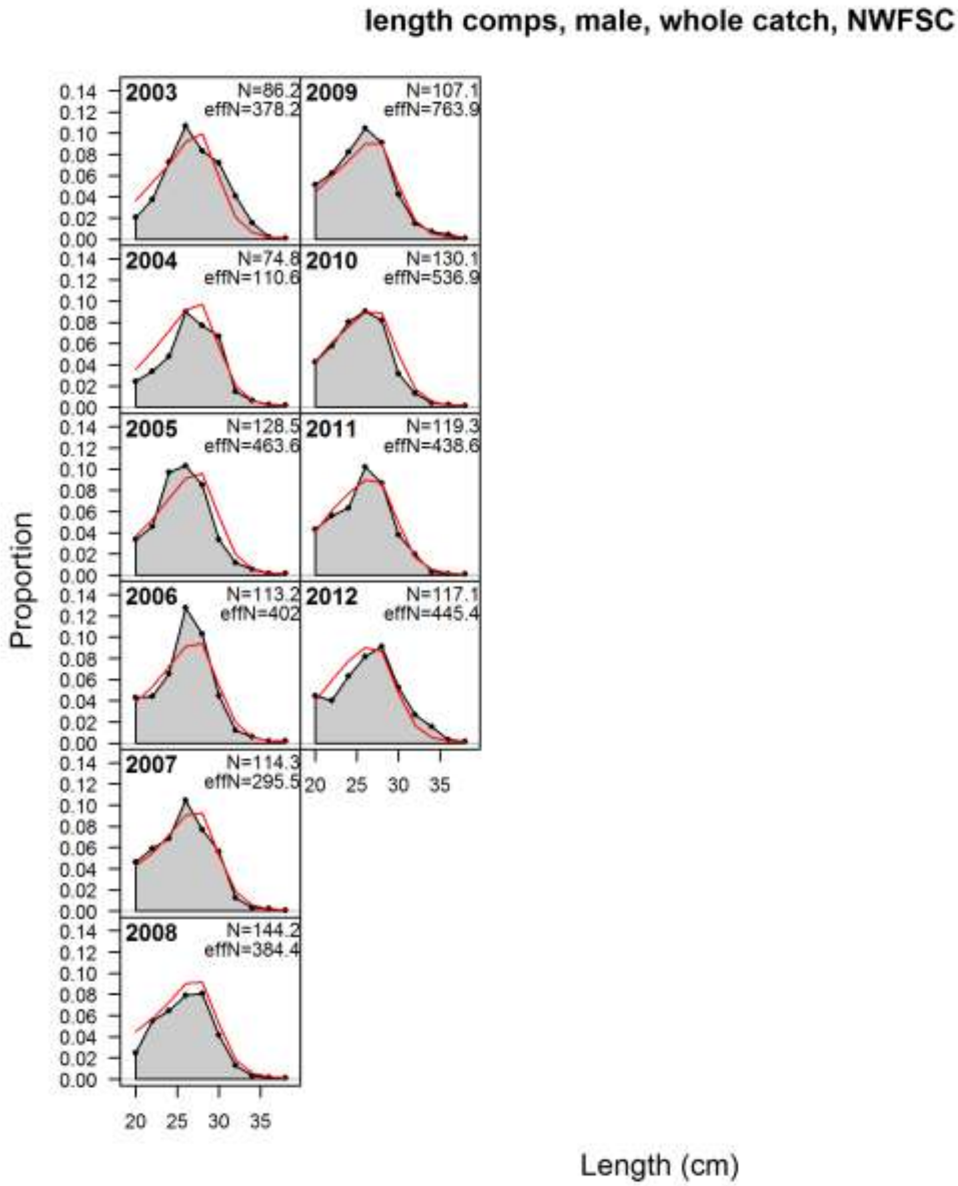



**Figure 46. Base case fits to the NWFSC shelf-slope survey male length composition data for aurora rockfish.**

### 9.3.1.3.2 Residuals: Discards

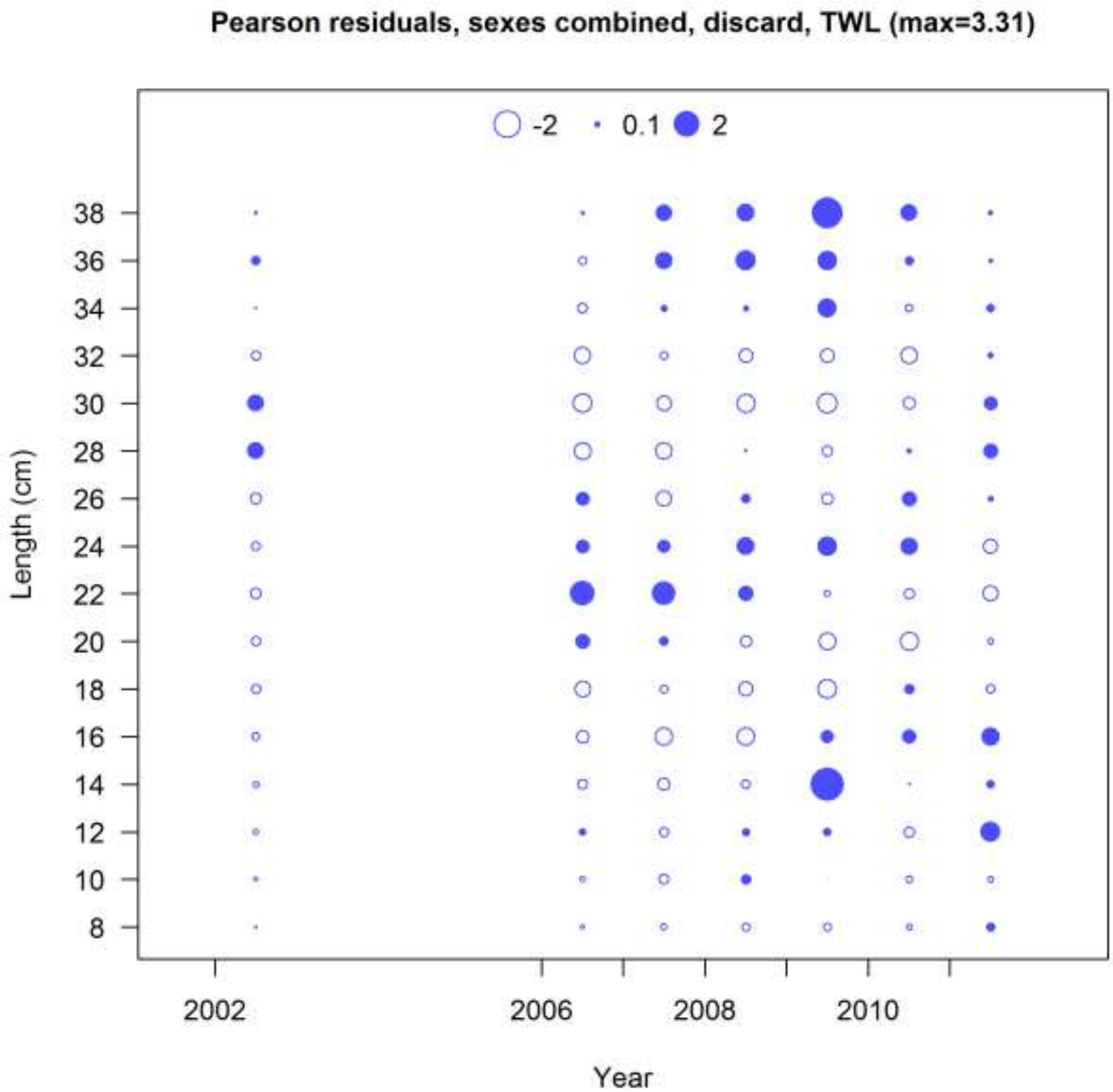



**Figure 47. Residual plots to the trawl fleet combined-sex discard length composition fits.**

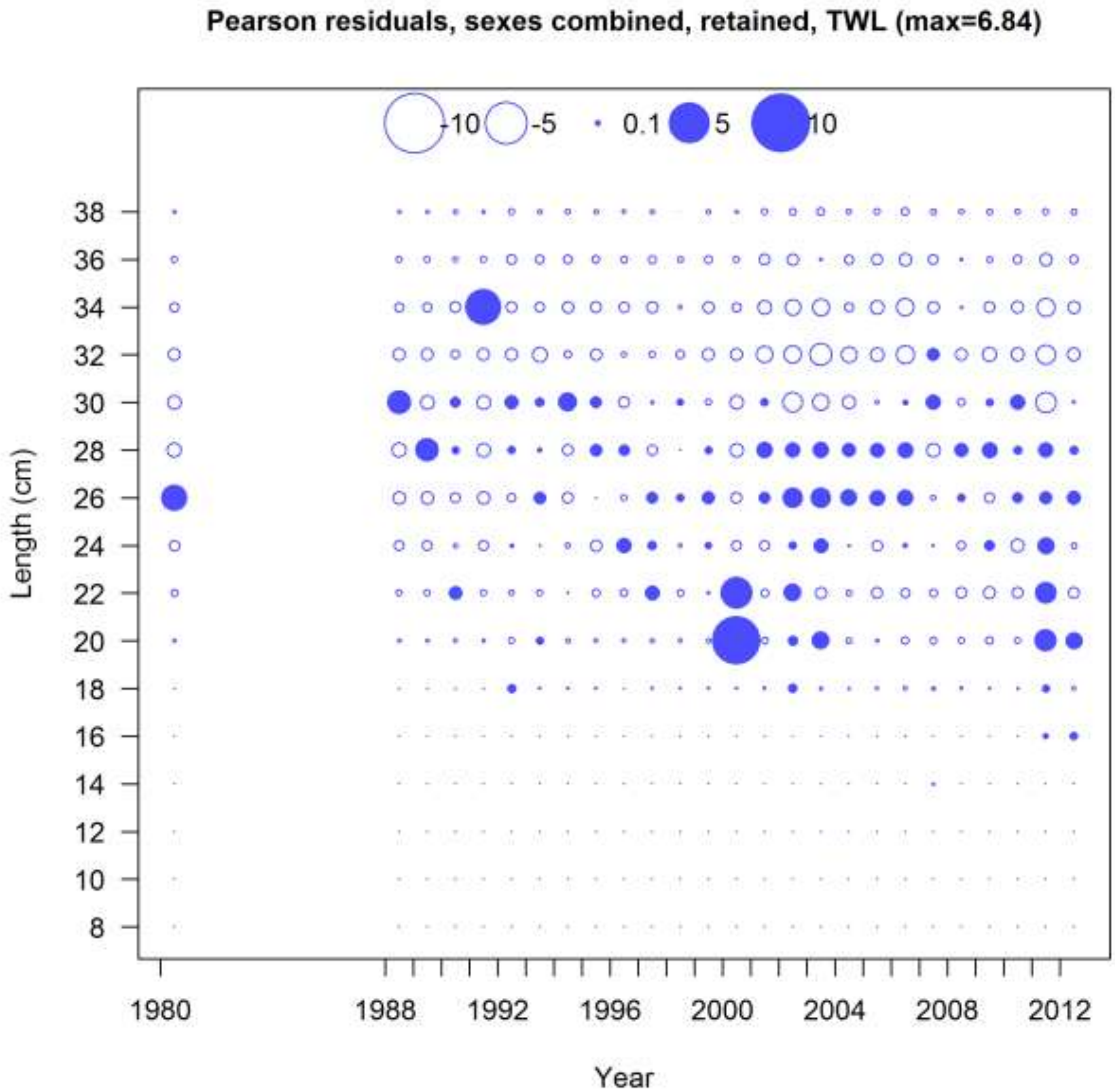



**Figure 48. Residual plots to the trawl fleet combined-sex retained length composition fits.**

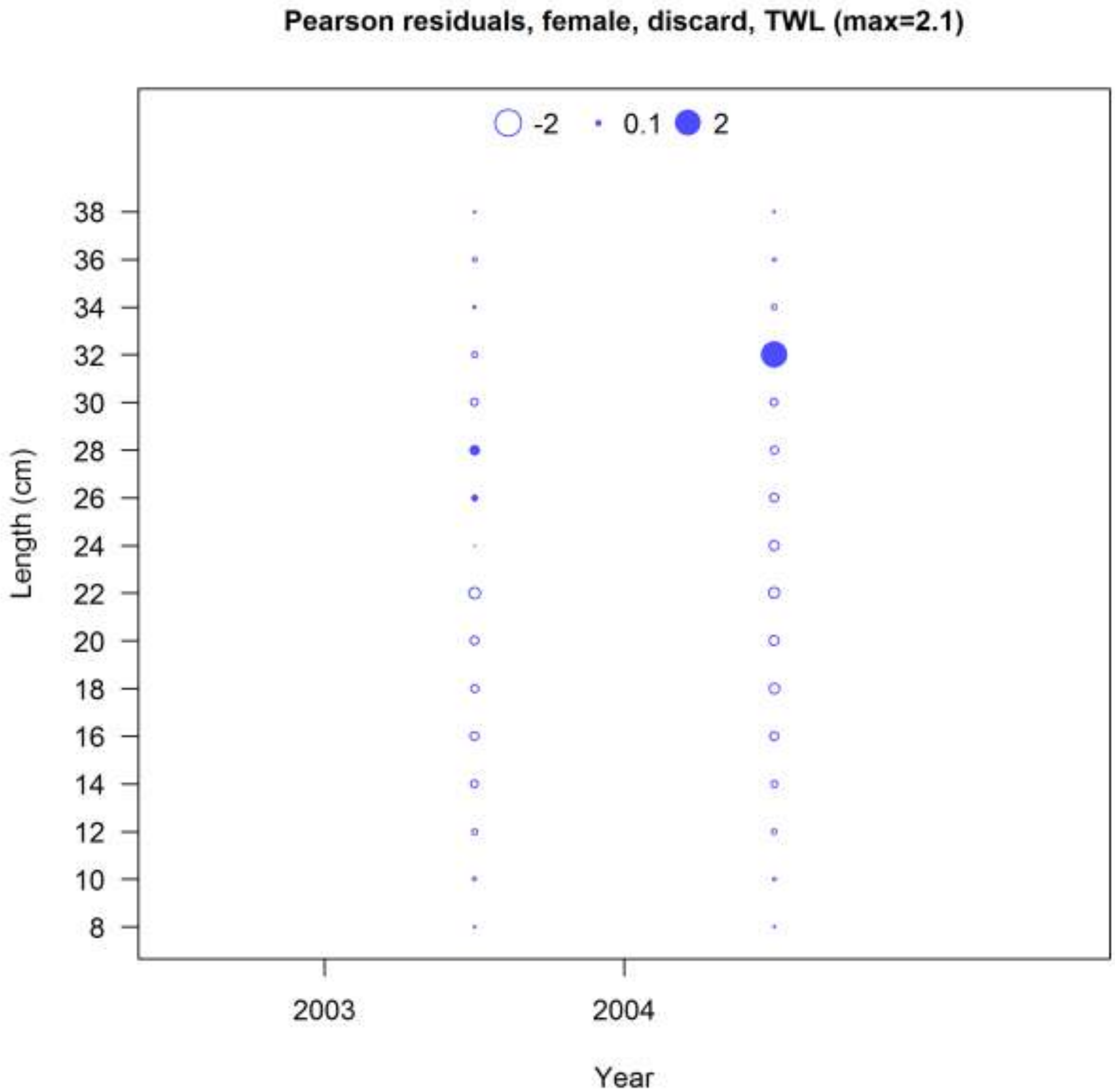



**Figure 49. Residual plots to the trawl fleet female discard length composition fits.**

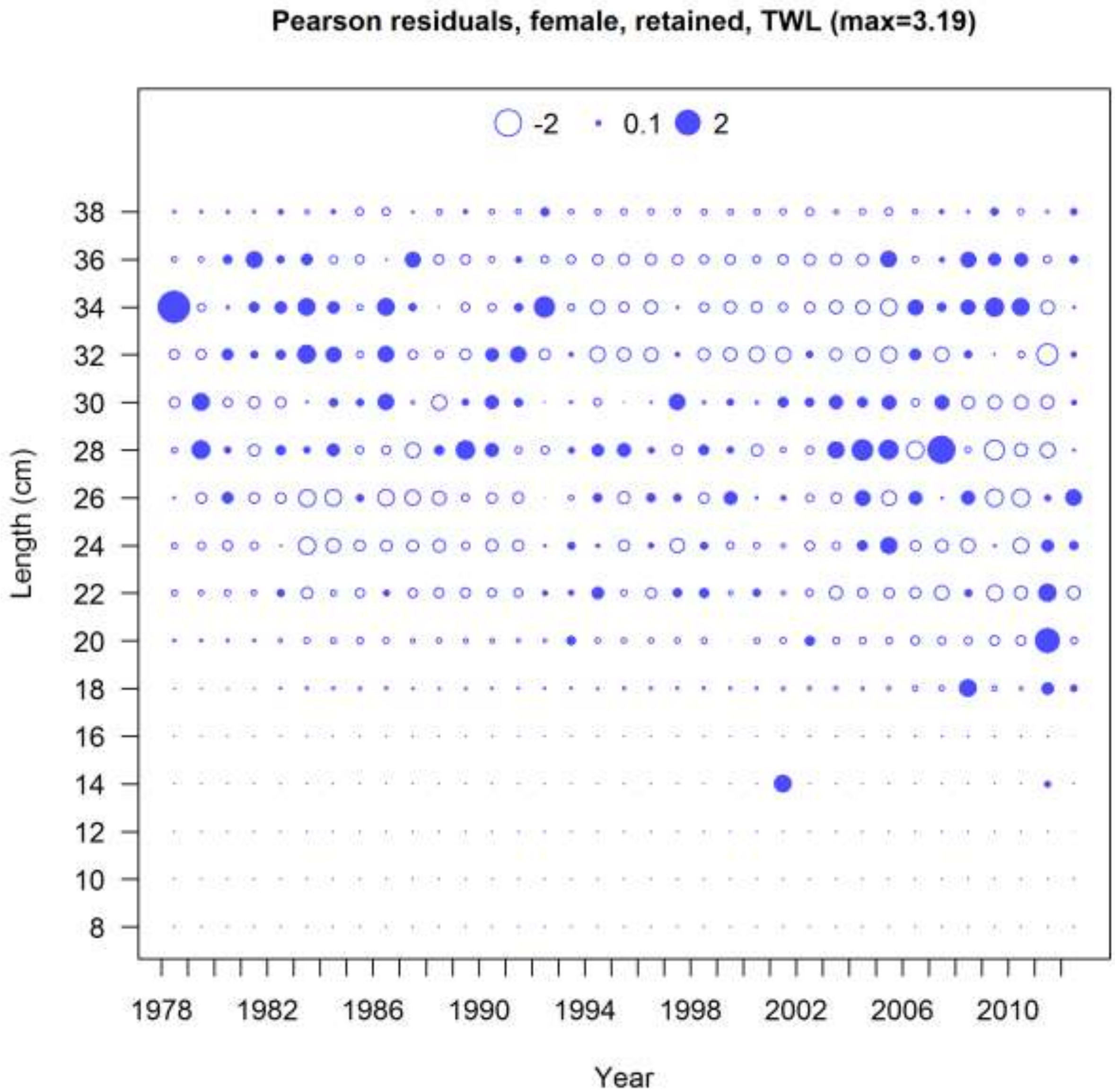



**Figure 50. Residual plots to the trawl fleet female retained length composition fits.**

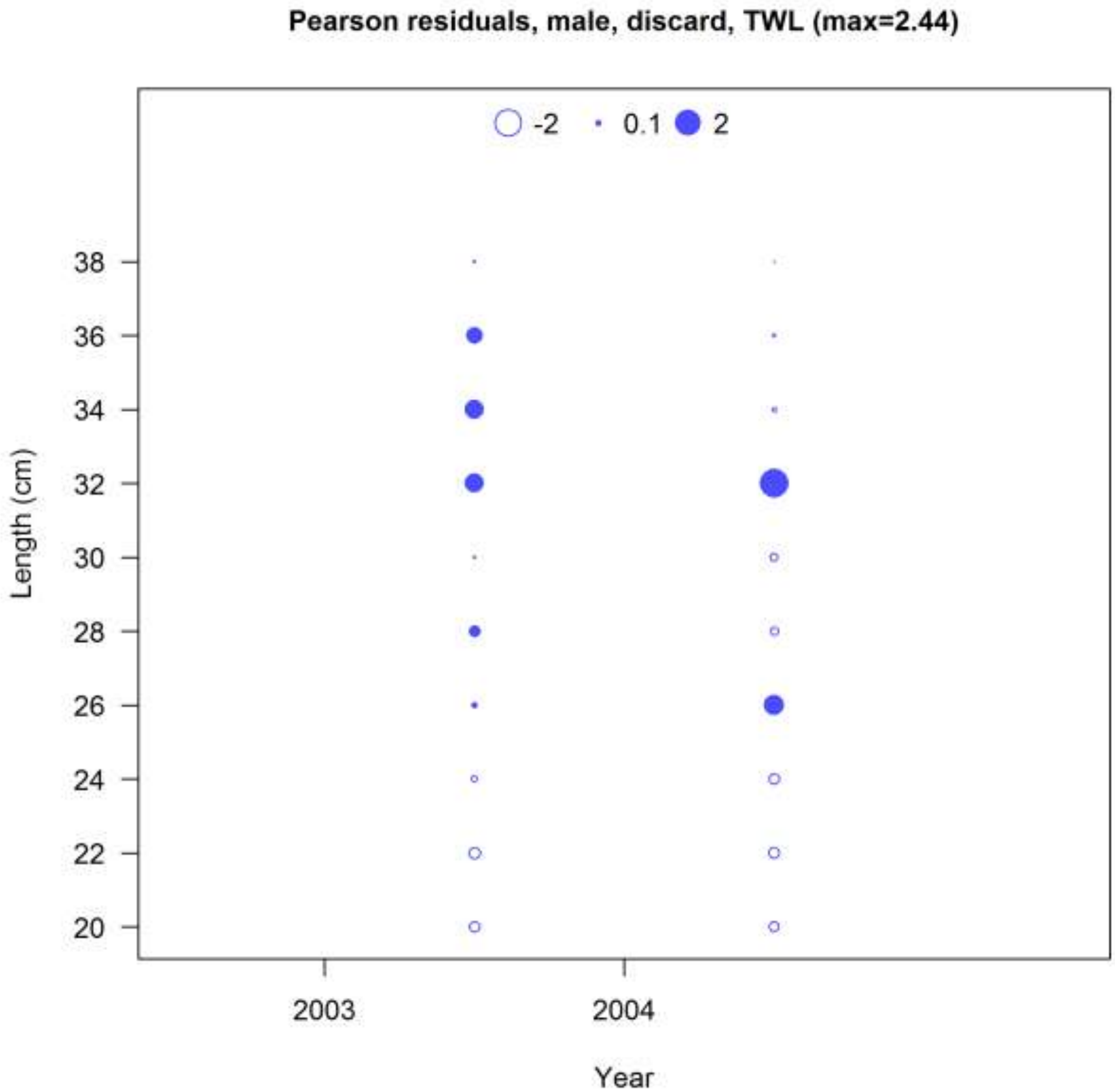



**Figure 51. Residual plots to the trawl fleet male discard length composition fits.**

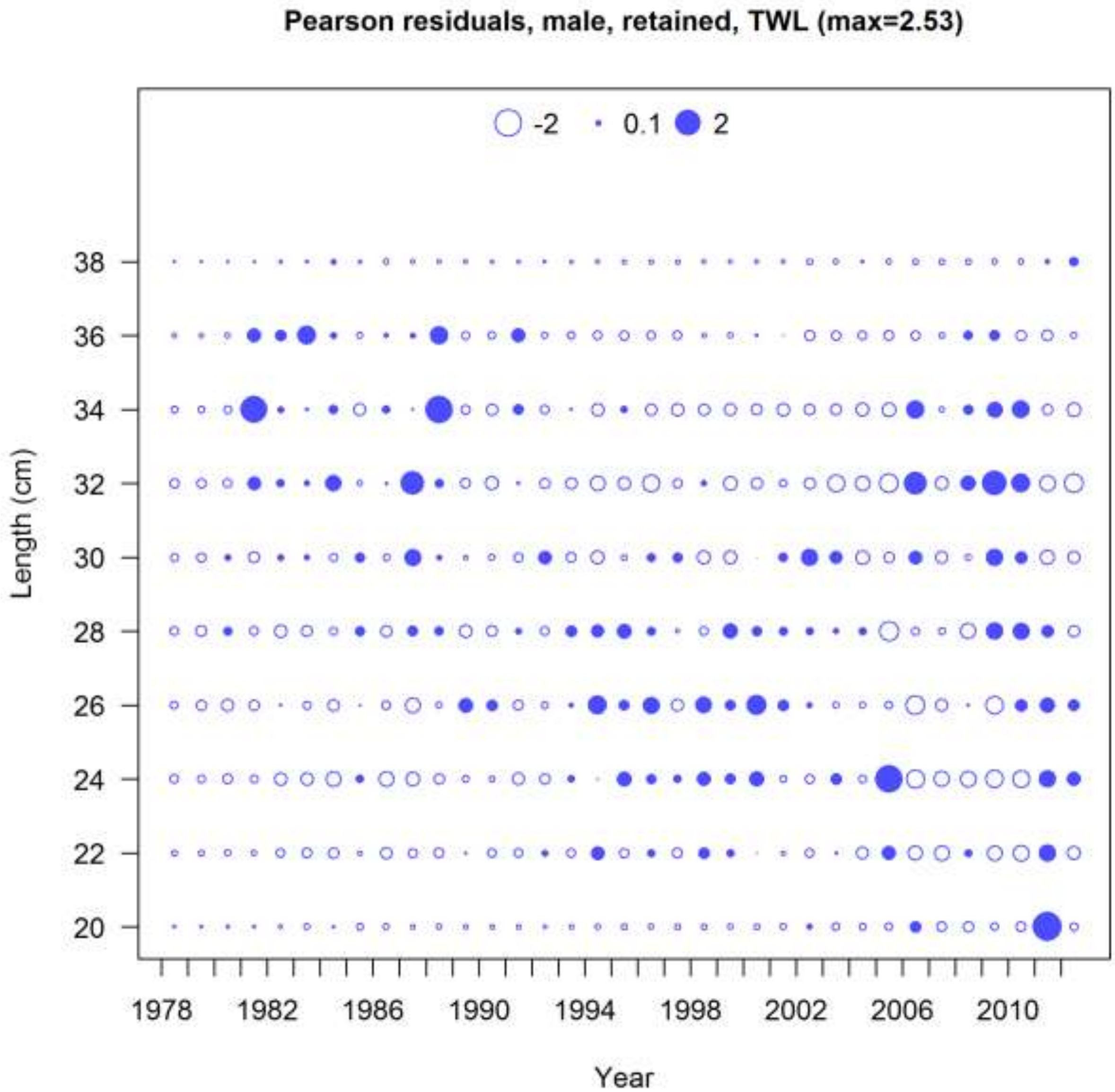



**Figure 52. Residual plots to the trawl fleet male retained length composition fits.**

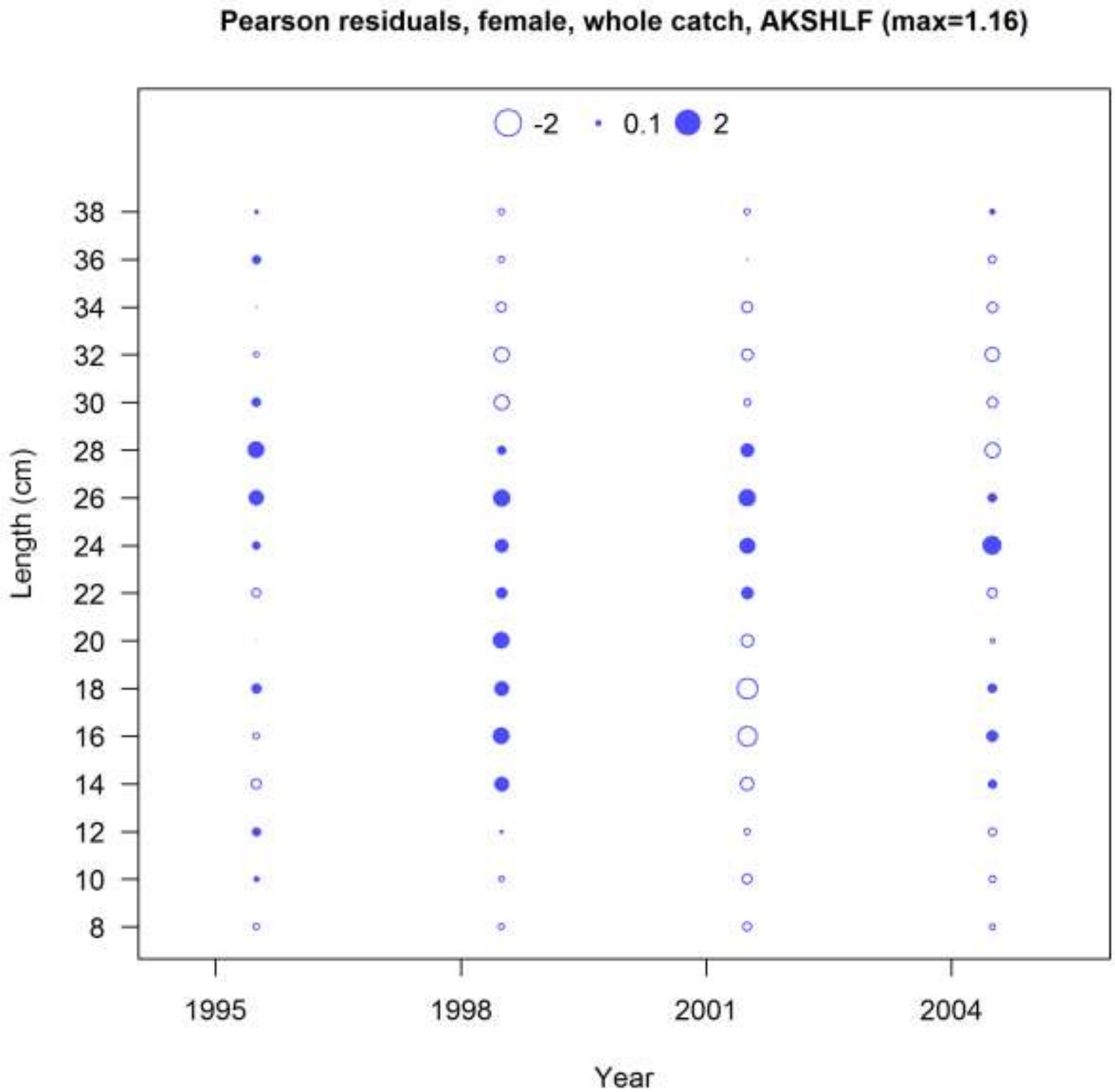



**Figure 53. Residual plots to the AFSC triennial survey female length composition fits.**

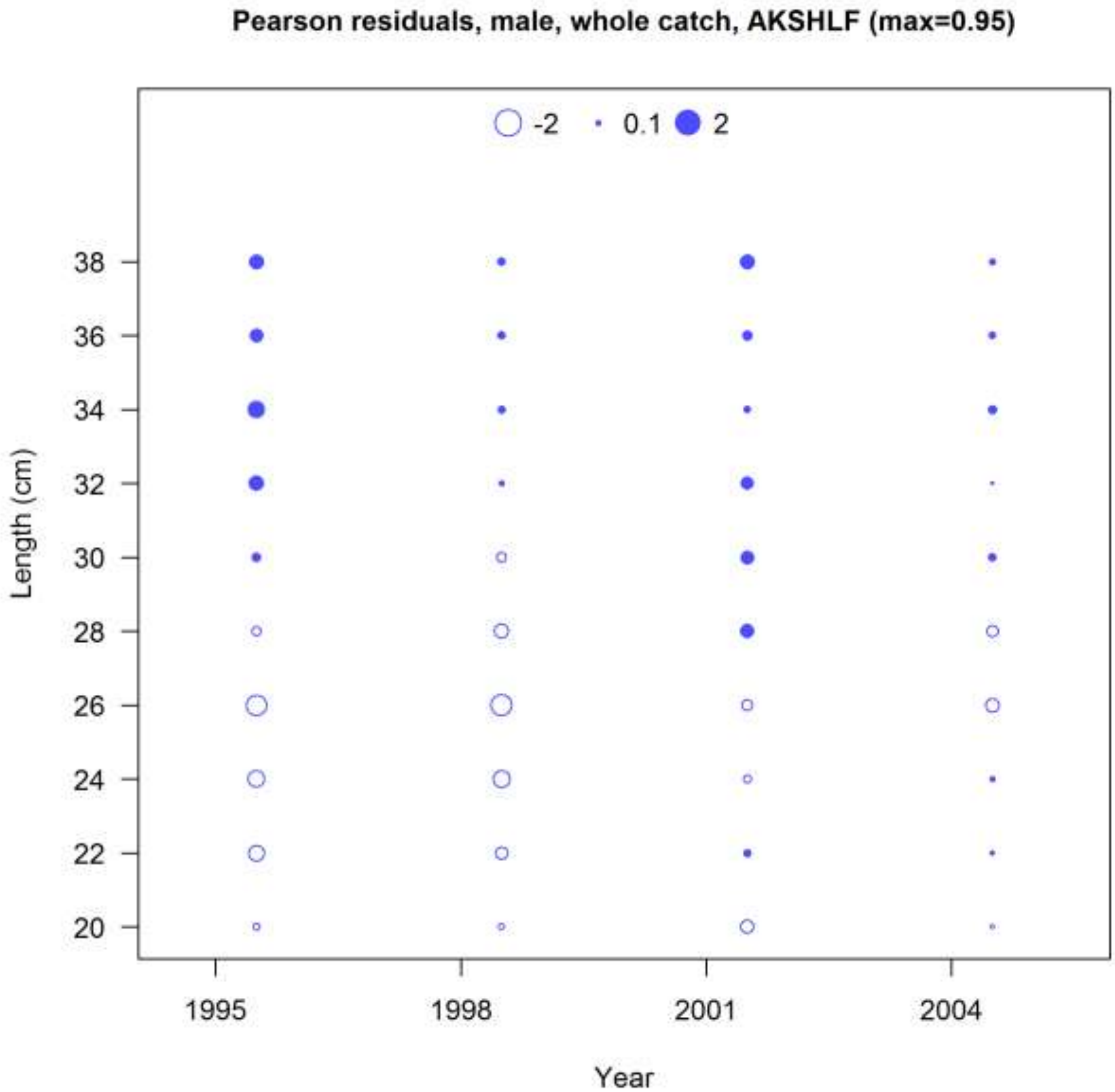



**Figure 54. Residual plots to the AFSC triennial survey male length composition fits.**

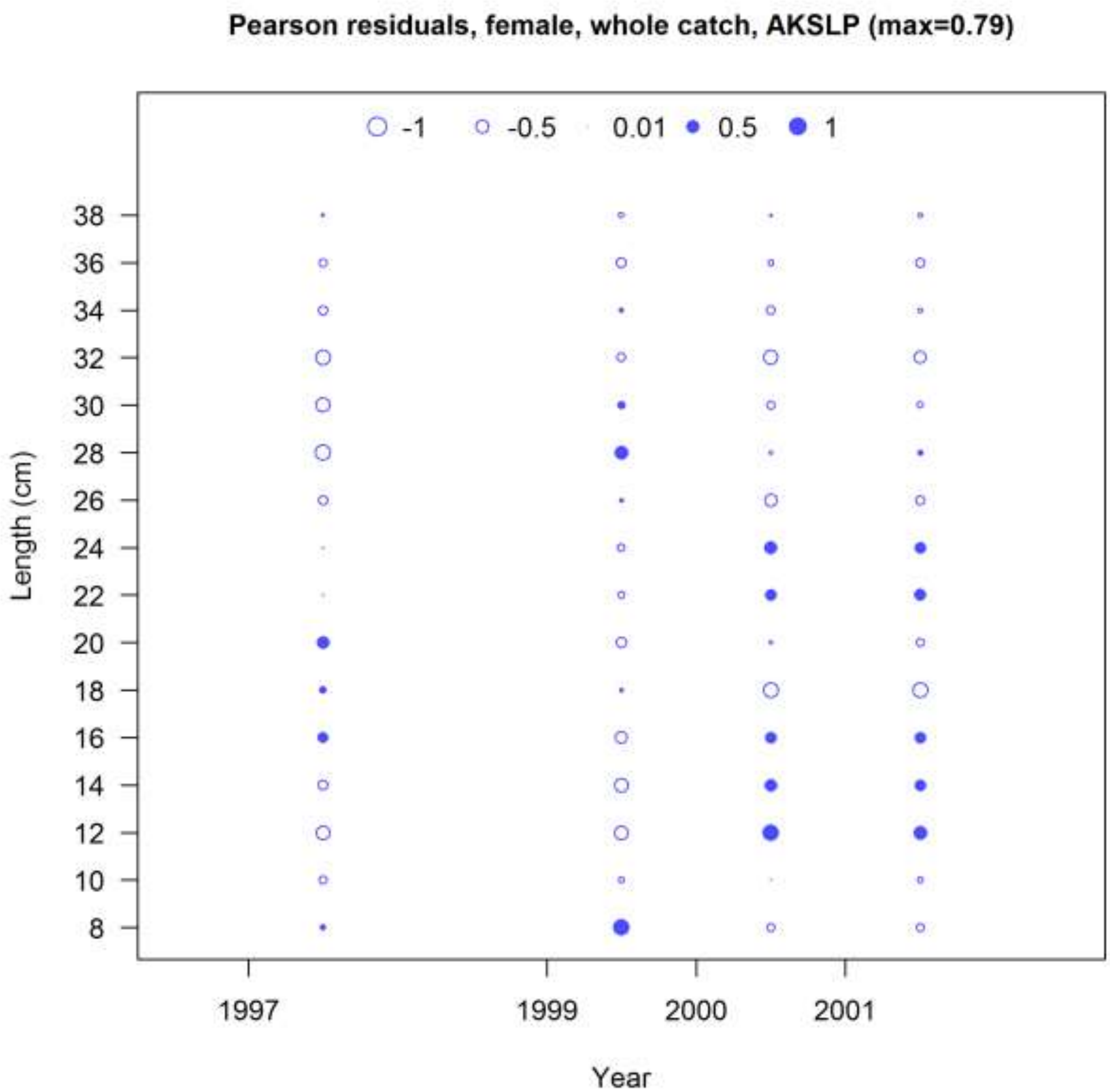



**Figure 55. Residual plots to the AFSC slope survey female length composition fits.**

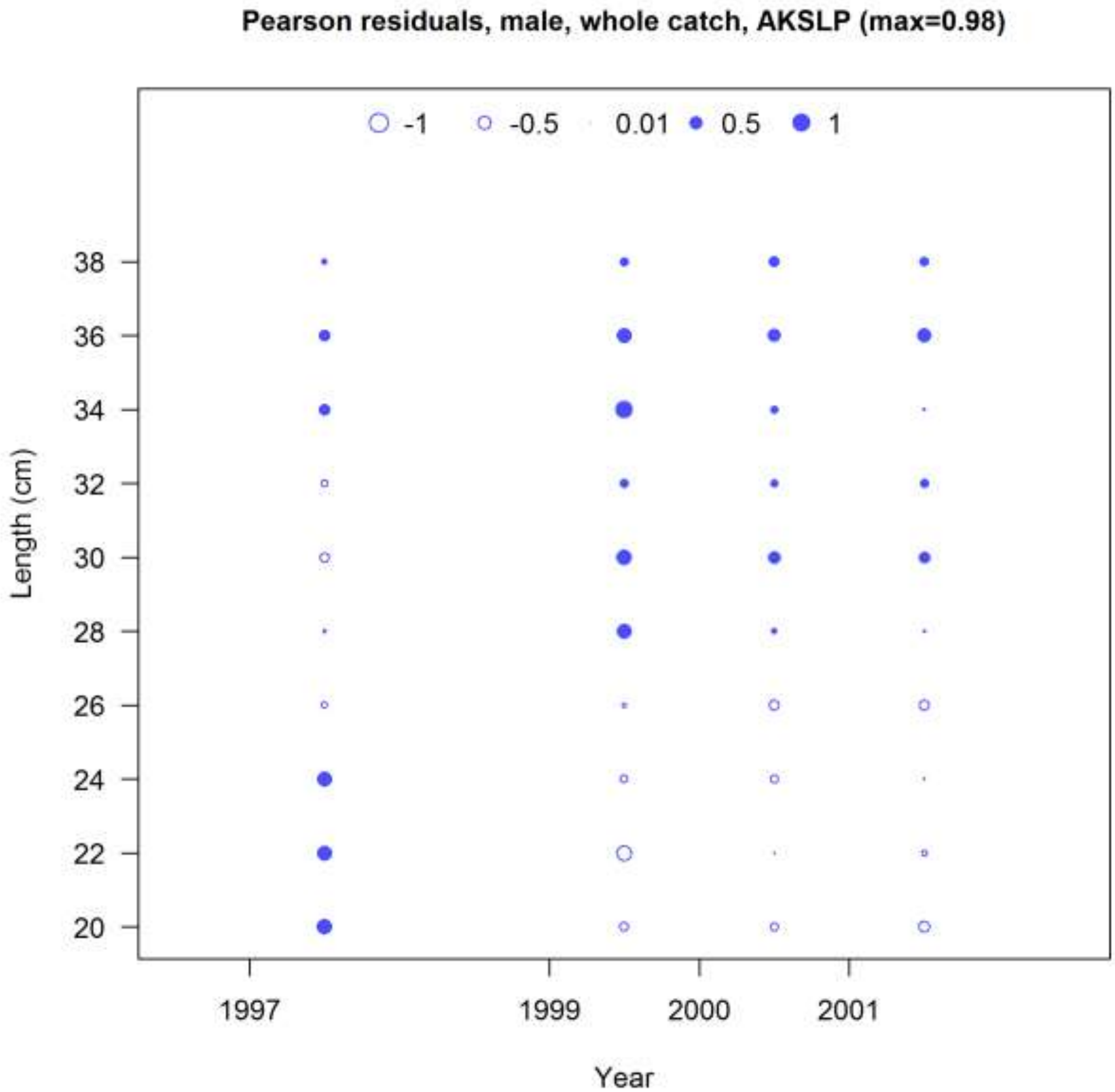



**Figure 56. Residual plots to the AFSC slope survey male length composition fits.**

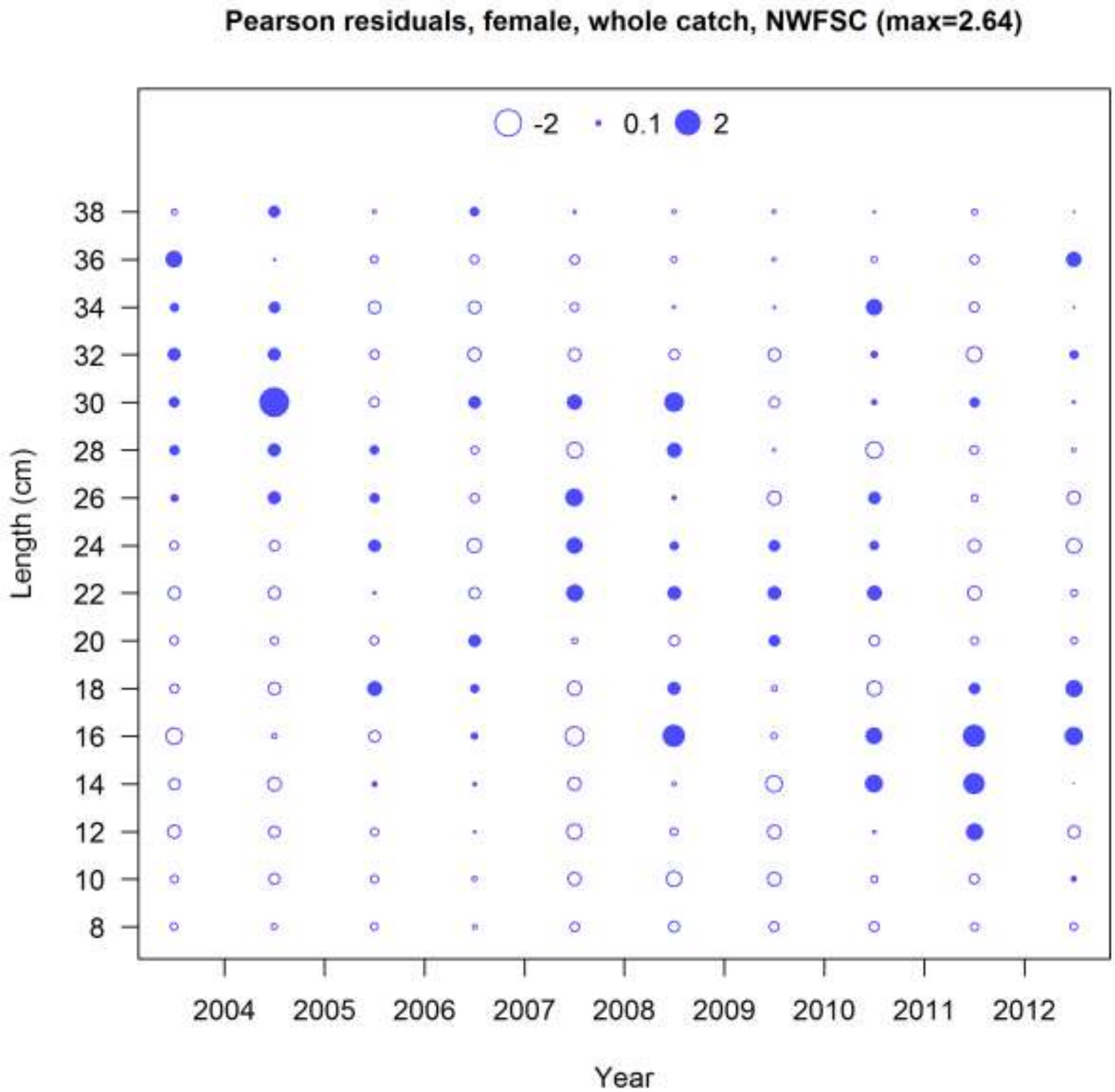



**Figure 57. Residual plots to the NWFSC shelf-slope survey female length composition fits.**

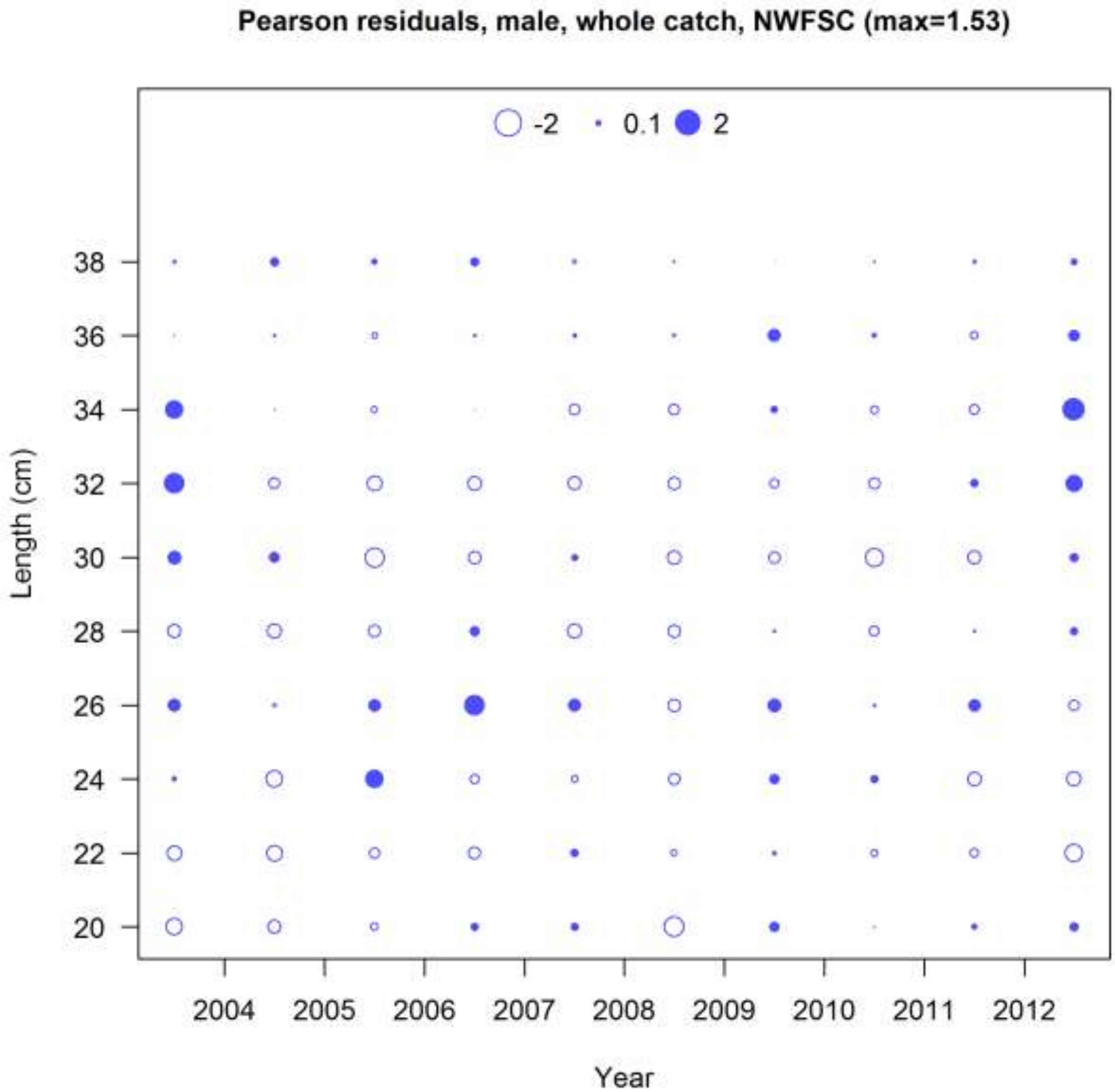



**Figure 58. Residual plots to the NWFSC shelf-slope survey male length composition fits.**

#### 9.3.1.3.3 Effective sample sizes: Discards

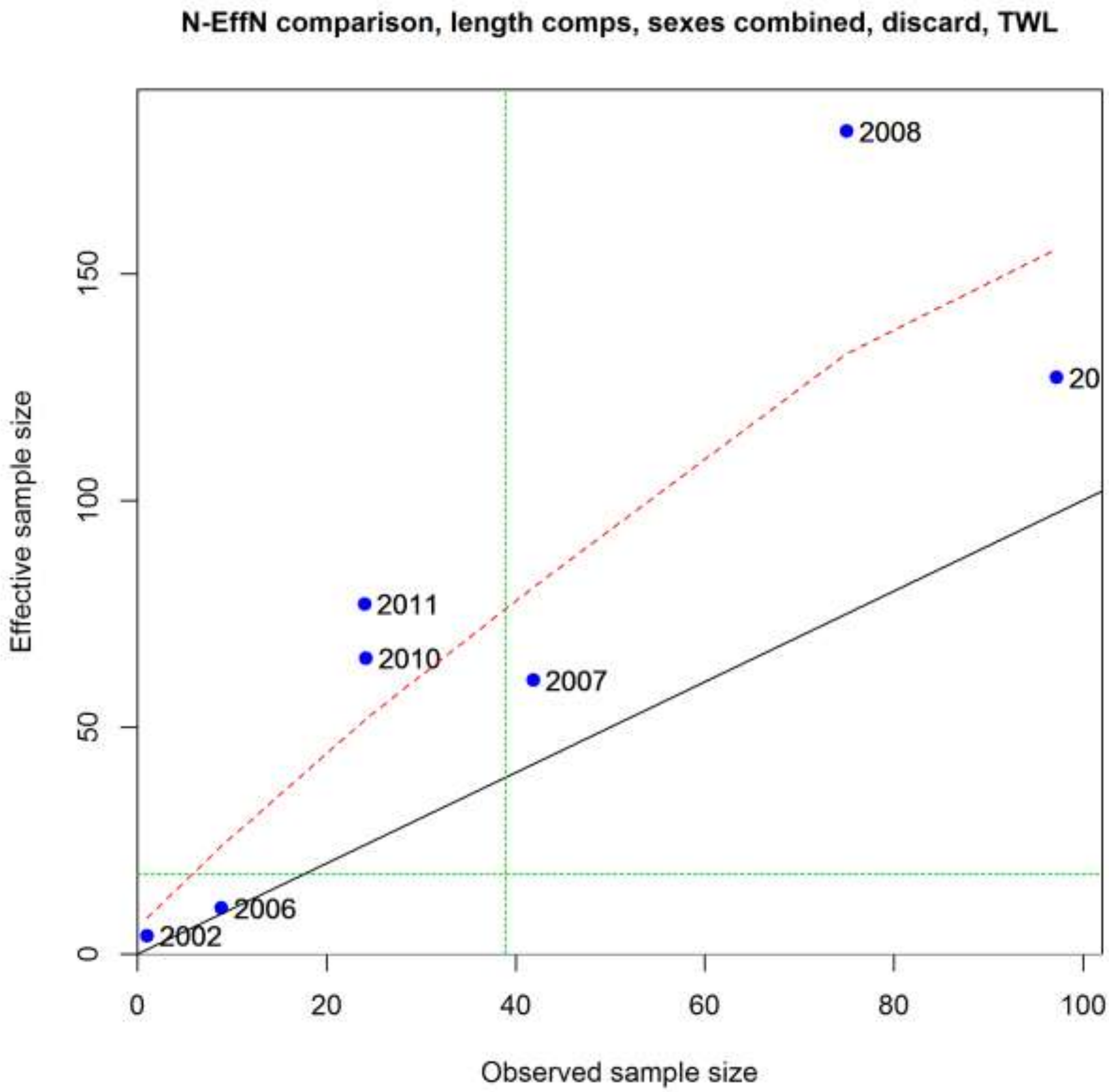



**Figure 59. Observed versus effective sample sizes for the trawl fleet combined-sex discard length compositions. Black solid line is the 1:1 line. Red broken line is the lowess fit.**

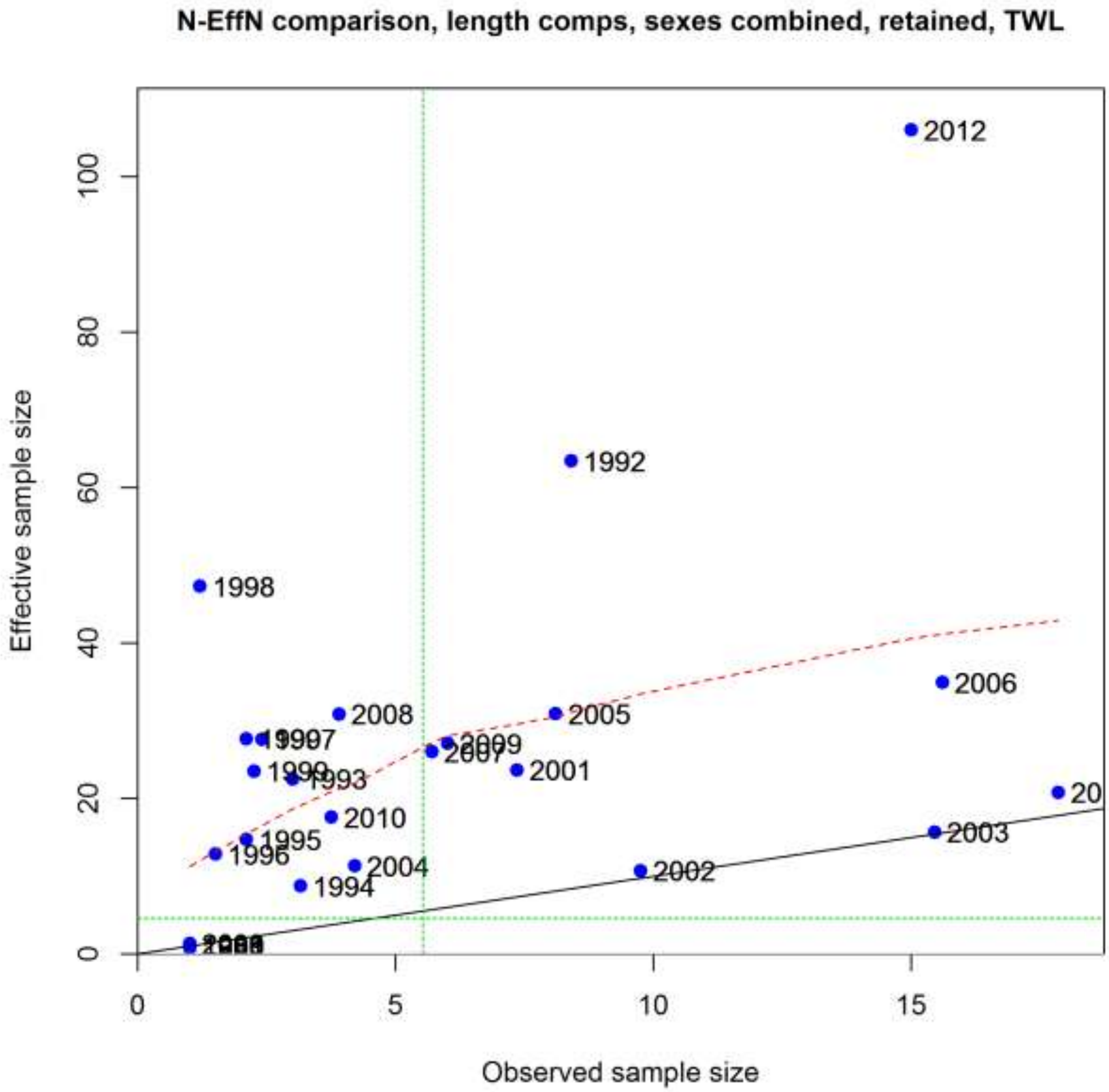



**Figure 60. Observed versus effective sample sizes for the trawl fleet combined-sex retained length compositions. Black solid line is the 1:1 line. Red broken line is the lowess fit.**

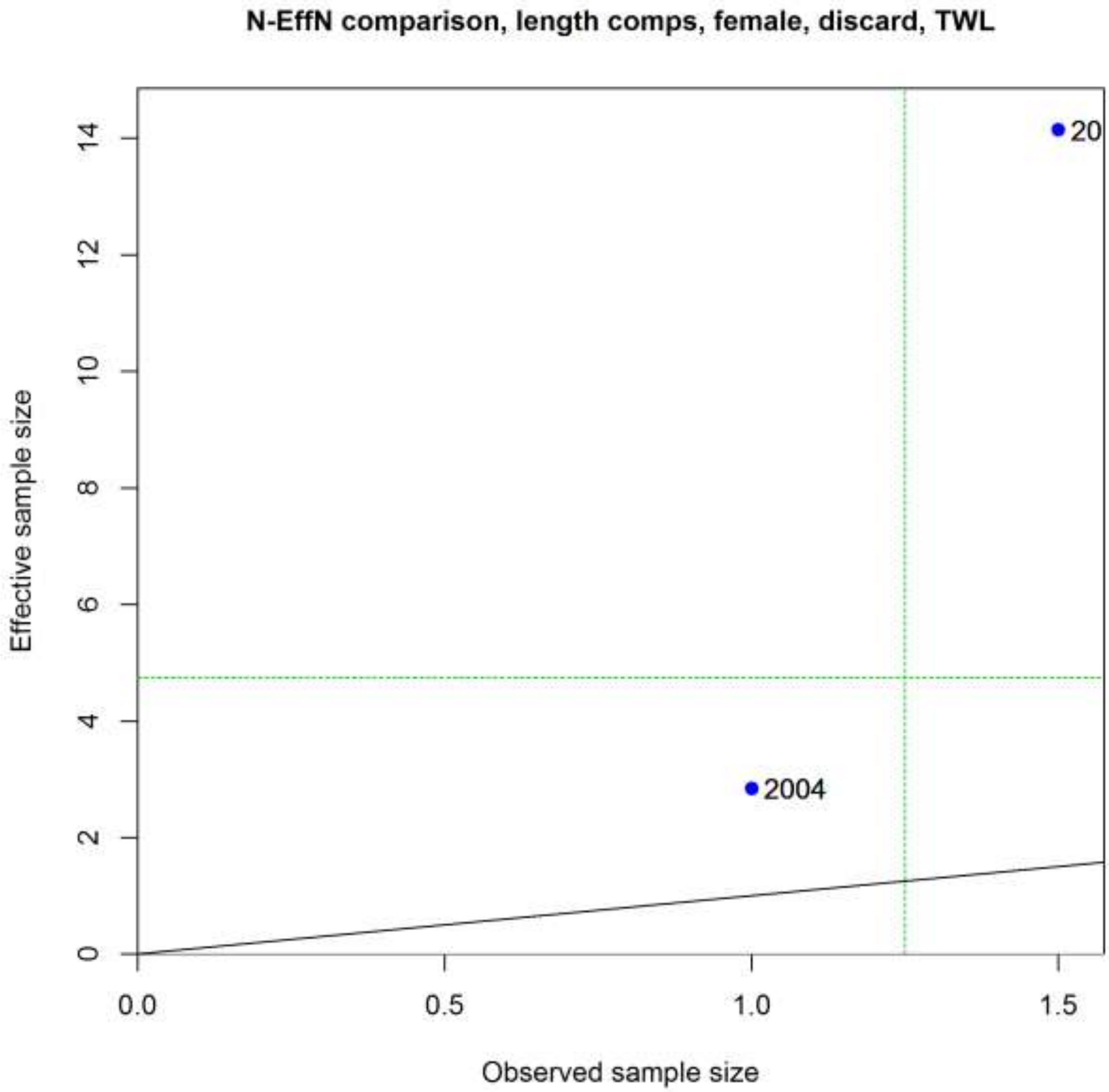



**Figure 61. Observed versus effective sample sizes for the trawl fleet female discard length compositions. Black solid line is the 1:1 line. Red broken line is the lowess fit.**

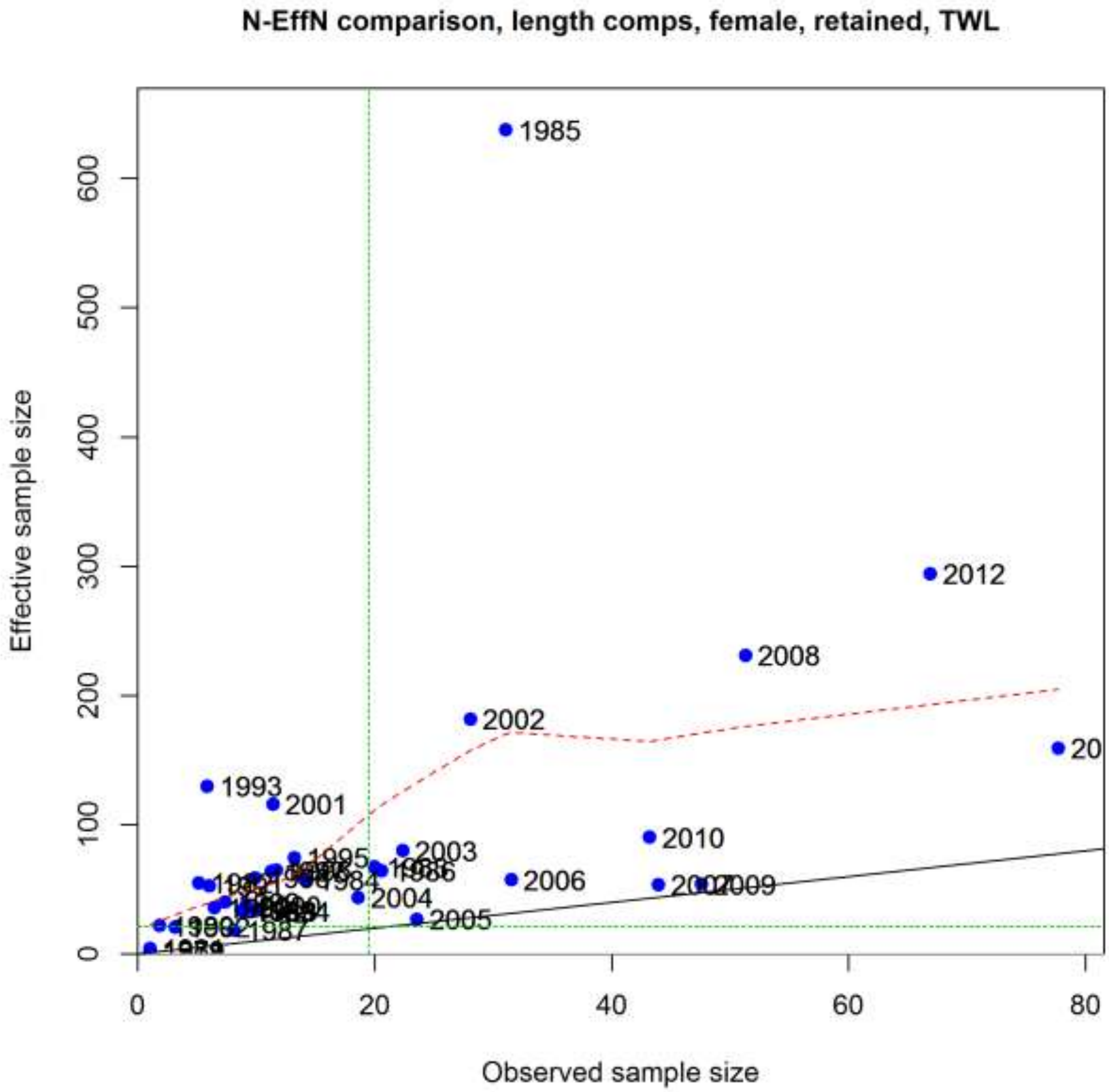



**Figure 62. Observed versus effective sample sizes for the trawl fleet female retained length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

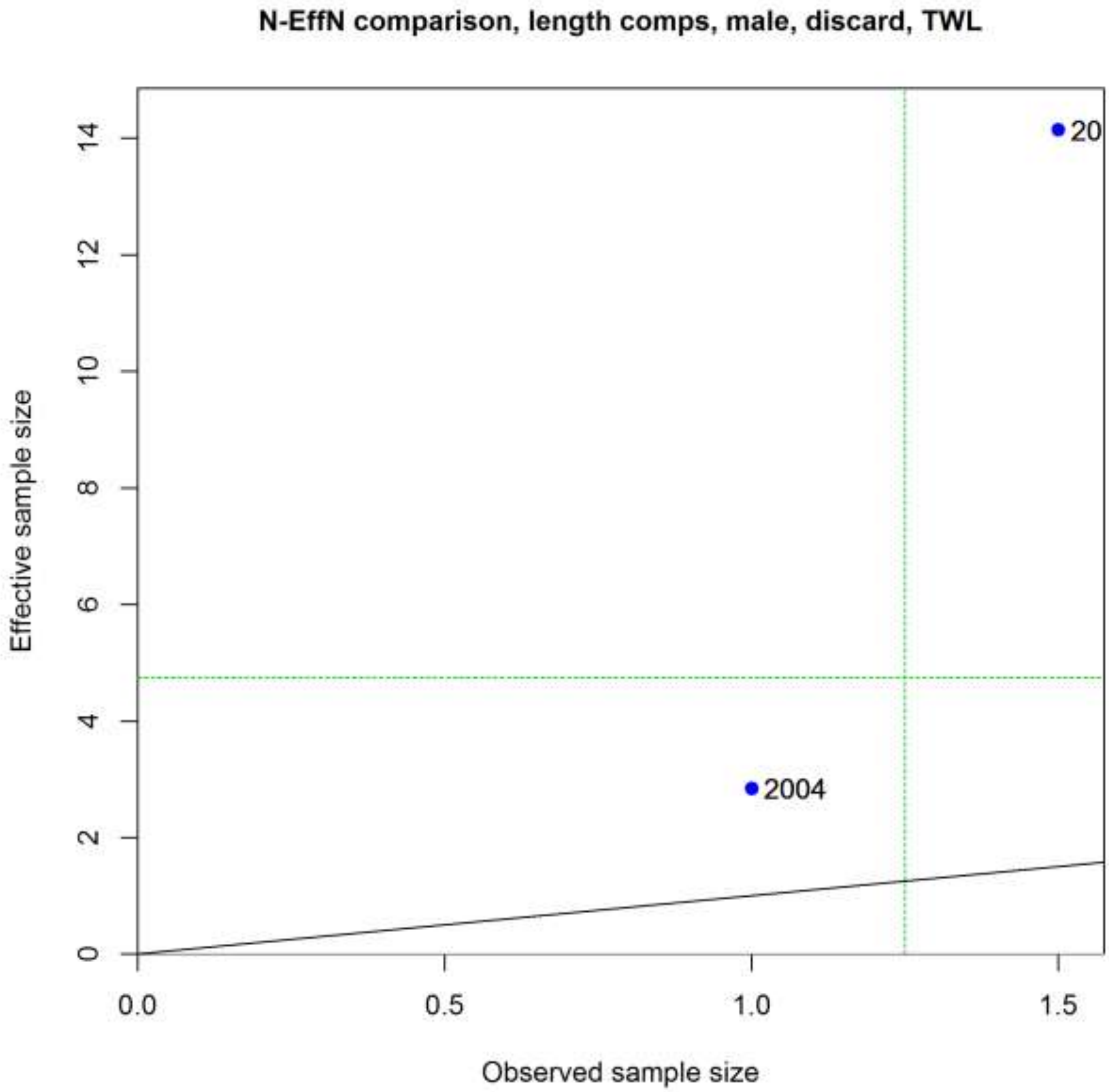



**Figure 63. Observed versus effective sample sizes for the trawl fleet male discard length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

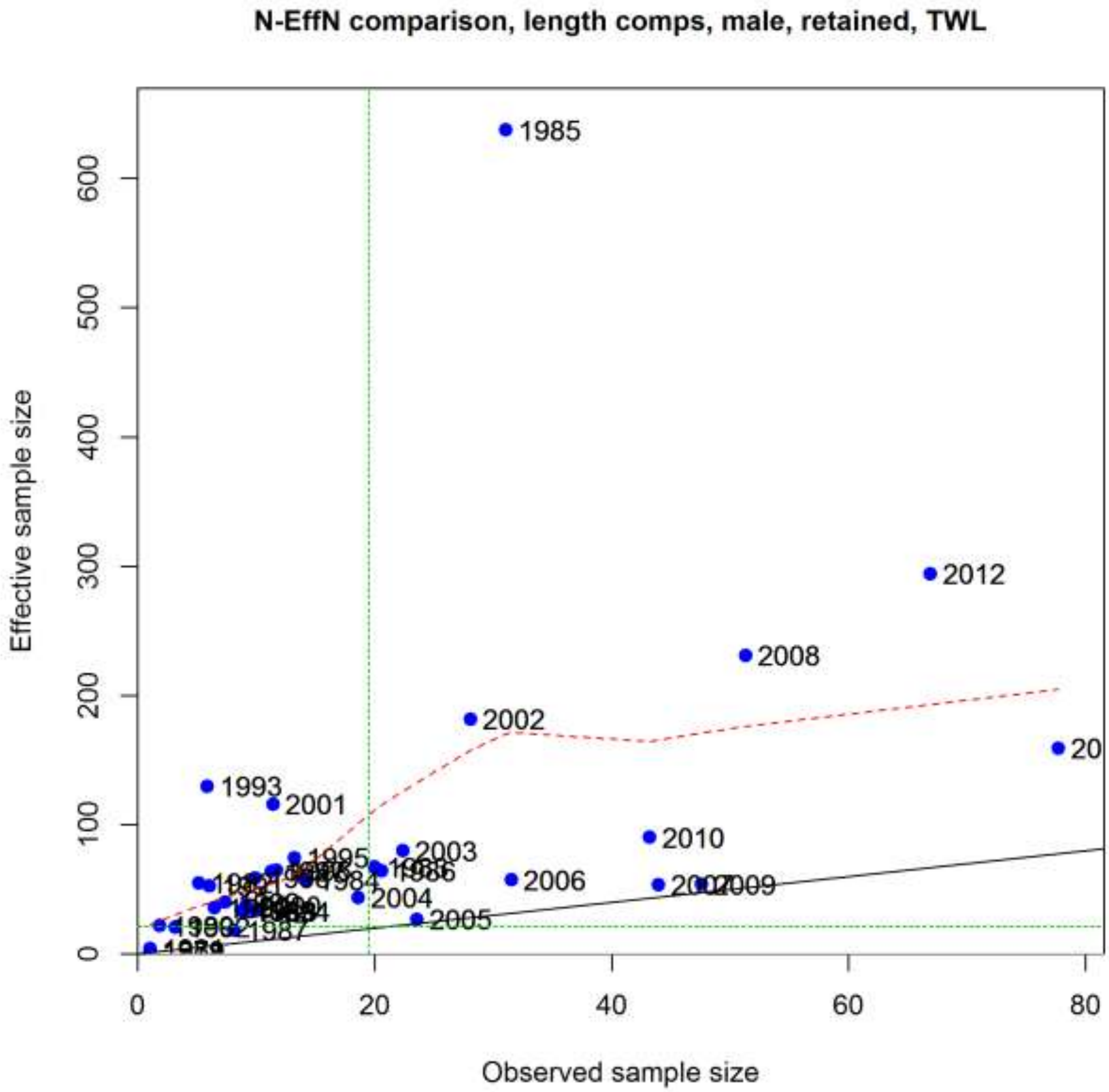



**Figure 64. Observed versus effective sample sizes for the trawl fleet male retained length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

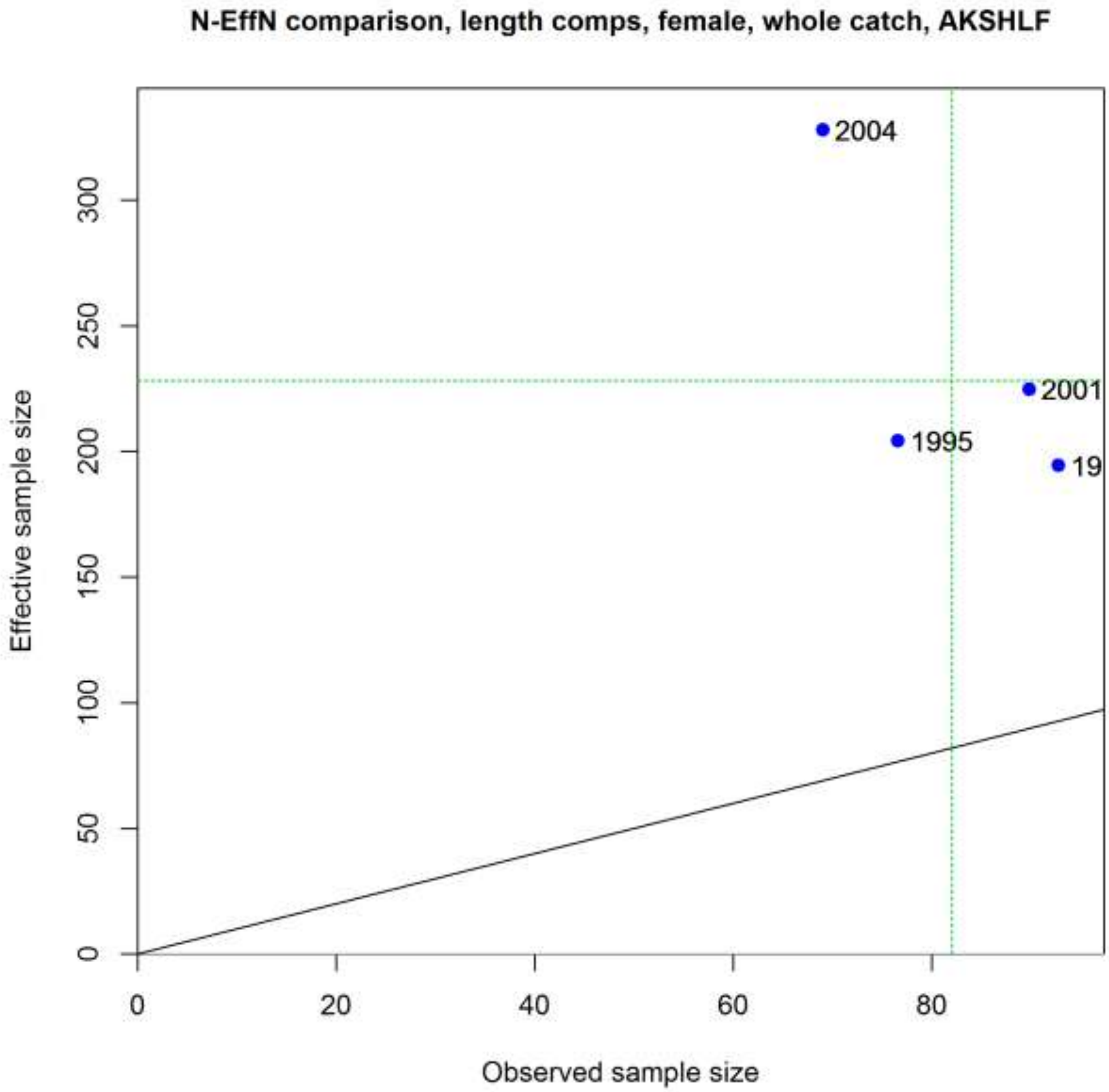



**Figure 65. Observed versus effective sample sizes for the AFSC triennial survey female length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

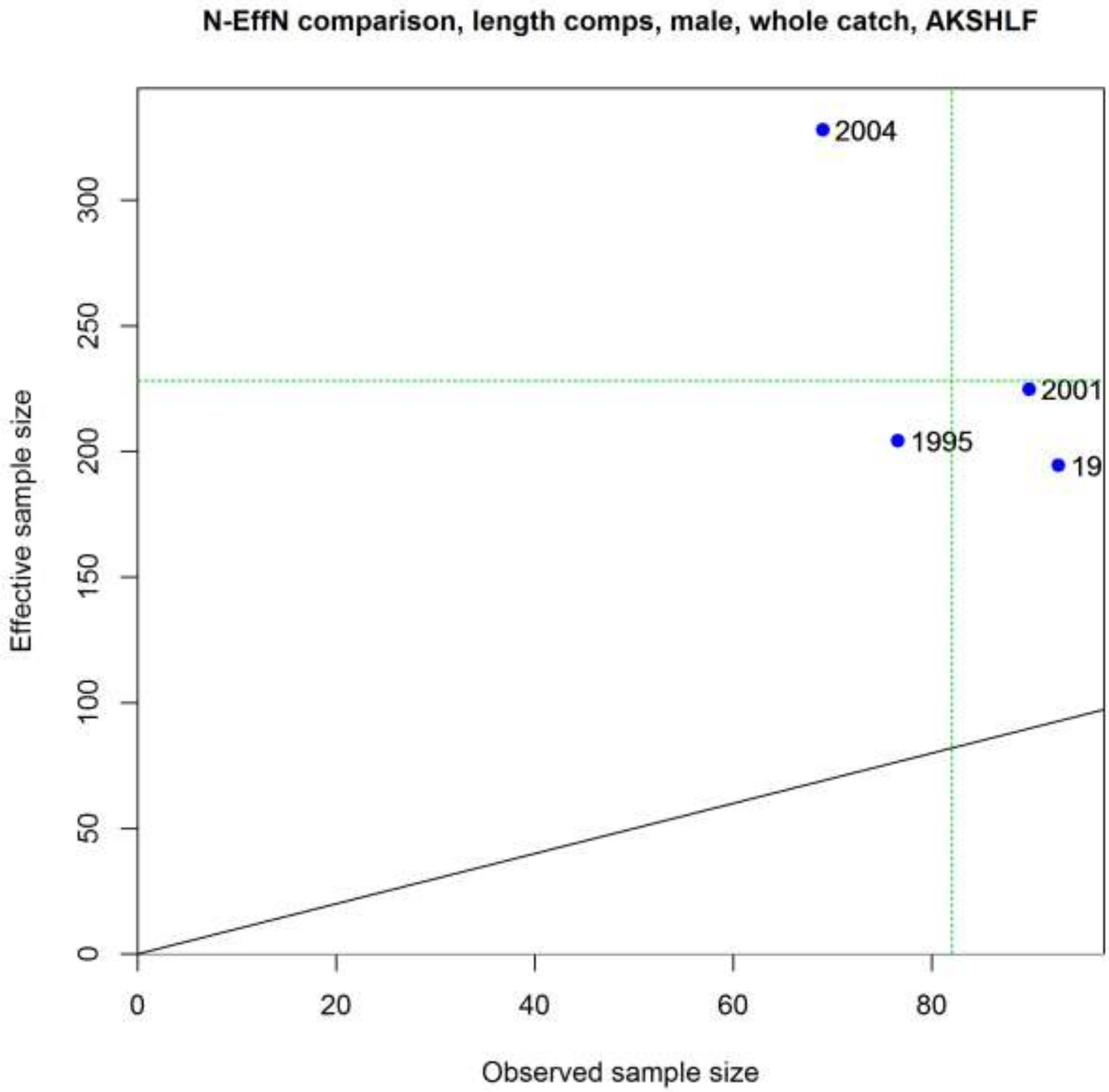



**Figure 66. Observed versus effective sample sizes for the AFSC triennial survey male length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

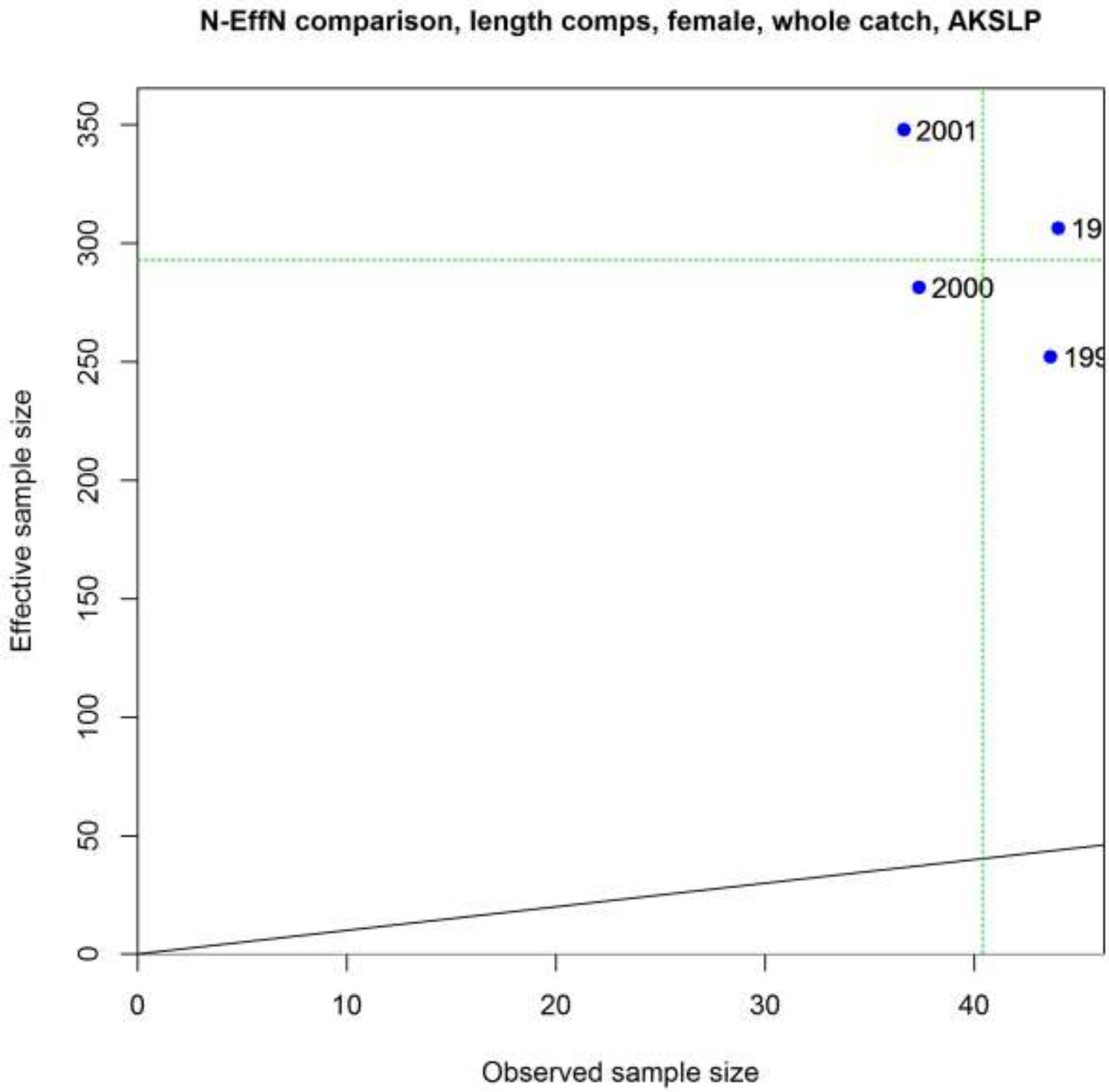



**Figure 67. Observed versus effective sample sizes for the AFSC slope survey female length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

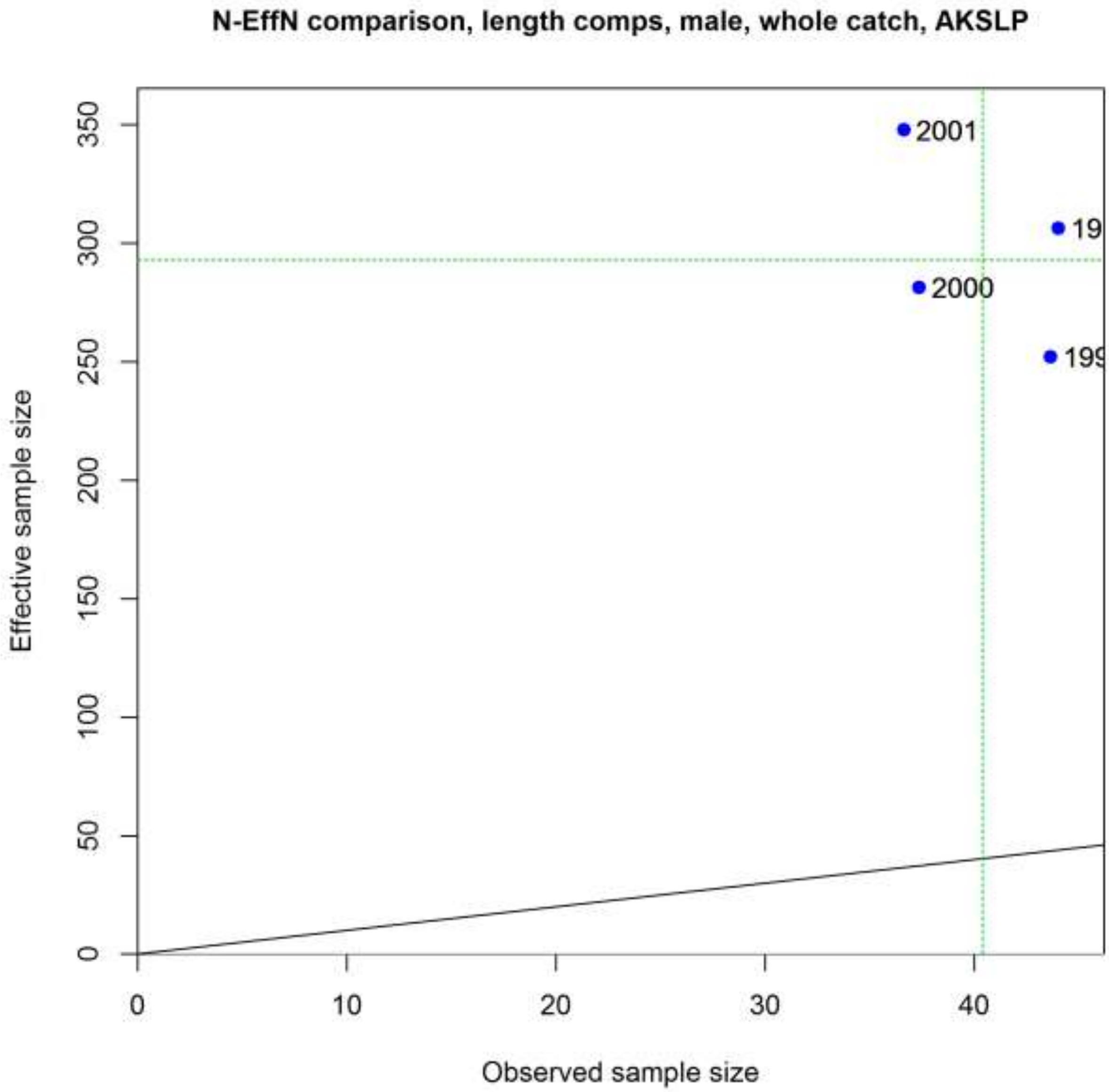



**Figure 68. Observed versus effective sample sizes for the AFSC slope survey male length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

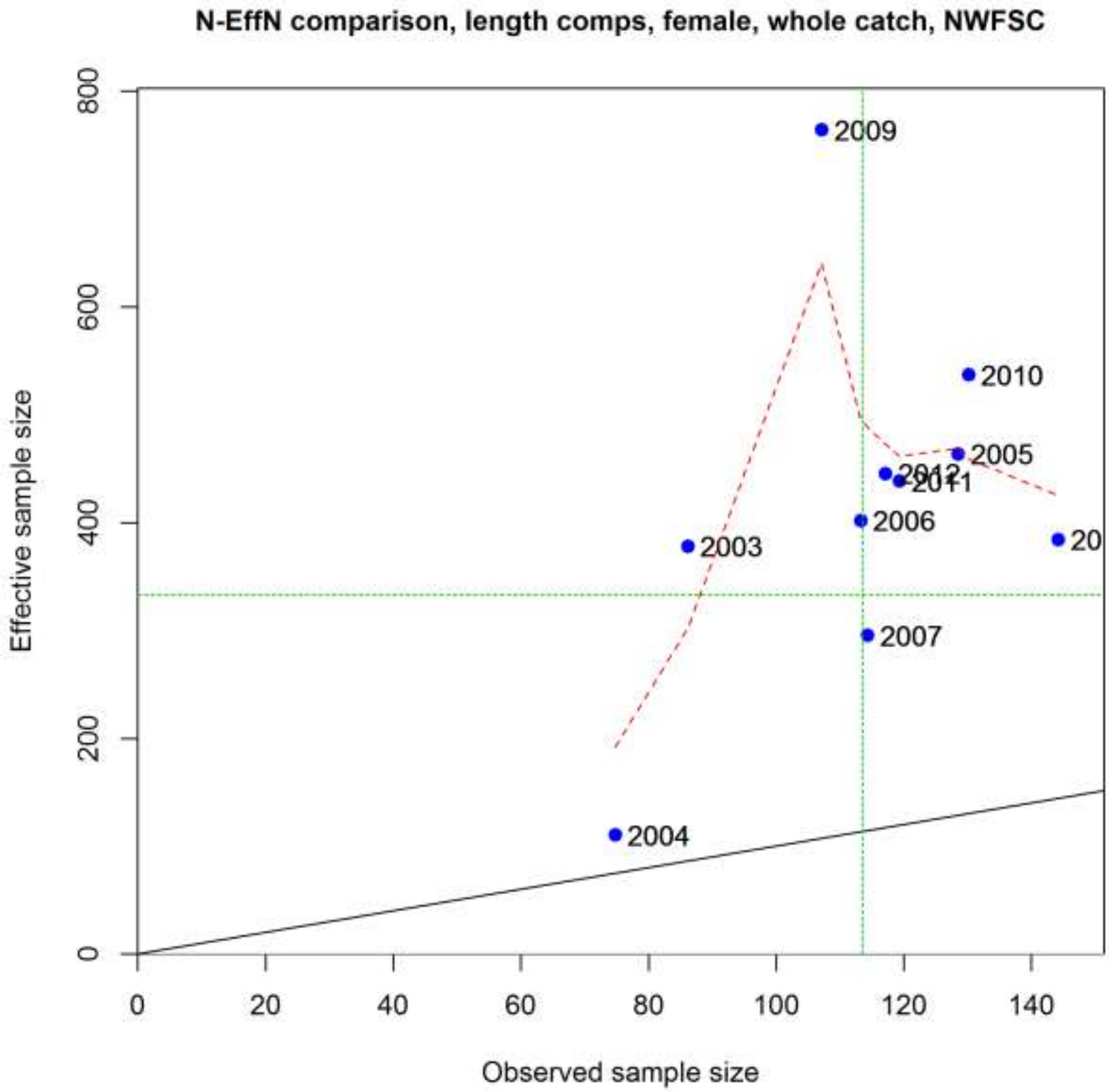



**Figure 69. Observed versus effective sample sizes for the NWFSC shelf-slope survey female length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

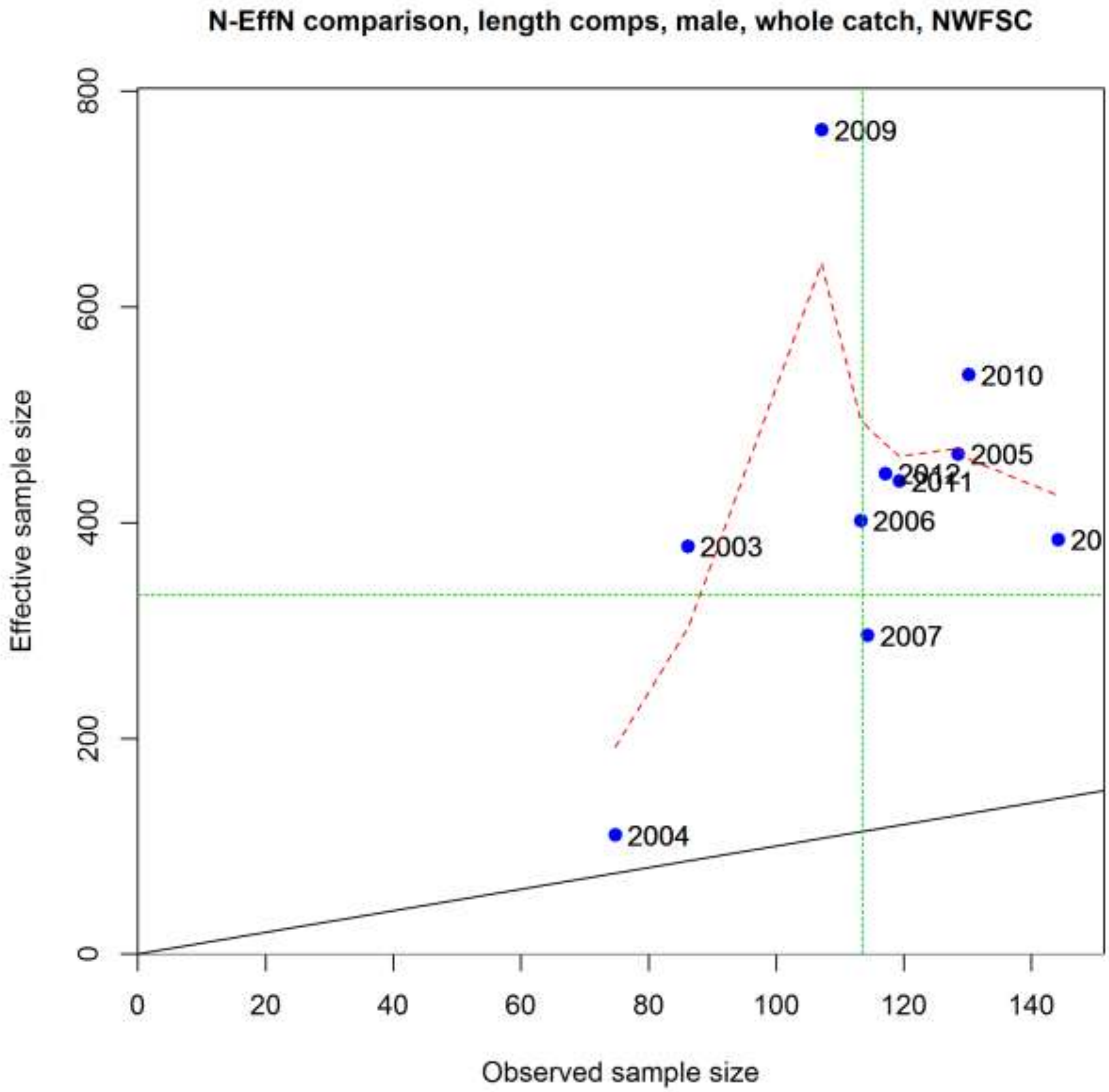



**Figure 70. Observed versus effective sample sizes for the NWFSC shelf-slope survey male length compositions. Black solid line is the 1:1 line. Red broken line is the LOWESS fit.**

### 9.3.1.3.4 Aggregated residuals: Fleets, retained catch

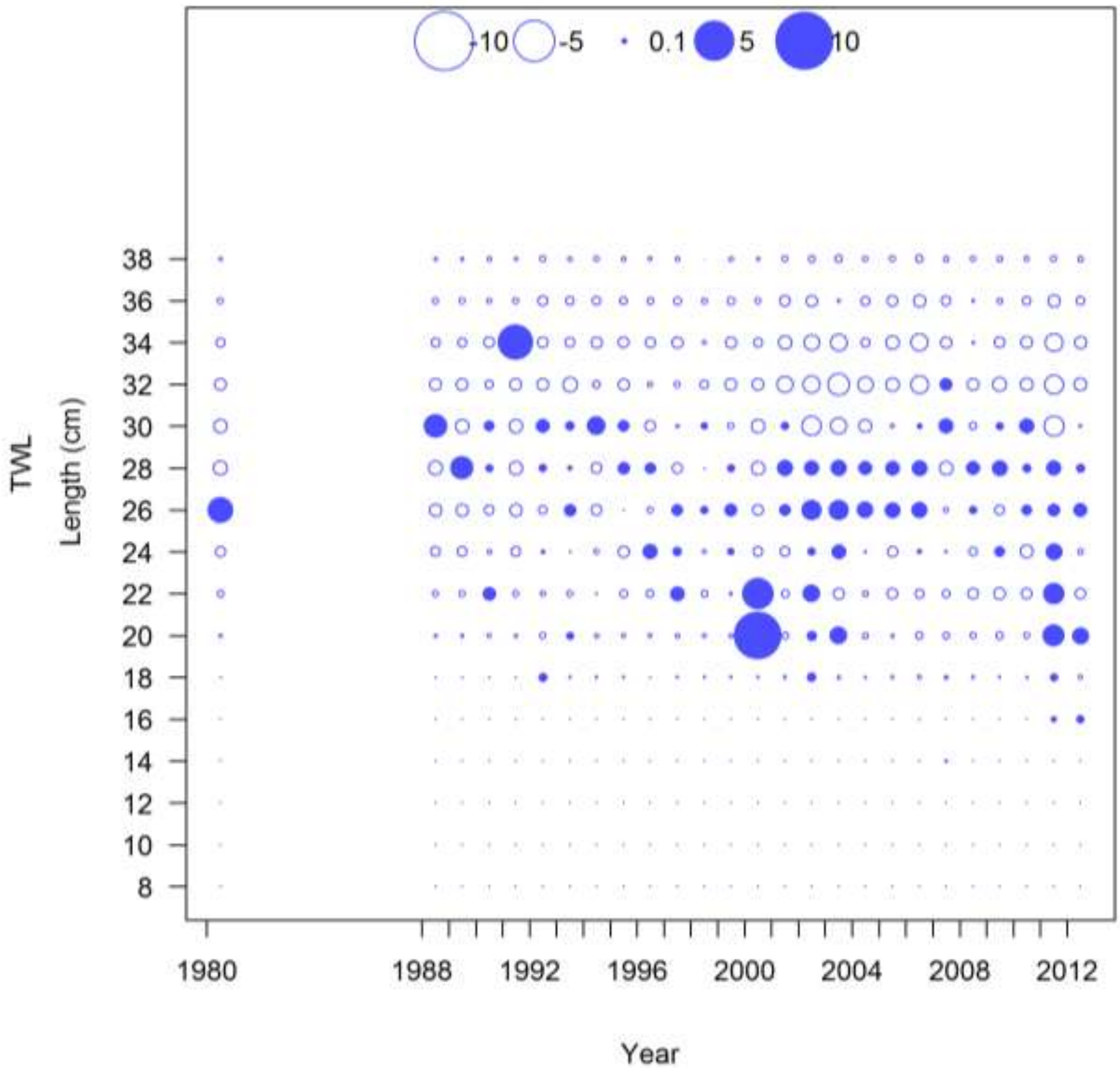



**Figure 71. Residuals to combined-sex retained length composition base case fits across years for the trawl fleet.**

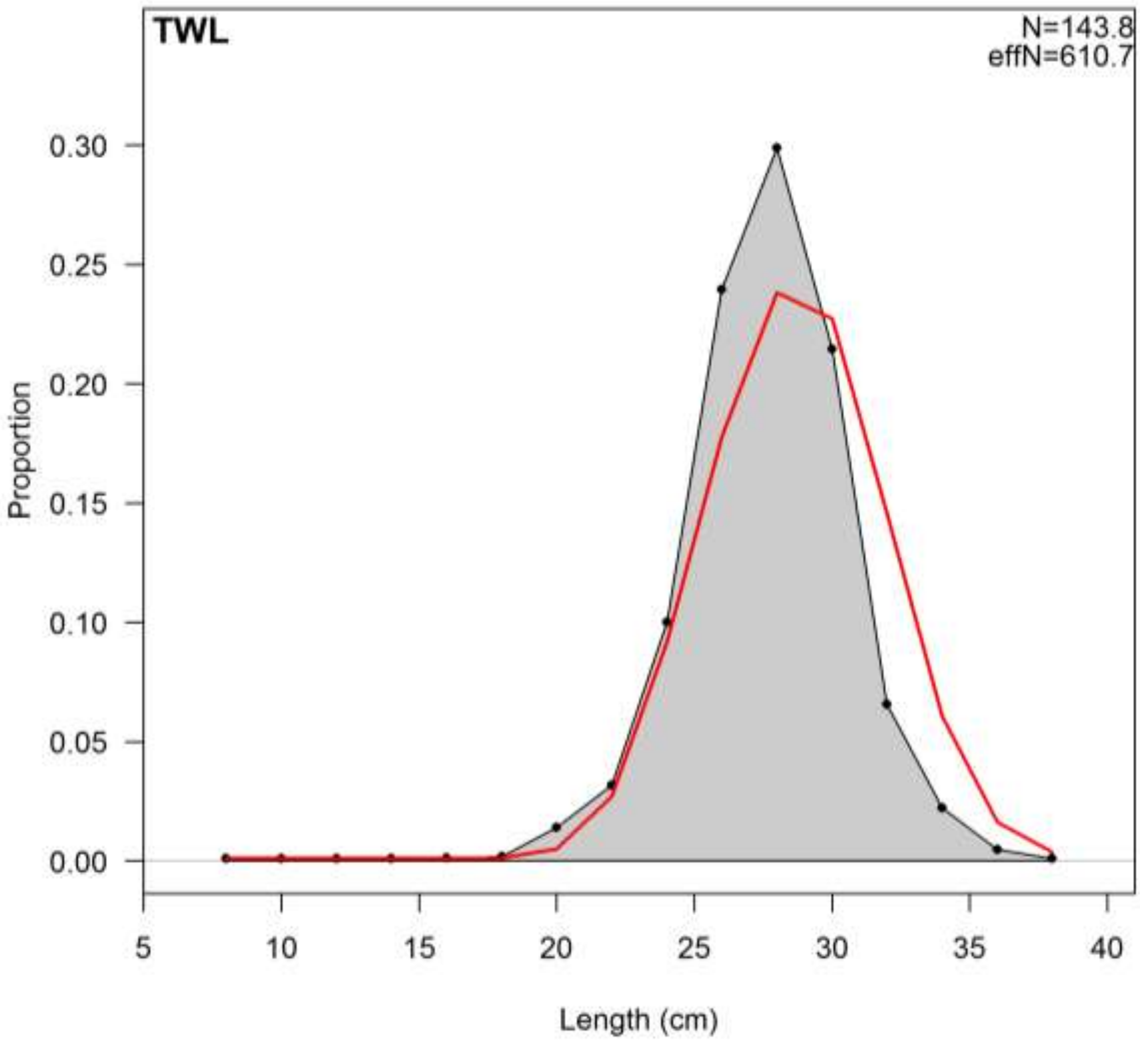



**Figure 72. Base case aggregate fit across years to the combined-sex retained length composition for the domestic fleet.**

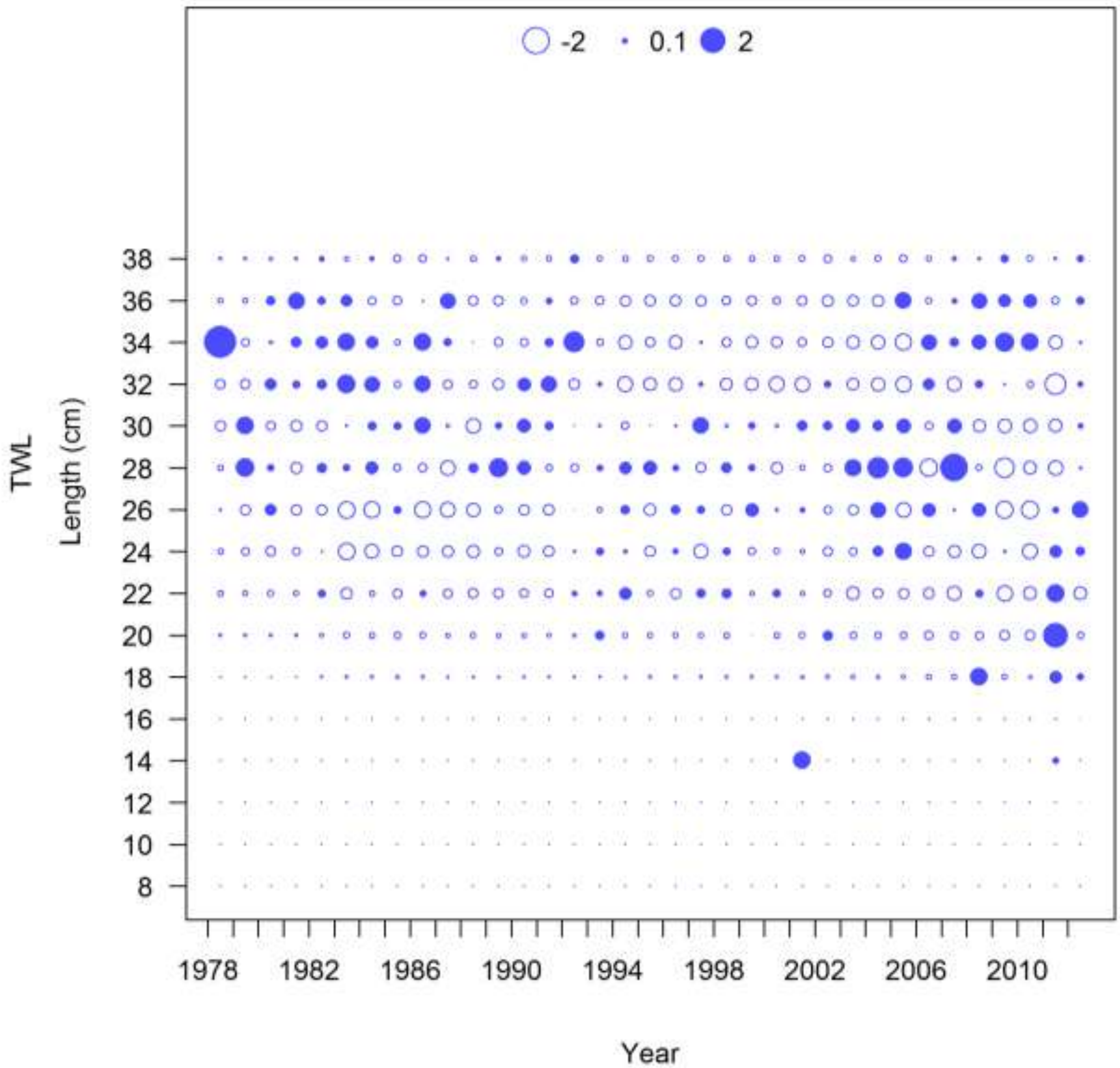



**Figure 73. Residuals to female retained length composition base case fits across all fleets and years.**

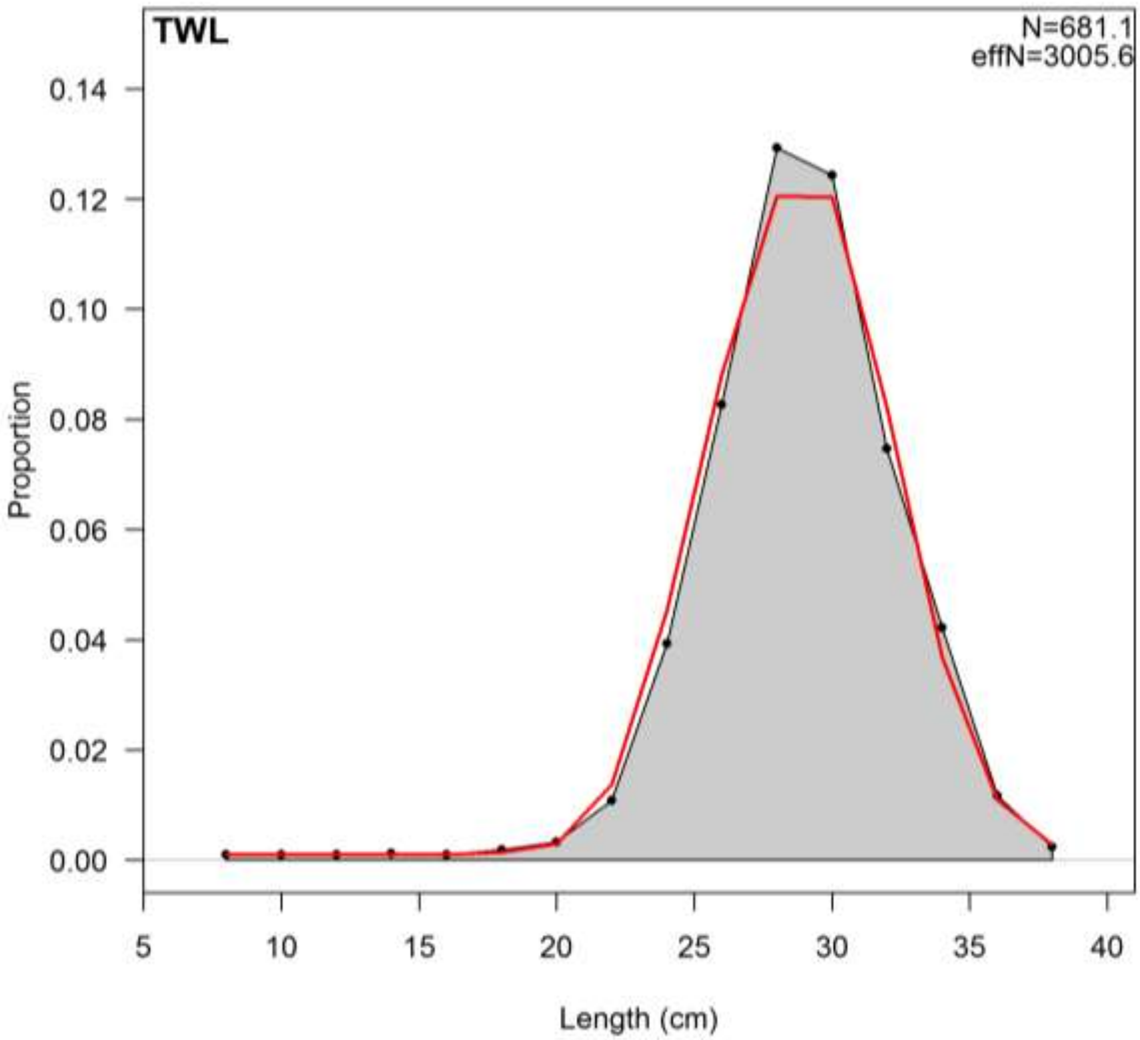



**Figure 74. Base case aggregate fit to the female retained length composition domestic fleet.**

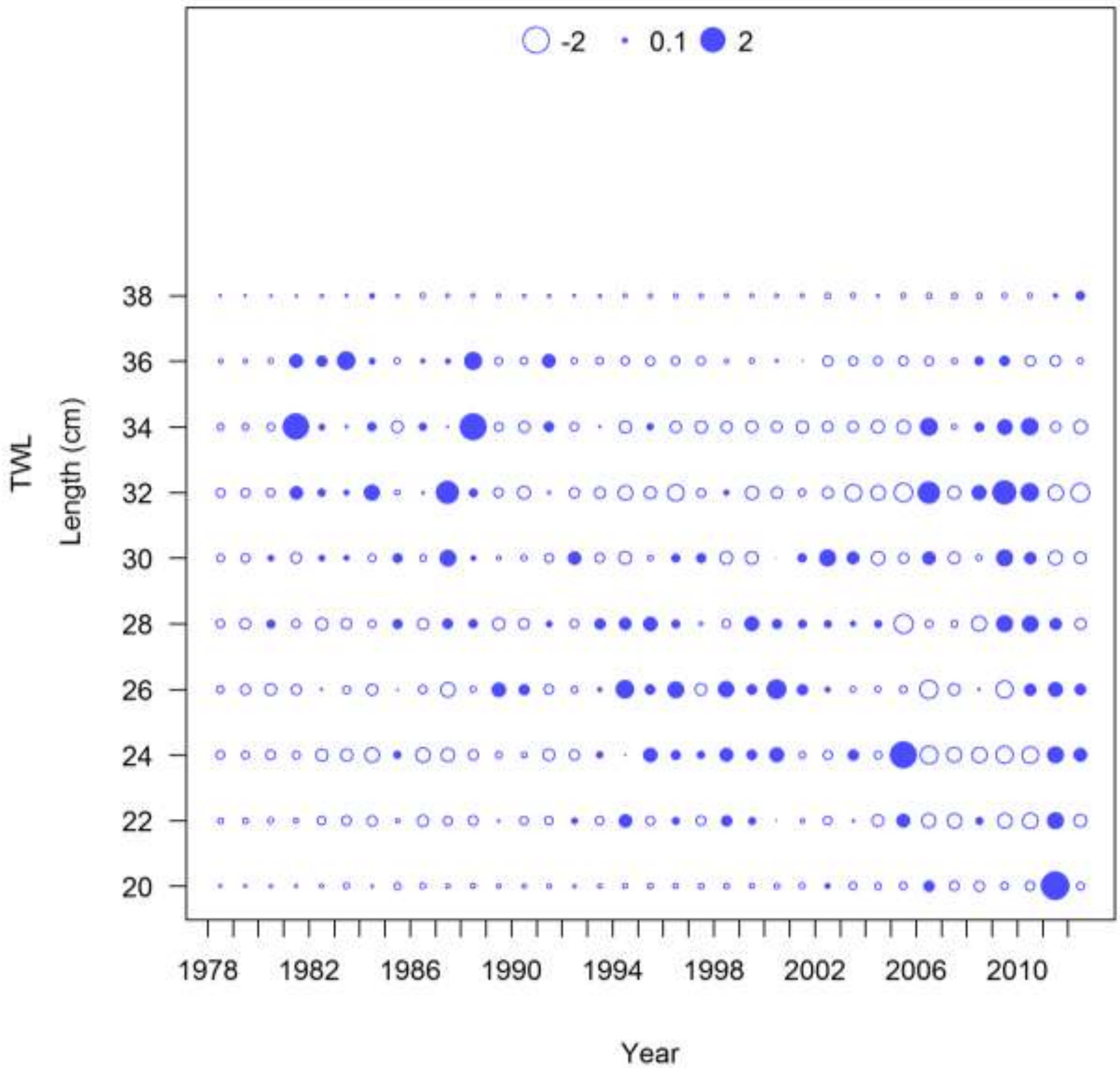


**Figure 75. Residuals to male retained length composition base case fits across all fleets and years.**

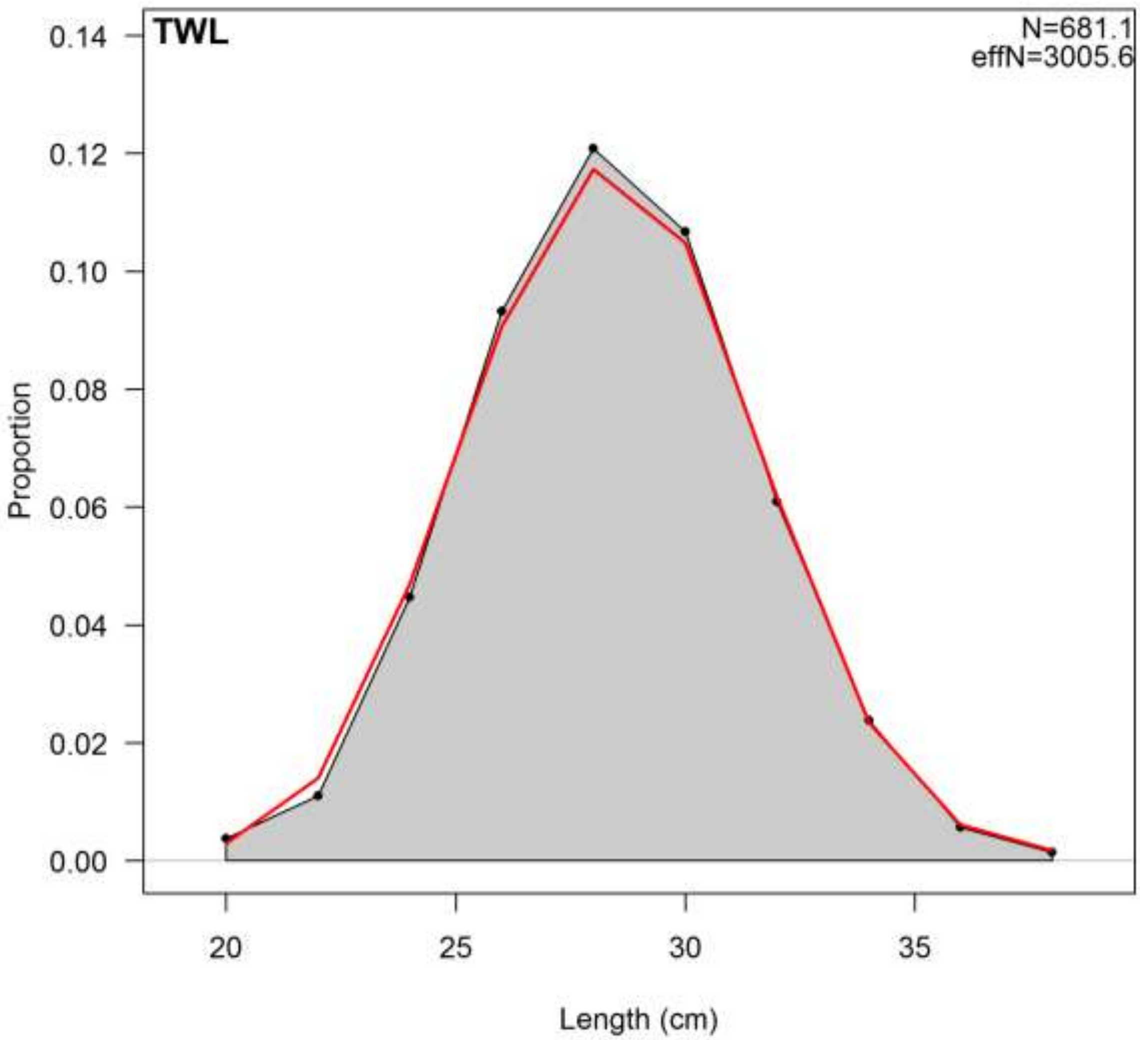



**Figure 76. Base case aggregate fit to the male retained length composition the domestic fleet.**

### 9.3.1.3.5 Aggregated residuals: Fleets, discarded catch

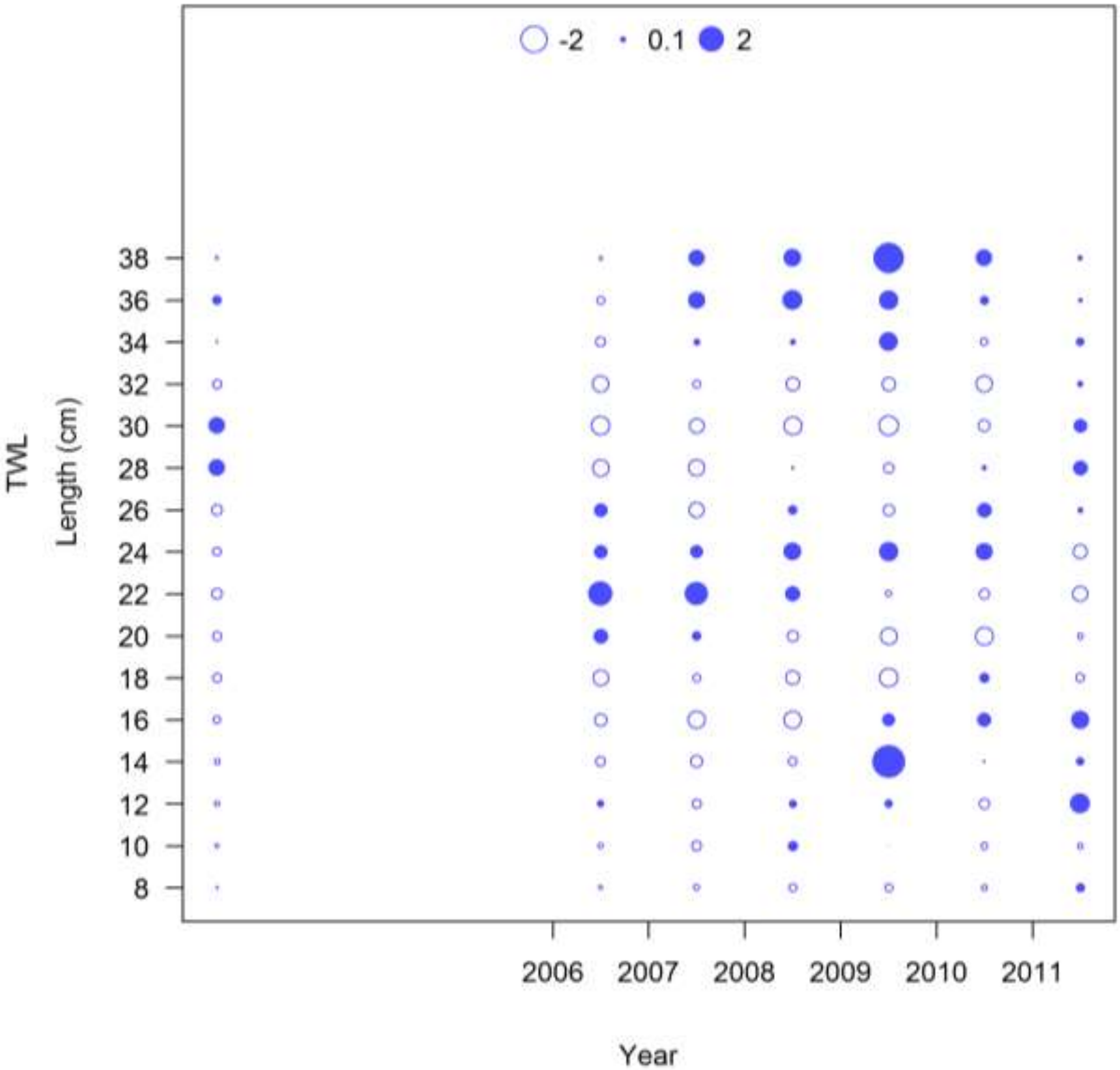



**Figure 77. Residuals to combined-sex discard length composition base case fits.**

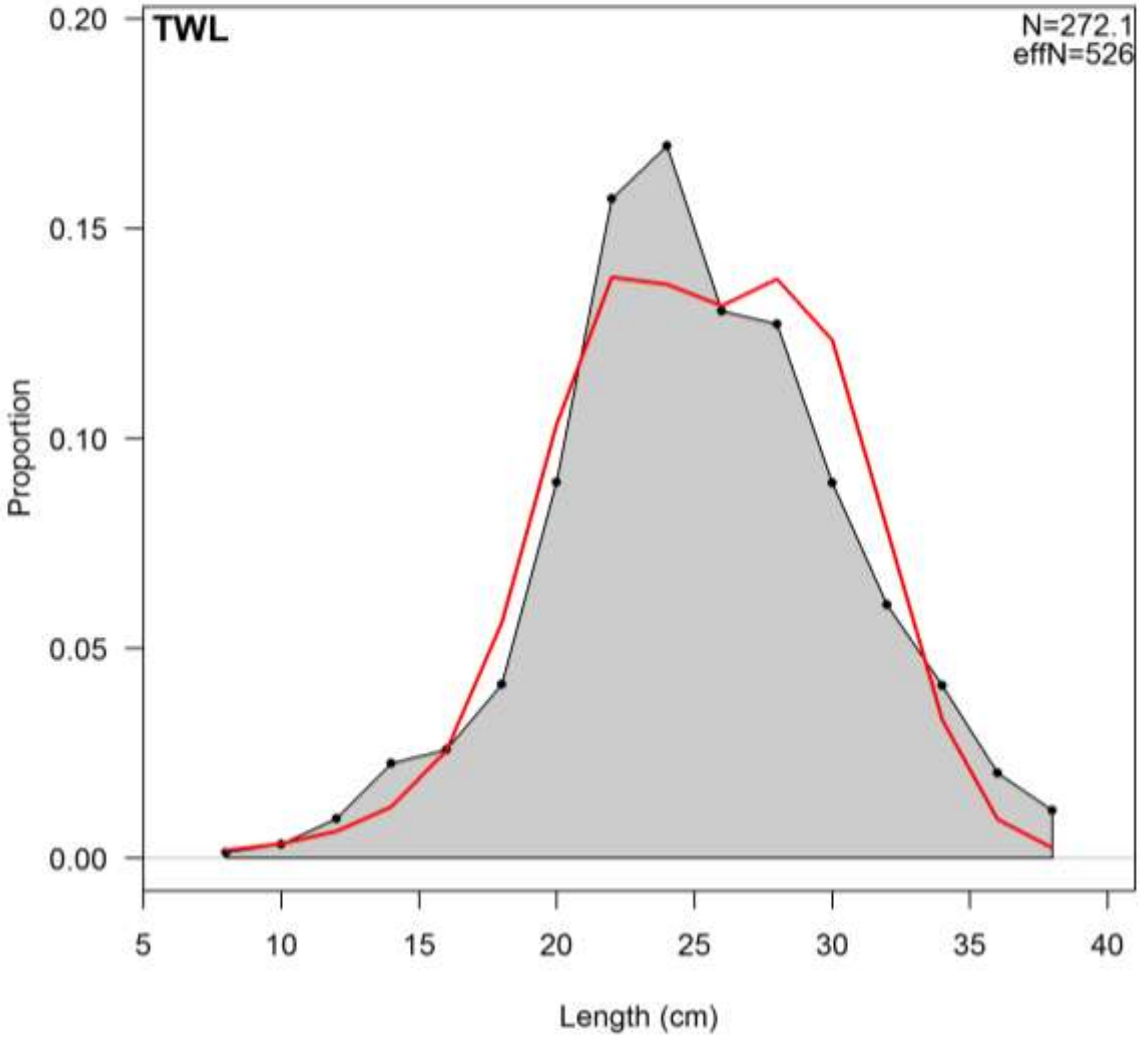



**Figure 78. Base case aggregate fit to the combined-sex discard length composition for the domestic fleet.**

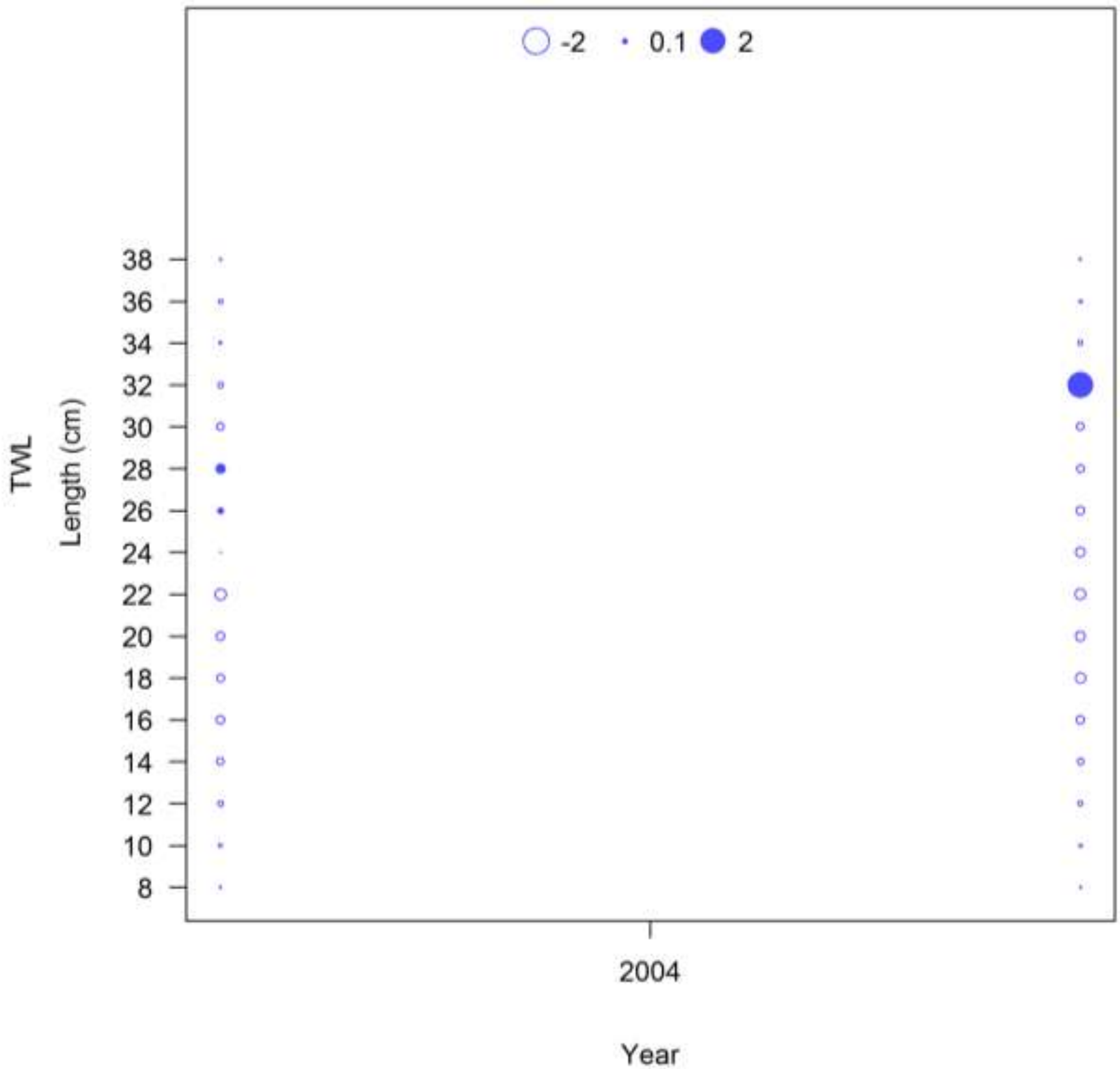



**Figure 79. Residuals to female discard length composition base case fits across all fleets and years.**

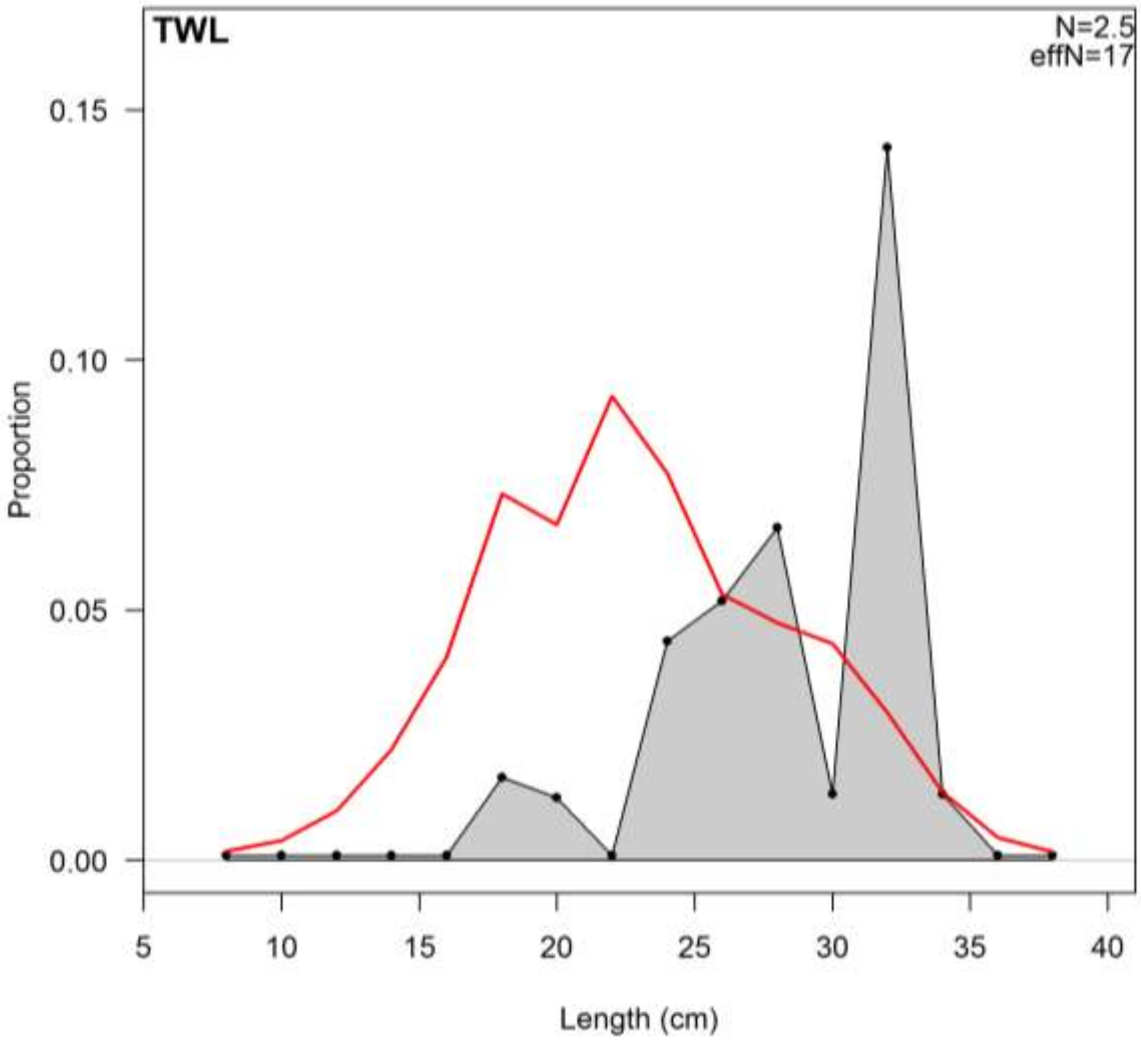



**Figure 80. Base case aggregate fit to the female discard length composition the trawl and non-trawl fleets.**

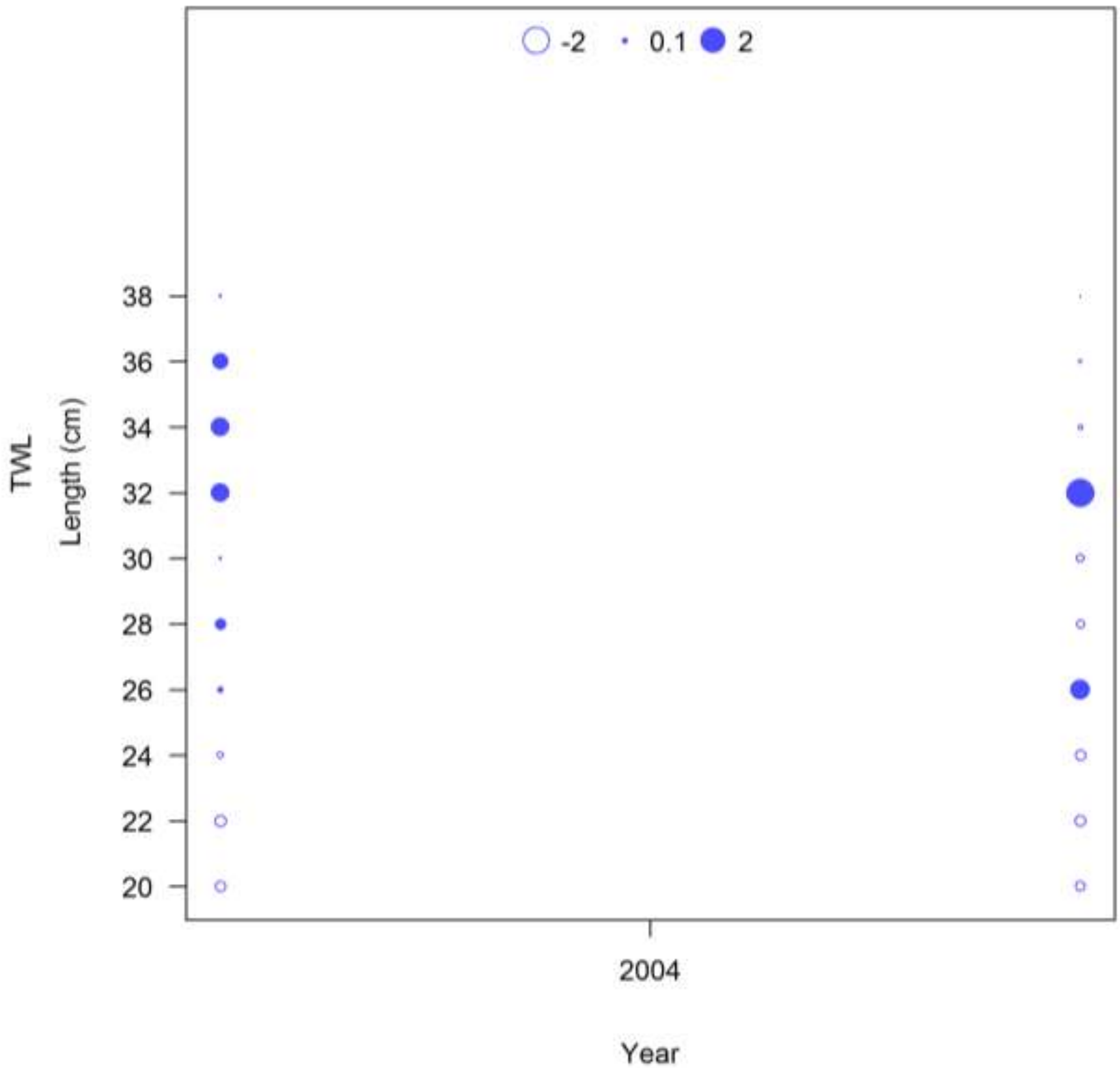


**Figure 81. Residuals to male discard length composition base case fits across all fleets and years.**

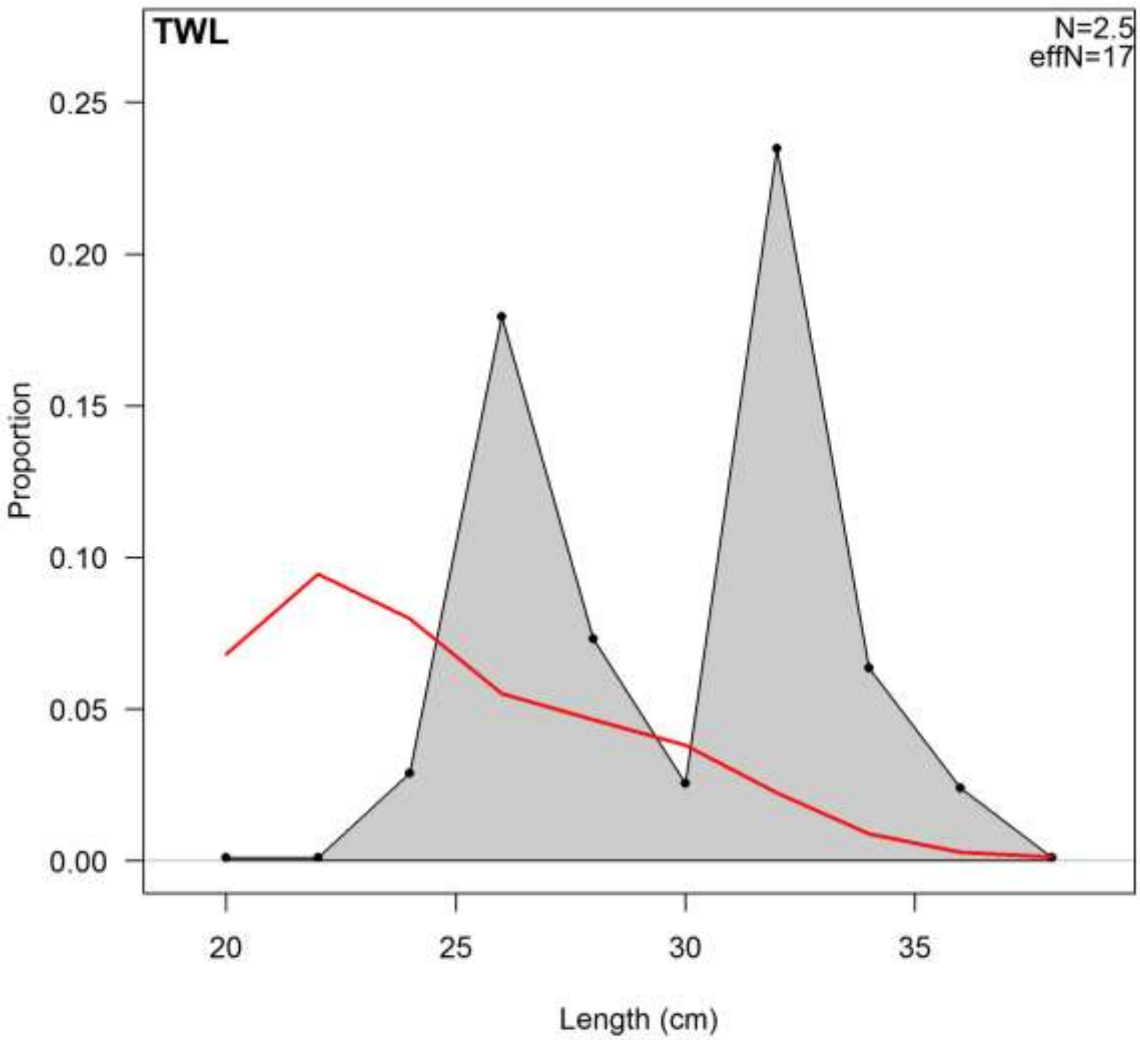



**Figure 82. Base case aggregate fit to the male discard length composition the trawl and non-trawl fleets.**

## 9.3.1.3.6 Aggregated residuals: Surveys

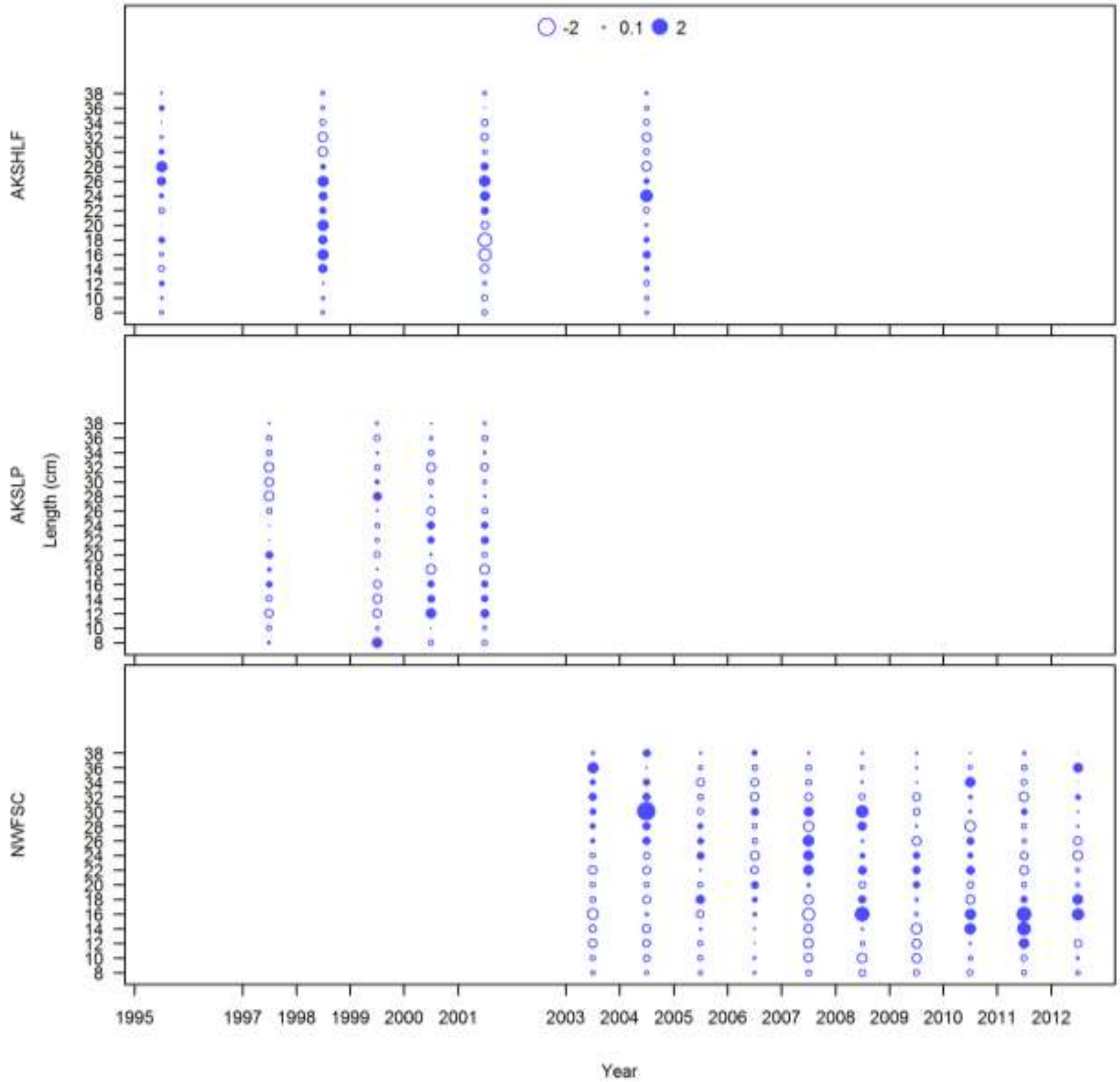



**Figure 83. Residuals to female length composition base case fits across all surveys and years.**

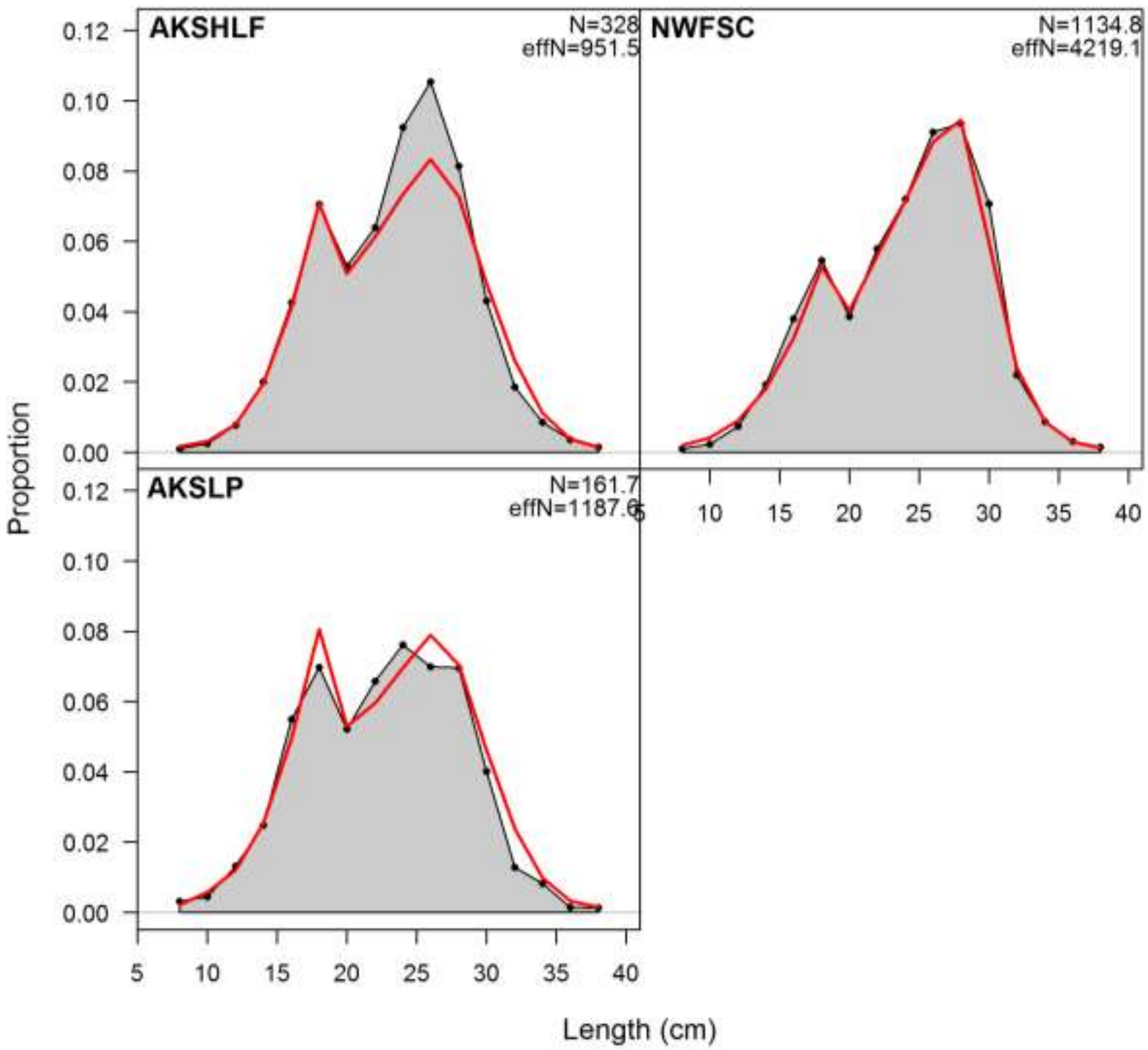



**Figure 84. Base case aggregate fit to the female length compositions for each survey.**

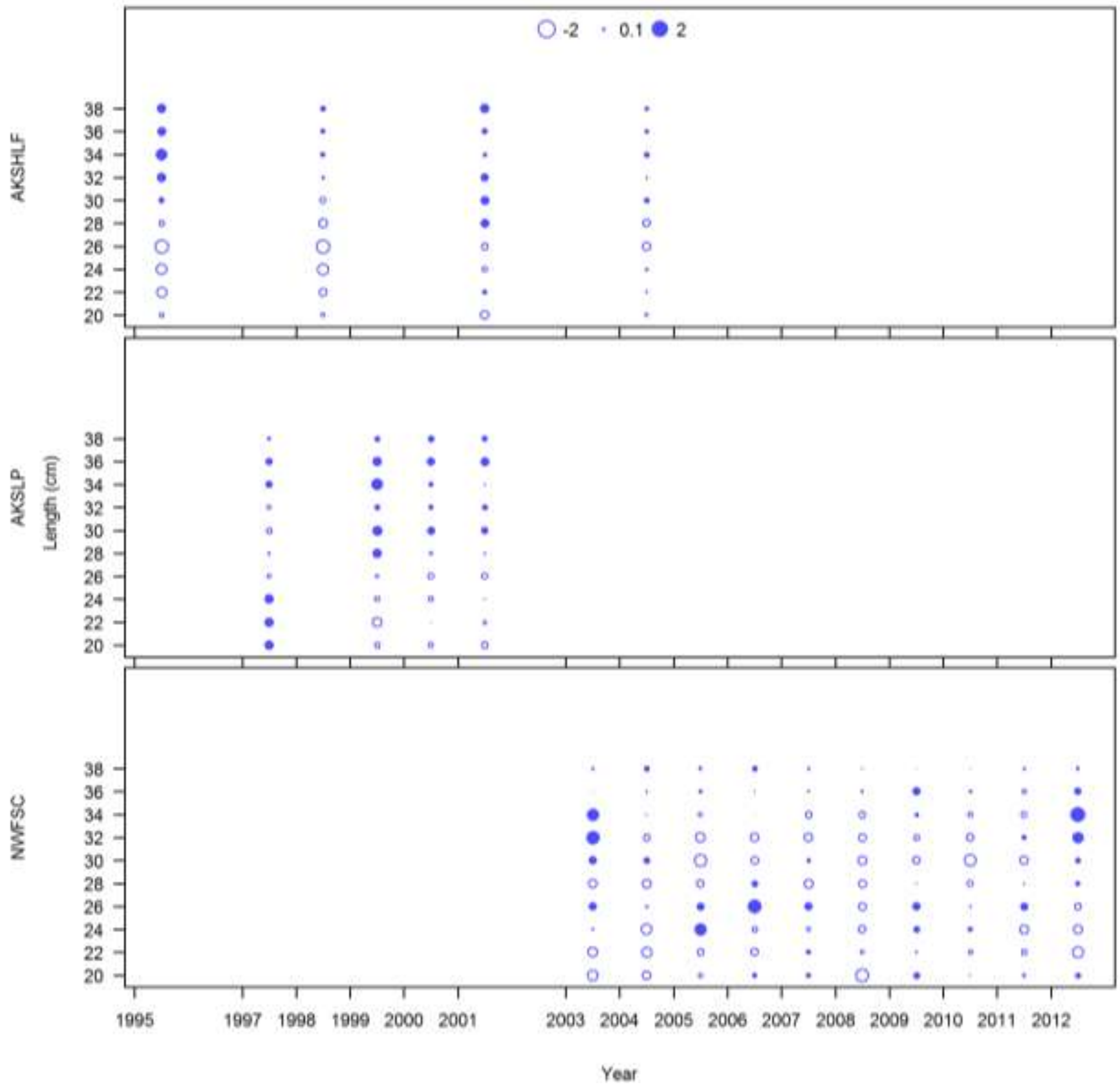



**Figure 85. Residuals to male length composition base case fits across all surveys and years.**

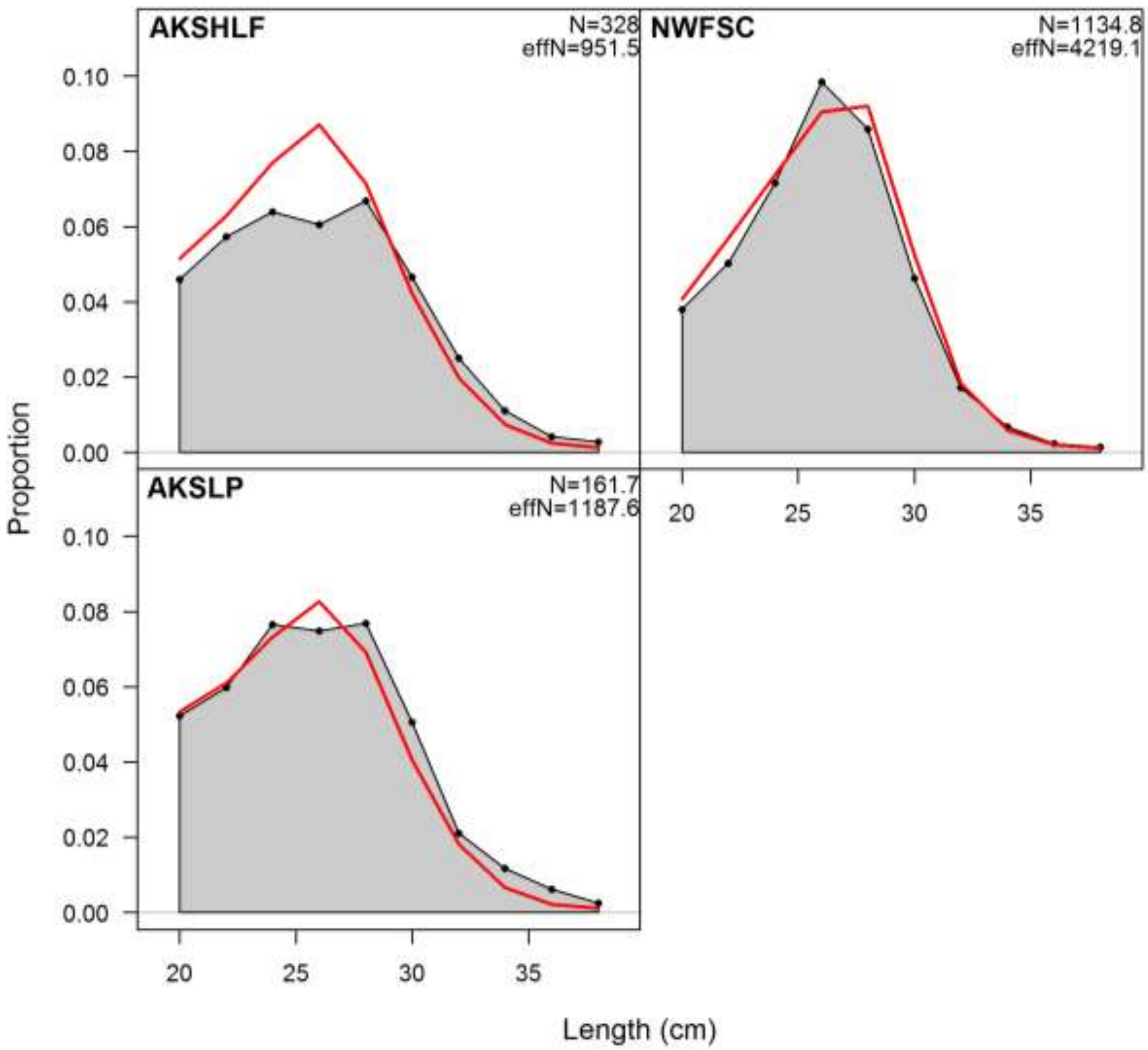



**Figure 86. Base case aggregate fit to the male length composition for each survey.**

### *9.3.1.4 Conditional-age-at-length*

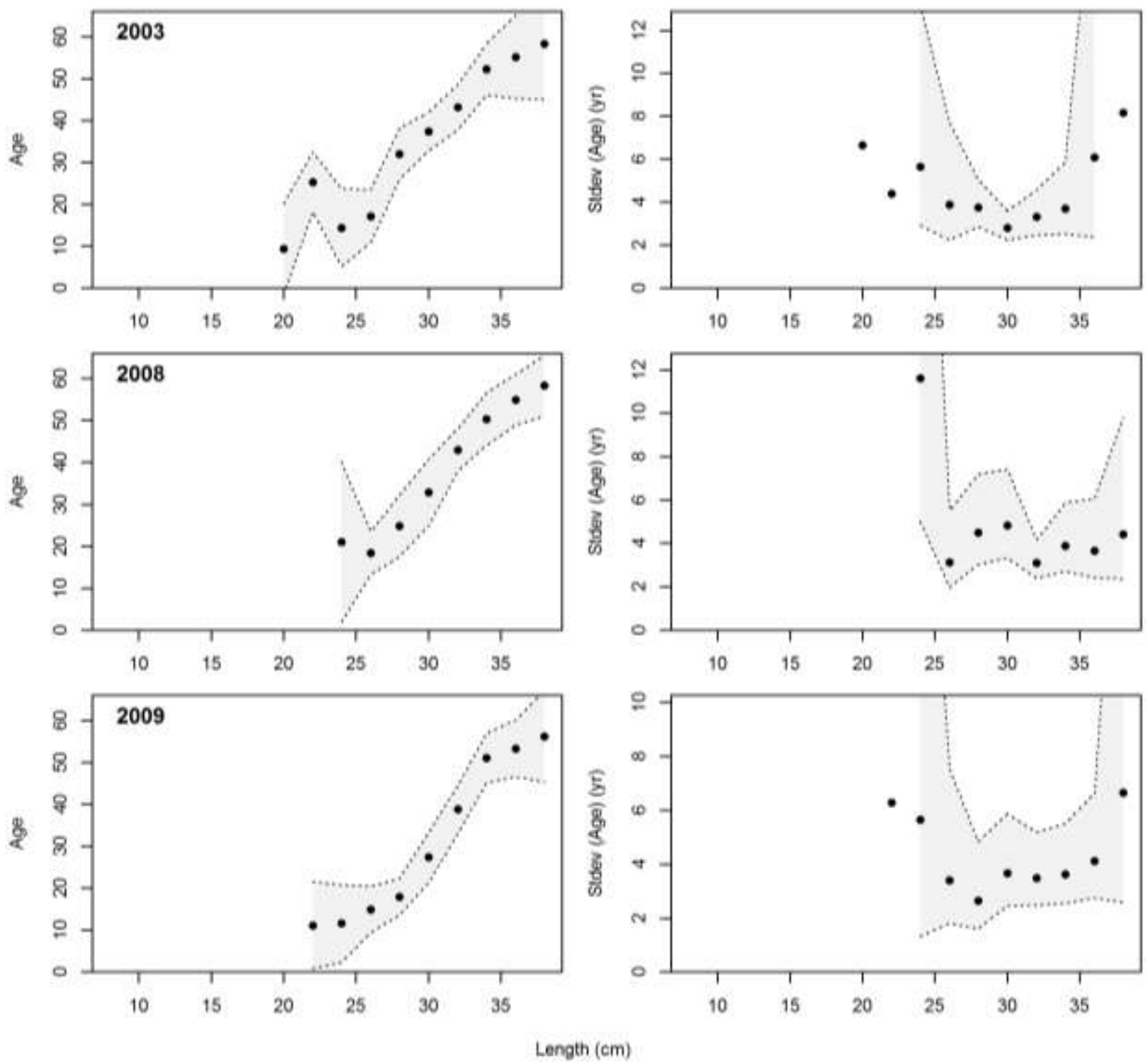



**Figure 87. Base case model fits to the conditional age-at-length data (left panels) and precision (right panels) for the trawl fishery for female aurora rockfish.**

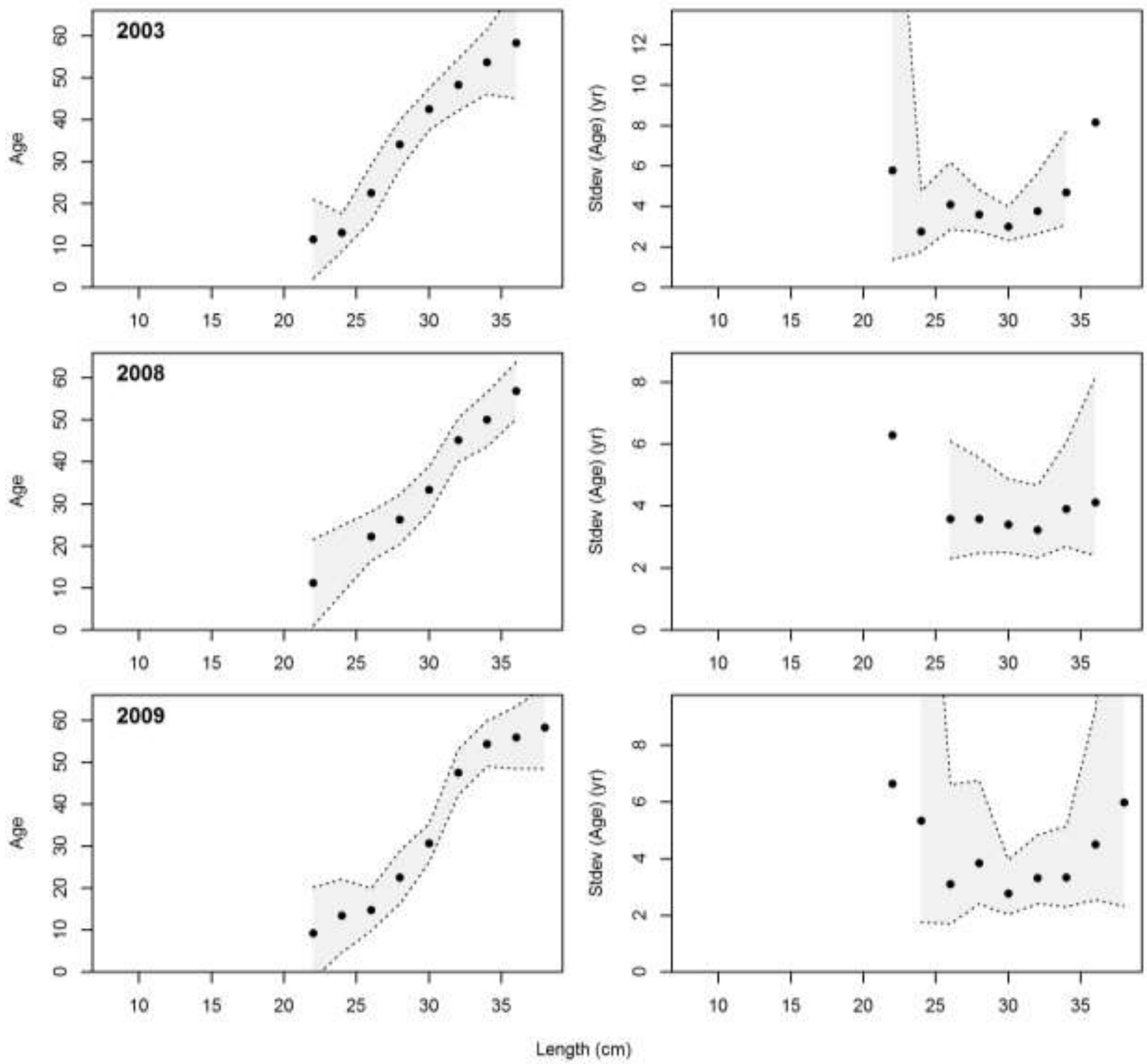



**Figure 88. Base case model fits to the conditional age-at-length data (left panels) and precision (right panels) for the trawl fishery for male aurora rockfish.**

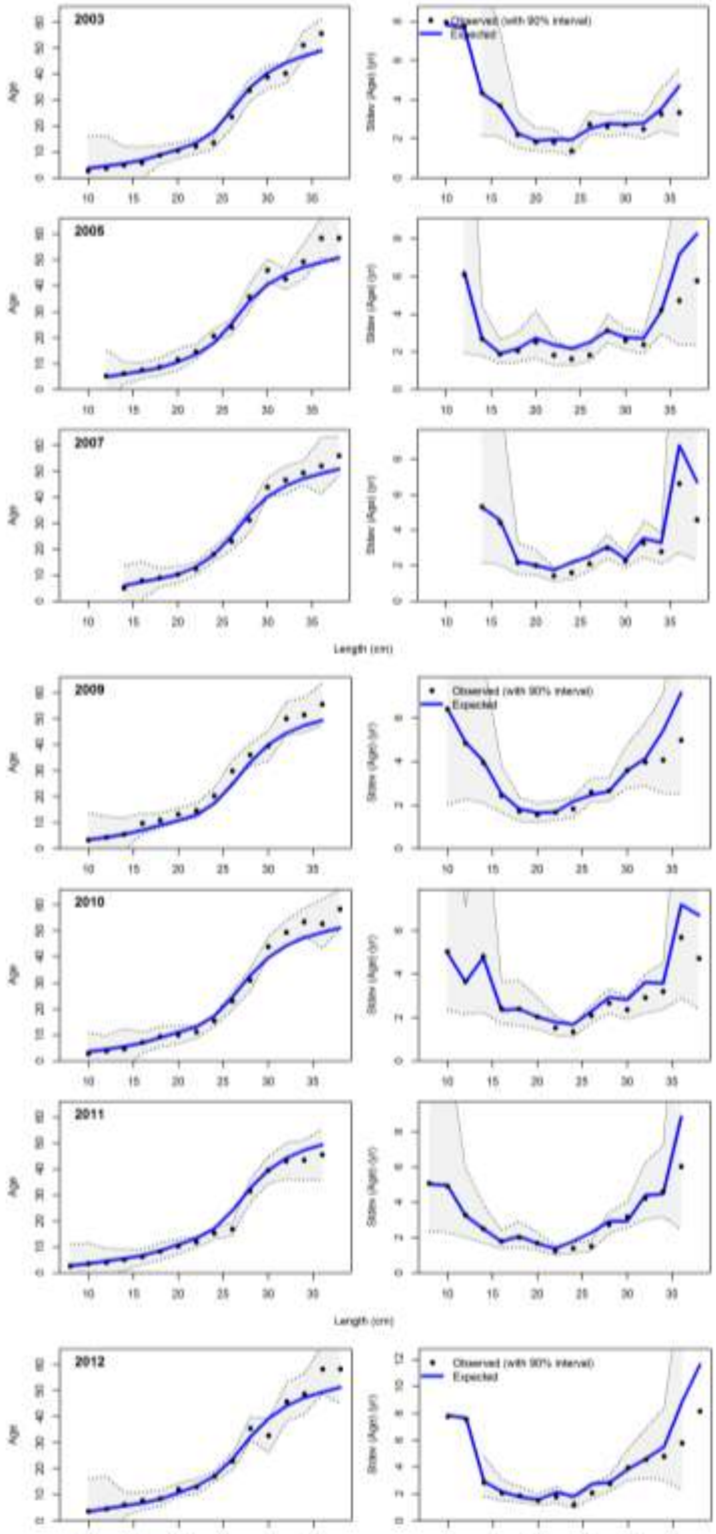



**Figure 89. Base case model fits to the conditional age-at-length data (left panels) and precision (right panels) for the NWFSC shelf-slope survey for female aurora rockfish.**

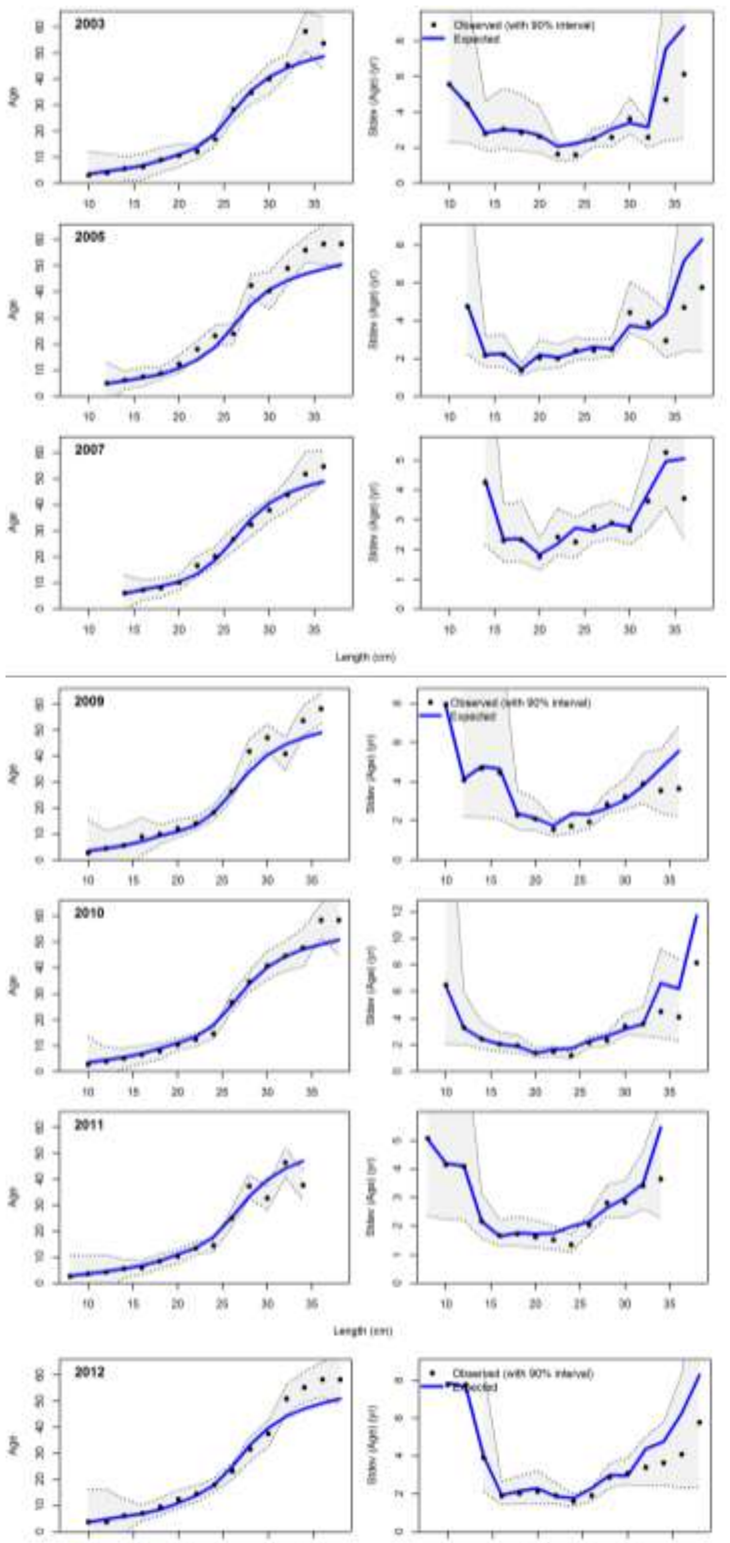



**Figure 90. Base case model fits to the conditional age-at-length data (left panels) and precision (right panels) for the NWFSC shelf-slope survey for male aurora rockfish.**

### *9.3.1.5 Selectivity*

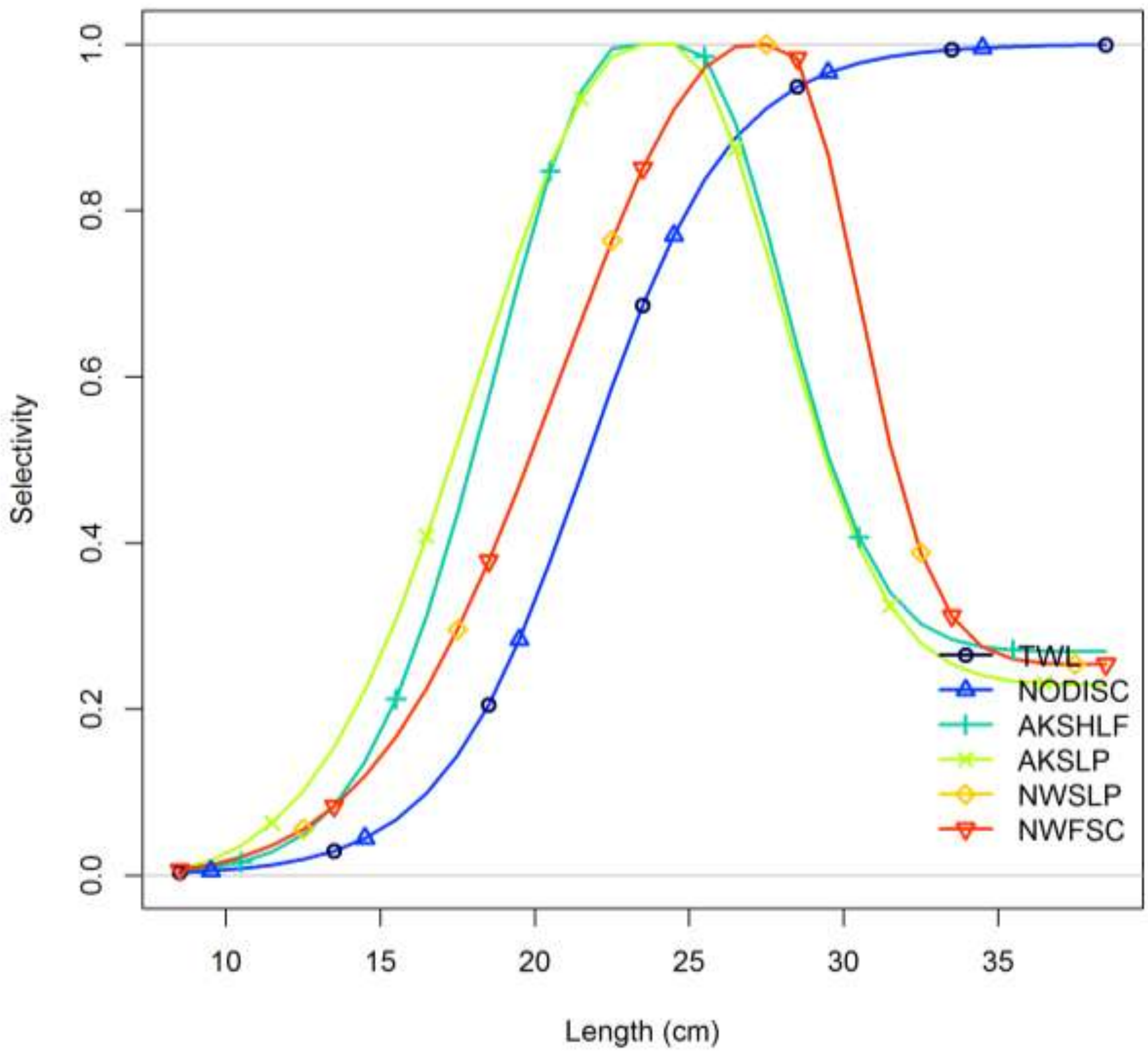
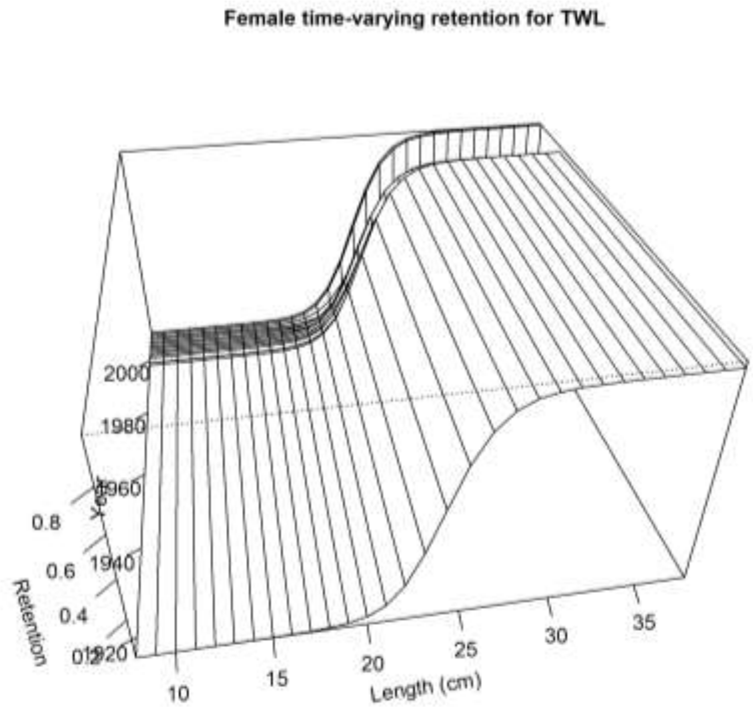



**Figure 91. Estimated length-based selectivity in each fleet and survey for the aurora rockfish base case model.**



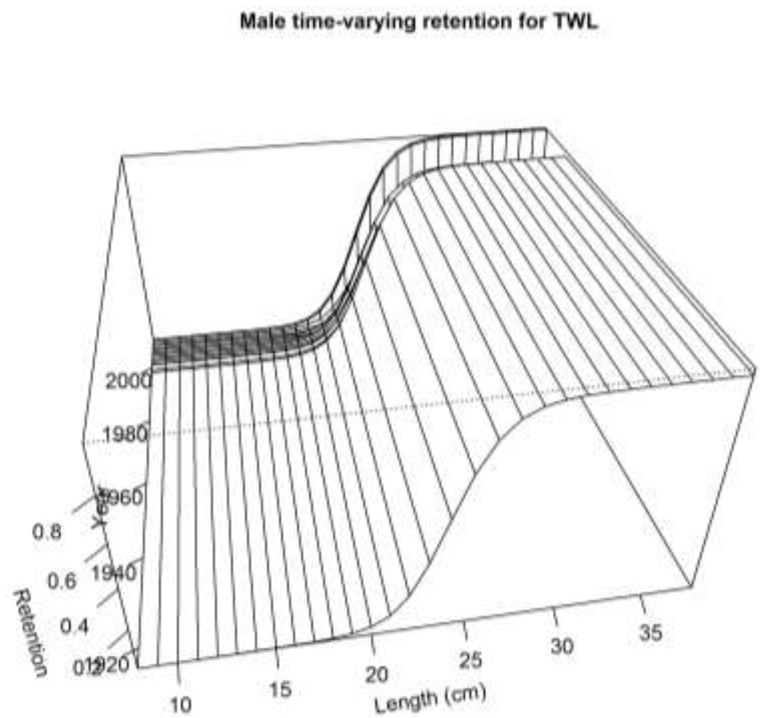




**Figure 92. Estimates of the female (top panel) and male (bottom panel) retention curves for each time block in the aurora rockfish base case model.**

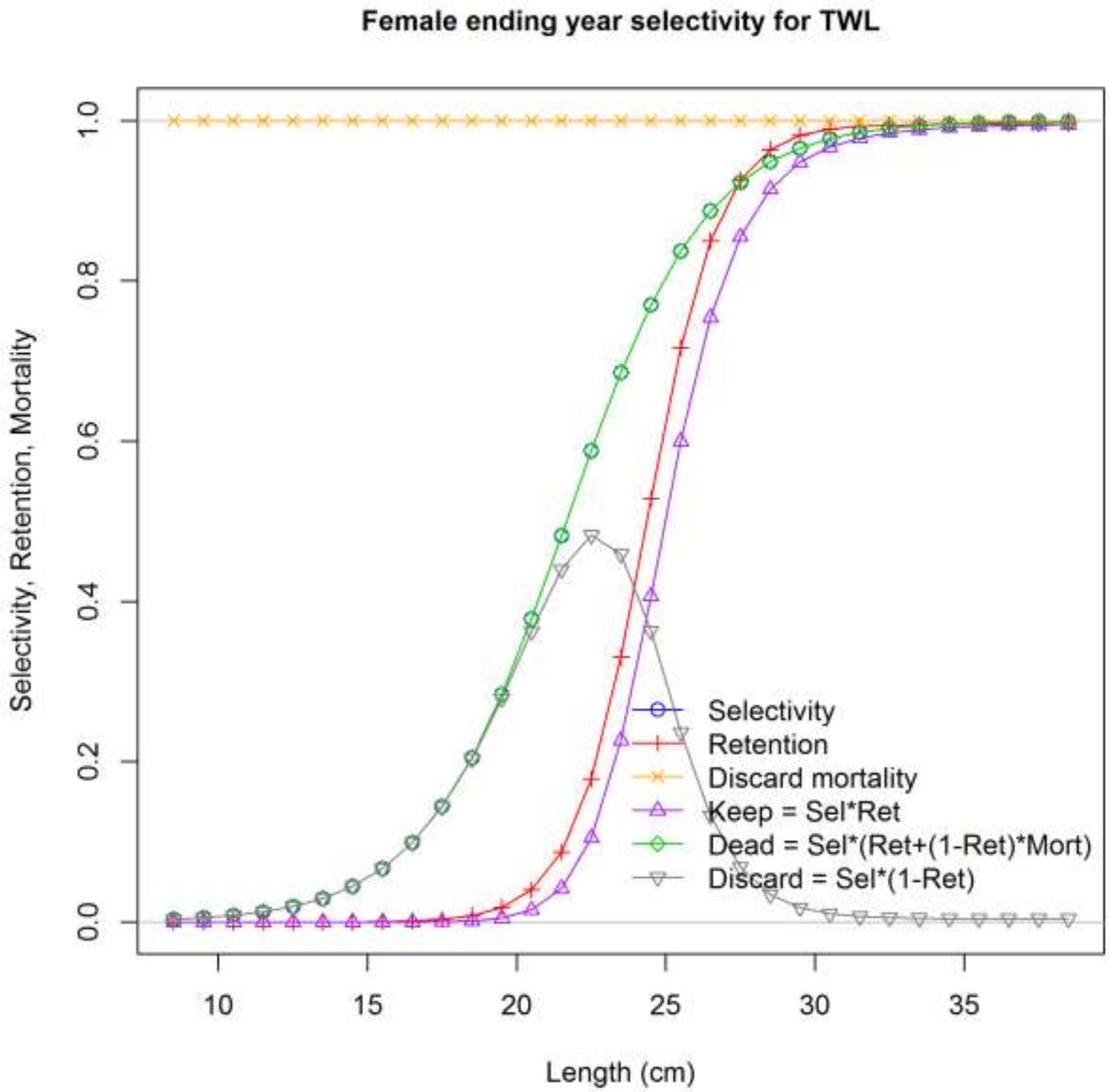



**Figure 93. Female selectivity, retention, and mortality curves for the trawl fishery as estimated from the aurora rockfish base case model.**

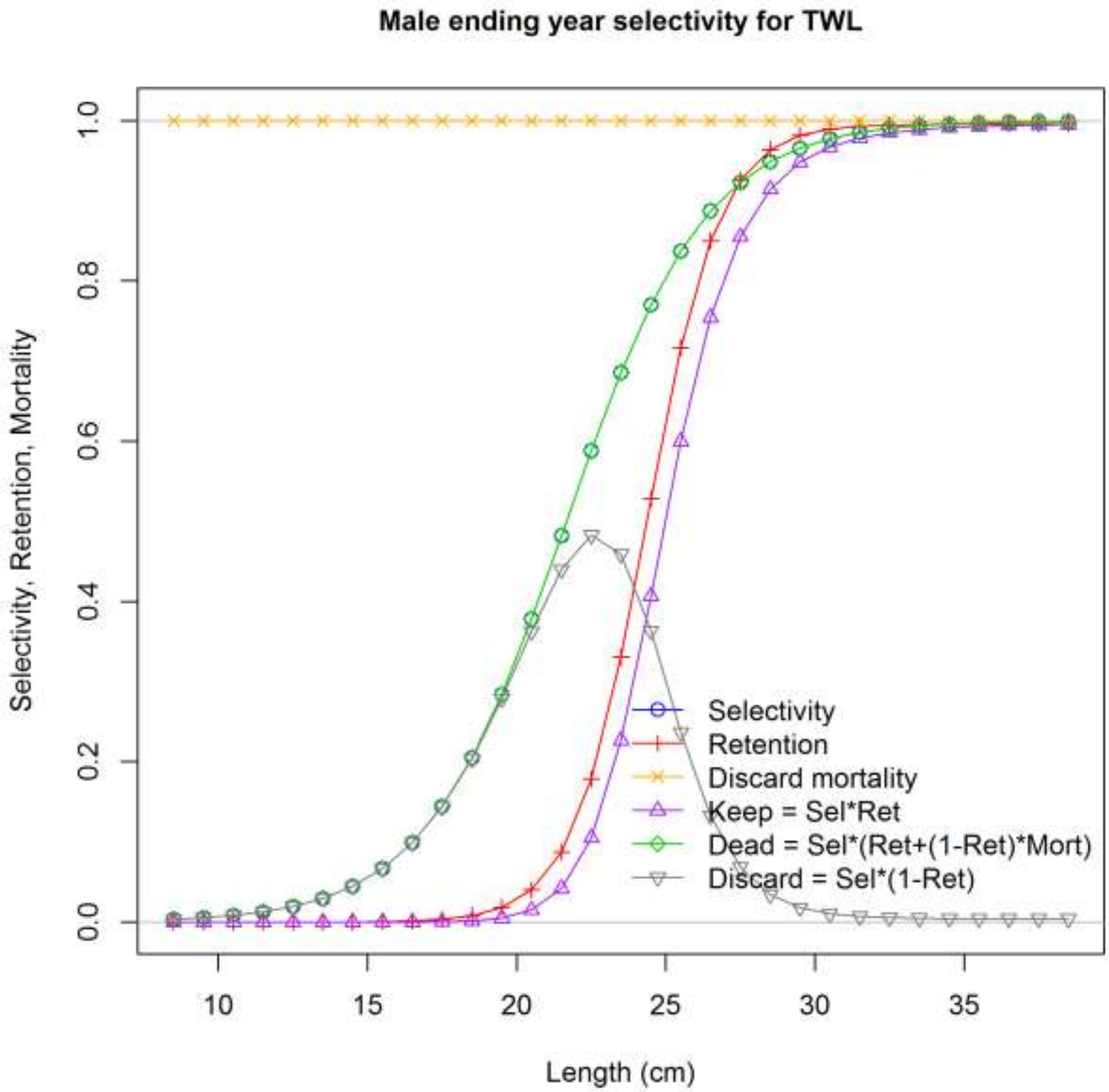



**Figure 94. Male selectivity, retention, and mortality curves for the trawl fishery as estimated from the aurora rockfish base case model.**

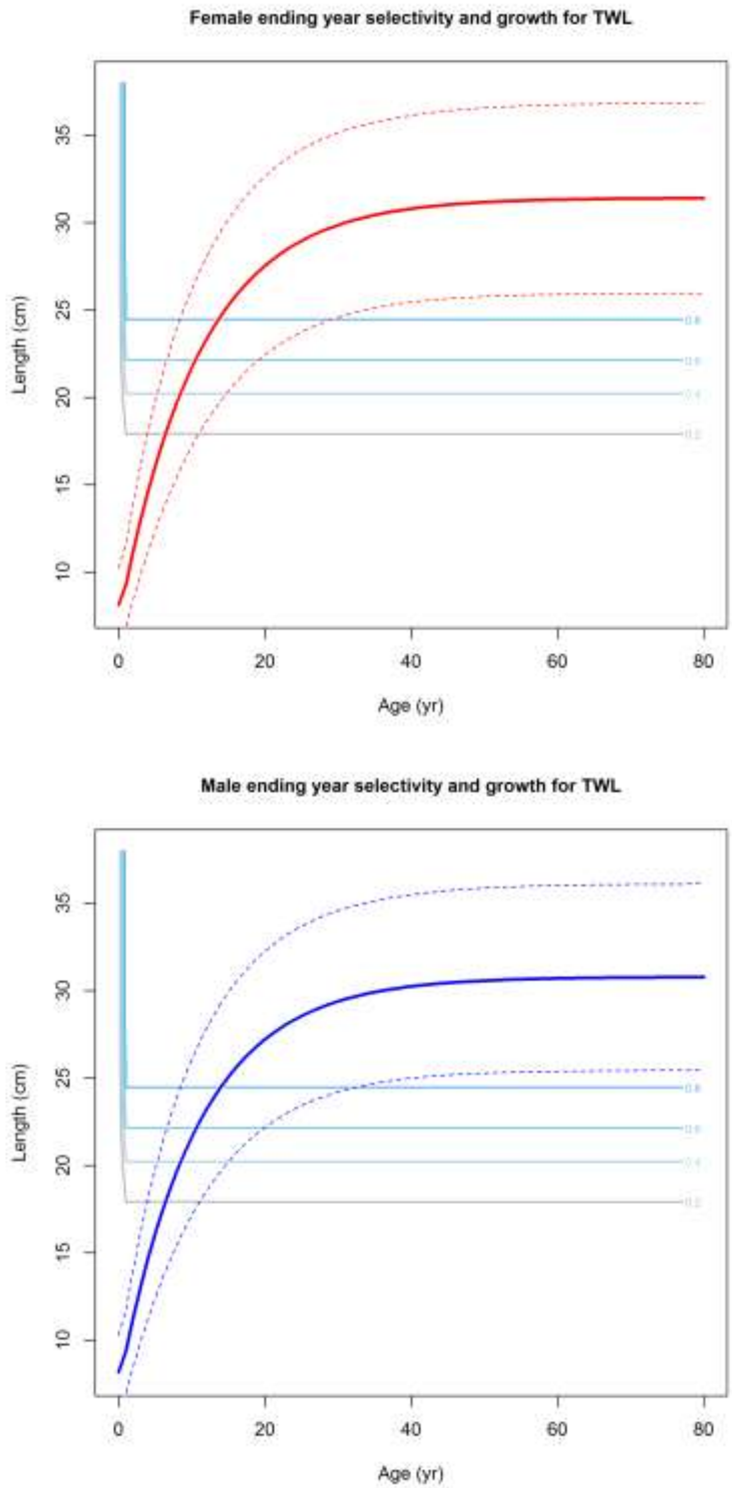



**Figure 95. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the trawl fleet from the aurora rockfish base case model.**

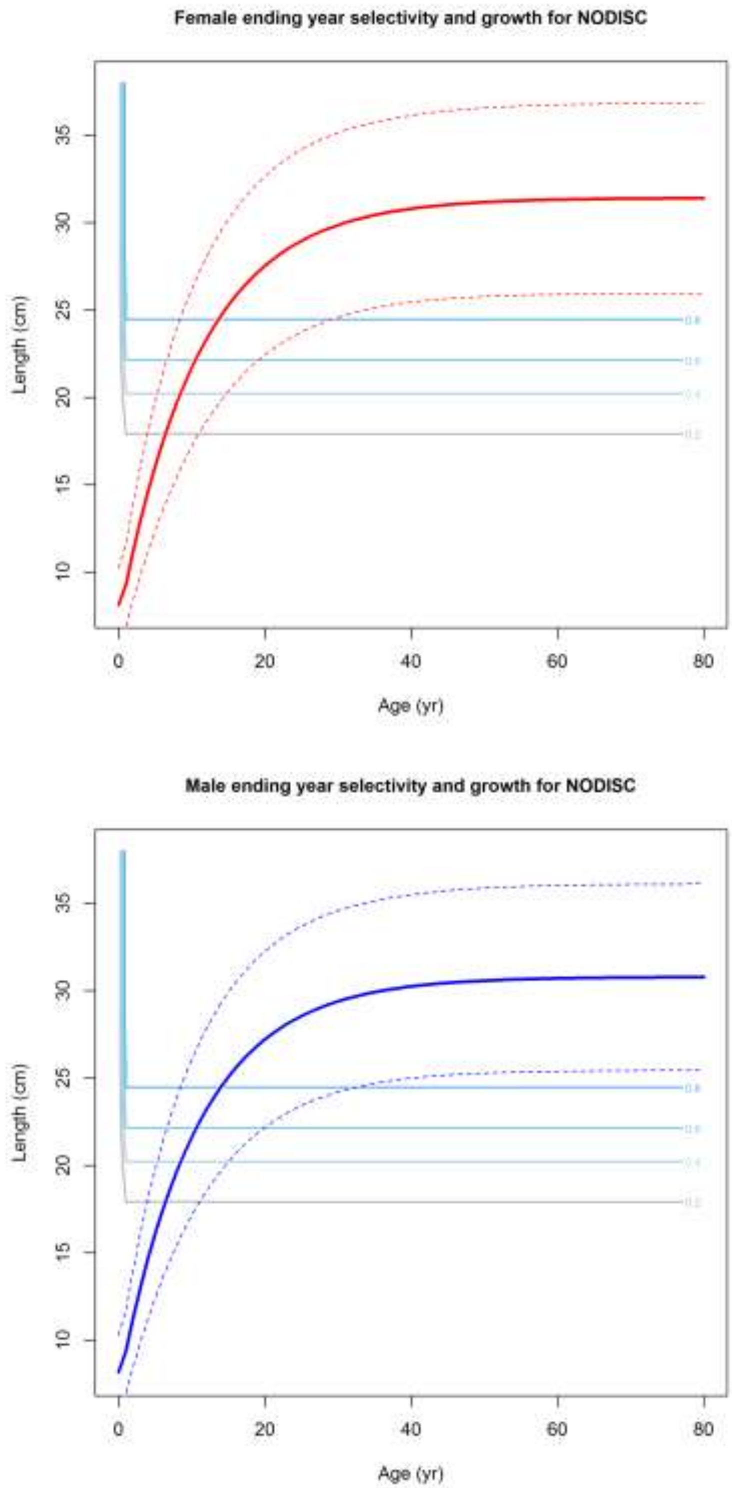



**Figure 96. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the full-retention fleet from the aurora rockfish base case model.**

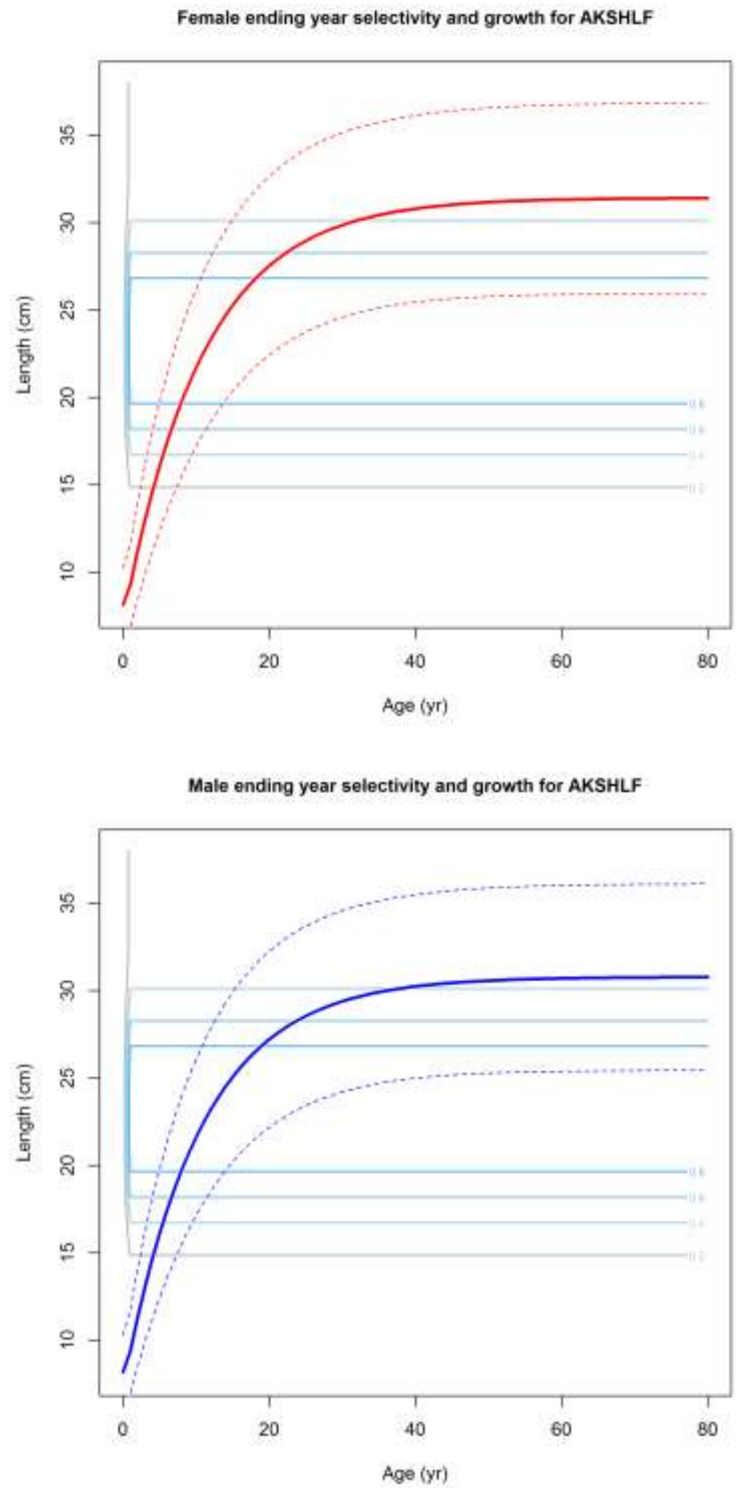



**Figure 97. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the AFSC triennial survey from the aurora rockfish base case model.**

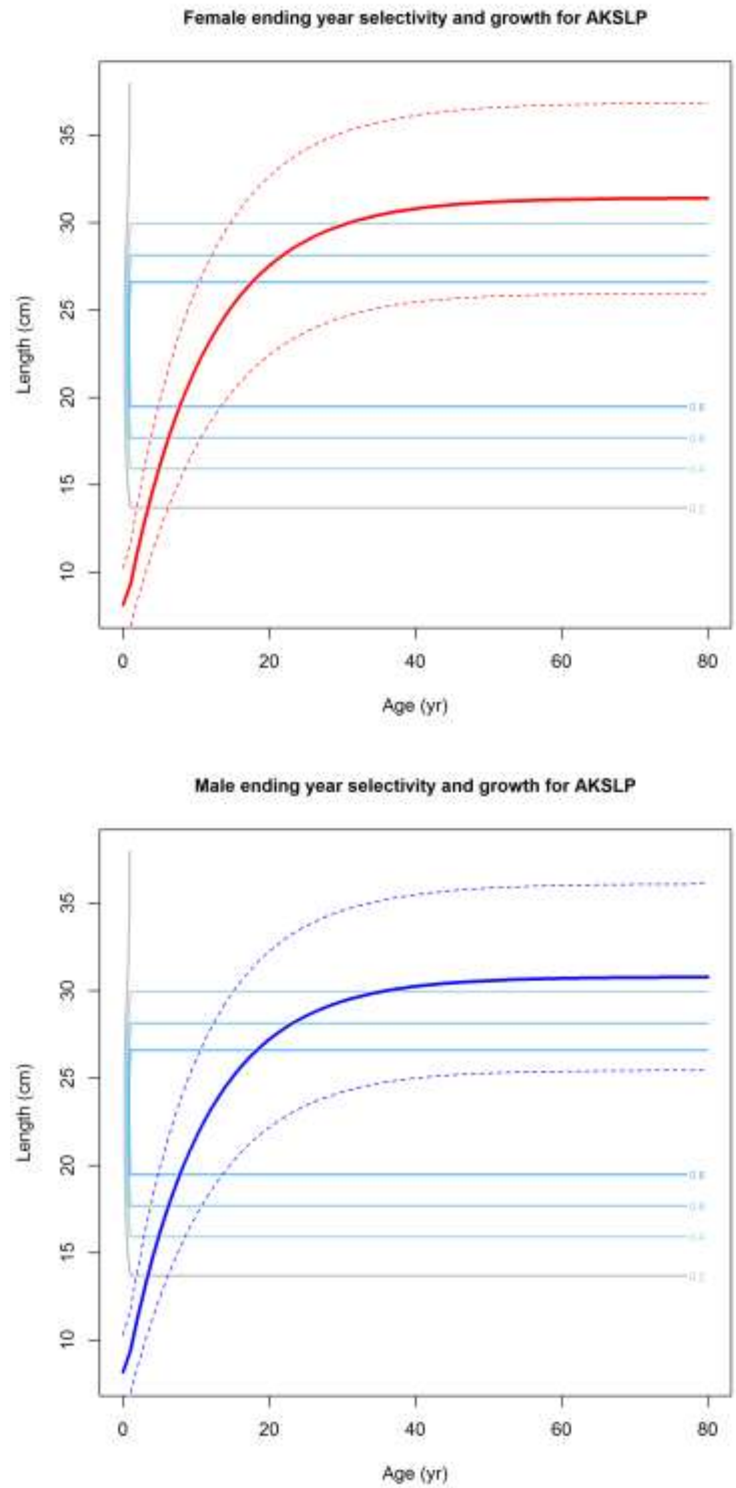



**Figure 98. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the AFSC slope survey from the aurora rockfish base case model.**

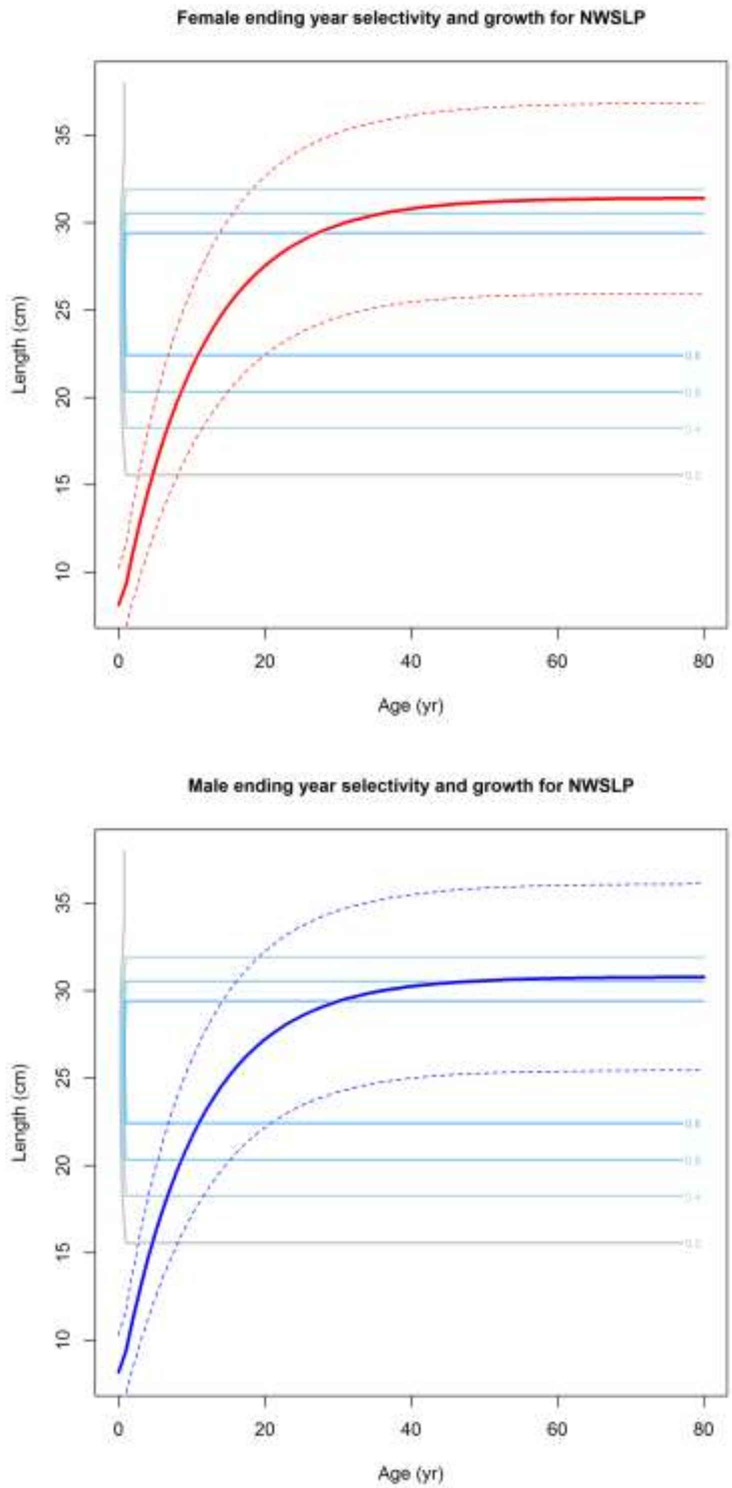



**Figure 99. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the NWFSC slope survey from the aurora rockfish base case model.**

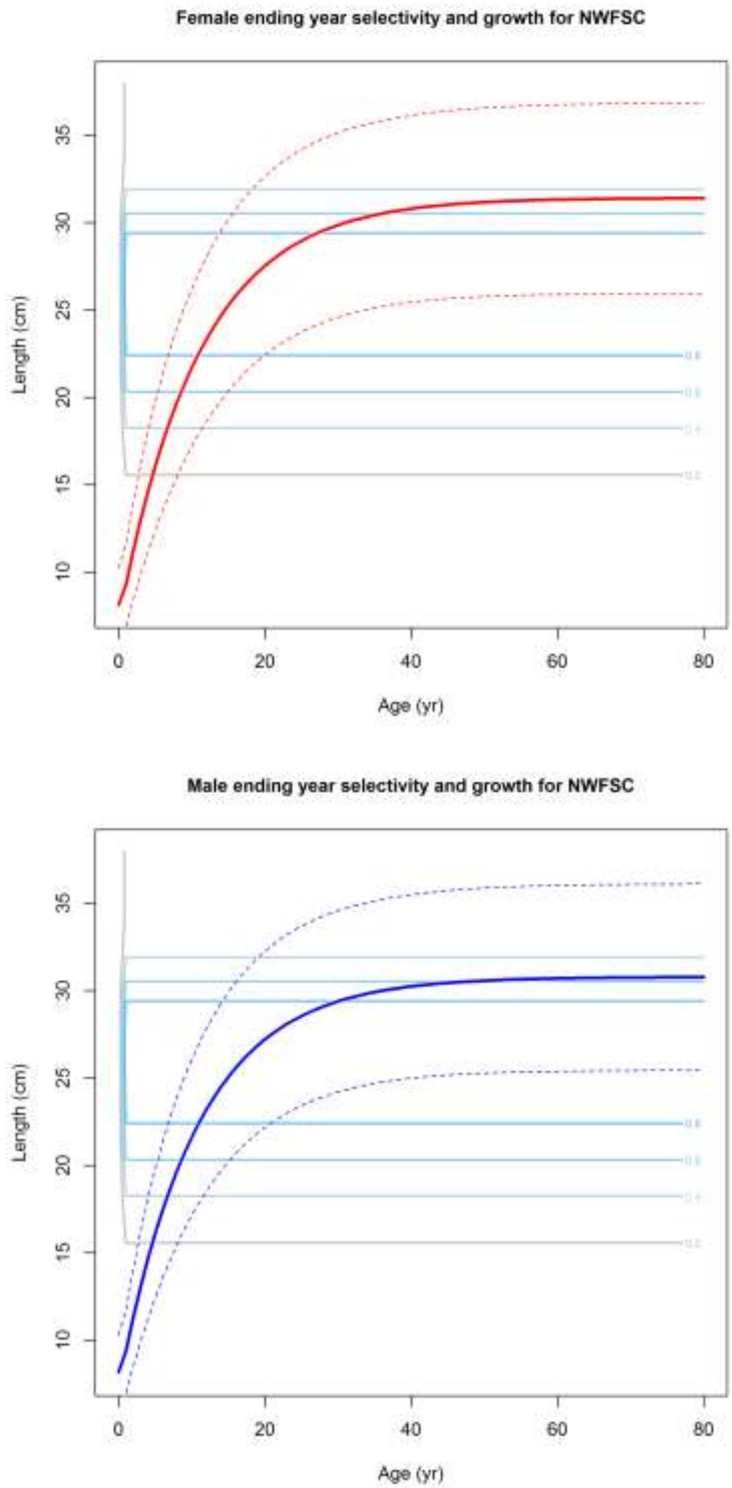



**Figure 100. Female (top panel) and male (bottom panel) age and growth (red and blue lines) relative to selectivity curves (lighter colored lines) for the NWFSC shelf-slope survey from the aurora rockfish base case model.**

#### *9.3.1.6 Recruitment*

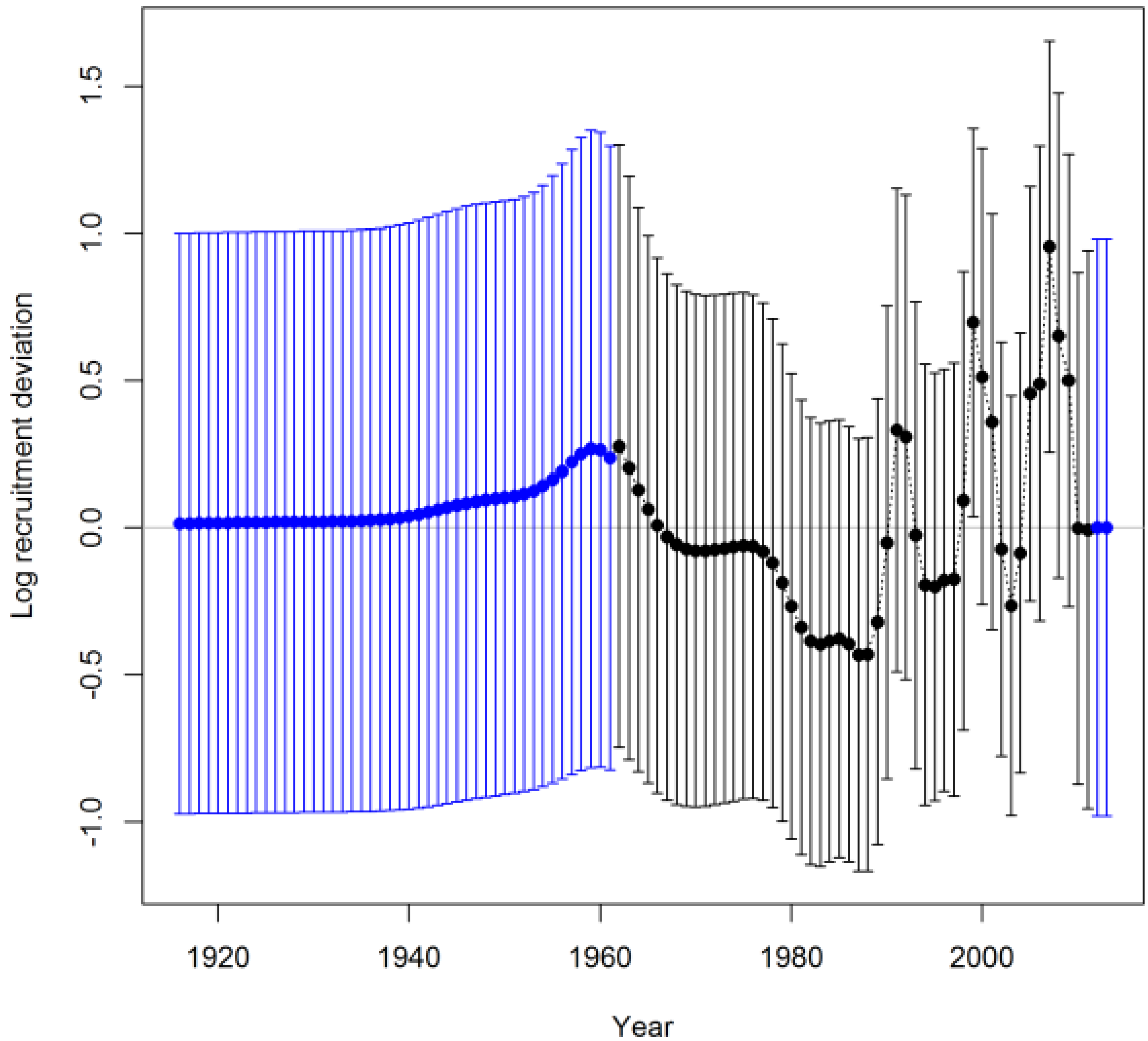



**Figure 101. Time series of estimated (black) or deterministic (blue) recruitment deviations from the aurora rockfish base case model. Vertical lines indicate the 95% CIs.**

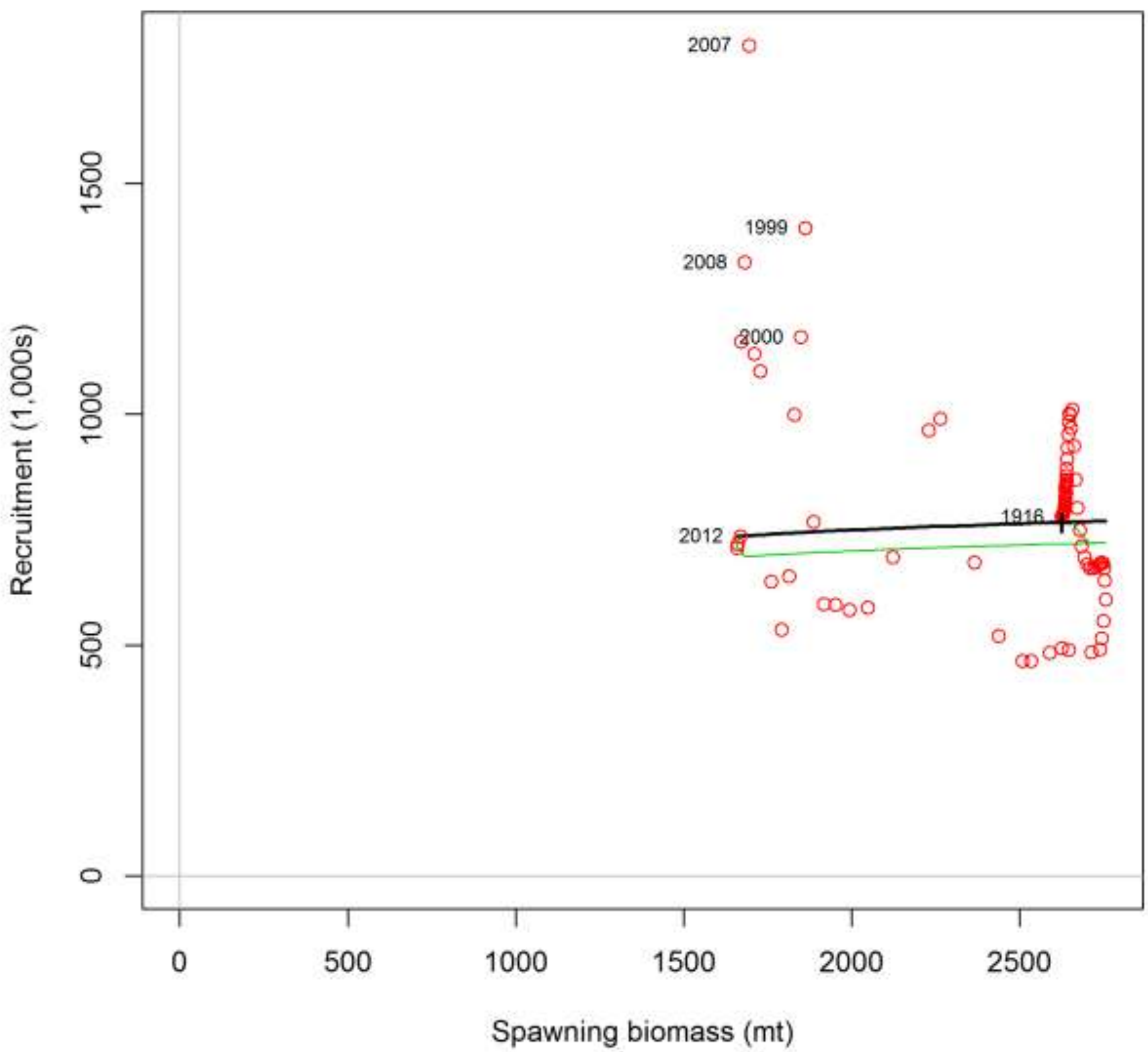



**Figure 102. Spawner-recruit time series from the aurora rockfish base case model. Reference years (beginning, ending, and high points) are labeled.**

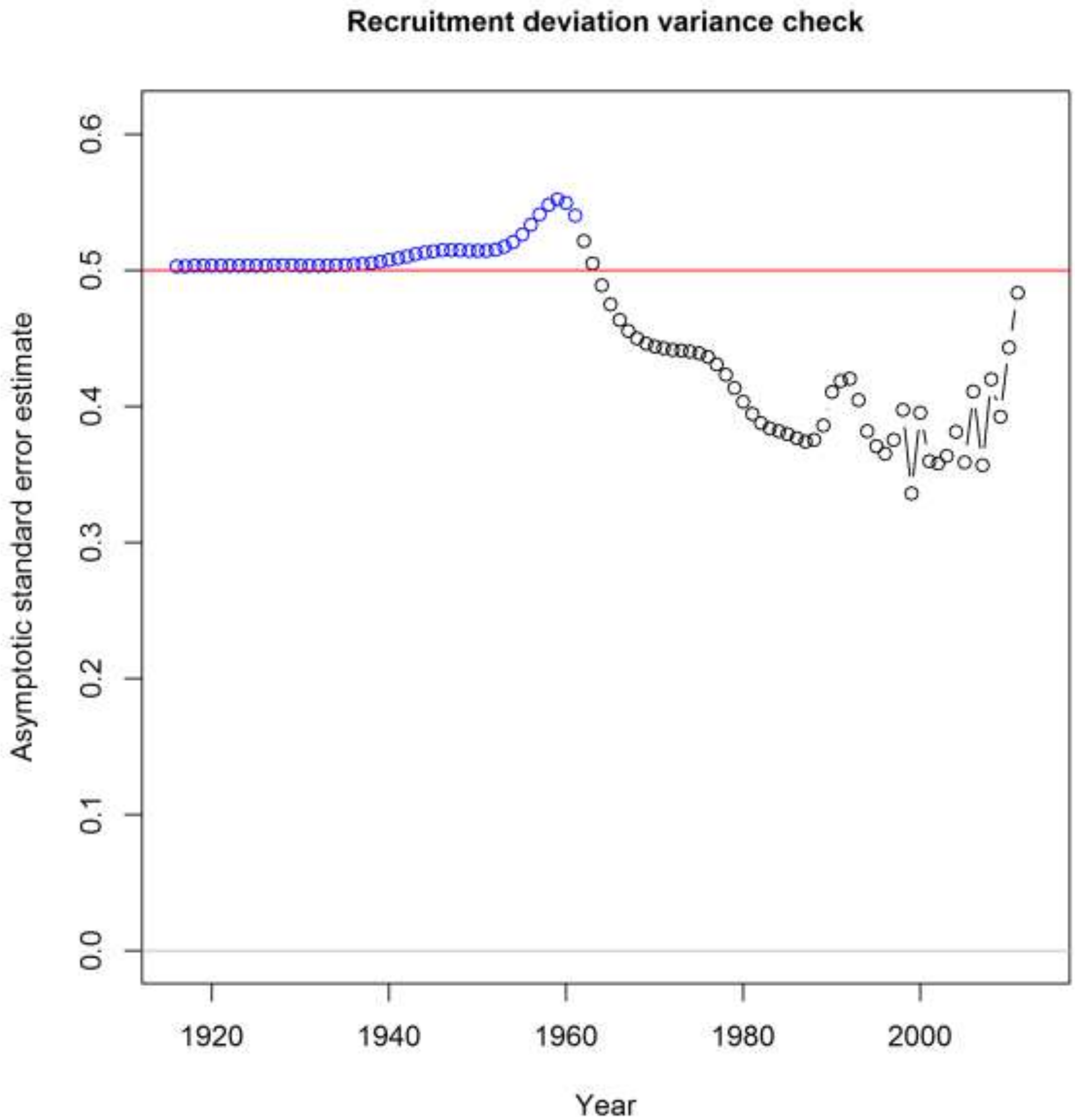



**Figure 103. Time series of the estimated asymptotic recruitment error for years with estimated (black) or deterministic (blue) recruitment deviations from the base case aurora rockfish assessment. Assumed model values are indicated by the red line.**

### *9.3.1.7 Biomass and status*

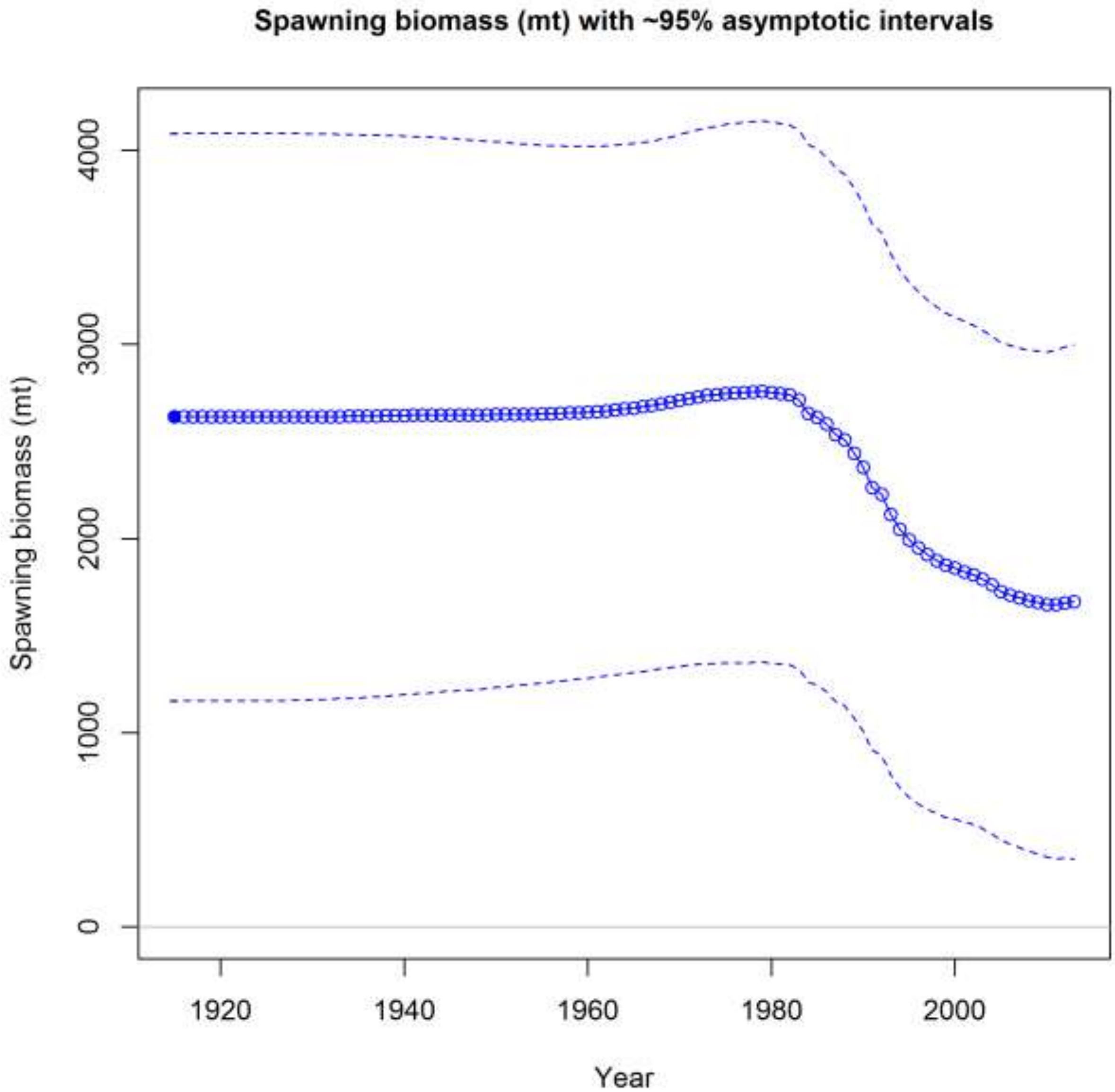



**Figure 104. Time series of spawning biomass with asymptotic estimated 95% CIs for the aurora rockfish base case model.**

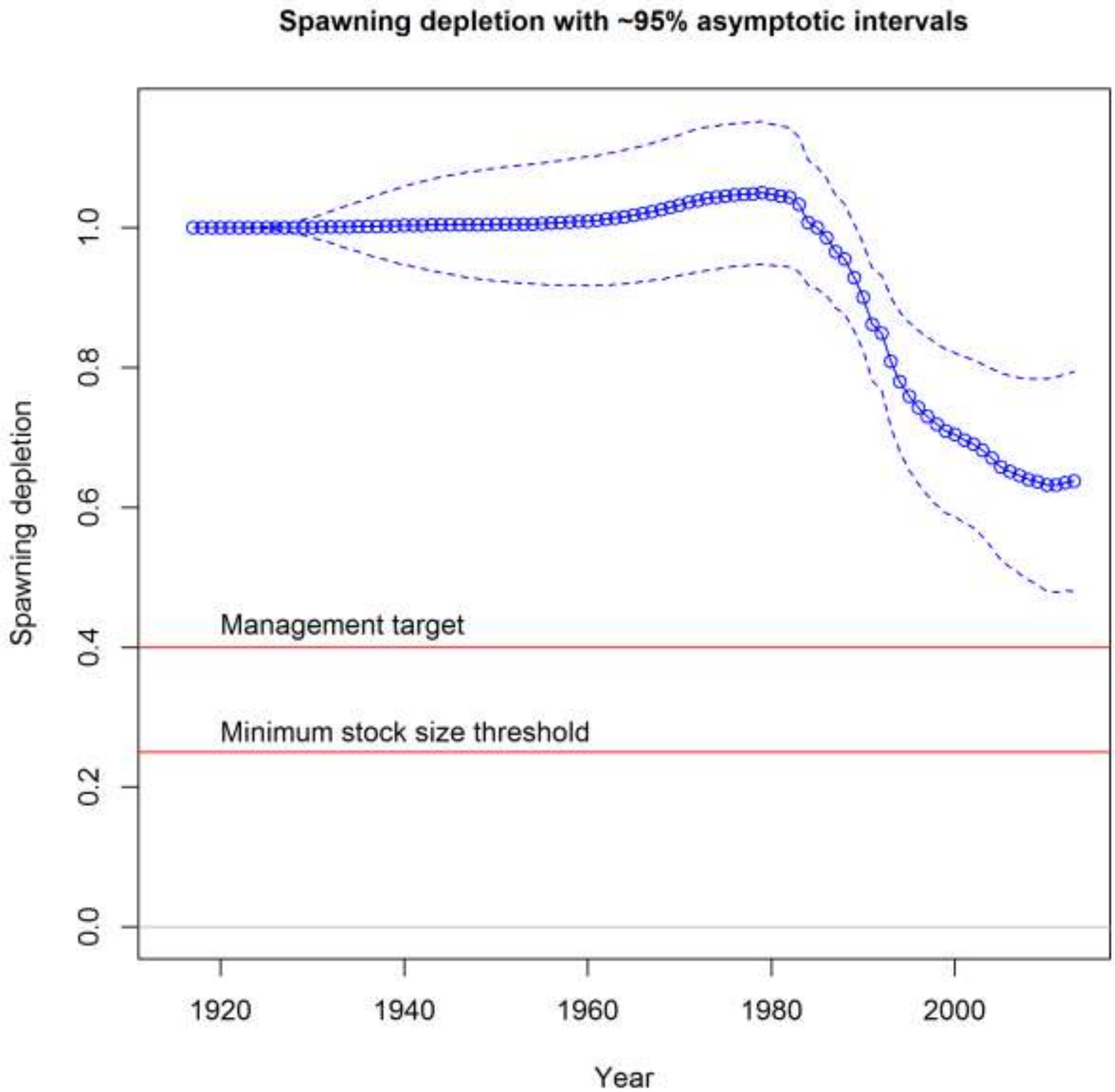



**Figure 105. Time series of stock status (depletion) with asymptotic estimated 95% CIs for the aurora rockfish base case model.**

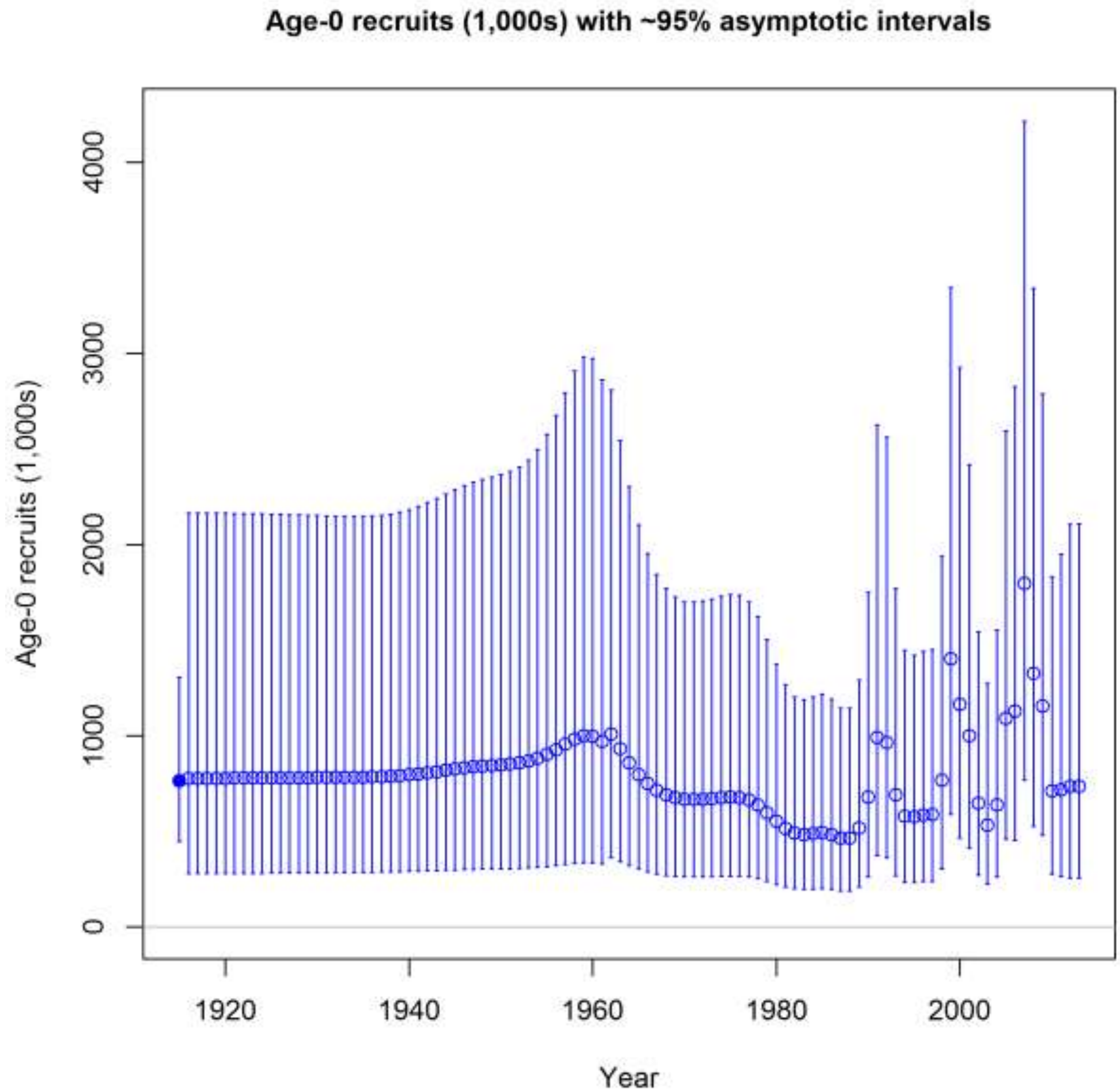



**Figure 106. Time series of recruitment with asymptotic estimated 95% CIs for the aurora rockfish base case model.**

### *9.3.1.8 Management outputs*

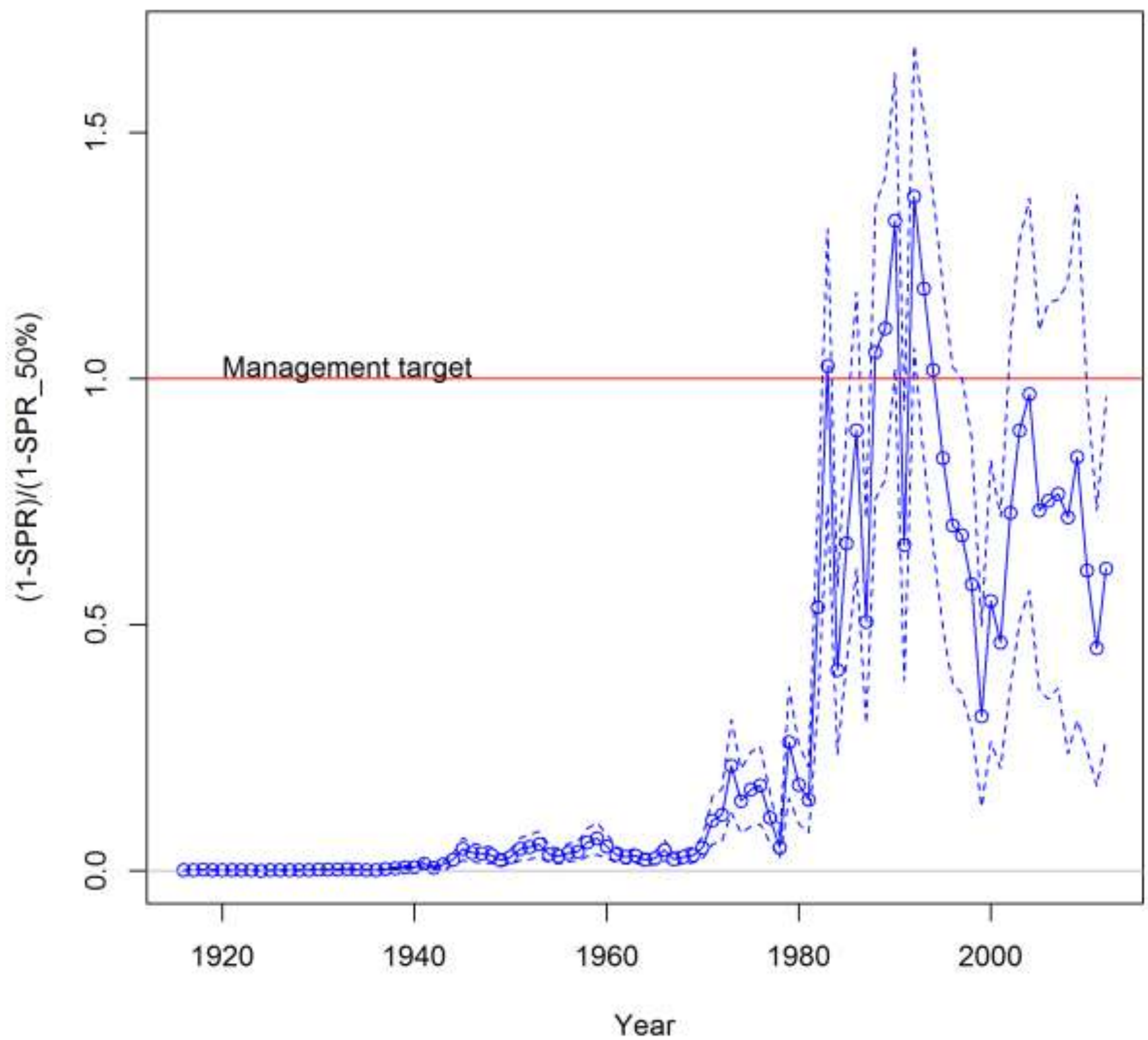



**Figure 107. Time series of exploitation relative to the management target from the aurora rockfish base case model. Symbols and line are the mean values. Broken lines indicate asymptotically estimated 95% CIs.**

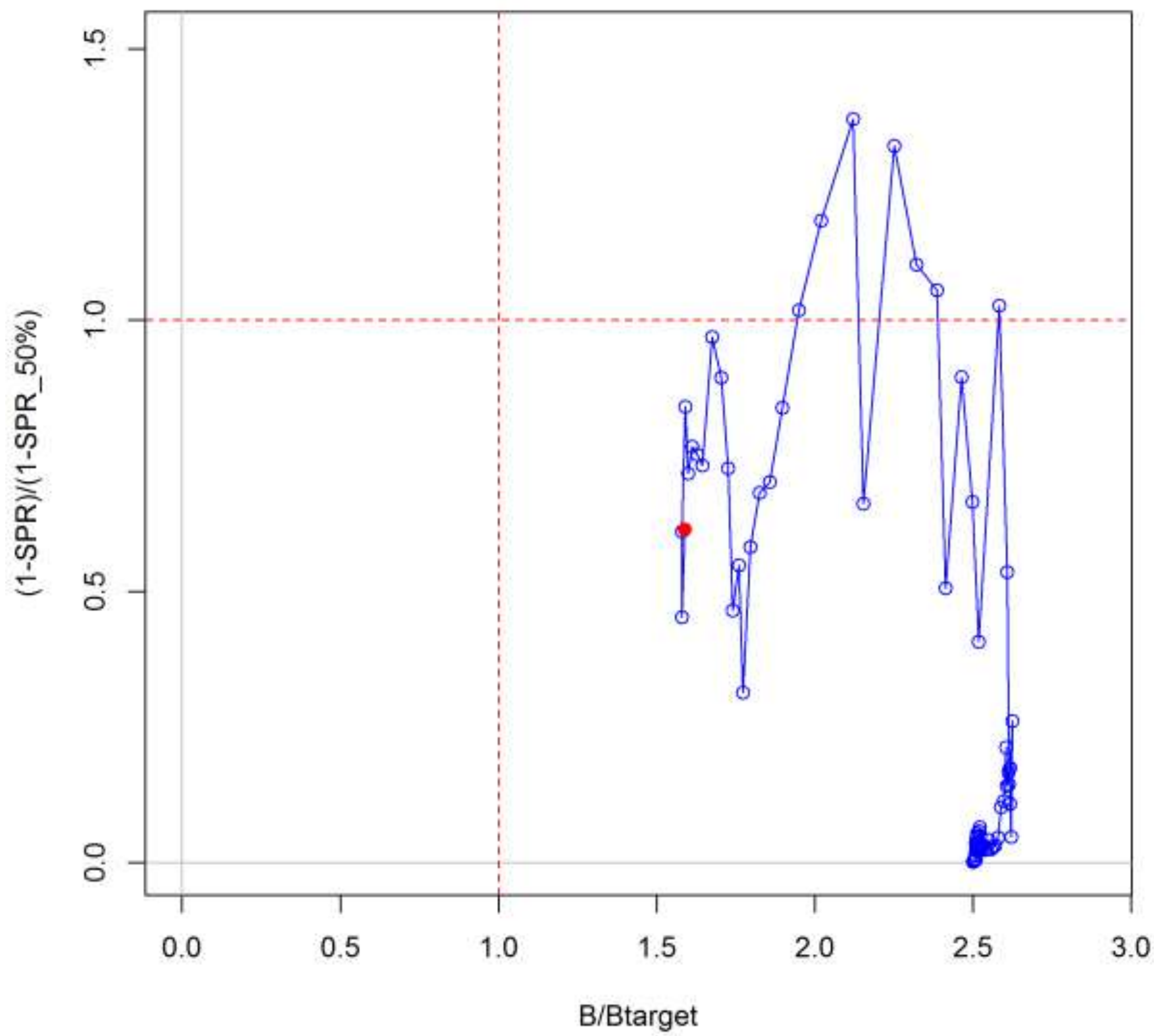



**Figure 108. Quadrant plot showing the time series of stock status (x-axis) and exploitation metrics (y-axis) from the aurora rockfish base case model. Red vertical broken line indicated biomass target; red horizontal broken line indicates exploitation target. Red dot is the current year.**

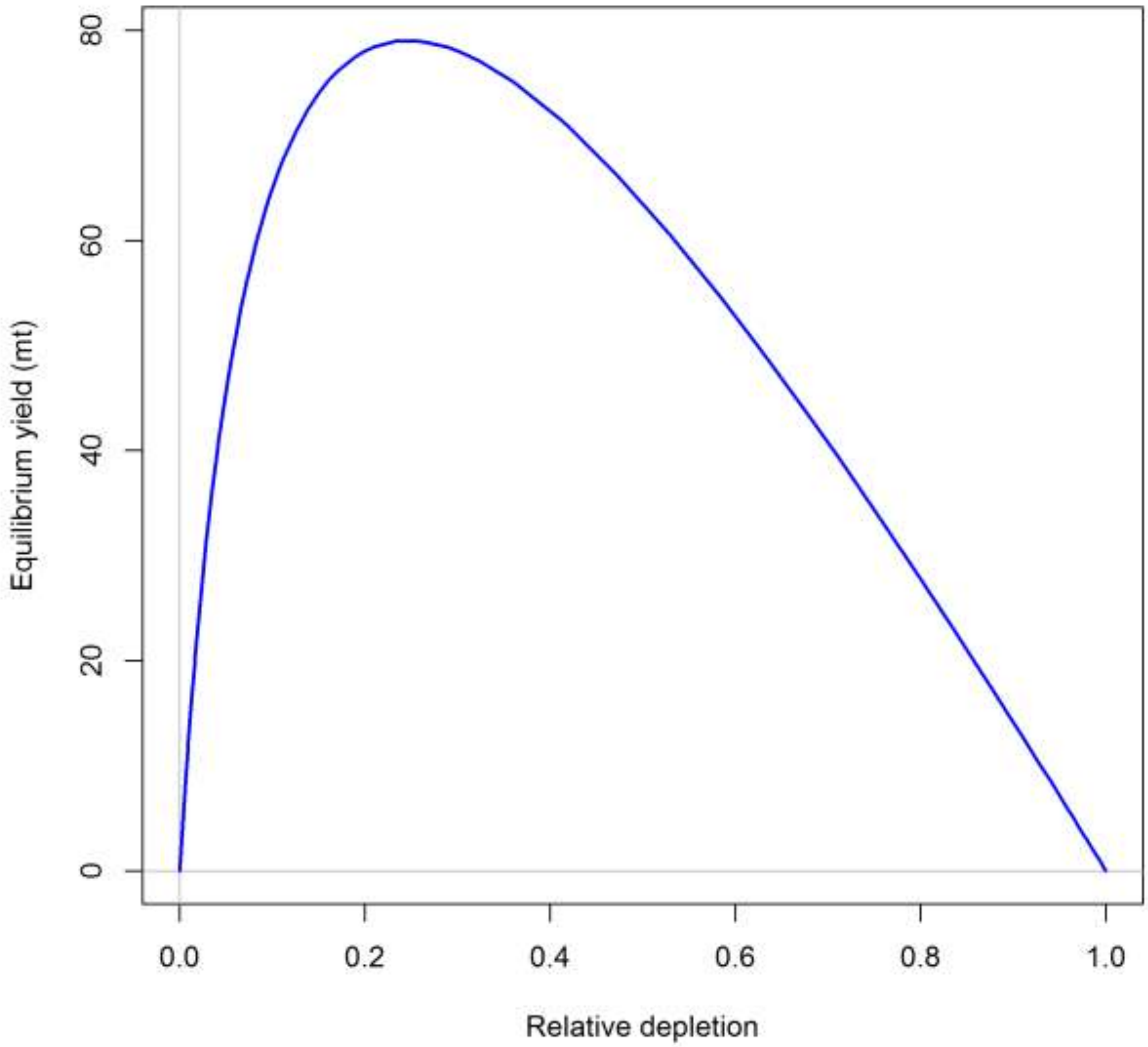



**Figure 109. Yield curve for aurora rockfish from the base case model.**

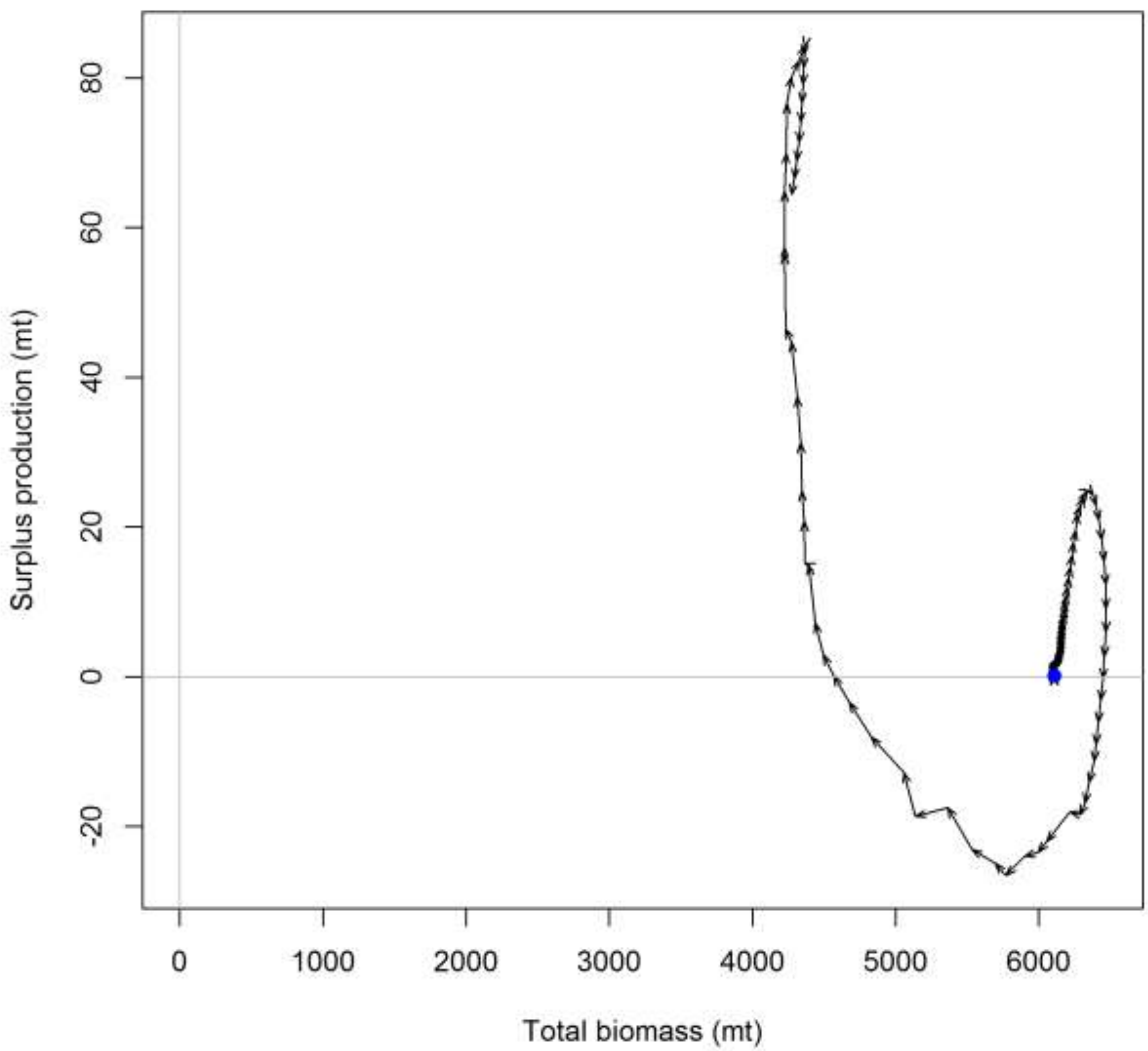



**Figure 110. Time series of surplus production from the aurora rockfish base case model.**

### 9.3.2 Profiles

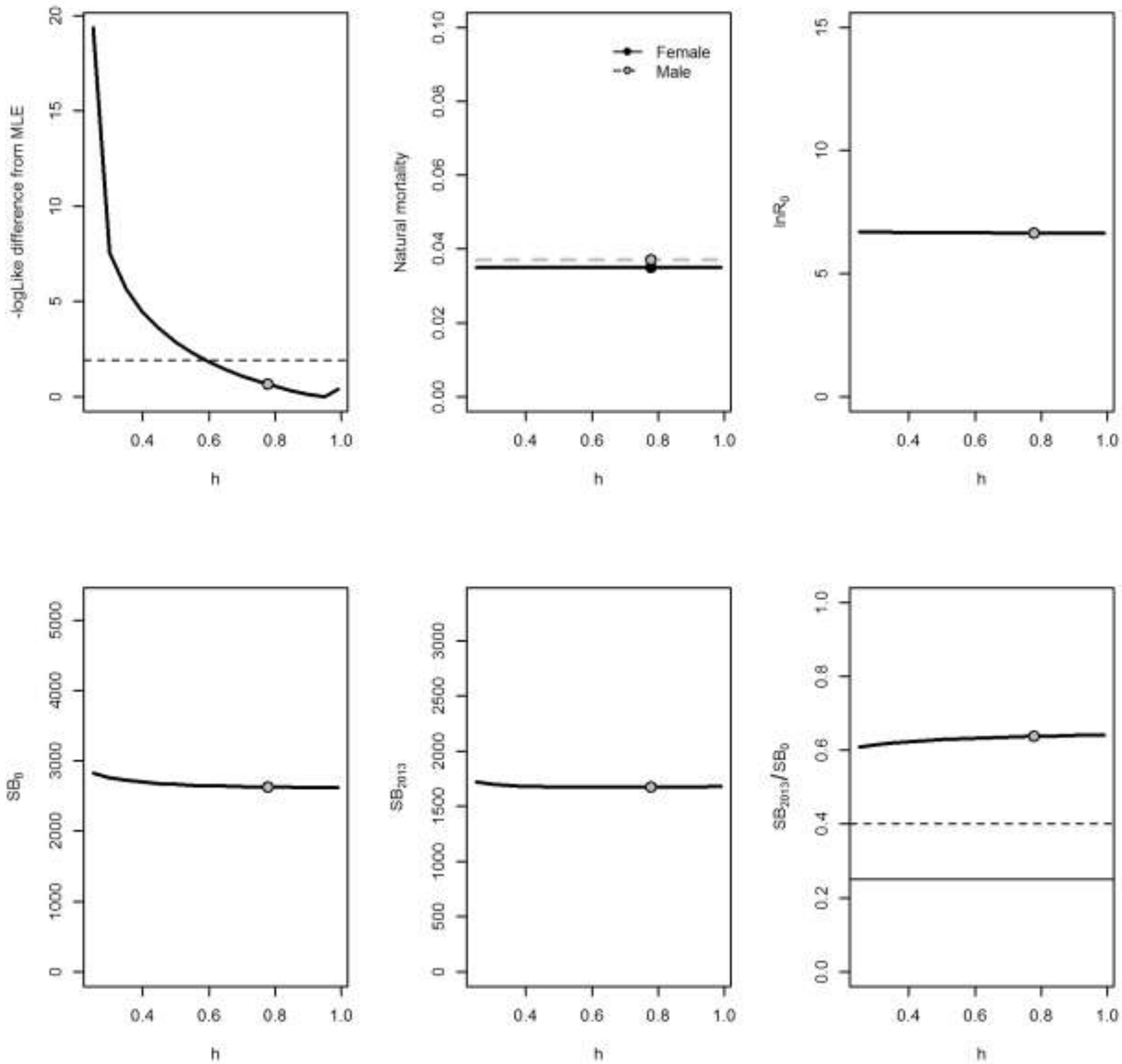



**Figure 111. Likelihood profile for steepness (*h*; top left panel) and sensitivity to *h* of estimated (top center and right panels) and derived assessment outputs (bottom panels) for aurora rockfish. The MLE is indicated by the circle. Top left panel: broken line is 95% interval; Top middle panel: solid and broken lines are the female and male *M* values; Bottom right panel: Solid and broken line are the target and limit biomass reference points.**

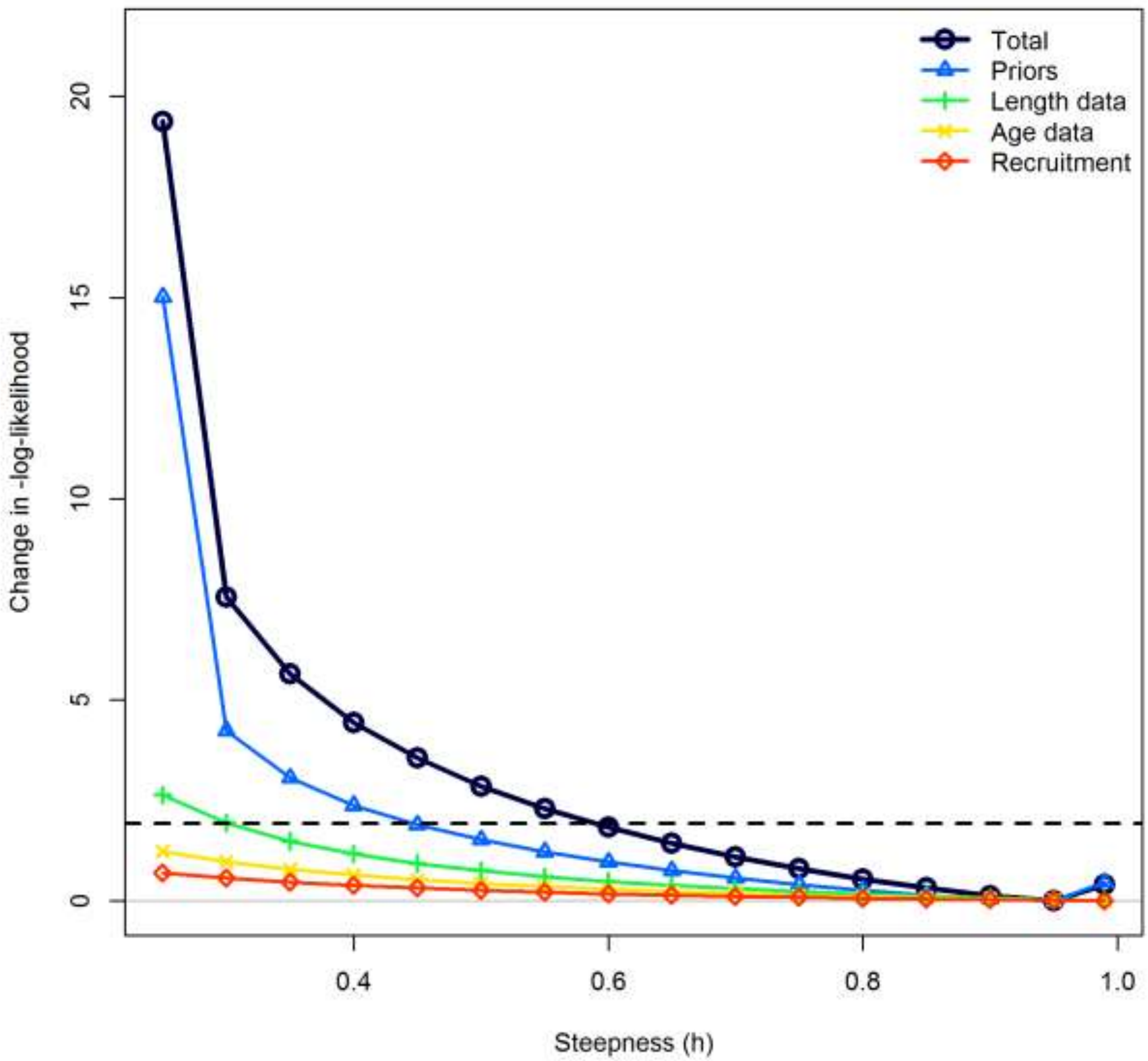



**Figure 112. Change in likelihood for the total likelihood and each likelihood component as profiled across steepness (h). Broken horizontal line indicates significant change in likelihood.**

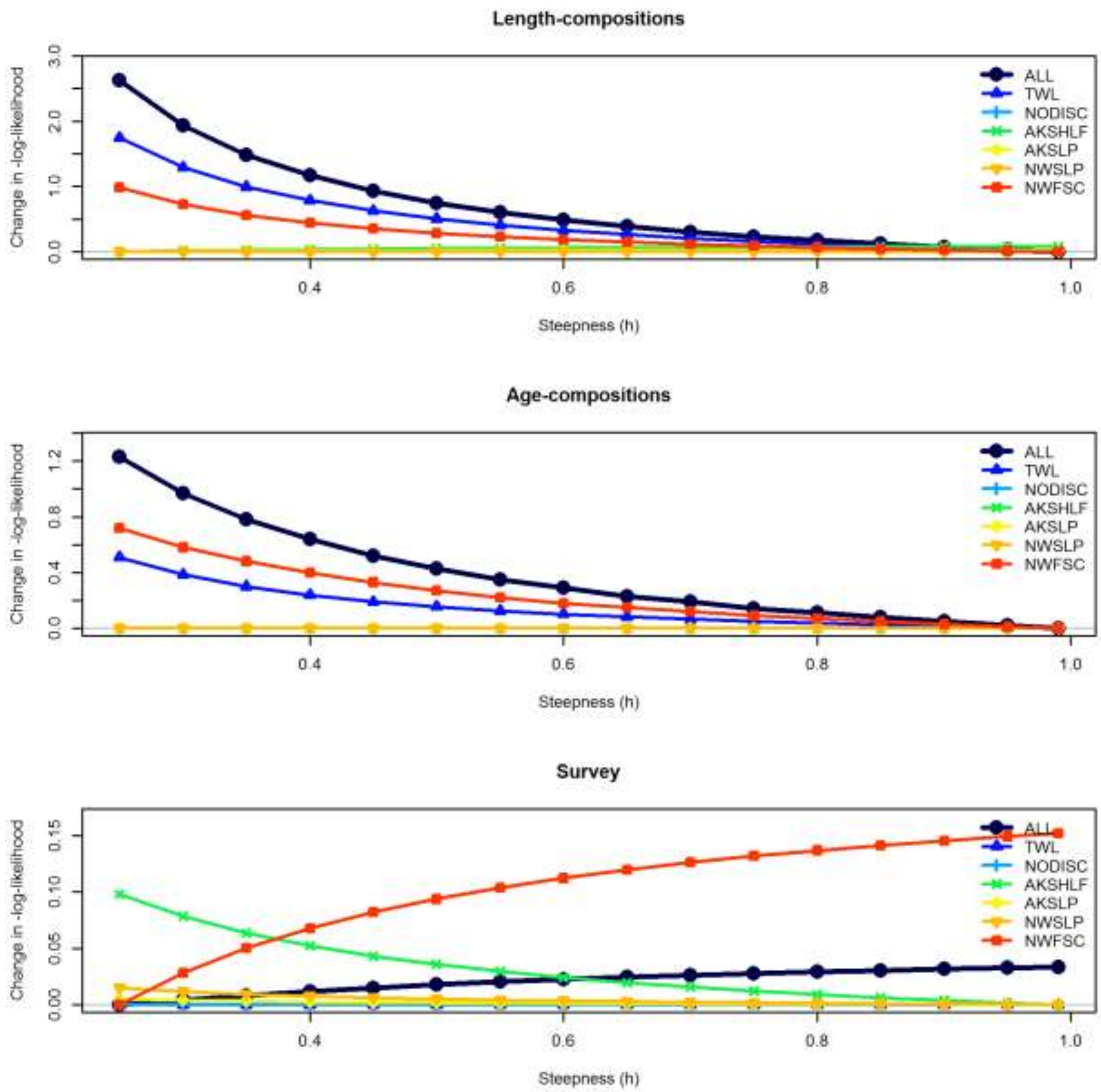



**Figure 113. Change in likelihood for each fleet contribution to the likelihood component as profiled across steepness (h).**

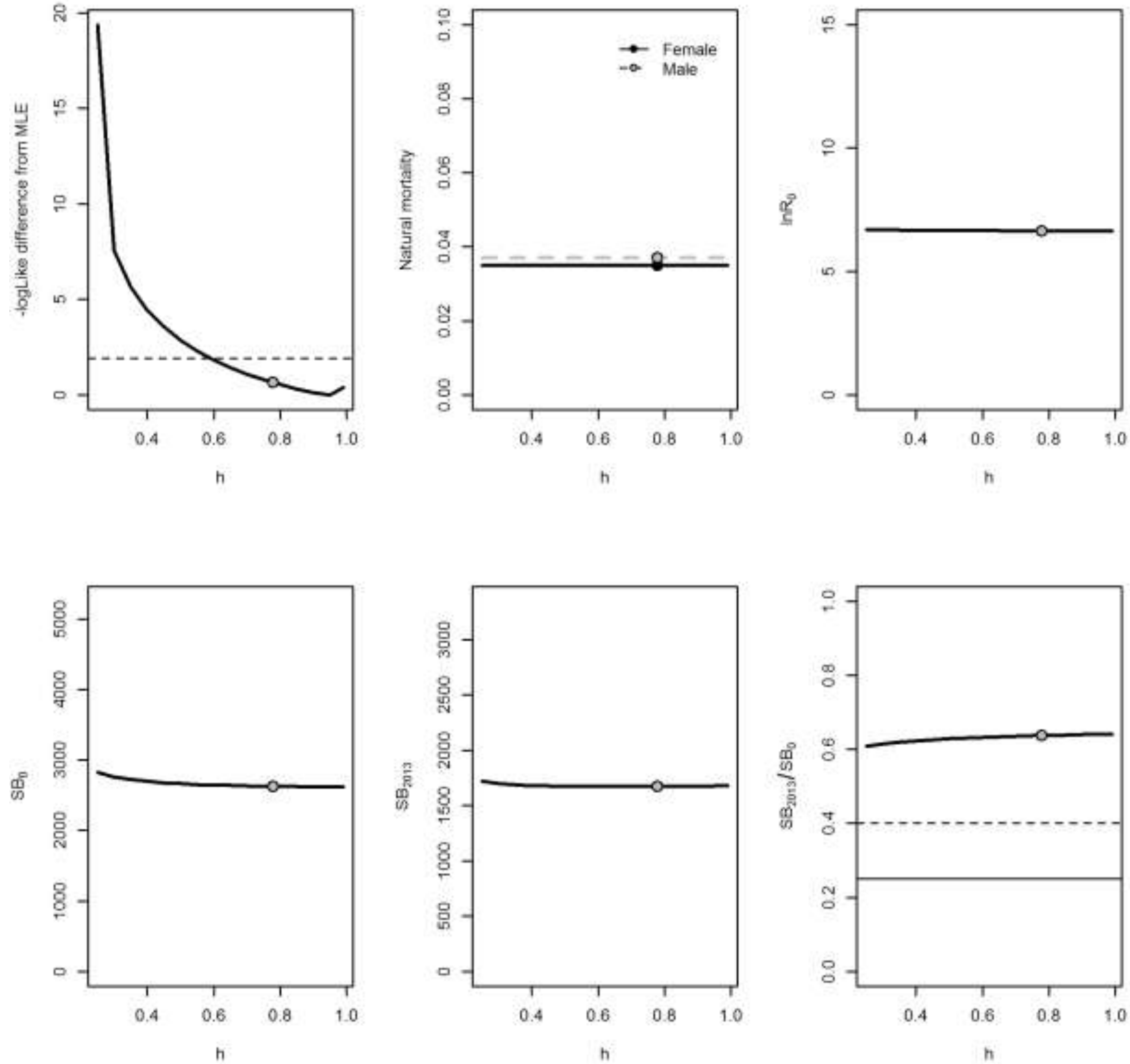



**Figure 114. Likelihood profile for steepness (*h*; top left panel) and sensitivity to *h* of estimated (top center and right panels) and derived assessment outputs (bottom panels) for aurora rockfish when both female and male natural mortality (M) is estimated. The base case MLE is indicated by the circle as a reference point. Top left panel: broken line is 95% interval; Top middle panel: solid and broken lines are the female and male *M* values; Bottom right panel: Solid and broken line are the target and limit biomass reference points.**

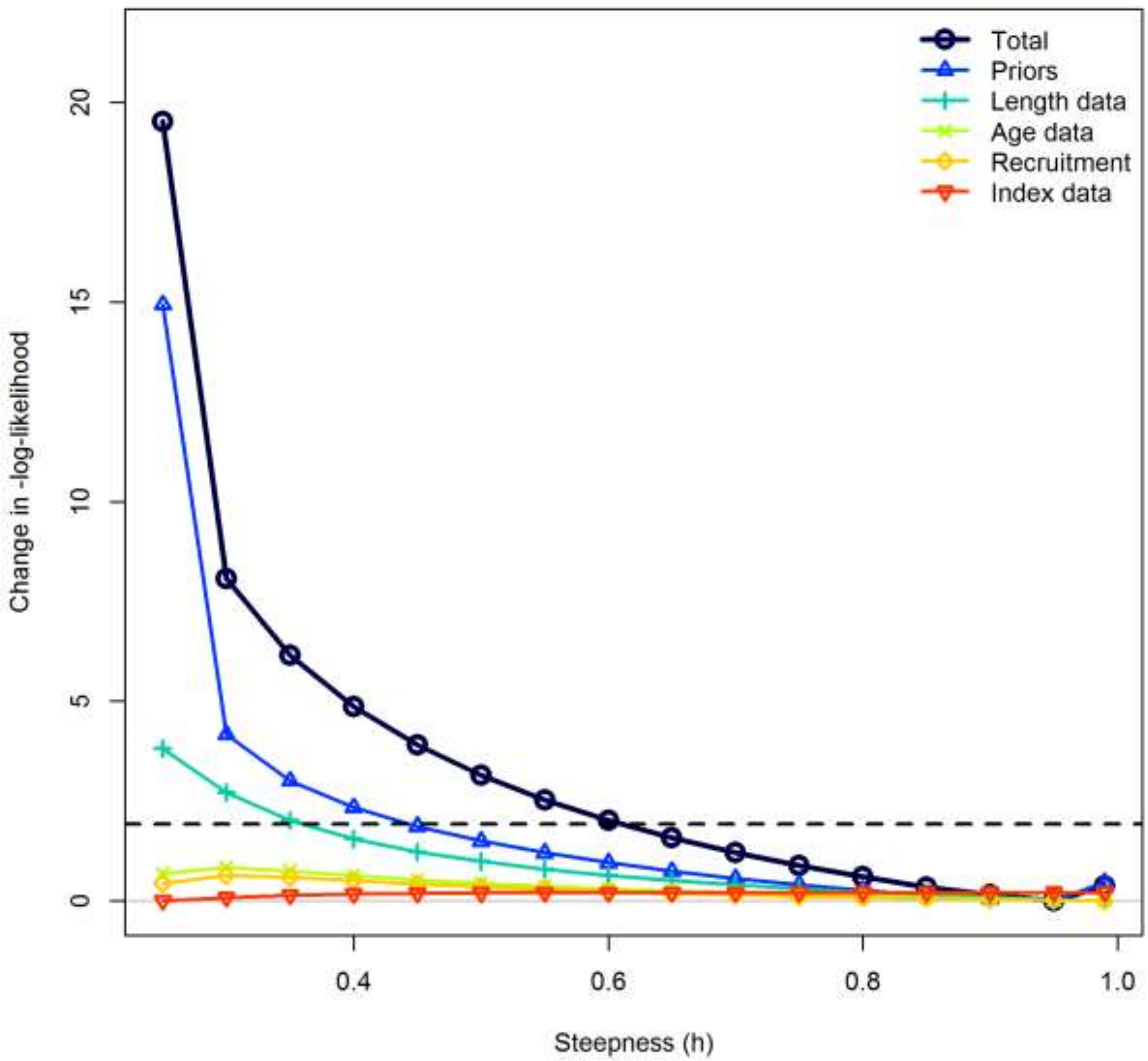



**Figure 115. Change in likelihood for the total likelihood and each likelihood component as profiled across steepness (h) when female and male natural mortality are being estimated. Broken horizontal line indicates significant change in likelihood.**

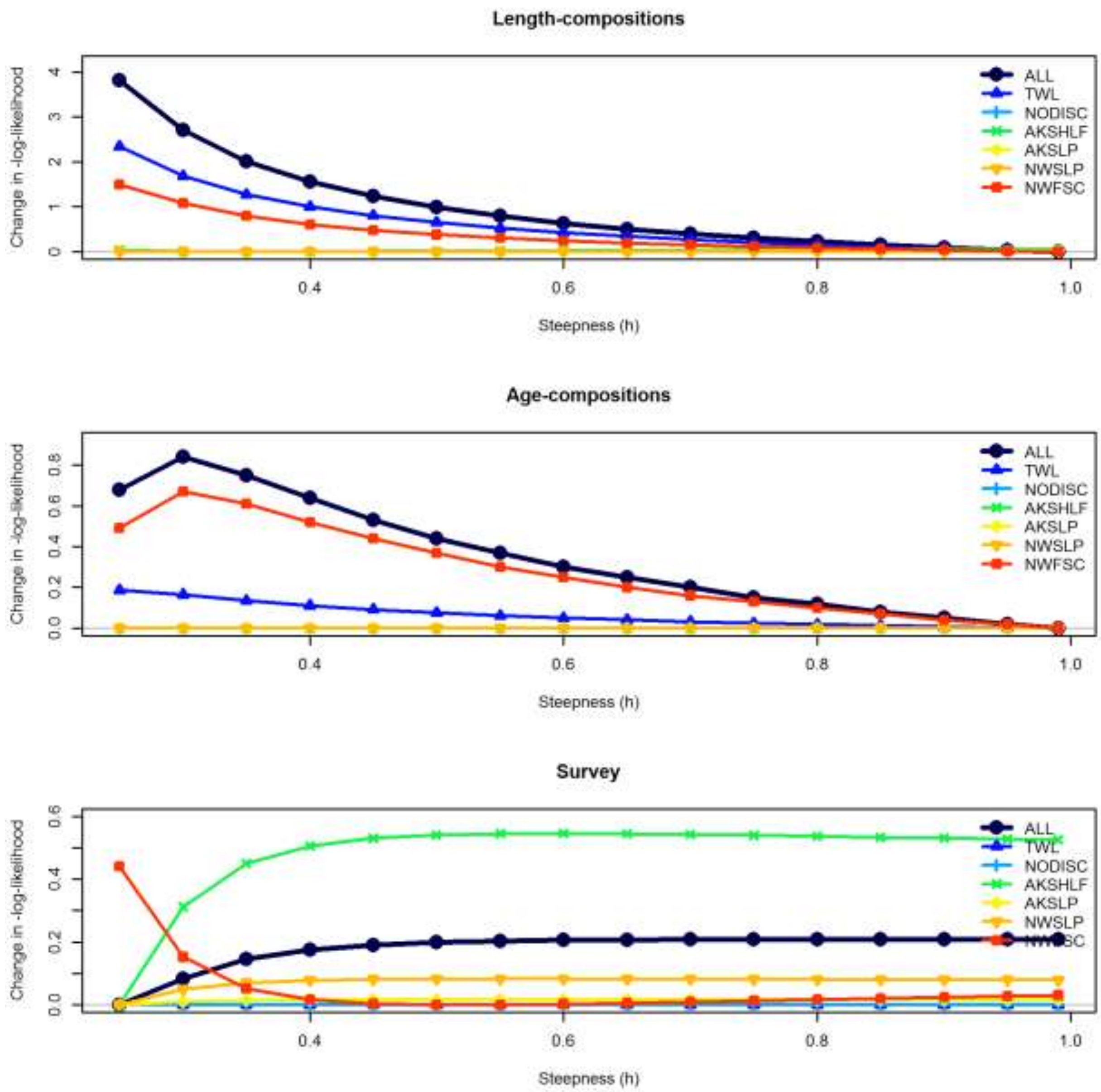



**Figure 116. Change in likelihood for each fleet contribution to the likelihood component as profiled across steepness (h) when female and male natural mortality are being estimated.**

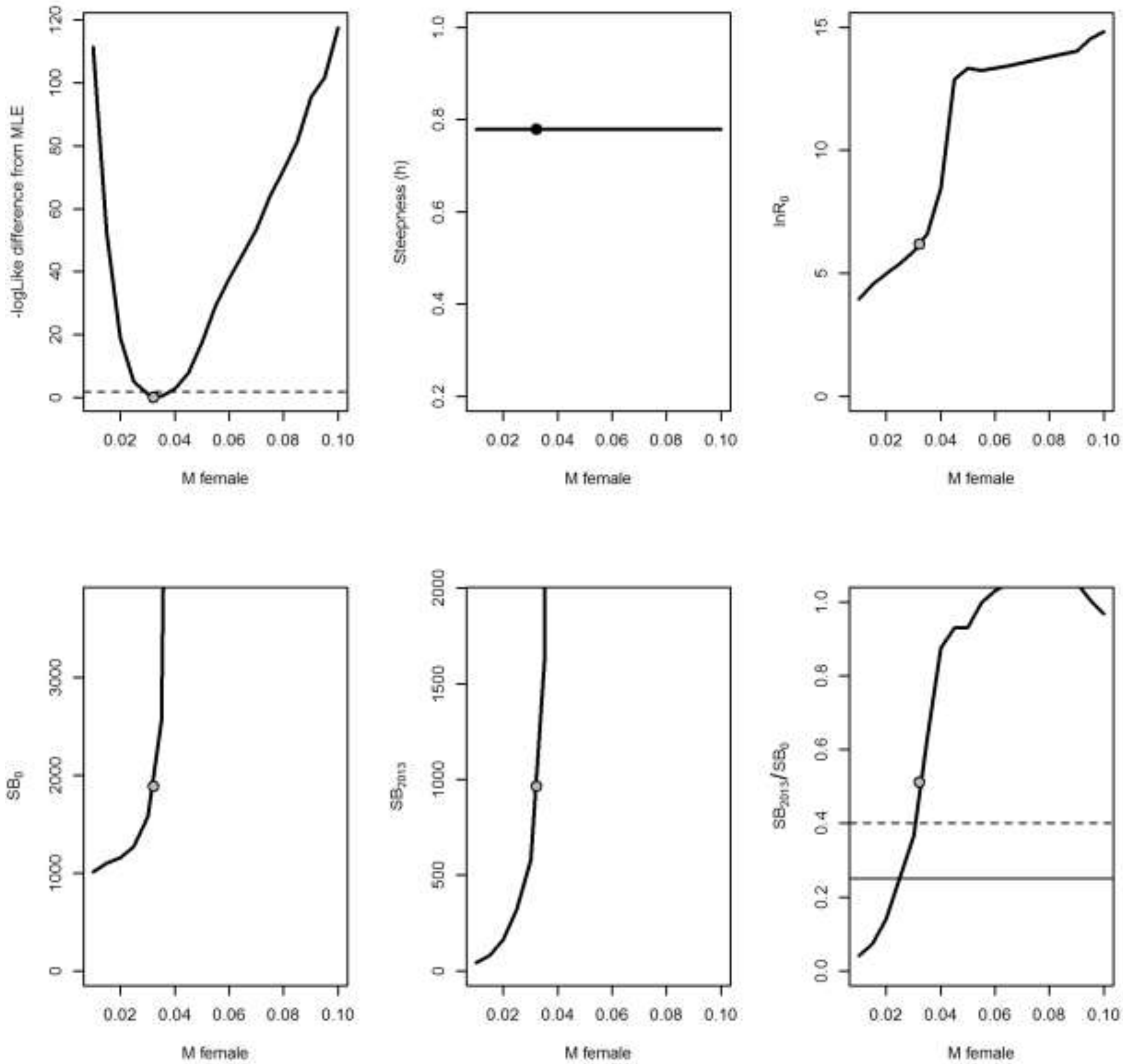



**Figure 117. Likelihood profile for female natural mortality (*M*; top left panel) and sensitivity to female *M* of estimated (top center and right panels) and derived assessment outputs (bottom panels) for aurora rockfish when male natural mortality is estimated. The base case MLE is indicated by the circle as a reference point. Top left panel: broken line is 95% interval. Bottom right panel: Solid and broken line are the target and limit biomass reference points.**

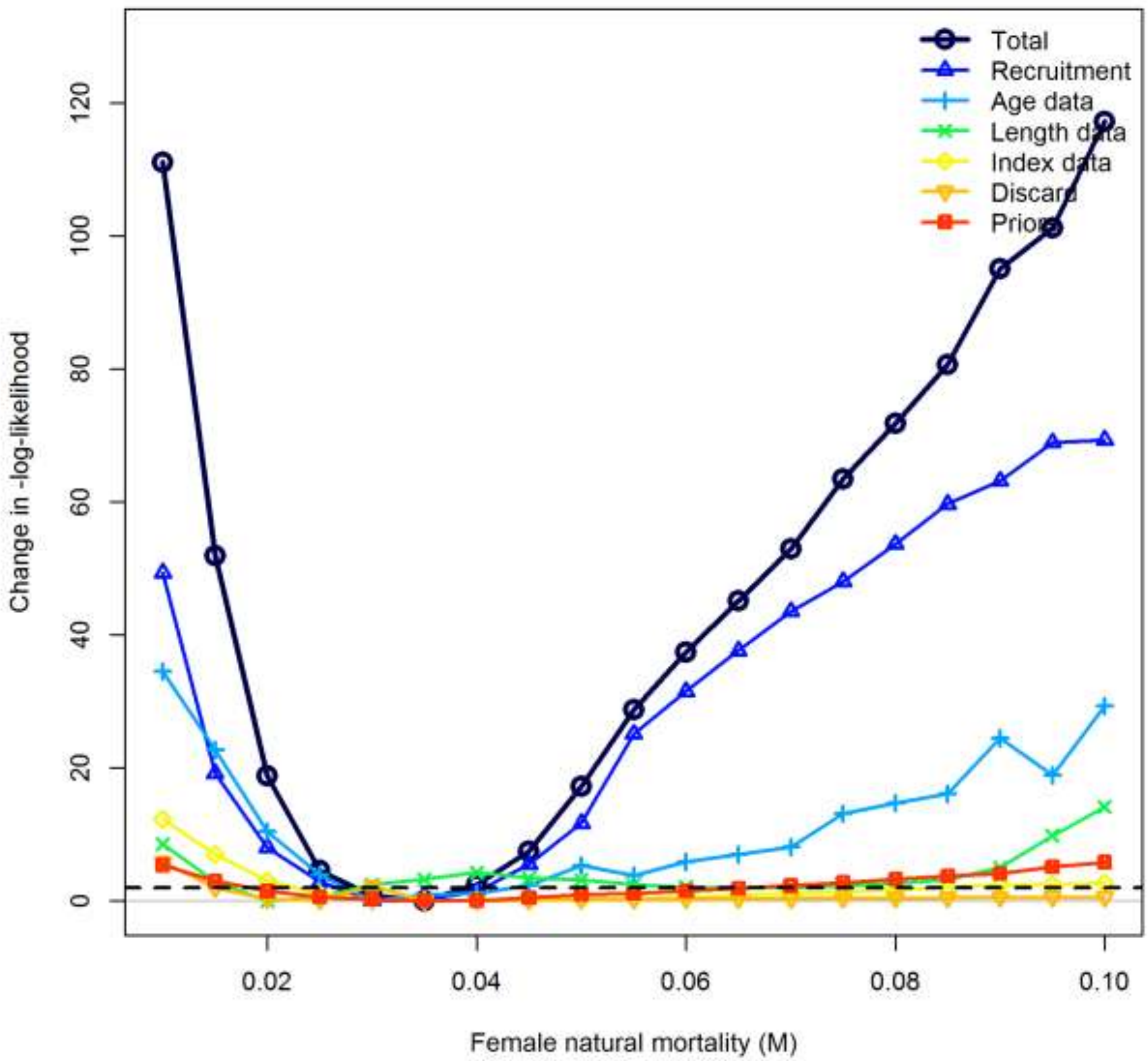



**Figure 118. Change in likelihood for the total likelihood and each likelihood component as profiled across female natural mortality (M) when male natural mortality is also being estimated. Broken horizontal line indicates significant change in likelihood.**

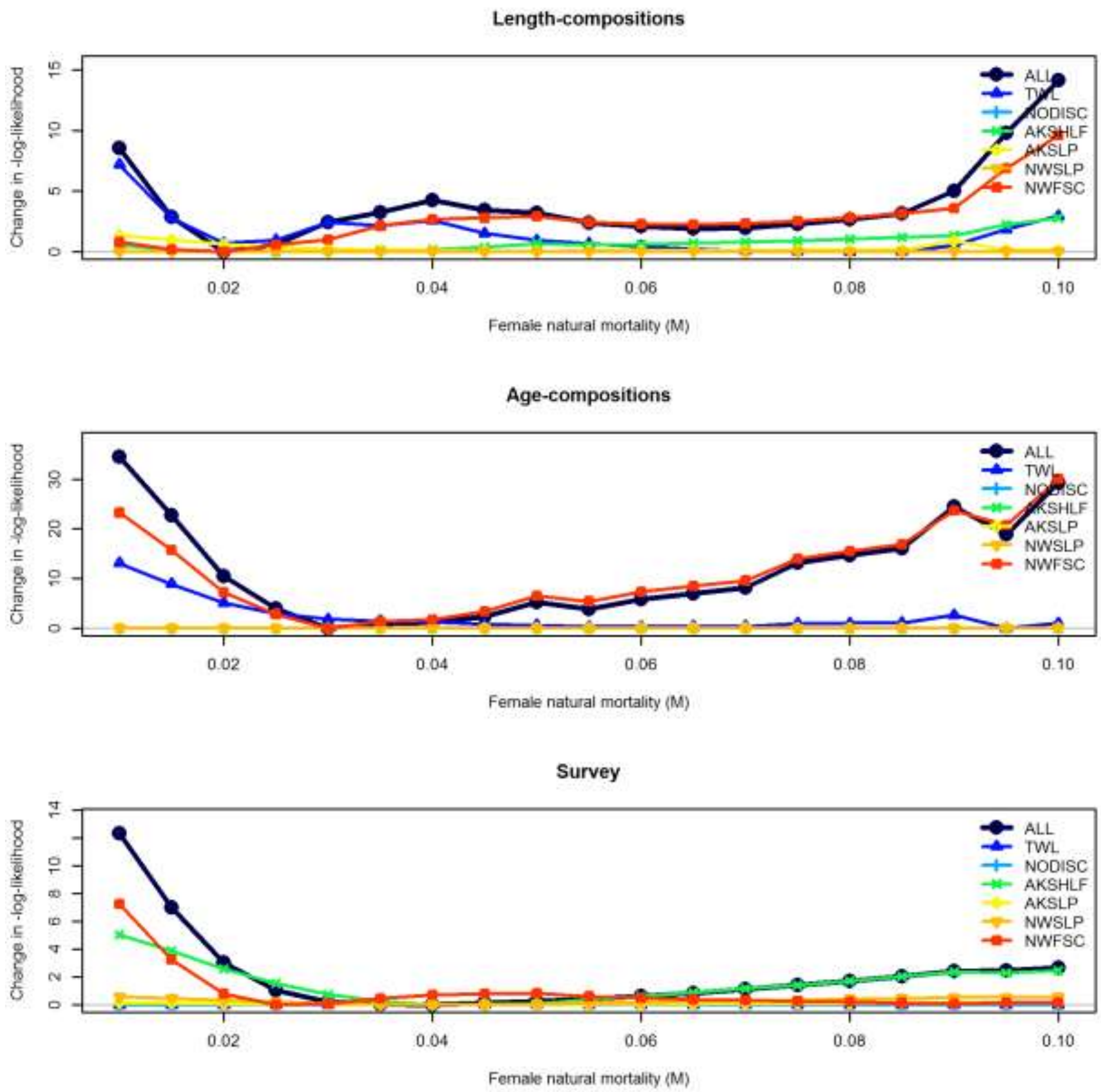



**Figure 119. Change in likelihood for each fleet contribution to the likelihood component as profiled across female natural mortality (M) when male natural mortality is also being estimated.**

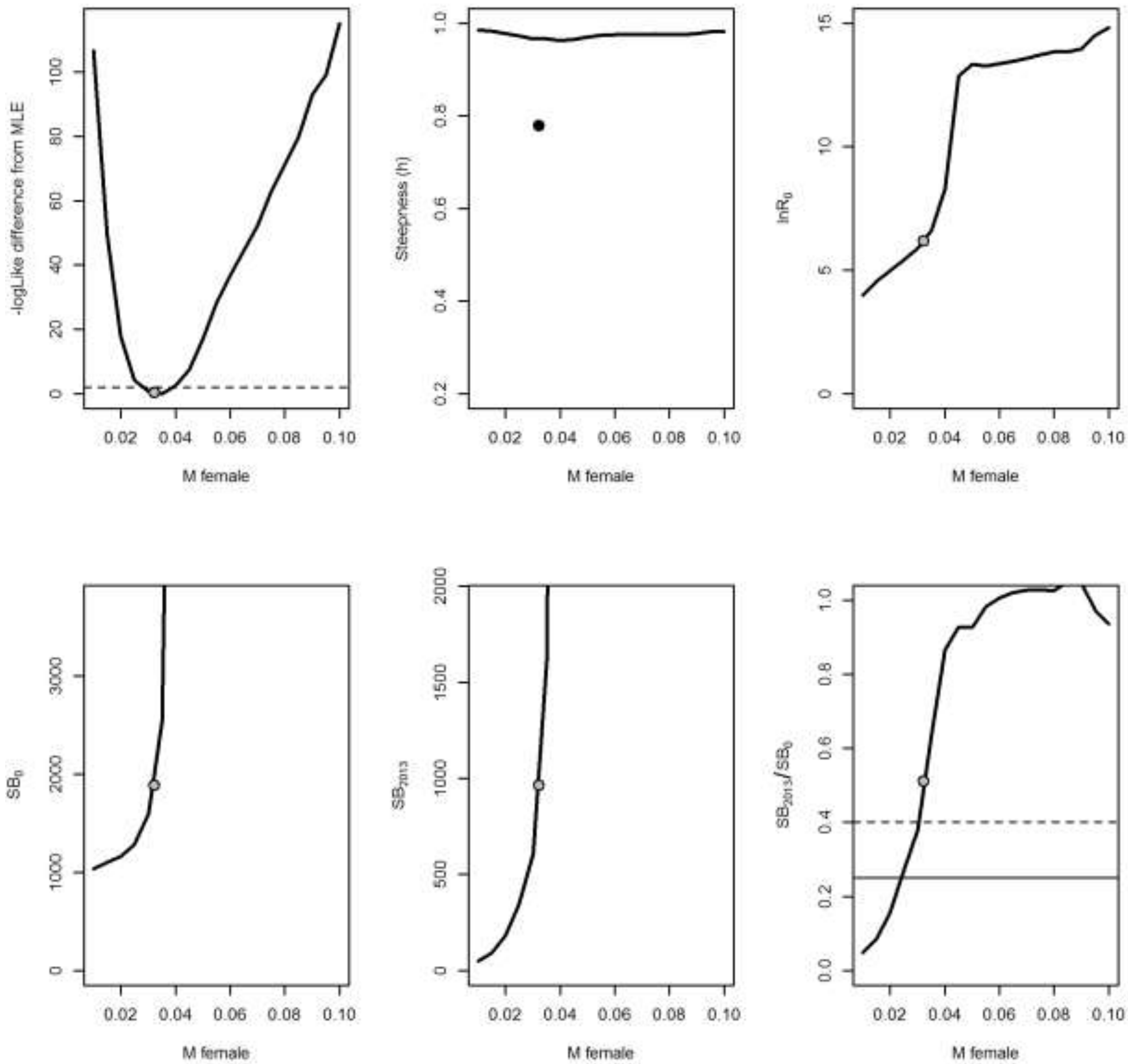



**Figure 120. Likelihood profile for female natural mortality (*M*; top left panel) and sensitivity to female *M* of estimated (top center and right panels) and derived assessment outputs (bottom panels) for aurora rockfish when steepness (*h*) male natural mortality is estimated. The base case MLE is indicated by the circle as a reference point. Top left panel: broken line is 95% interval. Bottom right panel: Solid and broken line are the target and limit biomass reference points.**

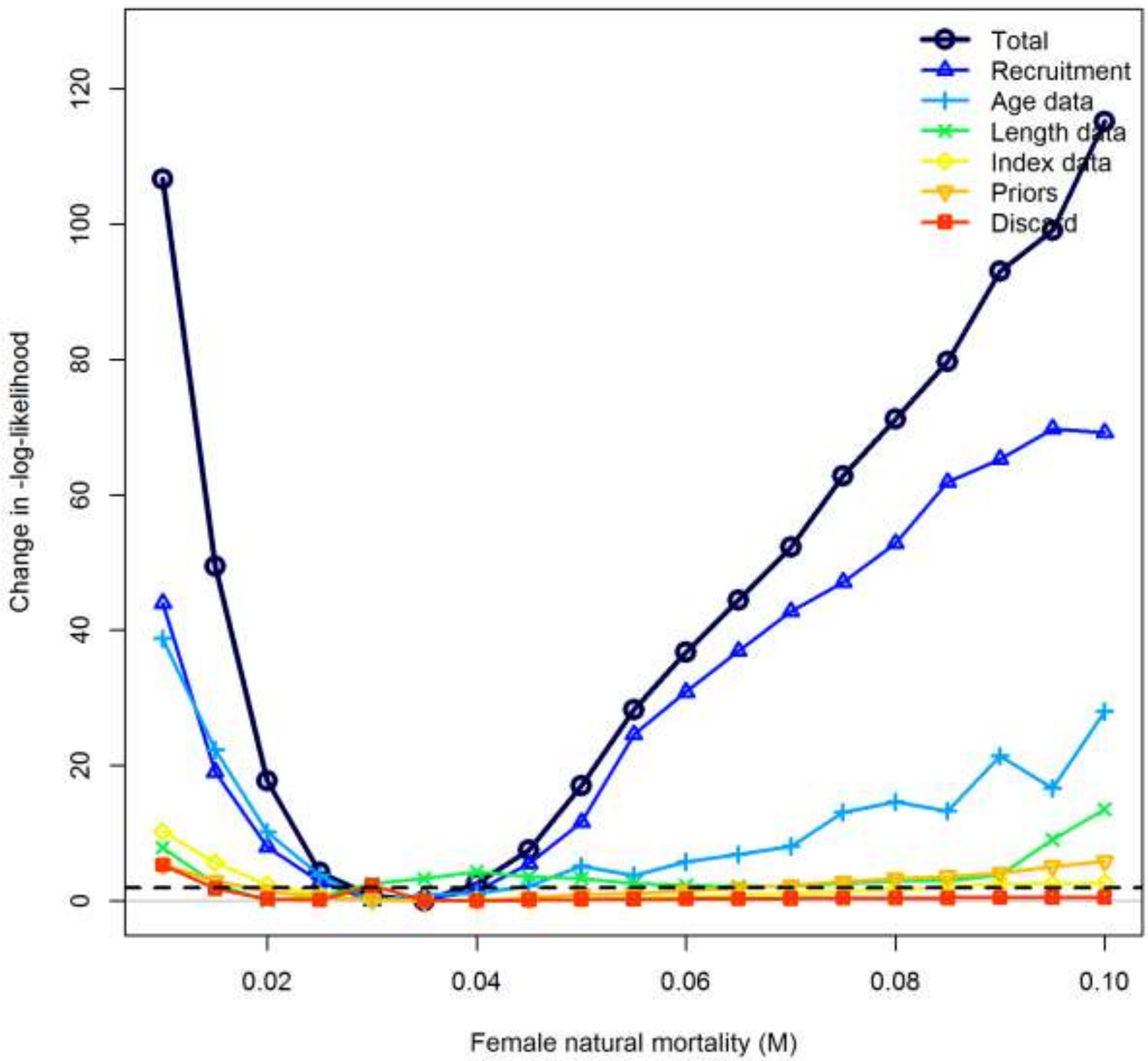



**Figure 121. Change in likelihood for the total likelihood and each likelihood component as profiled across female natural mortality (M) when male natural mortality and steepness are also being estimated. Broken horizontal line indicates significant change in likelihood.**

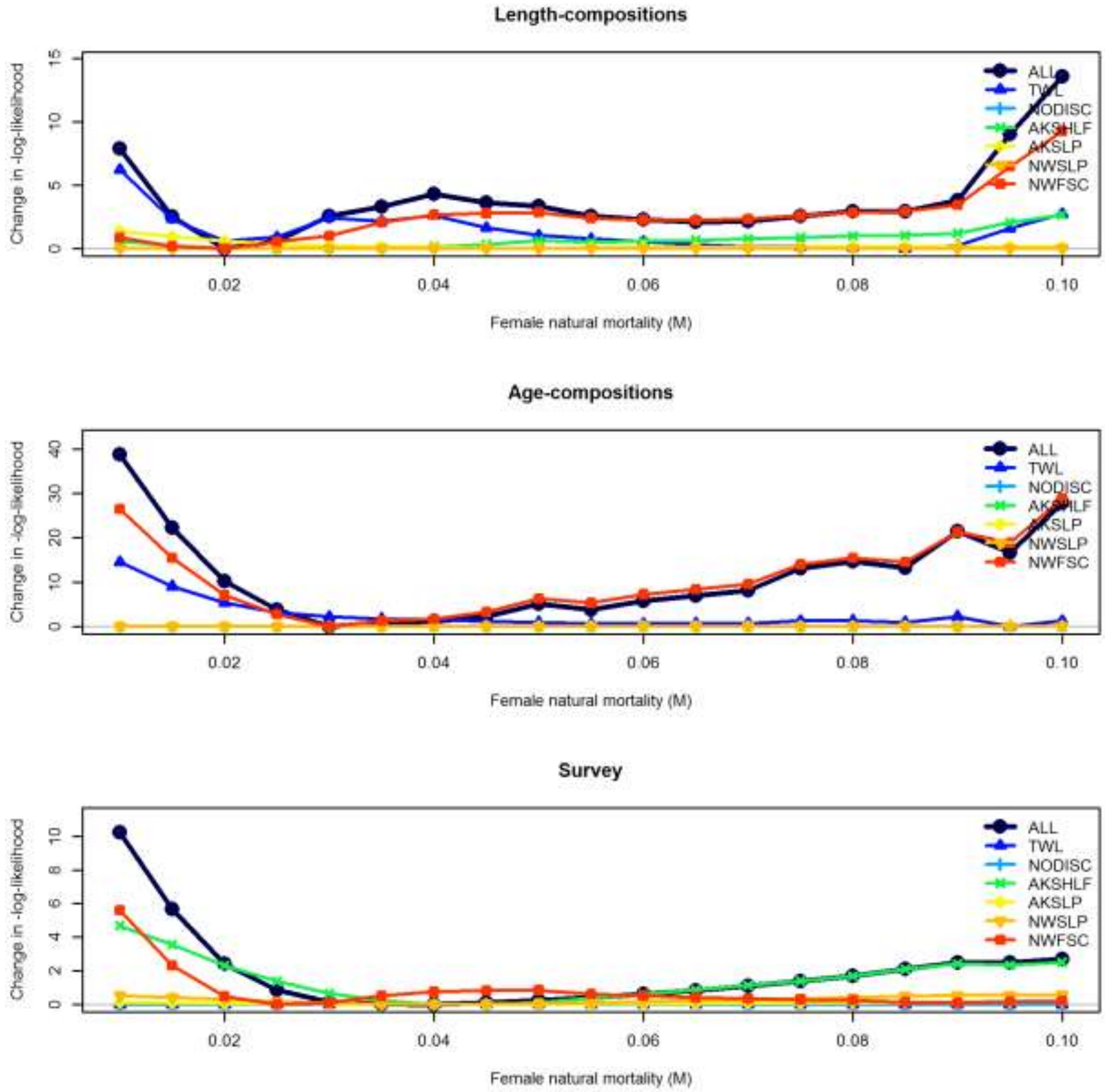



**Figure 122. Change in likelihood for each fleet contribution to the likelihood component as profiled across female natural mortality (M) when male natural mortality and steepness are also being estimated.**

### 9.3.3 Retrospective runs

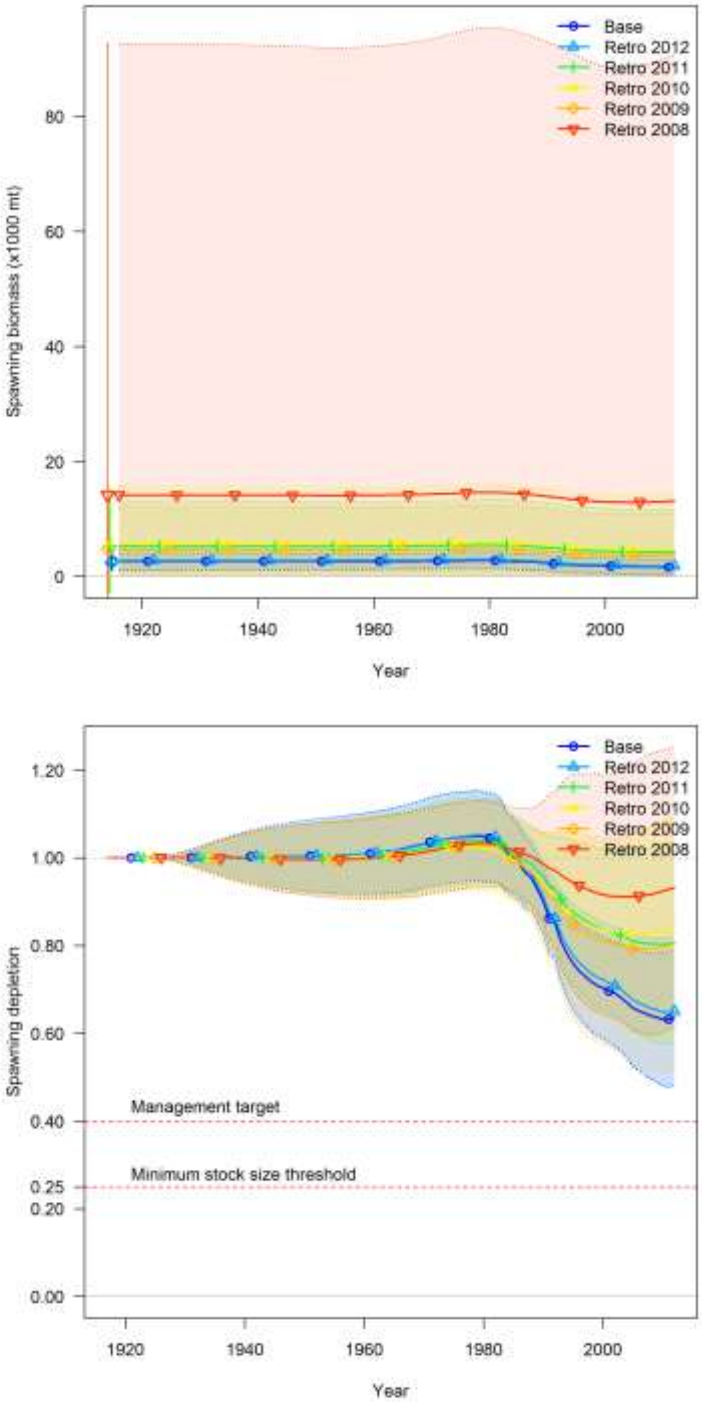



**Figure 123. Spawning biomass (top panel) and depletion for the base case and each retrospective run. Solid lines and symbols are median values; polygons are the 85% CI.**

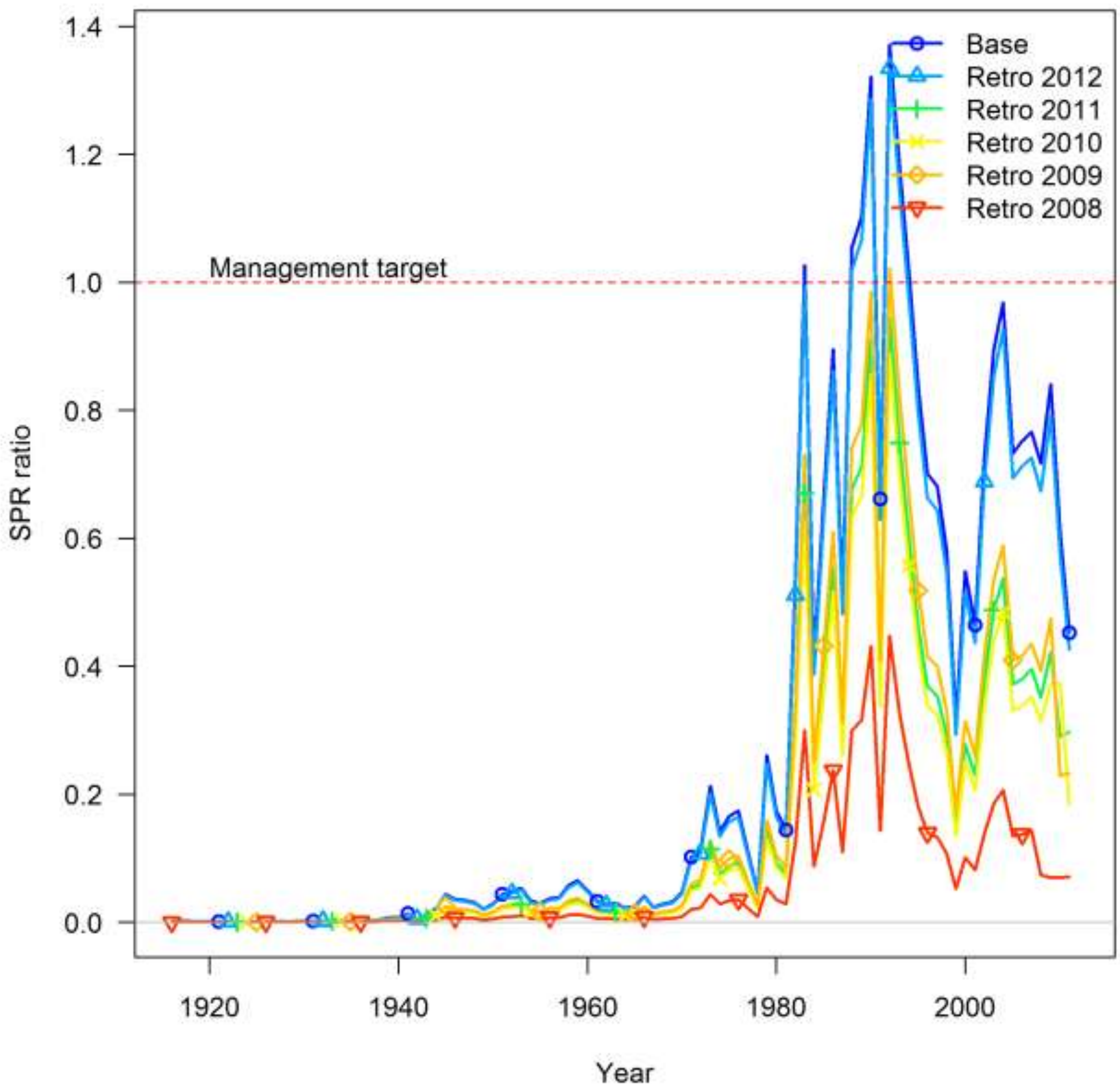



**Figure 124. Exploitation history (as measure by the SPR ratio) for the base case and each retrospective run.**

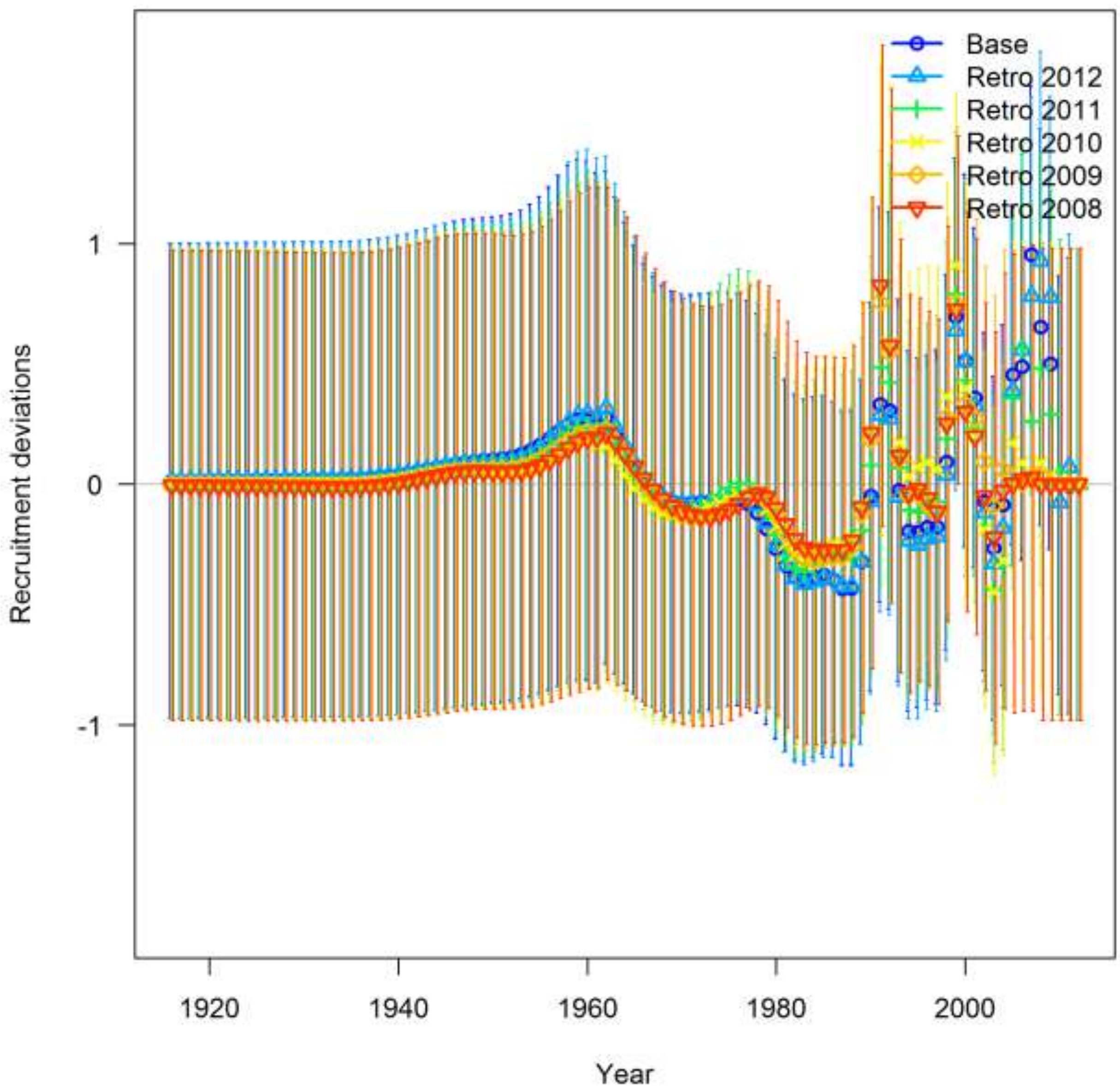



**Figure 125. Recruitment deviations across different retrospective runs and the base case. Vertical bars are the 95% CI.**

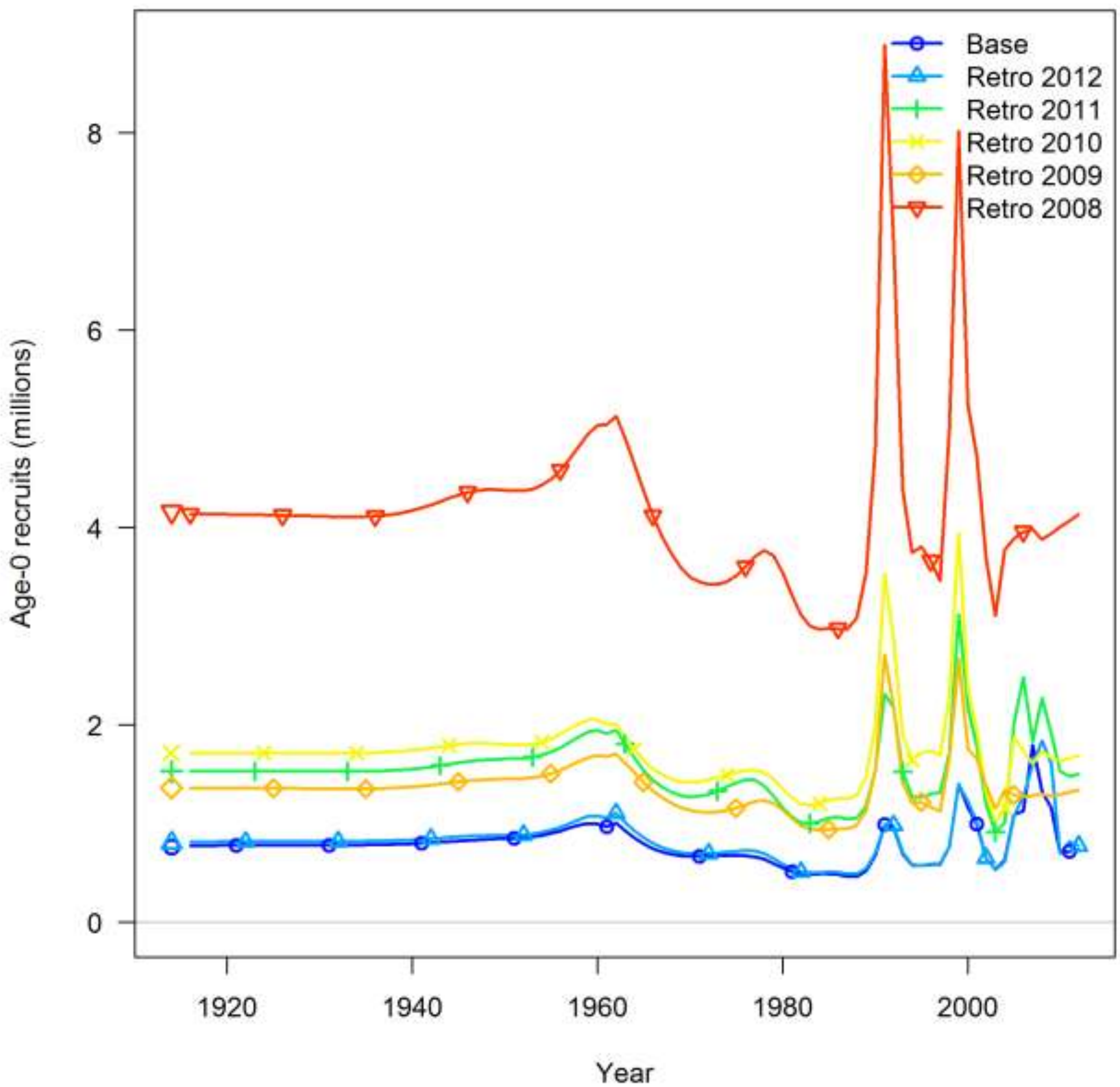



**Figure 126. Recruitment (in number of individuals) for the base case and each retrospective run.**

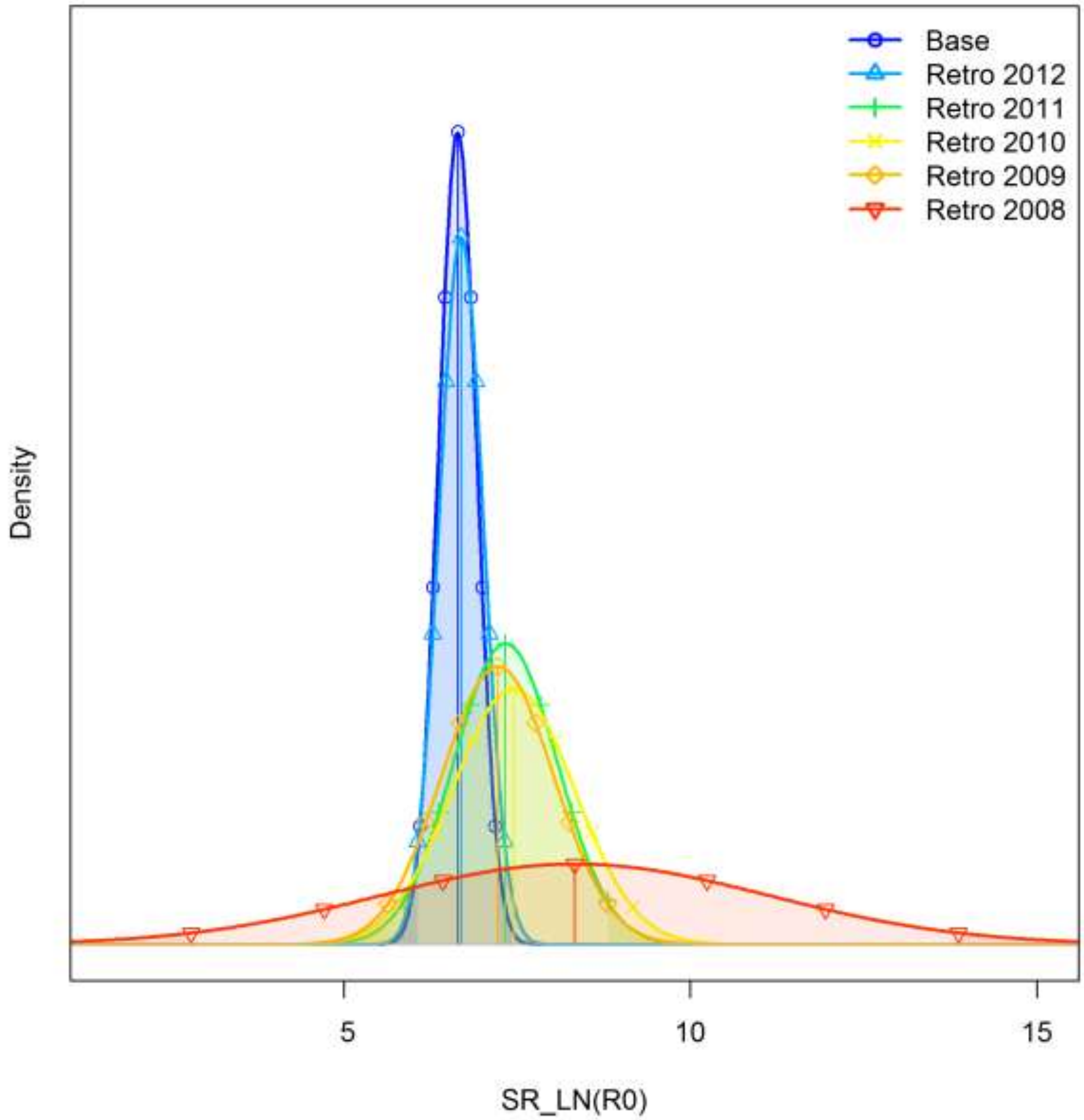



**Figure 127. Value of initial recruitment across different retrospective years and the base case.**

### 9.3.4 Alternative assessment methods

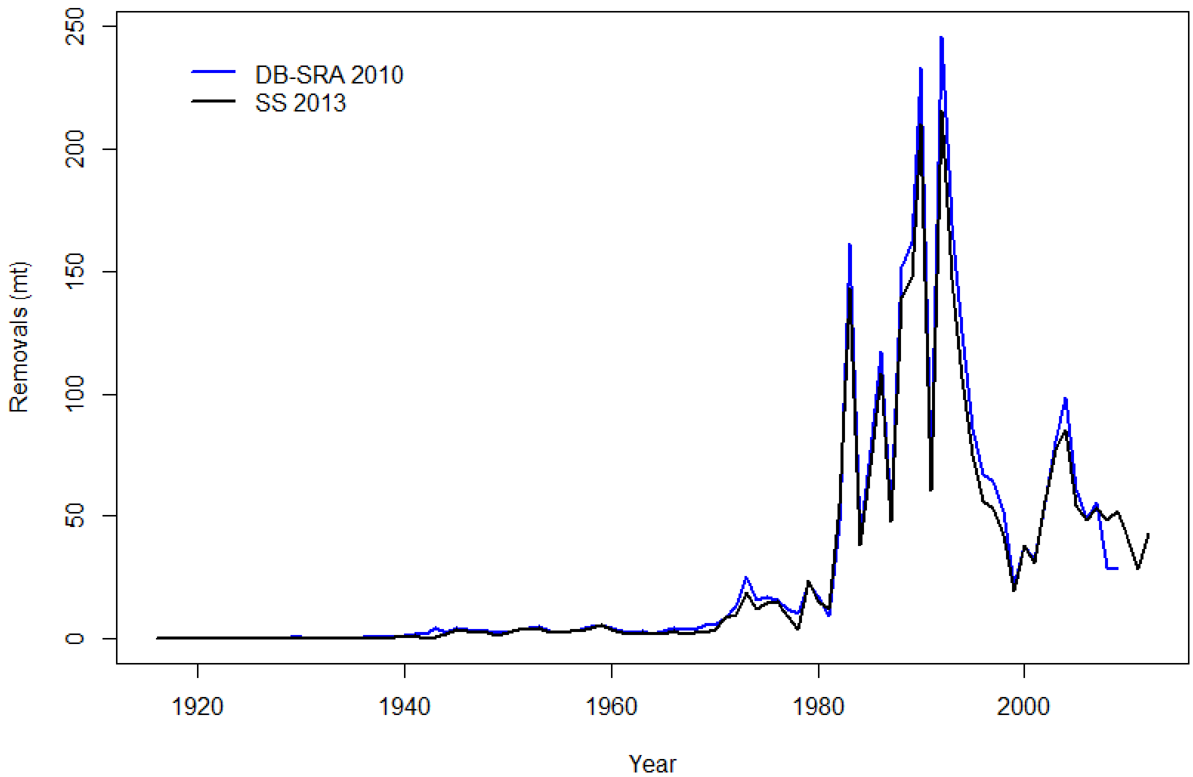



**Figure 128. Comparison of aurora rockfish removals in the 2013 base case (black line) to those used in the 2010 DB-SRA estimate of OFLs.**

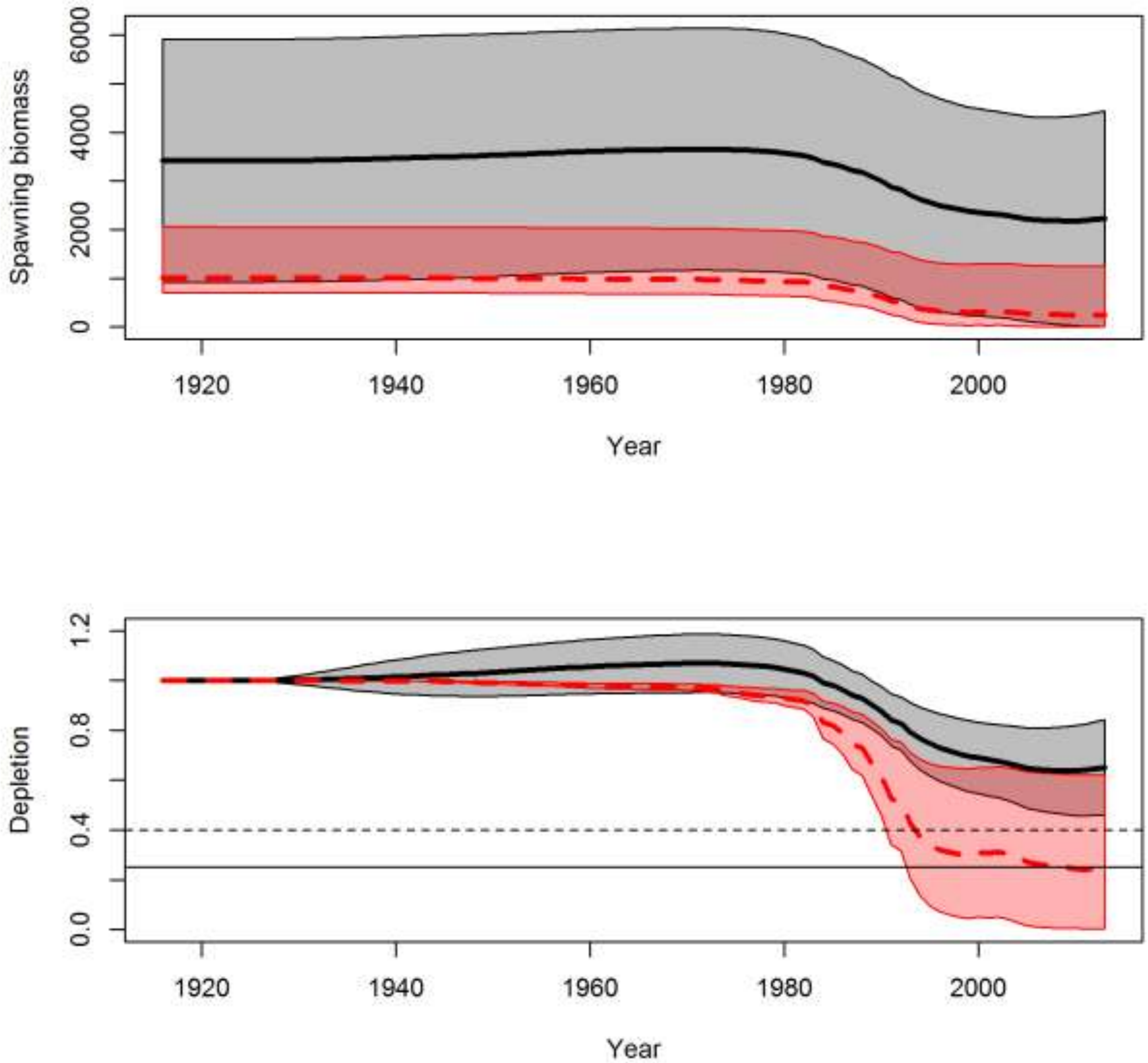



**Figure 129. Comparison of the aurora rockfish base case model (median: black line; 95% CI: gray polygon) with the catch-only SSS model (median: broken red line; 95% CI: red polygon).**

## Appendix A. Management history of minor slope rockfish

Effective 1982:

- *Sebastes* complex
- No limits on rockfish species except for a per/trip limit for the following four species: bocaccio, chilipepper, splitnose and yellowtail rockfish.

Effective 1983:

- *Sebastes* complex
- Per/trip and per/week limits are implemented for the *Sebastes* complex coastwide

Effective 1997:

- PFMC eliminates per/trip limits and moves to monthly or bi-monthly cumulative vessel limits to reduce discards.

Effective 1999:

- Limited Entry and Open Access *Sebastes* complex: north and south of Cape Mendocino, if a vessel takes and retains, possesses, or lands any splitnose or chilipepper rockfish south of Cape Mendocino, then the more restrictive *Sebastes* complex cumulative trip limit applies throughout the same cumulative limit period, no matter where the *Sebastes* complex is taken and retained, possessed, or landed.

Effective during 2000:

- *Sebastes* complex is dissolved
- Three rockfish complexes are implemented, each broken North and South of 40°10 N. lat.: Nearshore rockfish; Shelf rockfish; and Slope rockfish
- Slope rockfish complex includes aurora rockfish and rougheye rockfish both North and South of 40°10 N. lat.
- Slope rockfish complex is subject to bi-monthly vessel limits both North and South of 40°10 N. lat. (for both limited entry and open access commercial fisheries)

Effective during 2001:

- Implementation of the Northwest Fishery Science Center West Coast Groundfish Observer Program (NWFSC WCGOP), improving discard estimates.

Effective 2002:

- RCAs established
- Large footrope gear prohibited from waters inside 275 m (150 fm) following advent of rockfish conservation areas.
- Slope rockfish complex trip limit is revised for the open access fishery North of 40°10 N. lat.: the bi-monthly limit is removed and a new per trip limit is implemented that is a ratio of slope rockfish to sablefish (e.g. the weight of slope rockfish landed may be no more than 25% of the weight of sablefish landed)

Effective 2003:

- Vessel buyback program initiated (December 4, 2003).
- Yelloweye Rockfish Conservation Area established.

- Rockfish Conservation areas for several rockfish species established.

Effective 2007:

- Seasonal changes of trawl RCA boundaries and periodic closures within certain latitude boundaries (e.g., north of Cape Alava at 48°10’ N. latitude to the U.S.- Canada border) starting in 2007.

Effective during 2006:

- Amendment 19 was implemented, which established EFH boundaries and conservation areas.

Effective 2011:

- IFQ fishery begins.

## Appendix B. SS data file

```
# For Base 2 reduced Ninput for discard lengths at power of 0.9 which reduces largest by more than half (1330 to 648)
# For data9 - fixed survey to correct scale.
# For dat2 - added research catch to NODISC
#AURORA	ROCKFISH
########################################
###	Global	model	specifications	###
1916	#	Start	year
2012	#	End	year
1	#	Number	of	seasons/year
12	#	Number	of	months/season
1	#	Spawning	occurs	at	beginning	of	season
2	#	Number	of	fishing	fleets
4	#	Number	of	surveys
1	#	Number	of	areas
TWL%NODISC%AKSHLF%AKSLP%NWSLP%NWFSC
0.5	0.5	0.5	0.5	0.5	0.5	#Timing	of	each	fishery/survey
1	1	1	1	1	1	#Area	of	each	fleet
1	1	#_units	of	catch:	1=bio;	2=num
0.05	0.05	#_se	of	log(catch)	only	used	for	init_eq_catch	and	for	Fmethod
	2	and	3;	use	-1	for	discard	only	fleets
2	#	Number	of	genders
80	#	Number	of	ages	in	population	dynamics

###	Catch	section	###
0	0	#	Initial	equilibrium	catch	(landings	+	discard)	by	fishing	fleet
97 # Number of lines catch data
#_catch_biomass(mtons):_columns_are_fisheries,year,season
0.076360523	0	1916	1
0.119483193	0	1917	1
0.135390321	0	1918	1
0.092784047	0	1919	1
0.095990588	0	1920	1
0.079692657	0	1921	1
0.069291427	0	1922	1
0.077033907	0	1923	1
0.052117721	0	1924	1
0.061674556	0	1925	1
0.098446947	0	1926	1
0.078976648	0	1927	1
0.107287016	0	1928	1
0.128630289	0	1929	1
0.138200889	0	1930	1
0.143253663	0	1931	1
0.168920936	0	1932	1
0.231371388	0	1933	1
0.176165588	0	1934	1
0.133467121	0	1935	1
0.126507303	0	1936	1
0.216752647	0	1937	1
0.327272881	0	1938	1
0.48190626	0	1939	1
0.490051881	0	1940	1
0.962035876	0	1941	1
0.391775911	0	1942	1
0.874650878	0	1943	1
1.570407029	0	1944	1
3.109966474	0	1945	1
2.547995793	0	1946	1
2.43008343	0	1947	1
2.198769043	0	1948	1
1.453393464	0	1949	1
1.990710508	0	1950	1
3.093499088	0	1951	1
3.394203199	0	1952	1
3.766552421	0	1953	1
2.332047734	0	1954	1
2.060632506	0	1955	1
```

| | | | | | |
|---|---|---|---|---|---|
| 2.59353219 | | 0 | 1956 | 1 | |
| 2.756783257 | | 0 | 1957 | 1 | |
| 4.077096202 | | 0 | 1958 | 1 | |
| 4.628820905 | | 0 | 1959 | 1 | |
| 3.520909218 | | 0 | 1960 | 1 | |
| 2.334763217 | | 0 | 1961 | 1 | |
| 1.960652742 | | 0 | 1962 | 1 | |
| 2.137738654 | | 0 | 1963 | 1 | |
| 1.611818962 | | 0 | 1964 | 1 | |
| 1.77202298 | | 0 | 1965 | 1 | |
| 2.107669278 | | 1 | 1966 | 1 | |
| 1.691613777 | | 0 | 1967 | 1 | |
| 2.030084752 | | 0 | 1968 | 1 | |
| 2.278812926 | | 0 | 1969 | 1 | |
| 3.375146372 | | 0 | 1970 | 1 | |
| 5.841780929 | | 2 | 1971 | 1 | |
| 5.003982366 | | 4 | 1972 | 1 | |
| 6.174408744 | | 12 | 1973 | 1 | |
| 7.249700071 | | 4 | 1974 | 1 | |
| 7.512542875 | | 6 | 1975 | 1 | |
| 9.948895171 | | 4 | 1976 | 1 | |
| 7.750856498 | | 0.462287455 | | 1977 | 1 |
| 3.483719999 | | 0.006311736 | | 1978 | 1 |
| 20.99366657 | | 0.090407861 | | 1979 | 1 |
| 13.45932326 | | 0.129418089 | | 1980 | 1 |
| 10.23322689 | | 0.870864396 | | 1981 | 1 |
| 49.16355849 | | 0.002341033 | | 1982 | 1 |
| 127.9051123 | | 0.008754 | 1983 | 1 | |
| 33.6867196 | | 0.124245657 | | 1984 | 1 |
| 62.82970717 | | 0.104422914 | | 1985 | 1 |
| 96.50751671 | | 0.127899059 | | 1986 | 1 |
| 42.20365717 | | 0.069477668 | | 1987 | 1 |
| 123.8831574 | | 0.028952637 | | 1988 | 1 |
| 130.956 | 0 | 1989 | 1 | | |
| 186.4822 | 0.159079 | 1990 | 1 | | |
| 53.574 | 0.218443 | 1991 | 1 | | |
| 192.2462 | 0.012158 | 1992 | 1 | | |
| 130.9994 | 0.062875 | 1993 | 1 | | |
| 94.91195177 | | 0 | 1994 | 1 | |
| 65.9012 | 1.134795 | 1995 | 1 | | |
| 50.141 | 0.08863 | 1996 | 1 | | |
| 46.955 | 0.478651 | 1997 | 1 | | |
| 36.7129 | 0.999161 | 1998 | 1 | | |
| 15.564 | 0.717655 | 1999 | 1 | | |
| 30.9143 | 0.853514 | 2000 | 1 | | |
| 23.6457 | 2.103251 | 2001 | 1 | | |
| 39.9778 | 0.45459 | 2002 | 1 | | |
| 56.6134 | 0.40623 | 2003 | 1 | | |
| 69.6615 | 1.22181 | 2004 | 1 | | |
| 43.2527 | 0.53914 | 2005 | 1 | | |
| 33.3838 | 0.4964 | 2006 | 1 | | |
| 37.7508 | 0.53789 | 2007 | 1 | | |
| 18.7094 | 0.571669 | 2008 | 1 | | |
| 23.702 | 0.605653 | 2009 | 1 | | |
| 23.9161 | 0.487889 | 2010 | 1 | | |
| 24.5575 | 0.539087 | 2011 | 1 | | |
| 36.8526 | 0.51698 | 2012 | 1 | | |

22 #Number of index observations

#Units: 0=numbers,1=biomass,2=F; Errortype: -1=normal,0=lognormal,>0=T

| #Fleet | Units | Errortype | | |
|---|---|---|---|---|
| 1 | 1 | 0 | # | fleet |
| 2 | 1 | 0 | # | fleet |
| 3 | 1 | 0 | # | fleet |
| 4 | 1 | 0 | # | fleet |
| 5 | 1 | 0 | # | fleet |
| 6 | 1 | 0 | # | fleet |

| #_year | seas | index | obs | se(log) |
|---|---|---|---|---|

```
1995	1	3	1865.816371	0.171837138	#Triennial (N=4)
1998	1	3	2041.158359	0.156544604
2001	1	3	2358.5835 0.166949414
2004	1	3	2545.198395	0.191886201
1997	1	4	3008.572554	0.263786151	#AFSC	slope	(N=4)
1999	1	4	2981.684721	0.270980378
2000	1	4	3389.680055	0.260814263
2001	1	4	3214.149597	0.260413628
1999	1	5	1685.390011	0.215006357	#NWFSC	slope	(N=4)
2000	1	5	1858.324456	0.226571207
2001	1	5	2399.244372	0.220403969
2002	1	5	2205.016934	0.189393356
2003	1	6	4961.552718	0.324390564	#NWFSC	shelf-slope (N=10)
2004	1	6	5947.491393	0.275404119
2005	1	6	4540.534108	0.210266709
2006	1	6	4448.461087	0.212569
2007	1	6	4887.833126	0.229353875
2008	1	6	4273.365697	0.185446445
2009	1	6	4679.095564	0.20167377
2010	1	6	4077.921184	0.188342857
2011	1	6	4221.237679	0.213207433
2012	1	6	4543.376056	0.326099515
#

1	#_N_fleets_with_discard
#_discard_units	(1=same_as_catchunits(bio/num);	2=fraction;3=numbers)
#_discard_errtype:	>0	for	DF	of	T-dist(readCV	below);	0	for	normal	with
	CV;	-1	for	normal	with	se;	-2	for	lognormal

#Fleet	Disc_units err_type
1	2	0	#	TWL

13	#N	discard	obs
#_year	seas	index	obs	err
#TWL - first 3 Pikitch years (using six years of species associations) with cv
1985	1	1	0.11992959	0.3210479
1986	1	1	0.10447521	0.2970653
1987	1	1	0.10465784	0.2570422
#TWL continued - here use the calculated discard amounts along with very small cv = .2 throough2010, =0.1 for 2011
2002	1	1	0.274514407	0.2
2003	1	1	0.24475349	0.2
2004	1	1	0.166821589	0.2
2005	1	1	0.198077575	0.2
2006	1	1	0.446793952	0.2
2007	1	1	0.412941503	0.2
2008	1	1	0.630325695	0.2
2009	1	1	0.653249322	0.2
2010	1	1	0.418543881	0.2
2011	1	1	0.116861229	0.1
#

10	#_N_meanbodywt_obs
30	#_DF_for_meanbodywt_T-distribution_like
#Year	Seas	Fleet	Part	Obs	cv
2002	1	1	1	0.361627481	0.673976975
2003	1	1	1	0.362874585	0.838947339
2004	1	1	1	0.354727291	0.485848179
2005	1	1	1	0.310885964	0.505579076
2006	1	1	1	0.333343763	0.563202979
2007	1	1	1	0.329382272	0.611363151
2008	1	1	1	0.357433735	0.493804054
2009	1	1	1	0.36982669	0.669160118
2010	1	1	1	0.375657942	0.919349975
2011	1	1	1	0.253010272	0.501193866
```

#
# Population Length Structure
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
1 # binwidth for population size comp
8 # minimum size in the population (lower edge of first bin and size at age 0.00)
38 # maximum size in the population (lower edge of last bin)
#
-1 #_comp_tail_compression
0.001 #_add_to_comp
#
6 #_combine males into females at or below this bin number
#
16 #_N_LengthBins
# Data length bins
8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
#

88 #_N_Length_obs
#TWL (N=35), Females then Males
#Year Seas Fleet Gender Part Nsamp F-8 F-10 F-12 F-14 F-16 F-18 F-20 F-22 F-24 F-26 F-28 F-30 F-32 F-34 F-36 F-38 M-8 M-10 M-12 M-14 M-16 M-18 M-20 M-22 M-24 M-26 M-28 M-30 M-32 M-34 M-36 M-38
1978 1 1 3 2 3 0 0 0 0 0 0 0 0 3.336185488 13.34474195 13.34474195 3.336185488 0 96.81479457 0 0 0 0 0 0 0 0 0 0 0 6.672370977 6.672370977 6.672370977 0 0 0 0
1979 1 1 3 2 2 0 0 0 0 0 0 0 0 0 0 8392.730568 7484.513791 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 399.2418223 0 0 0 0
1980 1 1 3 2 12 0 0 0 0 0 0 0 0 0 2541.815284 2362.096041 817.3393405 2312.318492 401.0735797 433.3581403 0 0 0 0 0 0 0 0 0 0 0 2541.815284 1934.345628 298.3424523 0 0 0
1981 1 1 3 2 5 0 0 0 0 0 0 0 0 0 0 0 0 2903.383075 2108.732166 2108.732166 0 0 0 0 0 0 0 0 0 0 0 1054.366083 0 4217.464333 7380.562582 1054.366083 0
1982 1 1 3 2 34 0 0 0 0 0 0 0 31791.66667 71134.36633 85106.88406 296372.3566 136246.1039 209228.6169 127332.985 34731.91346 7960.784314 0 0 0 0 0 0 0 0 154349.7045 89063.54694 220256.7503 146335.8401 56706.27289 31791.66667 0
1983 1 1 3 2 133 0 0 0 0 0 0 0 5541.666667 8869.843924 280967.1849 1193224.777 1067646.302 1336757.022 692971.3828 169170.7913 8541.666667 0 0 0 0 0 0 0 28173.07692 170704.2752 665004.0197 834235.4424 1009907.569 600160.997 184168.7084 215462.7805 4270.833333
1984 1 1 3 2 94 0 0 0 0 0 0 0 17199.83312 20008.82353 69114.03071 456956.9267 395066.7727 369523.0379 158174.4878 11023.90701 8200 0 0 0 0 0 0 4901.960784 1886.792453 17697.87234 159066.8361 281395.1261 245032.7379 303705.5216 91670.93952 22372.93559 5250

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1985 | 1 | 1 | 3 | 2 | 207 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25299.53171 | | 137643.5901 | | 514137.092 | | 613719.4606 | | 733255.958 | | 406488.3488 | |
| | 176154.987 | | 31589.44064 | | 1429.579084 | | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 44632.54451 | | 255523.4894 | | 481485.2422 | | 745672.3162 | | 673177.5378 | | |
| | 313049.145 | | 61957.51176 | | 17330.89063 | | 2367.05905 | | | | | |
| 1986 | 1 | 1 | 3 | 2 | 137 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 69310.12266 | | 118244.3302 | | 193119.3648 | | 611331.8727 | | 1075356.876 | | 775412.5782 | |
| | 439443.1932 | | 58727.57658 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2723.3252 | 64776.18582 | | 412359.1583 | | 524742.3869 | | 554195.1462 | | 365501.3973 | | |
| | 172667.7386 | | 36802.23866 | | 0 | | | | | | | |
| 1987 | 1 | 1 | 3 | 2 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 6038.978243 | | 8520.037501 | | 28030.33633 | | 66914.18396 | | 32311.1384 | | |
| | 29210.60924 | | 20493.89436 | | 857.887218 | | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 511.5053841 | | 14102.38229 | | 89985.38742 | | 110323.1069 | | 115074.4618 | |
| | 13702.50833 | | 4344.31663 | | 0 | | | | | | | |
| 1988 | 1 | 1 | 3 | 2 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1865.944971 | | 9451.738101 | | 47479.24637 | | 15560.47885 | | 19584.65444 | | |
| | 11284.46116 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 5587.993041 | | 22845.03713 | | 45267.3186 | | 36242.538 | 25557.67741 | | 41765.38514 | | |
| | 9907.486033 | | 0 | | | | | | | | | |
| 1989 | 1 | 1 | 3 | 2 | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 4942.236539 | | 13472.38484 | | 51563.84679 | | 29620.99771 | | 10249.20994 | | |
| | 4464.832064 | | 0 | 738.5864142 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1783.437209 | | 5866.74192 | | 29703.35606 | | 14087.98844 | | 20641.25997 | | 7876.051881 | |
| | 2089.130143 | | 0 | 0 | | | | | | | | |
| 1990 | 1 | 1 | 3 | 2 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 9642.857143 | | 127020 | 511410.1773 | | 528733.6774 | | 374151.1275 | | 56011.86275 | |
| | 13100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78783.05516 | |
| | 338173.9528 | | 192530.2525 | | 243833.8655 | | 42195.93137 | | 0 | 0 | 0 | |
| 1991 | 1 | 1 | 3 | 2 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 902.1238564 | | 4087.806612 | | 9687.234918 | | 15075.05205 | | 16389.90698 | | |
| | 5445.447214 | | 1547.602938 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 326.4419277 | | 5188.383012 | | 13205.64919 | | 7150.22792 | | 5714.775147 | | |
| | 4175.799227 | | 2259.014462 | | 0 | | | | | | | |
| 1992 | 1 | 1 | 3 | 2 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 15558.82353 | | 44174.51575 | | 89714.72371 | | 90915.15746 | | 133989.1506 | | 29394.57071 | |
| | 205081.6538 | | 0 | 10370 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 18245.69222 | | 5373.737374 | | 65143.94534 | | 86068.85918 | | 216464.7598 | | 23892.15686 | |
| | 4166.666667 | | 0 | 0 | | | | | | | | |
| 1993 | 1 | 1 | 3 | 2 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 13870 |
| | 29201.53846 | | 106606.6745 | | 152413.5687 | | 300927.4423 | | 254870.8181 | | 201343.0692 | |
| | 52610.98361 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 111085.9463 | | 204404.6964 | | 356727.8511 | | 153978.5792 | | 54120.70045 | | 47750 | 0 |
| | 0 | | | | | | | | | | | |
| 1994 | 1 | 1 | 3 | 2 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90851.04042 | | 154796.8771 | | 410772.8572 | | 648558.4725 | | 411367.572 | | 93200.70777 | |
| | 18809.18367 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 104085.5102 | | 144555.8646 | | 710666.5665 | | 653911.5782 | | 231003.5051 | | 49131.30435 | |
| | 0 | 0 | 0 | | | | | | | | | |
| 1995 | 1 | 1 | 3 | 2 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 22430 | 72898.91731 | | 195967.5405 | | 703344.9915 | | 512147.493 | | 193074.1965 | | |
| | 91669.91997 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8640 |
| | 293255.6633 | | 449475.8973 | | 706237.3424 | | 403015.8078 | | 137811.5947 | | 125907.9666 | |
| | 0 | 0 | | | | | | | | | | |
| 1996 | 1 | 1 | 3 | 2 | 78 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 211428.4314 | | 515111.5686 | | 668890.5882 | | 606995.098 | | 195253.2353 | | |
| | 49069.21569 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 74620 |
| | 270223.9507 | | 750790.1961 | | 704521.1765 | | 645962.6106 | | 27720 | 33730 | 0 | 0 |
| 1997 | 1 | 1 | 3 | 2 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 56770 | 11470 | 335529.5652 | | 319431.3424 | | 729338.7356 | | 312804.2591 | | 136349.3878 | |
| | 1234.693878 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3100 | |
| | 167674.7826 | | 161199.7826 | | 381029.4339 | | 466506.5119 | | 156105.6415 | | 10489.38776 | |
| | 0 | 1 | | | | | | | | | | |
| 1998 | 1 | 1 | 3 | 2 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 63870 | 157780 | 177969.5148 | | 522244.2857 | | 406527.9962 | | 157620.0586 | | 74611.22523 | |
| | 8695.438796 | | 85.43879592 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 74224.28571 | | 251490 | 545330.9434 | | 324583.9215 | | 201888.5714 | | 252062.5397 | | |
| | 13513.73473 | | 12471.90938 | | 85.43879592 | | | | | | | |
| 1999 | 1 | 1 | 3 | 2 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 3070 |
| | 12990 | 43830 | 238857.7778 | | 248940 | 257994.5422 | | 61928.58586 | | 13195 | 0 | 0 |

0 0 0 0 0 0 0 31450 109380 211268.773 348900
92994.54224 27386.18521 64.54223925 5250 0
2000 1 1 3 2 61 0 0 0 0 0 0 0
25785.34653 40062.69696 116547.452 106028.6252 163387.999 30978.34927
20184.06951 5637.755102 0 0 0 0 0 0 0 0
14832.06883 112129.1291 270182.7606 204312.881 150000.5972 46394.53976
8096.997776 6321.782178 0
2001 1 1 3 2 76 0 0 0 5693.877551 0 0
0 5693.877551 21085.41692 54608.59803 68302.09044 97969.98542
19566.58647 15598.54168 1147.116113 25.62353838 0 0 0 0
0 0 0 5693.877551 19678.00249 71297.85696 87205.80582
83038.0499 32302.01417 2028.840549 3307.452038 26.16900599
2002 1 1 3 2 187 0 0 0 0 0 0
7478.297872 12524.2958 45753.94485 102861.1773 155823.4976 207601.7517
137828.5907 38982.68233 3840 0 0 0 0 0 0 0
4863.265306 10957.95918 46480.42517 133373.8785 187448.0787 240945.2382
67176.06194 19102.26415 1246.848995 0
2003 1 1 3 2 149 0 0 0 0 0 0
638.2978723 737.7641135 71525.3875 132821.0683 386581.3635 343391.6598
124971.5002 34903.34626 5031.578591 2713.843518 0 0 0 0
0 0 99.46624112 28889.46624 126553.9374 163092.6873 261666.7063
294592.6036 41556.83232 24968.32875 2433.398723 198.9324822
2004 1 1 3 2 124 0 0 0 0 0 0 0
7462.083333 90992.88409 198294.2971 345327.5132 225287.3973 72532.52634
20864.00151 1872.486266 631.07852 0 0 0 0 0 0 0
1302.083333 54057.52073 119171.3437 196887.6732 100237.3853 40814.30001
7731.003844 1874.010928 730.4289399
2005 1 1 3 2 157 0 0 0 0 0 0
2454.893617 46233.89491 771305.2046 436068.4934 1839682.717 1486108.664
371553.1001 48317.45359 270576.439 9.45667564 0 0 0 0
0 0 36.3071184 253283.8993 1317120.089 710416.4503 384584.5786
773735.8522 113396.4406 50190.44098 5470.451642 0
2006 1 1 3 2 210 0 0 0 0 0 0
42.09967954 7320.270216 44869.51496 154350.1777 87508.35852 145932.5487
139528.8073 84652.00728 10851.4272 1614.980677 0 0 0 0
0 0 8086.544124 1151.829463 15214.65471 49670.92907 140663.517
181398.2502 177609.1886 70410.63034 2250 21.49871402
2007 1 1 3 2 293 0 0 0 0 0 64.16080048
1031.383996 4862.179832 48013.17747 133059.9588 355994.4082 229984.6021
85361.55035 67458.32677 17914.47011 4057.450416 0 0 0 0
11.37437741 0 8.482161203 2646.973459 37970.08194 109401.6729
165255.9157 127600.7397 64949.08685 31549.32283 6056.882289 120.6845465
2008 1 1 3 2 342 0 0 0 0 0 558.8235294
1030.821816 21986.43185 36391.50935 138911.0717 139589.8016 120242.4018
110075.4376 67391.13648 25895.50533 2905.395851 0 0 0 0
0 7220 48.44699738 22621.23337 32329.56464 111889.709 104272.979
119320.716 103504.8263 35993.79165 9959.480772 145.1347456
2009 1 1 3 2 317 0 0 0 0 0 27.60693957
8.074994844 1217.927384 41857.57261 43141.78722 54049.94728 75218.24627
67319.09469 56990.08635 14535.31202 2999.713278 0 0 0 0
0 0 1008.171126 3179.055866 17754.64255 44491.46341 134199.0367
120293.1014 102729.8865 32041.9194 7543.205268 216.0198049
2010 1 1 3 2 288 0 0 0 0 0 0
13.78786588 3723.223773 16490.69646 31975.21316 56545.61196 54409.05316
43784.607 38220.9698 11084.27613 531.843109 0 0 0 0 0
173.3604107 0 1049.682111 13910.14687 69419.01956 95098.36992
74551.1624 60606.70856 26914.88061 654.922032 108.2125528
2011 1 1 3 2 518 0 0 0 0 6.525587974
1063.963653 29304.99638 60088.36709 120393.0821 182875.5375 178388.8359
179599.042 71333.39731 41703.03552 13831.94365 3078.764716 0 0
0 1006.525588 46.19092664 3824.803466 36391.18754 57017.32121
145908.7634 219529.004 247277.2356 147221.0273 71637.8815 30179.54893
3189.198885 2125.582656
2012 1 1 3 2 446 0 0 8.078104003 0 47.69684447
1924.387884 2081.953801 12066.32462 94921.09274 196670.5897 186988.7039
181421.2516 123662.08 53044.82736 18592.15244 4534.050728 0 0 0
0 70.82353519 335.7307568 1629.194287 12839.98686 110285.1534
172346.8135 154191.8565 127059.0315 44010.43512 17551.04483 5479.420019
3224.343349

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #TWL | (N=26), | Unsexed | | | | | | | | | | |
| #Year | Seas | Fleet | Gender | Part | Nsamp | F-8 | F-10 | F-12 | F-14 | F-16 | F-18 | F-20 |
| | F-22 | F-24 | F-26 | F-28 | F-30 | F-32 | F-34 | F-36 | F-38 | M-8 | M-10 | M-12 |
| | M-14 | M-16 | M-18 | M-20 | M-22 | M-24 | M-26 | M-28 | M-30 | M-32 | M-34 | M-36 |
| | M-38 | | | | | | | | | | | |
| 1980 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 683.6481473 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | | | | | | | | | | |
| 1988 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 3088.397288 | | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | | | | | | | | | | |
| 1989 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 994.5322013 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | | | | | | | | | | |
| 1990 | 1 | 1 | 0 | 2 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 18961.22449 | | 16900 | 26100 | 82562.72727 | | 91422.44898 | | 26120.83333 | | 0 | 2300 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | | | | | | | |
| 1991 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 902.1238564 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | | | | | | | | | | |
| 1992 | 1 | 1 | 0 | 2 | 56 | 0 | 0 | 0 | 0 | 0 | 6127.659574 | |
| | 0 | 25722.99058 | | 156123.778 | | 269550.0706 | | 525586.5442 | | 608812.6994 | | |
| | 190257.4784 | | 62016.98718 | | 6370 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 1993 | 1 | 1 | 0 | 2 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 2941.176471 | | 2941.176471 | | 26381.03067 | | 89467.76374 | | 87981.93027 | | 103034.3352 | |
| | 5154.655831 | | 7688.057334 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 1994 | 1 | 1 | 0 | 2 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 15204.08163 | | 44835.40373 | | 68555.62521 | | 119598.288 | | 375465.3769 | | 86368.8818 | |
| | 7602.040816 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 1995 | 1 | 1 | 0 | 2 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 500 | 33123.31411 | | 75968.46011 | | 72717.2007 | | 10646.78179 | | 1070.652174 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| 1996 | 1 | 1 | 0 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 67000 | 37546.70734 | | 112158.9344 | | 35408.8353 | | 36886.8542 | | 3 | 1 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | | | | | | | |
| 1997 | 1 | 1 | 0 | 2 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 24970.58824 | | 41619.64706 | | 91558.82353 | | 52718.51794 | | 75791.58218 | | 42051.22017 | |
| | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 1998 | 1 | 1 | 0 | 2 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1615.384615 | | 6461.538462 | | 6461.538462 | | 8304.708625 | | 2040 | 1360 | |
| | 85.43879592 | | 85.43879592 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 1999 | 1 | 1 | 0 | 2 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 43877.55102 | | 175510.2041 | | 484544.3539 | | 498533.9717 | | 341187.7551 | | 92597.55102 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 2000 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 15940 |
| | 15940 | 0 | 1041.666667 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | | | | | | | | | | |
| 2001 | 1 | 1 | 0 | 2 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 31031.83673 | | 131723.9717 | | 580503.7326 | | 940173.5224 | | 699718.3485 | | 127016.1538 | |
| | 31180 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 2002 | 1 | 1 | 0 | 2 | 65 | 0 | 0 | 0 | 0 | 0 | 4659.574468 | |
| | 13347.7551 | | 95572.1821 | | 128567.1815 | | 403539.2297 | | 413878.3164 | | 95831.47923 | |
| | 57251.92677 | | 6734.30762 | | 760 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |

2003 1 1 0 2 103 0 0 0 0 0 0 121700
51576.9988 741152.1086 1672105.954 1813448.29 834137.532 132332.5857
61447.79948 83800.89327 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2004 1 1 0 2 28 0 0 0 0 0 0 0
18940 97220 386475 405836.7172 139000.8586 27165 35600 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0
2005 1 1 0 2 54 0 0 0 0 0 0 9100
18700 176787.7778 826780 985243.8889 660070.5556 241615 45580 500 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2006 1 1 0 2 104 0 0 0 0 0 0 11340
182670.7692 1171074.615 3024892.115 3753379.808 2801678.077 693554.6154
56358.46154 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
2007 1 1 0 2 38 0 0 0 1186.868687 0
4318.181818 0 32030 221077.2048 398643.193 320559.9742 818200.6014
519287.8007 48580 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2008 1 1 0 2 26 0 0 0 0 0 0 0
0 13827.61905 50372.14286 81268.92857 41477.97619 15416.66667 14312.5
4125 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2009 1 1 0 2 40 0 0 0 0 0 115.0111386
0 704.6337801 63243.76657 60425.75418 161887.7505 111573.6367
25511.39766 10571.98397 4238.336714 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
2010 1 1 0 2 25 0 0 0 0 0 0 0
0 4838.24704 46979.82655 53808.06938 66728.24284 8411.730769
1319.144755 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
2011 1 1 0 2 119 0 0 0 0 1972.826087
4418.478261 63582.6732 184215.6928 326153.9813 455803.101 587004.3773
188902.7848 87937.76567 7982.630009 2066.666667 1509.803922 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0
2012 1 1 0 2 100 0 0 0 0 1227.406989 0
12882.22097 9233.972646 59637.57137 150121.0737 156293.7945 124264.8641
53575.32718 15719.0149 3990.683761 522.2222222 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0

#TWL DISCARD (N = 9), Unsexed except for 2003 and 2004
#Year Seas Fleet Gender Part Nsamp F-8 F-10 F-12 F-14 F-16 F-18 F-20
F-22 F-24 F-26 F-28 F-30 F-32 F-34 F-36 F-38 M-8 M-10 M-12
M-14 M-16 M-18 M-20 M-22 M-24 M-26 M-28 M-30 M-32 M-34 M-36
M-38

2002 1 1 0 1 3 0 0 0 0 0 0 1
1 2 0 12.58409091 11.58409091 0 1 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0
2003 1 1 3 1 10 0 0 0 0 0 1.35483871
1 0 3.709677419 4.41733871 5.685 1.0625 1 1.0625 0 0
0 0 0 0 0 0 0 0 2.41733871 4.2 6.25
2.125 8.9975 5.41733871 2 0
2004 1 1 3 1 1 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 1 0 0
0
2006 1 1 0 1 59 0 0 29 2 17.7 13
637.7262664 1323.946197 763.8824308 739.5963942 142.5544118 50.10882353
29.90746643 56.93887778 7.753054662 2.6 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2007 1 1 0 1 279 1.2 0 22.6 51.2 95.55 858.1225024
1751.342966 3162.489731 2144.995864 1117.187207 1003.3397 969.3928944
754.9992583 405.7479546 258.4 93.5284585 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2008 1 1 0 1 500 0 74 99.65 92.29854015 62.00881801
577.7176722 1360.494074 2587.091785 3134.090673 2949.711401 3062.539724

2063.124877 1433.191466 781.5560495 481.1699319 151.180529 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0
2009 1 1 0 1 648 0 60 161.2 1054.076801 616.4654313
537.1294689 1540.2595 2907.248582 4385.764714 3320.45641 3793.802625
2651.640789 1929.284021 1541.848154 579.5777999 443.1017133 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0
2010 1 1 0 1 161 0 4 5.5 52.87142857 160.4193548
238.1656448 169.1543517 448.103218 729.233768 591.3660329 466.9443264
293.363192 104.8979094 79.97996516 42.4 35 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
2011 1 1 0 1 160 12.2 9.6 143.768254 130.5516484
356.1451282 295.8192918 606.8064713 657.113329 438.1047619 234.7285714
120.7809524 47.64031311 11.43333333 8.326027397 2 2 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0

#
#AKShelf - "Triennial" Survey (N = 4)
#Year Seas Fleet Gender Part Nsamp F-8 F-10 F-12 F-14 F-16 F-18 F-20
F-22 F-24 F-26 F-28 F-30 F-32 F-34 F-36 F-38 M-8 M-10 M-12
M-14 M-16 M-18 M-20 M-22 M-24 M-26 M-28 M-30 M-32 M-34 M-36
M-38

1995 1 3 3 0 232 0.000000 0.001053 0.006618 0.008721 0.015926 0.030750 0.041702
0.049945 0.082645 0.115227 0.110607 0.060298 0.026543 0.011442 0.004888 0.000889 0.000000 0.001789 0.003818
0.006393 0.016827 0.034154 0.038956 0.038609 0.055305 0.054351 0.071685 0.053619 0.032489 0.017037 0.004828
0.002886
1998 1 3 3 0 281 0.000000 0.001075 0.004084 0.014979 0.039570 0.052819 0.070658
0.065774 0.086188 0.111051 0.083033 0.035227 0.015476 0.007642 0.002077 0.000000 0.000000 0.000088 0.001805
0.011117 0.024908 0.045204 0.047343 0.047050 0.051459 0.051294 0.058399 0.037728 0.021679 0.008556 0.002663
0.001055
2001 1 3 3 0 272 0.000000 0.000972 0.003517 0.002757 0.007034 0.017657 0.046465
0.080022 0.093860 0.109776 0.085752 0.043167 0.018739 0.006412 0.002789 0.000000 0.000000 0.000159 0.002456
0.005753 0.006803 0.022313 0.046013 0.073932 0.071073 0.074370 0.085462 0.053107 0.026080 0.007969 0.003048
0.002541
2004 1 3 3 0 209 0.000000 0.000464 0.003759 0.016516 0.025198 0.034002 0.051624
0.059340 0.116198 0.089570 0.046189 0.035220 0.011684 0.005611 0.001412 0.001130 0.000000 0.000464 0.002238
0.013834 0.036705 0.049568 0.052633 0.072474 0.084181 0.064611 0.052428 0.043040 0.018245 0.008431 0.002382
0.000847
#
#AKSlope Survey (N = 4)
#Year Seas Fleet Gender Part Nsamp F-8 F-10 F-12 F-14 F-16 F-18 F-20
F-22 F-24 F-26 F-28 F-30 F-32 F-34 F-36 F-38 M-8 M-10 M-12
M-14 M-16 M-18 M-20 M-22 M-24 M-26 M-28 M-30 M-32 M-34 M-36
M-38
1997 1 4 3 0 118 0.001695 0.001695 0.001444 0.011909 0.033686 0.040922 0.060436
0.054195 0.070641 0.073488 0.047671 0.028181 0.009167 0.005701 0.000848 0.000848 0.000000 0.000000 0.000867
0.010088 0.034629 0.042950 0.067441 0.078834 0.101829 0.082623 0.071923 0.035019 0.015358 0.010824 0.004238
0.000848
1999 1 4 3 0 119 0.003112 0.001729 0.000000 0.004150 0.023565 0.048513 0.043805
0.053478 0.062465 0.082966 0.093283 0.052796 0.018196 0.010636 0.000000 0.000000 0.003112 0.001037 0.001383
0.006436 0.012661 0.041273 0.046566 0.036214 0.065759 0.081124 0.094902 0.062353 0.022963 0.017971 0.006063
0.001489
2000 1 4 3 0 101 0.000000 0.003205 0.016398 0.020101 0.033818 0.030485 0.055957
0.078716 0.091245 0.057554 0.067802 0.038838 0.008408 0.005317 0.001455 0.000728 0.000000 0.002022 0.008215
0.014666 0.027026 0.023064 0.050265 0.064636 0.064552 0.069222 0.073615 0.055026 0.021991 0.008395 0.005093
0.002183
2001 1 4 3 0 99 0.000000 0.003188 0.016747 0.019706 0.030743 0.027576 0.050315
0.084254 0.088138 0.066163 0.072292 0.040353 0.012237 0.007671 0.000000 0.000000 0.000000 0.002011 0.008608

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.014300 | 0.026456 | 0.021493 | 0.044356 | 0.062863 | 0.076315 | 0.068297 | 0.068751 | 0.051667 | 0.022382 | 0.005370 | 0.006001 |
| | 0.001745 | | | | | | | | | | | |

#

#NWFSC Shelf-Slope Survey 2003-2012 (N=10)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #Year | Seas | Fleet | Gender | Part | Nsamp | F-8 | F-10 | F-12 | F-14 | F-16 | F-18 | F-20 |
| | F-22 | F-24 | F-26 | F-28 | F-30 | F-32 | F-34 | F-36 | F-38 | M-8 | M-10 | M-12 |
| | M-14 | M-16 | M-18 | M-20 | M-22 | M-24 | M-26 | M-28 | M-30 | M-32 | M-34 | M-36 |
| | M-38 | | | | | | | | | | | |
| 2003 | 1 | 6 | 3 | 0 | 128.6 | 0.00000 | 0.00039 | 0.00153 | 0.00624 | 0.00545 | 0.01722 | 0.03125 |
| | 0.04098 | 0.06312 | 0.09563 | 0.11303 | 0.07726 | 0.03576 | 0.01196 | 0.00797 | 0.00000 | 0.00000 | 0.00136 | 0.00230 |
| | 0.00629 | 0.00801 | 0.01984 | 0.02010 | 0.03741 | 0.07391 | 0.10846 | 0.08430 | 0.07285 | 0.04091 | 0.01520 | 0.00130 |
| | 0.00000 | | | | | | | | | | | |
| 2004 | 1 | 6 | 3 | 0 | 111.6 | 0.00000 | 0.00000 | 0.00099 | 0.00364 | 0.01479 | 0.01967 | 0.03044 |
| | 0.04061 | 0.06071 | 0.10656 | 0.11951 | 0.14291 | 0.03583 | 0.01345 | 0.00216 | 0.00234 | 0.00000 | 0.00000 | 0.00311 |
| | 0.00710 | 0.01615 | 0.01524 | 0.02399 | 0.03391 | 0.04810 | 0.09130 | 0.07805 | 0.06743 | 0.01391 | 0.00550 | 0.00142 |
| | 0.00117 | | | | | | | | | | | |
| 2005 | 1 | 6 | 3 | 0 | 191.8 | 0.00000 | 0.00080 | 0.00243 | 0.00772 | 0.01797 | 0.03366 | 0.03239 |
| | 0.05311 | 0.08170 | 0.09827 | 0.10686 | 0.05782 | 0.02191 | 0.00466 | 0.00139 | 0.00024 | 0.00000 | 0.00025 | 0.00254 |
| | 0.01192 | 0.01151 | 0.03259 | 0.03367 | 0.04641 | 0.09881 | 0.10465 | 0.08624 | 0.03336 | 0.01132 | 0.00449 | 0.00074 |
| | 0.00058 | | | | | | | | | | | |
| 2006 | 1 | 6 | 3 | 0 | 169.0 | 0.00061 | 0.00131 | 0.00202 | 0.00815 | 0.01534 | 0.03933 | 0.04754 |
| | 0.04414 | 0.05575 | 0.08327 | 0.09232 | 0.07306 | 0.01714 | 0.00426 | 0.00101 | 0.00150 | 0.00000 | 0.00061 | 0.00377 |
| | 0.00791 | 0.02312 | 0.02540 | 0.04299 | 0.04414 | 0.06627 | 0.12998 | 0.10484 | 0.04497 | 0.01170 | 0.00530 | 0.00130 |
| | 0.00098 | | | | | | | | | | | |
| 2007 | 1 | 6 | 3 | 0 | 170.6 | 0.00000 | 0.00000 | 0.00029 | 0.00407 | 0.00851 | 0.03185 | 0.04047 |
| | 0.07214 | 0.09016 | 0.11715 | 0.07632 | 0.07725 | 0.01713 | 0.00598 | 0.00074 | 0.00025 | 0.00000 | 0.00000 | 0.00029 |
| | 0.00353 | 0.00574 | 0.01526 | 0.04668 | 0.05974 | 0.06950 | 0.10634 | 0.07804 | 0.05693 | 0.01174 | 0.00251 | 0.00138 |
| | 0.00000 | | | | | | | | | | | |
| 2008 | 1 | 6 | 3 | 0 | 215.2 | 0.00000 | 0.00000 | 0.00422 | 0.00782 | 0.02631 | 0.05005 | 0.03890 |
| | 0.06805 | 0.07681 | 0.09142 | 0.11165 | 0.08412 | 0.01951 | 0.00760 | 0.00151 | 0.00024 | 0.00000 | 0.00000 | 0.00186 |
| | 0.00490 | 0.02330 | 0.01677 | 0.02441 | 0.05548 | 0.06498 | 0.08015 | 0.08176 | 0.04187 | 0.01229 | 0.00278 | 0.00096 |
| | 0.00025 | | | | | | | | | | | |
| 2009 | 1 | 6 | 3 | 0 | 159.9 | 0.00000 | 0.00048 | 0.00176 | 0.00307 | 0.01884 | 0.03269 | 0.05224 |
| | 0.07273 | 0.08324 | 0.07329 | 0.09331 | 0.05097 | 0.01627 | 0.00808 | 0.00171 | 0.00021 | 0.00000 | 0.00000 | 0.00224 |
| | 0.00245 | 0.00595 | 0.01710 | 0.05156 | 0.06241 | 0.08357 | 0.10663 | 0.09274 | 0.04278 | 0.01411 | 0.00615 | 0.00324 |
| | 0.00017 | | | | | | | | | | | |
| 2010 | 1 | 6 | 3 | 0 | 194.2 | 0.00000 | 0.00162 | 0.00561 | 0.01576 | 0.02402 | 0.02218 | 0.03675 |
| | 0.07445 | 0.08195 | 0.10132 | 0.07255 | 0.05979 | 0.02458 | 0.01402 | 0.00137 | 0.00030 | 0.00000 | 0.00163 | 0.00504 |
| | 0.01621 | 0.01929 | 0.01499 | 0.04281 | 0.05858 | 0.08159 | 0.09214 | 0.08299 | 0.03128 | 0.01229 | 0.00333 | 0.00136 |
| | 0.00021 | | | | | | | | | | | |
| 2011 | 1 | 6 | 3 | 0 | 178.0 | 0.00000 | 0.00035 | 0.01022 | 0.01805 | 0.03473 | 0.02527 | 0.03685 |
| | 0.04790 | 0.06523 | 0.08546 | 0.08596 | 0.06293 | 0.01246 | 0.00472 | 0.00070 | 0.00000 | 0.00000 | 0.00133 | 0.00836 |
| | 0.02364 | 0.02669 | 0.03289 | 0.04330 | 0.05628 | 0.06406 | 0.10403 | 0.08837 | 0.03830 | 0.01895 | 0.00264 | 0.00031 |
| | 0.00000 | | | | | | | | | | | |
| 2012 | 1 | 6 | 3 | 0 | 174.8 | 0.00000 | 0.00203 | 0.00275 | 0.01092 | 0.02847 | 0.04380 | 0.03717 |
| | 0.05589 | 0.06166 | 0.07654 | 0.08932 | 0.05582 | 0.02467 | 0.00715 | 0.00529 | 0.00043 | 0.00000 | 0.00125 | 0.00184 |
| | 0.01150 | 0.03146 | 0.02984 | 0.04508 | 0.04042 | 0.06404 | 0.08267 | 0.09279 | 0.05289 | 0.02631 | 0.01484 | 0.00255 |
| | 0.00059 | | | | | | | | | | | |

#

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #Age | composition | | set-up | | | | | | | | | |
| 61 | #_N_age_bins | | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | #_N_ageerror_definitions | | | | | | | | | | | |
| 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | 6.5 | 7.5 | 8.5 | 9.5 | 10.5 | 11.5 | 12.5 |
| | 13.5 | 14.5 | 15.5 | 16.5 | 17.5 | 18.5 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.5 |
| | 25.5 | 26.5 | 27.5 | 28.5 | 29.5 | 30.5 | 31.5 | 32.5 | 33.5 | 34.5 | 35.5 | 36.5 |
| | 37.5 | 38.5 | 39.5 | 40.5 | 41.5 | 42.5 | 43.5 | 44.5 | 45.5 | 46.5 | 47.5 | 48.5 |
| | 49.5 | 50.5 | 51.5 | 52.5 | 53.5 | 54.5 | 55.5 | 56.5 | 57.5 | 58.5 | 59.5 | 60.5 |
| | 61.5 | 62.5 | 63.5 | 64.5 | 65.5 | 66.5 | 67.5 | 68.5 | 69.5 | 70.5 | 71.5 | 72.5 |
| | 73.5 | 74.5 | 75.5 | 76.5 | 77.5 | 78.5 | 79.5 | 80.5 | | | | |
| 0.561982 | 0.561982 | 0.670791 | 0.778158 | 0.884103 | 0.988645 | 1.0918 | 1.19359 | 1.29404 | 1.39315 | 1.49095 | 1.58746 | 1.68268 |
| | 1.77665 | 1.86937 | 1.96086 | 2.05114 | 2.14023 | 2.22814 | 2.31488 | 2.40047 | 2.48493 | 2.56827 | 2.65051 | 2.73166 |
| | 2.81173 | 2.89074 | 2.96871 | 3.04564 | 3.12156 | 3.19646 | 3.27038 | 3.34332 | 3.41529 | 3.48631 | 3.55639 | 3.62554 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.69377 | 3.7611 | 3.82754 | 3.8931 | 3.95779 | 4.02163 | 4.08461 | 4.14677 | 4.2081 | 4.26862 | 4.32834 | 4.38726 |
| | 4.44541 | 4.50278 | 4.5594 | 4.61527 | 4.67039 | 4.72479 | 4.77846 | 4.83143 | 4.88369 | 4.93526 | 4.98615 | 5.03637 |
| | 5.08592 | 5.13481 | 5.18305 | 5.23066 | 5.27764 | 5.32399 | 5.36973 | 5.41486 | 5.4594 | 5.50335 | 5.54671 | 5.5895 |
| | 5.63172 | 5.67339 | 5.7145 | 5.75507 | 5.7951 | 5.8346 | 5.87358 | 5.91204 | | | | |
| # | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| # | | | | | | | | | | | | |
| 259 | #_N_Agecomp_obs | | | | | | | | | | | |
| 3 | #_Lbin_method: | | 1=poplenbins; | | 2=datalenbins; | | 3=lengths | | | | | |
| 9 | #_combinemales | | into | females | at | or | below | this | bin | number | | |
| # | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| #TWL | (N=51) | | | | | | | | | | | |
| #Conditional | | ages | at | length | (N=51), | not | expanded | | | | | |
| #Females | | | | | | | | | | | | |
| #Year | Seas | Fleet | Gender | Part | AgeErr | LbinLo | LbinHi | Nsamp | A0 | A1 | A2 | A3 |
| | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 |
| | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 |
| | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 | A39 |
| | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 | A51 |
| | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | A0 | A1 | A2 |
| | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 |
| | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 |
| | A27 | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 |
| | A39 | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 |
| | A51 | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 20 | 20 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 22 | 22 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 24 | 24 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 2 | 2 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 2 | 2 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 26 | 26 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 1 | 1 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 1 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 1 | 1 | 1 | 2 | 1 | 28 | 28 | 56 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 1 | 1 |
| | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 0 | 4 |
| | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 1 | 2 | 1 |
| | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 3 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 1 |
| | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 0 |
| | 4 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 1 | 2 |
| | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 3 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 30 | 30 | 81 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 3 | 1 | 0 | 1 | 5 | 3 | 2 | 4 | 3 |
| | 3 | 4 | 3 | 2 | 0 | 1 | 3 | 1 | 1 | 4 | 2 | 1 |
| | 4 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 1 |
| | 0 | 1 | 3 | 1 | 0 | 0 | 1 | 1 | 12 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 3 | 1 | 0 | 1 | 5 | 3 | 2 | 4 |
| | 3 | 3 | 4 | 3 | 2 | 0 | 1 | 3 | 1 | 1 | 4 | 2 |
| | 1 | 4 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 2 | 0 | 0 |
| | 1 | 0 | 1 | 3 | 1 | 0 | 0 | 1 | 1 | 12 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 32 | 32 | 49 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 2 | 2 | 1 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 3 |
| | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| | 1 | 1 | 0 | 2 | 3 | 1 | 1 | 0 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 2 | 2 | 1 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 3 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 1 |
| | 1 | 1 | 1 | 0 | 2 | 3 | 1 | 1 | 0 | 8 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 34 | 34 | 27 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| | 0 | 0 | 1 | 2 | 0 | 1 | 2 | 1 | 11 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 2 | 0 | 0 | 1 | 2 | 0 | 1 | 2 | 1 | 11 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 36 | 36 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | | |
| 2003 | 1 | 1 | 1 | 2 | 1 | 38 | 38 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 24 | 24 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 26 | 26 | 19 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 1 | 2 |
| | 1 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 1 |
| | 2 | 1 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 28 | 28 | 26 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 1 |
| | 0 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 |
| | 1 | 0 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 1 | 0 | 2 | 1 |
| | 1 | 2 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 1 | 0 | 2 |
| | 1 | 1 | 2 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 32 | 32 | 59 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 1 |
| | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 2 | 0 | 2 | 3 | 0 |
| | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 14 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 |
| | 1 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 2 | 0 | 2 | 3 |
| | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 |
| | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 14 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 34 | 34 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 2 | 1 | 1 | 2 | 0 | 1 | 2 | 1 | 12 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 2 | 1 | 1 | 2 | 0 | 1 | 2 | 1 | 12 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 36 | 36 | 23 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 15 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 15 | | |
| 2008 | 1 | 1 | 1 | 2 | 1 | 38 | 38 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 22 | 22 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 24 | 24 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 26 | 26 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 2 | 1 |
| | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 2 |
| | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 28 | 28 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 2 |
| | 3 | 0 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| | 2 | 3 | 0 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 30 | 30 | 26 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 2 |
| | 0 | 1 | 0 | 3 | 1 | 3 | 0 | 1 | 0 | 0 | 2 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 2 | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 1 | 1 | 1 | 0 |
| | 2 | 0 | 1 | 0 | 3 | 1 | 3 | 0 | 1 | 0 | 0 | 2 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1 | 1 | 1 | 2 | 1 | 32 | 32 | 35 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 2 | 3 | 1 | 1 | 3 | 0 | 3 | 2 | 1 | 1 | 0 |
| | 0 | 1 | 1 | 0 | 3 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 2 | 3 | 1 | 1 | 3 | 0 | 3 | 2 | 1 | 1 |
| | 0 | 0 | 1 | 1 | 0 | 3 | 0 | 1 | 1 | 1 | 0 | 1 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 34 | 34 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 |
| | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 16 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 36 | 36 | 25 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 16 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 16 | | |
| 2009 | 1 | 1 | 1 | 2 | 1 | 38 | 38 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | | |

#Males

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #Year | Seas | Fleet | Gender | Part | AgeErr | LbinLo | LbinHi | Nsamp | A0 | A1 | A2 | A3 |
| | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 |
| | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 |
| | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 | A39 |
| | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 | A51 |
| | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | A0 | A1 | A2 |
| | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 |
| | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 |
| | A27 | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 |
| | A39 | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 |
| | A51 | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 22 | 22 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 24 | 24 | 20 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 4 | 5 | 2 | 1 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 4 | 5 | 2 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 26 | 26 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 5 | 2 | 2 | 0 |
| | 2 | 2 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 5 | 2 | 2 |
| | 0 | 2 | 2 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 28 | 28 | 58 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 |
| | 0 | 3 | 0 | 2 | 6 | 0 | 2 | 4 | 0 | 0 | 1 | 2 |
| | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 3 | 1 | 1 | 0 |
| | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 7 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| | 1 | 0 | 3 | 0 | 2 | 6 | 0 | 2 | 4 | 0 | 0 | 1 |
| | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 3 | 1 | 1 |
| | 0 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 1 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 7 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 30 | 30 | 63 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 2 | 1 | 0 | 1 | 3 |
| | 1 | 0 | 2 | 1 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 1 |
| | 3 | 2 | 3 | 0 | 2 | 1 | 0 | 4 | 2 | 2 | 0 | 2 |
| | 2 | 0 | 3 | 2 | 2 | 1 | 0 | 1 | 9 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 2 | 1 | 0 | 1 |
| | 3 | 1 | 0 | 2 | 1 | 0 | 0 | 2 | 2 | 0 | 2 | 0 |
| | 1 | 3 | 2 | 3 | 0 | 2 | 1 | 0 | 4 | 2 | 2 | 0 |
| | 2 | 2 | 0 | 3 | 2 | 2 | 1 | 0 | 1 | 9 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 32 | 32 | 33 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 2 | 3 | 1 | 3 | 0 | 1 | 2 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 2 | 3 | 1 | 3 | 0 | 1 | 2 | 1 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 34 | 34 | 23 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 15 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 15 | | |
| 2003 | 1 | 1 | 2 | 2 | 1 | 36 | 36 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 22 | 22 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 26 | 26 | 21 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| | 3 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 1 | 3 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 28 | 28 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| | 1 | 2 | 1 | 0 | 2 | 2 | 4 | 1 | 0 | 1 | 0 | 1 |
| | 1 | 1 | 1 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 1 | 1 | 2 | 1 | 0 | 2 | 2 | 4 | 1 | 0 | 1 | 0 |
| | 1 | 1 | 1 | 1 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 30 | 30 | 42 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 0 | 0 | 1 | 4 | 1 | 2 | 2 | 2 | 2 |
| | 0 | 3 | 2 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 2 |
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 4 | 1 | 2 | 2 | 2 |
| | 2 | 0 | 3 | 2 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 32 | 32 | 39 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| | 4 | 1 | 3 | 0 | 1 | 0 | 1 | 3 | 2 | 1 | 1 | 1 |
| | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 0 | 6 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 0 | 4 | 1 | 3 | 0 | 1 | 0 | 1 | 3 | 2 | 1 | 1 |
| | 1 | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 0 | 6 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 34 | 34 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 2 | 3 | 0 |
| | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 11 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 2 | 3 |
| | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 11 | | |
| 2008 | 1 | 1 | 2 | 2 | 1 | 36 | 36 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 22 | 22 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 24 | 24 | 5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 26 | 26 | 12 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 2 | 3 |
| | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 2 |
| | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 28 | 28 | 19 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| | 1 | 2 | 1 | 0 | 1 | 3 | 0 | 0 | 1 | 2 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 2 | 1 | 2 | 1 | 0 | 1 | 3 | 0 | 0 | 1 | 2 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 30 | 30 | 42 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | 2 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 2 | 1 | 3 | 0 |
| | 3 | 1 | 1 | 2 | 2 | 1 | 3 | 0 | 3 | 2 | 1 | 0 |
| | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 2 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 2 | 1 | 3 |
| | 0 | 3 | 1 | 1 | 2 | 2 | 1 | 3 | 0 | 3 | 2 | 1 |
| | 0 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 32 | 32 | 38 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 |
| | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 3 | 2 | 2 |
| | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 9 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 |
| | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 3 | 2 |
| | 2 | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 9 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 34 | 34 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 1 | 18 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 1 | 18 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 36 | 36 | 13 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 9 | | |
| 2009 | 1 | 1 | 2 | 2 | 1 | 38 | 38 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | | |

#

#Survey Cond L at age by year, F then M within year (N = 198)

| #Year | Seas | Fleet | Gender | Part | AgeErr | LbinLo | LbinHi | Nsamp | A0 | A1 | A2 | A3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 |
| | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 |
| | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 | A39 |
| | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 | A51 |
| | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | A0 | A1 | A2 |
| | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 |
| | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 |
| | A27 | A28 | A29 | A30 | A31 | A32 | A33 | A34 | A35 | A36 | A37 | A38 |
| | A39 | A40 | A41 | A42 | A43 | A44 | A45 | A46 | A47 | A48 | A49 | A50 |
| | A51 | A52 | A53 | A54 | A55 | A56 | A57 | A58 | A59 | A60 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 10 | 10 | 1 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 3 | 0 | 0 | 0 | 2 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 4 | 0 | 0 | 0 | 1 |
| | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 2 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 3 | 2 | 2 | 3 | 1 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 2 | 4 | 1 | 0.5 | 2 | 1.5 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 3 | 3 | 4 | 8 | 4 | 3 | 2 | 0 |
| | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 34.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 6 | 1 | 1 | 1 |
| | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 1 |
| | 2 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 0 |
| | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 25.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 2 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| | 1 | 1 | 0 | 1 | 1 | 0.5 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 4 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 10 | 10 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 3.5 | 1 | 2.5 | 2 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 27 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 4 | 2 | 1 | 1 |
| | 1 | 0 | 3 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 36.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 3 | 1 |
| | 0 | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 2 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 2 | 1 | 0 | 1 |
| | 0 | 0.5 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 26 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 3 | 1 | 2 |
| | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 19 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 19.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 4 | 0 | 0 | 1.5 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 3 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 2 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | | |
| 2003 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 1.5 | 0 | 0 | 0 | 0.5 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 7.5 | 0 | 0 | 1 | 0 |
| | 2 | 1.5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 14.5 | 0 | 0 | 0 | 0 |
| | 2 | 3.5 | 3 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 2 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 3 | 3 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 24 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 |
| | 1 | 1 | 4 | 0 | 0 | 6 | 0 | 4 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 34 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 4 | 0 |
| | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 2 | 0 | 1 | 2 | 0 |
| | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 1 |
| | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 26 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 |
| | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 |
| | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 3 | 1 |
| | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 9 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 27 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 |
| | 0 | 0 | 2 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 |
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| 2005 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 1 | 2 | 1 | 38 | 38 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 2.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 1.5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 11.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 1 | 4 | 4.5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 10.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 1 | 1.5 | 6 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
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| 2005 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 26 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 6 | 9 | 6 | 2 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 2 | 1 | 2 | 0 | 1 |
| | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2005 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 3 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 24 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 2 |
| | 0 | 0 | 1 | 2 | 0 | 0 | 4 | 0 | 1 | 1 | 2 | 0 |
| | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 33 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 3 | 3 |
| | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 1 |
| | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 40 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 3 | 0 | 1 | 2 | 2 |
| | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 9 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2005 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 15 | 0 | 0 | 0 | 0 |
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| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 9 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 6 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | | |
| 2005 | 1 | 6 | 2 | 2 | 1 | 38 | 38 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 2 | 0 | 0 | 0.5 | 0 |
| | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2007 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 2.5 | 0 | 0 | 0 | 0 |
| | 0 | 0.5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 10 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 2 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 12.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 2 | 2 | 4 | 1.5 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 20 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 0 | 2 | 1 | 6 | 4 | 1 | 2 | 2 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 23 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 3 | 1 | 1 |
| | 3 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 5 | 0 | 0 |
| | 2 | 0 | 1 | 0 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 0 |
| | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 27 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 2 | 1 | 3 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 2 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 42 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 |
| | 2 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 1 | 1 | 0 | 1 |
| | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 1 | 2 | 1 | 38 | 38 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 |
| | 0 | 0.5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 9.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 2.5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 4 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 15.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 5 | 0 | 2.5 | 1 | 2 | 2 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 2 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| | 2 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 32 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 5 |
| | 1 | 2 | 0 | 0 | 2 | 3 | 1 | 0 | 0 | 1 | 1 | 1 |
| | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 31 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 1 | 4 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 |
| | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 2 |
| | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 13 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 7 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | | |
| 2007 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 10 | 10 | 1.5 | 0 | 0.5 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 2.5 | 0 | 0 | 1 | 1 |
| | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 3.5 | 0 | 0 | 0 | 0 |
| | 3.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 8.5 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 2 | 0 | 1 | 2.5 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 15 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 2 | 0 | 4 | 4 | 1 | 1 | 2 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 18 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 0 | 0 | 3 | 5 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 21 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 1 | 4 | 1 | 3 | 1 | 1 | 1 | 2 |
| | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 23 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 1 | 2 |
| | 2 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 33 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 | 1 | 0 |
| | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 2 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 37 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 0 | 1 | 1 | 0 | 0 | 3 | 3 | 2 | 1 | 1 | 0 | 3 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 19 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 12 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 10 | 10 | 0.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 3.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 2.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 2.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 3 | 0 | 1 | 2 | 1 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 2 | 1 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 21 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 6 | 3 | 1 | 2 | 1 |
| | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 22 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 3 | 1 |
| | 0 | 2 | 0 | 2 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 0 |
| | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 39 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 5 |
| | 0 | 0 | 2 | 0 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 1 |
| | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 37 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 1 | 0 | 3 | 2 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 3 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 1 |
| | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 11 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 25 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 13 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 8 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | | |
| 2009 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 10 | 10 | 2.5 | 0 | 2.5 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 4.5 | 0 | 0 | 4 | 0.5 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 2.5 | 0 | 0 | 0.5 | 1.5 |
| | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 10 | 0 | 0 | 0 | 1.5 |
| | 2.5 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 9 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 2 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 12 | 0 | 0 | 0 | 0 |
| | 0 | 2 | 1 | 1 | 3 | 0 | 0 | 3 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 18 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 4 | 5 | 1 | 6 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 37 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 4 | 3 | 3 | 2 | 5 | 3 | 1 | 5 |
| | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 38 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 2 | 0 | 2 | 2 | 3 |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 1 |
| | 1 | 0 | 1 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 1 |
| | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 |
| | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 31 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 1 |
| | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 1 | 4 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 1 | 2 | 1 | 38 | 38 | 3 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 10 | 10 | 1.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 5.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 9.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 |
| | 3.5 | 2.5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 13 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2.5 | 4.5 | 3 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 14 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 4 | 3 | 0 | 2 | 0 | 4 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 26 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 4 | 3 | 2 | 2 | 4 | 2 | 4 | 1 | 2 | 1 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 23 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 2 | 4 | 1 | 3 | 1 | 4 | 3 | 1 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 39 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 4 | 7 | 2 | 3 | 3 | 5 | 2 |
| | 1 | 1 | 4 | 1 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 40 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 3 | 2 | 0 |
| | 0 | 2 | 0 | 1 | 2 | 3 | 2 | 2 | 1 | 2 | 1 | 2 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 36 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 4 | 2 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 3 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 24 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 3 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 5 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 16 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | | |
| 2010 | 1 | 6 | 2 | 2 | 1 | 38 | 38 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 8 | 8 | 2.5 | 1 | 0.5 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1 | 6 | 1 | 2 | 1 | 10 | 10 | 2.5 | 0 | 0 | 2.5 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 5.5 | 0 | 0 | 3.5 | 1.5 |
| | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 9 | 0 | 0 | 0 | 4.5 |
| | 3.5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 17 | 0 | 0 | 0 | 4 |
| | 3 | 5 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 12 | 0 | 0 | 0 | 0 |
| | 0 | 3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 18 | 0 | 0 | 0 | 0 |
| | 0 | 2 | 3 | 2 | 4 | 0 | 1 | 2 | 1 | 0 | 1 | 1 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 4 | 3 | 4 | 6 | 1 | 1 | 3 | 1 | 4 |
| | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 31 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 2 | 5 | 2 | 0 | 1 |
| | 3 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 37 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 4 | 1 | 3 | 0 | 0 |
| | 3 | 3 | 1 | 1 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 0 |
| | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 30 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 2 |
| | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 1 | 0 |
| | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| | 0 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 2 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 0 |
| | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 6 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 9 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 8 | 8 | 2.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 10 | 10 | 3.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.5 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 3.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 |
| | 1.5 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 12 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 3.5 | 1.5 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 20 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 6 | 6 | 4 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 2 | 2 | 3 | 4 | 1 | 3 | 1 | 0 | 1 | 0 | 0 |
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| 2011 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 1 | 5 | 1 | 4 | 2 | 2 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 20 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 1 | 1 | 2 | 0 |
| | 1 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 4 | 2 | 4 | 3 | 1 |
| | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 45 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 3 | 1 | 1 | 0 |
| | 3 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 1 |
| | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 37 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1 |
| | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 2 | 1 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 1 |
| | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 9 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 27 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 2 | 1 | 0 | 2 | 2 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | | |
| 2011 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 10 | 10 | 0.5 | 0 | 0 | 0.5 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 12 | 12 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 14 | 14 | 6.5 | 0 | 0 | 0 | 0 |
| | 2 | 4 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 16 | 16 | 11.5 | 0 | 0 | 0 | 0 |
| | 0.5 | 2 | 4 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2012 | 1 | 6 | 1 | 2 | 1 | 18 | 18 | 16.5 | 0 | 0 | 0 | 0 |
| | 1 | 6 | 1 | 4 | 0.5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 20 | 20 | 21 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 2 | 4 | 3 | 0 | 2 | 2 | 1 | 1 | 3 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 22 | 22 | 13 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 | 1 | 3 | 0 | 1 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 24 | 24 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 4 | 2 | 2 |
| | 1 | 3 | 1 | 4 | 4 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 26 | 26 | 25 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 1 | 1 |
| | 1 | 0 | 0 | 3 | 1 | 1 | 0 | 1 | 1 | 1 | 3 | 0 |
| | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 28 | 28 | 31 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 0 | 2 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| | 2 | 1 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2012 | 1 | 6 | 1 | 2 | 1 | 30 | 30 | 17 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 2 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 32 | 32 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 34 | 34 | 6 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 1 | 2 | 1 | 36 | 36 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2012 | 1 | 6 | 1 | 2 | 1 | 38 | 38 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2012 | 1 | 6 | 2 | 2 | 1 | 10 | 10 | 0.5 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 2012 | 1 | 6 | 2 | 2 | 1 | 12 | 12 | 1 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 14 | 14 | 3.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 16 | 16 | 14.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 3.5 | 5 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 18 | 18 | 11.5 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 3 | 0 | 4.5 | 2 | 1 | 0 | 1 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 20 | 20 | 10 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 0 | 0 | 0 |
| | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 22 | 22 | 18 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 3 | 3 | 0 |
| | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 24 | 24 | 36 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 5 | 4 | 0 | 3 | 0 |
| | 3 | 2 | 3 | 4 | 0 | 2 | 2 | 1 | 1 | 1 | 0 | 1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 26 | 26 | 39 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 3 | 4 |
| | 0 | 2 | 1 | 2 | 2 | 2 | 0 | 2 | 1 | 1 | 1 | 0 |
| | 0 | 0 | 3 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 28 | 28 | 29 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 |
| | 0 | 2 | 0 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 30 | 30 | 28 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 2 | 1 | 1 | 0 | 0 |
| | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 6 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 32 | 32 | 11 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 5 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 34 | 34 | 8 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 5 | | |
| 2012 | 1 | 6 | 2 | 2 | 1 | 36 | 36 | 4 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2012 | 1 | 6 | 2 | 2 | 1 | 38 | 38 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | | |
| # | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| #TWL | ghost | marginal | ages | (N=3), | not | expanded | | | | | | |
| #Year | Seas | Fleet | Gender | part | AgeErr | LbinLo | LbinHi | Nsamp | | | | |
| 2003 | 1 | -1 | 3 | 2 | 1 | -1 | -1 | 481 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 4 | 2 | 3 | 7 | 6 | 2 | 2 |
| | 3 | 4 | 4 | 5 | 2 | 1 | 3 | 10 | 4 | 4 | 5 | 7 |
| | 5 | 7 | 4 | 6 | 4 | 4 | 3 | 4 | 1 | 6 | 6 | 6 |
| | 7 | 3 | 4 | 3 | 3 | 3 | 2 | 3 | 4 | 1 | 5 | 6 |
| | 1 | 3 | 4 | 5 | 4 | 3 | 5 | 2 | 41 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 3 | 5 | 10 | 7 | 6 |
| | 1 | 2 | 6 | 2 | 5 | 6 | 3 | 4 | 6 | 3 | 2 | 2 |
| | 5 | 2 | 2 | 2 | 5 | 0 | 1 | 3 | 5 | 4 | 3 | 2 |
| | 3 | 5 | 3 | 6 | 5 | 5 | 7 | 1 | 5 | 4 | 5 | 2 |
| | 3 | 3 | 1 | 3 | 2 | 4 | 2 | 1 | 4 | 45 | | |
| 2008 | 1 | -1 | 3 | 2 | 1 | -1 | -1 | 382 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 2 | 6 | 4 | 5 |
| | 1 | 7 | 1 | 5 | 5 | 4 | 3 | 4 | 3 | 1 | 5 | 3 |
| | 3 | 3 | 5 | 4 | 4 | 3 | 4 | 2 | 3 | 3 | 4 | 2 |
| | 1 | 2 | 0 | 2 | 3 | 2 | 1 | 2 | 3 | 5 | 4 | 1 |
| | 3 | 1 | 4 | 3 | 1 | 2 | 2 | 5 | 57 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 0 |
| | 2 | 5 | 4 | 3 | 2 | 4 | 4 | 10 | 4 | 2 | 5 | 3 |
| | 3 | 2 | 5 | 4 | 3 | 5 | 2 | 2 | 4 | 3 | 0 | 1 |
| | 0 | 4 | 3 | 6 | 3 | 2 | 1 | 2 | 7 | 2 | 4 | 4 |
| | 4 | 2 | 1 | 3 | 3 | 2 | 2 | 1 | 1 | 31 | | |
| 2009 | 1 | -1 | 3 | 2 | 1 | -1 | -1 | 323 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 4 | 1 | 5 | 5 |
| | 4 | 3 | 7 | 3 | 0 | 3 | 1 | 1 | 2 | 3 | 1 | 2 |
| | 0 | 3 | 4 | 6 | 2 | 6 | 1 | 4 | 2 | 2 | 3 | 0 |
| | 0 | 3 | 1 | 1 | 4 | 1 | 1 | 2 | 5 | 1 | 1 | 3 |
| | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 2 | 41 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 | 1 | 3 | 3 |
| | 9 | 3 | 5 | 1 | 0 | 2 | 5 | 0 | 1 | 4 | 3 | 4 |
| | 1 | 3 | 1 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 3 | 2 |
| | 0 | 2 | 2 | 5 | 2 | 3 | 0 | 0 | 1 | 4 | 4 | 3 |
| | 2 | 2 | 1 | 3 | 1 | 4 | 3 | 2 | 1 | 42 | | |
| # | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| #Survey ghost | | marginal | ages | (N=7), | not | expanded | | | | | | |
| 2003 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 404 | 0 | 1 | 1 | 3 |
| | 2 | 3 | 4 | 7 | 9 | 12 | 10 | 15.5 | 13 | 8.5 | 4 | 3 |
| | 3 | 4 | 3 | 1 | 3 | 3 | 0 | 3 | 2 | 3 | 5 | 2 |
| | 3 | 3 | 2 | 5 | 4 | 2 | 3 | 1 | 2 | 3 | 4 | 3 |
| | 3.5 | 2 | 3 | 1 | 3 | 1.5 | 1 | 2 | 1 | 3 | 0 | 2 |
| | 2 | 1 | 1 | 0 | 2 | 2 | 1 | 0 | 29 | 0 | 1 | 3 |
| | 4 | 6 | 4 | 3 | 3 | 2 | 10 | 7 | 8.5 | 6 | 6.5 | 5 |
| | 2 | 1 | 6 | 3 | 2 | 1 | 4 | 3 | 2 | 5 | 2 | 3 |
| | 4 | 4 | 0 | 5 | 2 | 4 | 2 | 1 | 4 | 2 | 0 | 3 |
| | 1 | 1.5 | 0 | 5 | 3 | 0 | 1.5 | 2 | 1 | 2 | 0 | 2 |
| | 0 | 3 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 17 | | |
| 2005 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 428 | 0 | 0 | 1 | 0.5 |
| | 5 | 5 | 8 | 9 | 7 | 2 | 2 | 5 | 8 | 4 | 7 | 6 |
| | 2 | 6 | 7 | 3 | 1 | 8 | 1 | 6 | 1 | 4 | 6 | 0 |
| | 2 | 1 | 4 | 2 | 2 | 0 | 2 | 2 | 3 | 6 | 1 | 1 |
| | 4 | 4 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 |
| | 2 | 2 | 0 | 5 | 1 | 1 | 0 | 1 | 26 | 0 | 0 | 0 |
| | 2.5 | 6 | 8 | 14 | 10 | 8 | 7 | 7 | 3 | 6 | 6 | 12 |
| | 4 | 4 | 5 | 3 | 2 | 2 | 5 | 2 | 2 | 4 | 4 | 4 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 2 | 4 | 0 | 3 | 4 | 0 | 1 | 2 | 0 | 0 | 0 |
| | 0 | 1 | 4 | 2 | 2 | 2 | 0 | 5 | 0 | 2 | 3 | 3 |
| | 1 | 0 | 1 | 2 | 1 | 0 | 1 | 2 | 1 | 37 | | |
| 2007 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 395 | 0 | 0 | 0.5 | 0 |
| | 2.5 | 0.5 | 4 | 6 | 9 | 6.5 | 3 | 7 | 9 | 10 | 5 | 4 |
| | 7 | 4 | 7 | 7 | 5 | 4 | 1 | 1 | 2 | 1 | 5 | 0 |
| | 1 | 4 | 6 | 2 | 2 | 3 | 1 | 2 | 1 | 0 | 4 | 5 |
| | 3 | 0 | 1 | 3 | 3 | 5 | 2 | 2 | 3 | 1 | 1 | 1 |
| | 1 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 35 | 0 | 0 | 0.5 |
| | 0 | 1.5 | 4.5 | 10 | 11 | 3 | 3.5 | 3 | 4 | 8 | 4 | 11 |
| | 5 | 8 | 2 | 1 | 5 | 7 | 2 | 1 | 3 | 3 | 2 | 6 |
| | 1 | 2 | 5 | 1 | 1 | 2 | 1 | 0 | 3 | 4 | 1 | 2 |
| | 4 | 3 | 3 | 1 | 0 | 1 | 2 | 1 | 3 | 2 | 3 | 3 |
| | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 3 | 21 | | |
| 2009 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 403 | 0 | 0.5 | 2 | 1 |
| | 5 | 0 | 2 | 5 | 3 | 13 | 11.5 | 5 | 7 | 9 | 9 | 6 |
| | 3 | 7 | 4 | 7 | 1 | 4 | 4 | 4 | 3 | 4 | 2 | 6 |
| | 6 | 0 | 0 | 2 | 6 | 0 | 0 | 2 | 2 | 4 | 2 | 1 |
| | 3 | 2 | 0 | 3 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 2 |
| | 2 | 2 | 1 | 0 | 1 | 1 | 2 | 1 | 24 | 0 | 0.5 | 1 |
| | 2 | 3 | 1 | 3 | 3 | 2 | 7 | 11.5 | 7 | 6 | 6 | 8 |
| | 3 | 4 | 5 | 6 | 6 | 4 | 5 | 4 | 6 | 1 | 3 | 0 |
| | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 3 | 3 | 2 | 5 | 2 |
| | 1 | 2 | 0 | 1 | 4 | 0 | 0 | 1 | 2 | 2 | 1 | 2 |
| | 0 | 3 | 1 | 0 | 0 | 1 | 3 | 1 | 0 | 39 | | |
| 2010 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 487 | 0 | 2.5 | 4.5 | 3.5 |
| | 3 | 7 | 3 | 2 | 16 | 13 | 4 | 15 | 7 | 7 | 6 | 10 |
| | 8 | 4 | 2 | 3 | 1 | 4 | 2 | 2 | 3 | 1 | 3 | 4 |
| | 1 | 0 | 2 | 0 | 4 | 5 | 2 | 3 | 2 | 1 | 2 | 2 |
| | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 1 | 3 | 6 | 1 | 3 |
| | 0 | 1 | 0 | 2 | 1 | 0 | 4 | 3 | 26 | 0 | 1.5 | 5.5 |
| | 7.5 | 11 | 12 | 4 | 7 | 10 | 19 | 9 | 9 | 11 | 12 | 4 |
| | 6 | 6 | 6 | 5 | 4 | 4 | 3 | 3 | 5 | 4 | 3 | 5 |
| | 2 | 1 | 2 | 3 | 2 | 1 | 1 | 4 | 6 | 4 | 1 | 0 |
| | 1 | 2 | 0 | 2 | 2 | 0 | 3 | 2 | 1 | 3 | 2 | 1 |
| | 3 | 1 | 3 | 1 | 2 | 1 | 1 | 2 | 1 | 19 | | |
| 2011 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 502 | 1 | 0.5 | 7 | 10 |
| | 7 | 11 | 9 | 9 | 10 | 15 | 21 | 11 | 8 | 9 | 3 | 9 |
| | 7 | 10 | 4 | 4 | 2 | 4 | 3 | 2 | 2 | 3 | 1 | 2 |
| | 2 | 4 | 1 | 0 | 2 | 5 | 1 | 1 | 1 | 2 | 2 | 0 |
| | 2 | 1 | 0 | 3 | 2 | 3 | 2 | 0 | 0 | 1 | 2 | 0 |
| | 3 | 2 | 0 | 0 | 3 | 2 | 0 | 0 | 14 | 1 | 0.5 | 8 |
| | 11 | 10 | 8 | 8 | 7 | 10 | 14 | 20 | 9 | 9 | 8 | 2 |
| | 8 | 5 | 3 | 6 | 7 | 3 | 4 | 3 | 3 | 4 | 3 | 3 |
| | 3 | 3 | 6 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 0 | 2 |
| | 2 | 3 | 5 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 |
| | 2 | 3 | 2 | 1 | 1 | 0 | 1 | 1 | 0 | 17 | | |
| 2012 | 1 | -6 | 3 | 2 | 1 | -1 | -1 | 407 | 0 | 0 | 0.5 | 1 |
| | 3.5 | 12 | 6.5 | 9 | 7.5 | 6 | 2 | 9 | 6 | 13 | 4 | 8 |
| | 6 | 5 | 5 | 9 | 6 | 3 | 3 | 6 | 1 | 1 | 4 | 3 |
| | 2 | 3 | 3 | 0 | 4 | 1 | 0 | 1 | 0 | 0 | 2 | 2 |
| | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 3 | 16 | 0 | 0 | 1.5 |
| | 0 | 5.5 | 6 | 5.5 | 2 | 9.5 | 7 | 12 | 13 | 5 | 10 | 6 |
| | 5 | 7 | 7 | 8 | 4 | 5 | 8 | 6 | 4 | 3 | 1 | 1 |
| | 1 | 2 | 5 | 3 | 0 | 1 | 2 | 0 | 5 | 1 | 1 | 2 |
| | 1 | 2 | 3 | 1 | 1 | 2 | 0 | 2 | 1 | 0 | 1 | 1 |
| | 2 | 0 | 1 | 1 | 2 | 0 | 4 | 0 | 1 | 25 | | |

#

0 #_N_MeanSize-at-Age_obs
0 #_N_environ_variables
0 #_N_environ_obs
0 #_N sizefreq methods to read
0 # no tag data
0 # no morphcomp data
#
999

## Appendix C. SS control file

#Aurora Control File
1  #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
1 #_Nblock_Patterns
11 #_blocks_per_pattern
#1916 1998
1999 2001
2002 2002
2003 2003
2004 2004
2005 2005
2006 2006
2007 2007
2008 2008
2009 2009
2010 2010
2011 2012
#
#1916 2001 Block for nontrwl selectivity
#2002 2012
# begin and end years of blocks
#
0.5 #_fracfemale
0 #_natM_type:_0=1Parm;
1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
  #_no additional input for selected M option; read 1P per morph
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
1 #_Growth_Age_for_L1
40 #_Growth_Age_for_L2
0 #_SD_add_to_LAA
0 #_CV_Growth_Pattern
1 #_maturity_option
#_placeholder for empirical age-maturity by growth pattern
0 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt)
0 #_hermaphroditism option: 0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none)
2 #_env/block/dev_adjust_method(2=logistic transform keeps in base parm bounds)
#
#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
0.001 2 0.0350 -3.353 3 0.541 -2 0 0 0 0 0 0 0 # NatM_p_1_Fem_GP_1
1 11.82328614 8.5 6 1 10 2 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
1 73.8 31 31 -1 10 3 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
0.01 1 0.09 0.1 -1 0.8 3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
0.03 0.2 0.1 0.09 -1 0.8 3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1

0.03 0.2 0.07 0.05 -1 0.8 3 0 0 0 0 0 0
0 # CV_old_Fem_GP_1
0.001 2 0.0371 -3.295 3 0.540 -2 0 0 0 0 0 0 0 # NatM_p_1_Mal_GP_1
1 11.82328614 8.5 6 1 10 2 0 0 0 0 0 0 0 # L_at_Amin_Mal_GP_1
1 73.8 30 31 -1 10 4 0 0 0 0 0 0 0 # L_at_Amax_Mal_GP_1
0.01 1 0.092 0.1 -1 0.8 3 0 0 0 0 0 0 0 # VonBert_K_Mal_GP_1
-1 1 0 0 -1 0.8 -3 0 0 0 0 0 0 0 # CV_young_Mal_GP_1
-1 1 0 0 -1 0.8 -3 0 0 0 0 0 0 0 # CV_old_Mal_GP_1
-3 3 0.000009933699 2.44E-06 -1 0.8 -3 0 0 0
0 0 0 0 # Wtlen_1_Fem
-3 4 3.144807 3.34694-1 0.8 -3 0 0 0 0 0
0 0 # Wtlen_2_Fem
1 1000 25.54 55 -1 0.8 -3 0 0 0 0 0 0 0 # Mat50%_Fem
-30 3 -0.616 -0.25 -1 0.8 -3 0 0 0 0 0 0
0 # Mat_slope_Fem
-3 3 1 1 -1 0.8 -3 0 0 0 0 0 0
0 # Eggs/kg_inter_Fem
-3 3 0 0 -1 0.8 -3 0 0 0 0 0 0
0 # Eggs/kg_slope_wt_Fem
-3 3 0.000009618973 2.44E-06 -1 0.8 -3 0 0 0
0 0 0 0 # Wtlen_1_Mal
-3 4 3.147253.34694-1 0.8 -3 0 0 0 0 0 0
0 # Wtlen_2_Mal
0 0 0 0 -1 0 -4 0 0 0 0 0 0
0 # RecrDist_GP_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0
0 # RecrDist_Area_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0
0 # RecrDist_Seas_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0
0 # CohortGrowDev
#
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-
environ parameters
#
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-
block parameters
#_Cond No MG parm trends
#
#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0
#_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no
seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
3 #_SR_function

#_LO HI INIT PRIOR PR_type SD PHASE
1 31 7.5 7.5 -1 10 1 # SR_R0
0.25 0.99 0.779 0.779 2 0.152 -3 # SR_steep
0 2 0.5 0.8 -1 0.8 -4 # SR_sigmaR
-5 5 0.1 0 -1 1 -3 # SR_envlink
-5 5 0 0 -1 1 -4 # SR_R1_offset
0 0 0 0 -1 0 -99 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1962 # first year of main recr_devs; early devs can preceed this era
2011 # last year of main recr_devs; forecast devs start in following year
2 #_recdev phase
1 # (0/1) to read 13 advanced options
1916 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
3 #_recdev_early_phase

5 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
1 #_lambda for fore_recr_like occurring before endyr+1
1962 #_last_early_yr_nobias_adj_in_MPD
1970 #_first_yr_fullbias_adj_in_MPD
2008 #_last_yr_fullbias_adj_in_MPD
2012 #_first_recent_yr_nobias_adj_in_MPD
0.5 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
0 #_period of cycles in recruitment (N parms read below)
-5 #min rec_dev
5 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_Yr Input_value
#
# all recruitment deviations
#
#Fishing Mortality info
0.3 # F ballpark for tuning early phases
-2001 # F ballpark year (neg value to disable)
3 # F_Method: 1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
0.9 # max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
# if Fmethod=3; read N iterations for tuning for Fmethod 3
5 # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms

```
#_LO HI INIT PRIOR PR_type SD PHASE
 0 1 0 0.01 0 99 -1 # InitF_1FISHERY1
 0 1 0 0.01 0 99 -1 # InitF_1FISHERY1
#
#_Q_setup
 # Q_type options:  <0=mirror, 0=median_float, 1=mean_float, 2=parameter, 3=parm_w_random_dev,
4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
 #_Den-dep  env-var  extra_se  Q_type
 0 0 0 0 # 1 TRAWL
 0 0 0 0 # 2 BYCATCH
 0 0 0 0 # 3 Tri
 0 0 0 0 # 4 AFSC slope
 0 0 0 0 # 5 NWFSC slope
 0 0 0 0 # 6 NWFSC shelf-slope
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a
parm for each year of index
#_Q_parms(if_any)
# LO HI INIT PRIOR PR_type SD PHASE
# 0 5 0.01 0.01 0 99 1 # InitF_1FISHERY1
# 0 5 0.01 0.01 0 99 1 # InitF_1FISHERY1
# 0 5 0.01 0.01 0 99 1 # InitF_1FISHERY1
# 0 5 0.01 0.01 0 99 1 # InitF_1FISHERY1
#_SELEX_&_RETENTION_PARAMETERS
# Size-based setup
# A=Selex option: 1-24
# B=Do_retention: 0=no, 1=yes
# C=Male offset to female: 0=no, 1=yes
# D=Extra input (#)
# A B C D
# Size selectivity
1	1	0	0	# TWL
15	0	0	1	# NODISC
24	0	0	0	# Late Triennial
24	0	0	0	# AFSC Slope
24	0	0	0	# NWFSC slope
15	0	0	5	# NWFSC Combo
# Age selectivity
10	0	0	0  # Fishery
10	0	0	0  # NODISC
10	0	0	0   # Late Triennial
10	0	0	0   # AFSC Slope
10	0	0	0   # NWFSC Slope
10	0	0	0   # NWFSC Combo

# Selectivity parameters
# Lo	Hi	Init	Prior	Prior	Prior	Param	Env	Use	Dev	Dev	Dev	Block
	block
# bnd	bnd	value	mean	type	SD	phase	var	dev	minyr	maxyr	SD	design
	switch
# Fishery age-based
```

# Selectivity parameters

| # Lo | Hi | Init | Prior | Prior | Prior | Param | Env | Use | Dev | Dev | Dev | Block | block | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # bnd | bnd | value | mean | type | SD | phase | var | dev | minyr | maxyr | SD | design | switch | |
| # Block design 1 means that parm’ = baseparm + blockparm, 2 means that parm’ = blockparm | | | | | | | | | | | | | | |
| # TWL Fishery length-based | | | | | | | | | | | | | | |
| #18 | 40 | 24 | 24 | -1 | 50 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Peak |
| #-6 | 4 | -1 | -1 | -1 | 50 | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Top |
| #-1 | 9 | 2 | 4 | -1 | 50 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Asc width |
| #-1 | 9 | 0 | 4 | -1 | 50 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Desc width |
| #-5 | 9 | -4.99 | -4 | -1 | 50 | -4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Init |
| #-5 | 9 | 1 | -2 | -1 | 50 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Final |
| 15 | 30 | 22 | 22 | -1 | 99 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | #infl_for_logistic |
| 0.001 | 50 | 7 | 9 | -1 | 99 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | #95%width_for_logistic |
| # TWL Retention | | | | | | | | | | | | | | |
| 10 | 35 | 25 | 25 | -1 | 99 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | # Inflection |
| 0.1 | 10 | 2 | 1 | -1 | 99 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | # Slope |
| 0.001 | 1 | 0.95 | 0.95 | -1 | 99 | 1 | 0 | 0 | 0 | 0 | 0.5 | 1 | 2 | # Asymptote |
| 0 | 0 | 0 | 0 | -1 | 99 | -3 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0 | # Male offset |
| # Triennial Survey | | | | | | | | | | | | | | |
| 10 | 30 | 25 | 23 | -1 | 50 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Peak |
| -6 | 4 | -2 | -2 | -1 | 50 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Top |
| -1 | 9 | 3 | 4 | -1 | 50 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Asc width |
| -1 | 9 | 3 | 4 | -1 | 50 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Desc width |
| -5 | 9 | -4.99 | -4 | -1 | 50 | -4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Init |
| -5 | 9 | 0 | -2 | -1 | 50 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Final |
| # AKslope | | | | | | | | | | | | | | |
| 10 | 30 | 23.5 | 23.5 | -1 | 50 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Peak |
| -6 | 4 | -3 | -3 | -1 | 50 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | # Top |

```
-1      9       3.5     4       -1      50      3       0       0       0       0       0       0
        0 # Asc width
-1      9       2       4       -1      50      3       0       0       0       0       0       0
        0 # Desc width
-5      9       -4.99   -4      -1      50      -4      0       0       0       0       0       0
        0 # Init
-5      9       0       -2      -1      50      2       0       0       0       0       0       0
        0 # Final
# NWFSC slope and Combo
10      30      26      26      -1      50      2       0       0       0       0       0       0
        0 # Peak
-6      4       -4      -4      -1      50      4       0       0       0       0       0       0
        0 # Top
-1      9       4       4       -1      50      3       0       0       0       0       0       0
        0 # Asc width
-1      9       2       3       -1      50      3       0       0       0       0       0       0
        0 # Desc width
-5      9       -4.99   -4      -1      50      -4      0       0       0       0       0       0
        0 # Init
-5      9       0       -2      -1      50      2       0       0       0       0       0       0
        0 # Final

#18     40      25      25      -1      99      2       0       0       0       0       0       0
        0       #infl_for_logistic
#0.001  50      11      15      -1      99      3       0       0       0       0       0       0
        0       #95%width_for_logistic
1       # Selex block setup: 0=Read one line apply all, 1=read one line each parameter
# Lo    Hi      Init    Prior   P_type  SD      Phase
0.1     1       .9      .9      0       99      -1 #1999-2001
0.1     1       .8      .8      0       99      1  #2002
0.1     1       .8      .8      0       99      1
0.1     1       .9      .9      0       99      1
0.1     1       .9      .9      0       99      1
0.1     1       .7      .7      0       99      1
0.1     1       .7      .7      0       99      1
0.1     1       .5      .5      0       99      1
0.1     1       .5      .5      0       99      1
0.1     1       .7      .7      0       99      1
0.1     1       .95     .95     0       99      1
#
#0.001  1       .75     .75     0       99      1 #
#15     35      20      25      -1      99      1

1 #Selectivity parameters above are applied directly without regard to bounds

 # Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3
```

#TWL NONTWL DISC TRI AKSL NWSL NWFSC
0 0 0 0 0 0 #_0add_to_survey_CV
0 0 0 0 0 0 #_add_to_discard_stddev
0 0 0 0 0 0 #_add_to_bodywt_CV
.15 1 .33 .37 1 .67 #_mult_by_lencomp_N
.31 1 1 1 1 1 #_mult_by_agecomp_N
1 1 1 1 1 1 #_mult_by_size-at-age_N
#
1 #_maxlambdaphase
1 #_sd_offset
#
0 # number of changes to make to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
# 9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
#like_comp fleet/survey  phase  value  sizefreq_method
#
# lambdas (for info only; columns are phases)
#  0 0 0 0 #_CPUE/survey:_1
#  1 1 1 1 #_CPUE/survey:_2
#  1 1 1 1 #_CPUE/survey:_3
#  1 1 1 1 #_lencomp:_1
#  1 1 1 1 #_lencomp:_2
#  0 0 0 0 #_lencomp:_3
#  1 1 1 1 #_agecomp:_1
#  1 1 1 1 #_agecomp:_2
#  0 0 0 0 #_agecomp:_3
#  1 1 1 1 #_size-age:_1
#  1 1 1 1 #_size-age:_2
#  0 0 0 0 #_size-age:_3
#  1 1 1 1 #_init_equ_catch
#  1 1 1 1 #_recruitments
#  1 1 1 1 #_parameter-priors
#  1 1 1 1 #_parameter-dev-vectors
#  1 1 1 1 #_crashPenLambda
0 # (0/1) read specs for more stddev reporting

999

## Appendix D. SS starter file

#C starter comment here
ARRA_dat3.ss
ARRA_ctl5.ss
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
0 # detailed age-structured reports in REPORT.SSO (0,1)
1 # write detailed checkup.sso file (0,1)
4 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
1 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)

1 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
1 # Number of bootstrap datafiles to produce
10 # Turn off estimation for parameters entering after this phase
1 # MCeval burn interval
1 # MCeval thin interval
0.0 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-2 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
#vector of year values
#1960 1970 1980 1990 2000 2010
0.0001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
0 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
1 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
3 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates)
0 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file

## Appendix E. SS forecast file

#V3.21f
#C  generic forecast file
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.5 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0 0 0
#  2010 2010 2010 2010 2010 2010 # after processing
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
12 # N forecast years
0.2 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0
#  2010 2010 2010 2010 # after processing
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.4 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0.1 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)

0.95577 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2013 #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
2013 # Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2013 # Rebuilder: year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F: 1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F: rows are seasons, columns are fleets
#_Fleet: FISHERY
# 1
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
-1 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
-1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
0 0
#_Conditional on >1 allocation group
# allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
2 # basis for input Fcast catch: 2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
# Input fixed catch values
#Year Seas Fleet Catch(or_F)
# 2013 1 1 5
# 2013 1 2 0
# 2013 1 3 0
# 2014 1 1 5
# 2014 1 2 0
# 2014 1 3 0

999 # verify end of input

Agenda Item G.3.a
Attachment 2
September 2013

# Stock Assessment Review (STAR) Panel Report for Aurora Rockfish

Northwest Fisheries Science Center Auditorium
Montlake Blvd, Seattle, Washington
8-12 July 2013

**STAR Panel Members**

| | |
|---|---|
| David Sampson (Chair) | Oregon State University, PFMC Scientific & Statistical Committee |
| Chris Francis | Center for Independent Experts |
| John Field | NMFS, Southwest Fisheries Science Center |
| Yan Jiao | Center for Independent Experts |

**Pacific Fishery Management Council (PFMC) Advisors**

| | |
|---|---|
| John DeVore | PFMC Staff |
| Colby Brady | NMFS Northwest Region, PFMC Groundfish Management Team |
| Gerry Richter | PFMC Groundfish Advisory Subpanel |

**Stock Assessment Team (STAT)**

| | |
|---|---|
| Owen Hamel | NMFS, Northwest Fisheries Science Center (NWFSC) |
| Jason Cope | NMFS, NWFSC |
| Sean Matson | NMFS, Northwest Regional Office |

## Summary of the STAR Panel Meeting

*Overview*

During 8-12 July 2013 a Stock Assessment Review (STAR) Panel met in Seattle, Washington to review a draft stock assessment document for aurora rockfish (Hamel et. al, 2013) that had been prepared by Hamel and Cope of the Northwest Fisheries Science Center and Matson of the Northwest Regional Office. The Panel operated under the Pacific Fishery Management Council's (PFMC) Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment and Review Process for 2013-2014 (PFMC 2012). This same panel also reviewed a draft assessment for rougheye rockfish.

Aurora rockfish (*Sebastes aurora*) is a long-lived, deep-dwelling rockfish ranging from the Queen Charlotte Islands in northern British Columbia to the mid-peninsula of Baja California, Mexico. The fish of this species found off the US West Coast are assumed to be a self-sustaining unit stock. This stock, which has been managed since 2000 as part of the minor slope rockfish complex, has not previously been assessed. Its high score in the Council's productivity and susceptibility analysis (PSA) indicated that it was vulnerable to becoming overfished (Cope et al, 2013).

The draft assessment document and other background materials were made available on the Council's ftp site on 06/25/2013, and the STAR Panelists all had adequate time to review the assessment document in advance of the meeting. The slide presentations prepared by the STAT were also made available from the ftp site, which greatly facilitated the panel's review and subsequent preparation of this STAR Panel report.

Results for the base model developed during the STAR Panel are summarized as follows. The assessment estimates that the spawning stock biomass of aurora rockfish at the start of 2013 was 1673 metric tons and was depleted to 64% of its unfished level. There is very little chance that the stock's spawning biomass has ever been below the Council's target level (40% of unfished), let alone the minimum stock size threshold (25% of unfished).

The STAR Panel commends the STAT members for their excellent presentations and complete and well-written documentation. Their willingness to respond to STAR Panel requests and to engage in productive discussions greatly contributed to the collegial atmosphere of the STAR meeting. The STAR Panel also extends its thanks to the NWFSC and PFMC staff who provided administrative support and hosted the meeting.

The STAR Panel recommends that the assessment for aurora rockfish constitutes the best available scientific information on the current status of the stock and that the assessment provides a suitable basis for management decisions.

*Summary of the Assessment Data and Model*

The assessment, which was conducted using the Stock Synthesis software (SS3 version 3.24o), was structured as a single coastwide region with removals taken from 1916 through 2012. The model as configured for the draft assessment had three fishing fleets, but during the STAR Panel meeting the non-trawl fleet, which accounted for a relatively small amount of the cumulative landings, was combined with the trawl fleet into a trawl + non-trawl fleet. There were discard data associated with the trawl fleet and its landings. The other fleet, which was assumed to produce no discards, accounted for removals by the historic foreign trawl fishery, by the at-sea hake fishery, and by research surveys.

Natural mortality rates (separate by sex, constant by age and time) were fixed at the median values of the prior distributions. The steepness parameter for the recruitment versus spawning biomass function was fixed at the mean of its prior distribution. Growth was estimated separately by sex. Fishery selection was length-based and fishery selectivity curves were assumed to be asymptotic. An asymptotic retention curve was estimated for the combined domestic trawl + non-trawl fleet.

The assessment considers biomass indices from four trawl surveys: the Triennial shelf survey; the Alaska Fishery Science Center slope survey; the Northwest Fisheries Science Center (NWFSC) slope survey; and the NWFSC shelf-slope survey. Survey length composition data were available for all but NWFSC slope survey. Conditional age-at-length composition data were available for the NWFSC shelf-slope survey.

Fishery length composition data were available for the combined trawl + non-trawl fleet but very little and variable amounts of data were available for the non-trawl portion of the fleet, so the composition data included in the model were exclusively from the trawl portion of the fleet. Limited amounts of conditional age-at-length composition data were available from the trawl fleet for three years near the end of the time series. Discard data included observed discard rates, length compositions of discards, and mean body weight observations of discarded fish.

*Analyses Requested by the STAR and the STAT's Responses*

Because the assessments for aurora rockfish and rougheye rockfish were based on similar data sources, the efficiency of the review process was greatly enhanced. Several Panel requests for more detailed background information were common to both assessment reviews (e.g., Requests 1, 2 and 3, below), but unique aspects of each assessment required special probing.

**Request 1:** Report additional diagnostics from the GLMMs, including predictions for model covariates. We would also like to see summarized model predictions of the distinct GLMM components (positive model and binomial model).

Rationale: Given the potential for trends in the random vessel effects over time, it is important to feel confident that the estimated effects are plausible. Strong effects may also have implications with respect to how length expansions are developed.

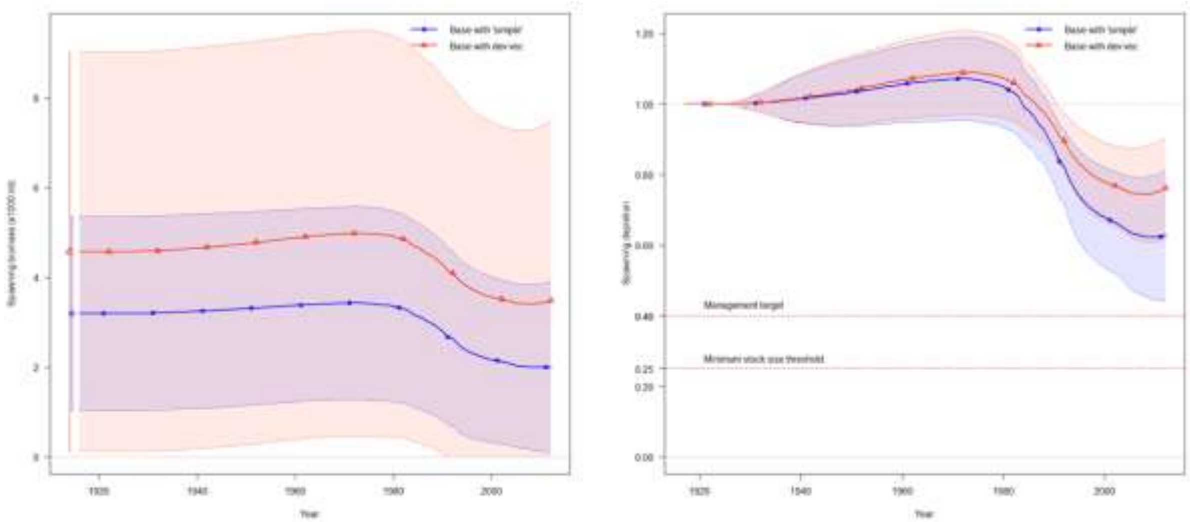
Response: There were no obvious unusual patterns observed in the time-series plots, for two latitude strata, of the binomial and positive catch-rate indices for the triennial survey. However, the AFSC slope survey plots appeared to be the same as the triennial survey plots, probably due to a plotting error. The NWFSC slope survey time-series plots were provided for four latitude strata. Plots of possible *Vessel* effects were not provided.

During discussion Melissa Haltuch (NWFSC) reported that the symbols shown in the standard plots of *Vessel* x *Year* effects don't uniquely identify each survey vessel. Further discussion of the issue of *Vessel x Year* effects was tabled until later in the meeting when Jim Thorson (NWFSC) was available to explain and interpret the random effect plots of the NWFSC shelf/slope survey results for rougheye rockfish.

The STAT began their presentation of responses with an admission that they had mistakenly used an incorrect specification for the recruitment deviations in their base model, as presented in the draft assessment document. Instead of specifying in the SS3 control file that the model should have a standard “dev-vector”, the STAT had specified that the model have “simple” recruitment deviations, which are not constrained to sum to zero. The STAT and STAR Panel agreed that the base model going forward should use the dev-vector configuration.

The simple dev-vector approach had some surprising effects. It produced much wider uncertainty bounds surrounding the estimates of spawning biomass, increased the scale of the spawning biomass, and resulted in the stock being less depleted (see below). It is rather alarming that such a subtle and easily overlooked change in the SS3 model specification could have such a significant impact on the assessment results.

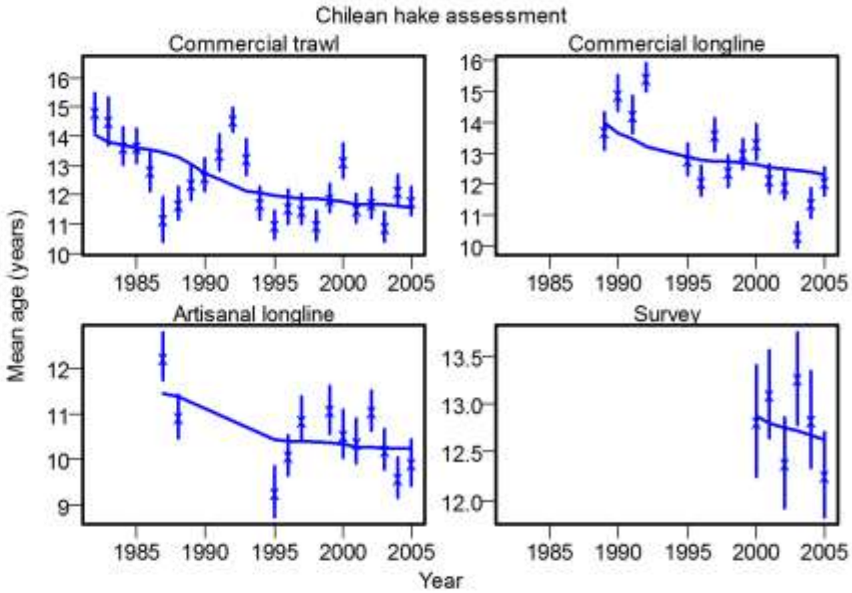
Base model with “simple” recruitment deviations versus configured with a dev-vector.




**Request 2:** Explore alternative effective sample size iteration methods. Based on the Francis (2011) approach, a new set of effective sample sizes can be jointly developed by the STAR Panel (Francis) and STAT. Do new runs with these re-weighted compositional data (as a sensitivity analysis to the current base model).

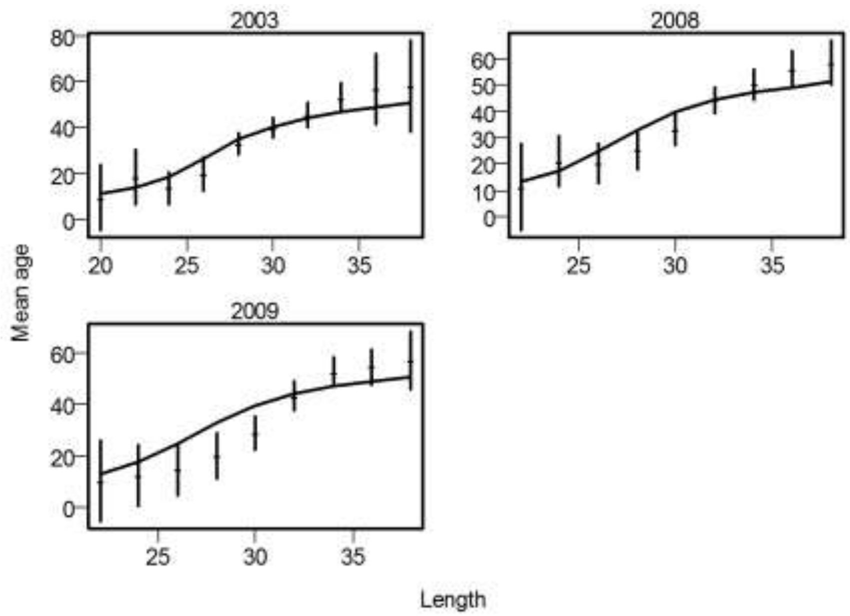
<u>Rationale:</u> The observation that there are strong autocorrelations in residuals indicates that correlations in the data are not accounted for in estimates of effective sample size. This re-weighting process may need to be done separately for the discard data.

<u>Response:</u> Because Chris Francis developed this relatively new method and R software to implement it, and worked with the STAT to develop the new estimates of effective sample size, he took the lead in presenting the response to this request. To illustrate the problem of autocorrelation leading to underestimates of variability, Chris presented an example (below) from a Chilean hake assessment, which shows several observed average values for which the predicted values do not overlap with the confidence limits based on the data.




Using the aurora rockfish assessment data, Chris showed that the variance of the estimated mean length can be quite variable for the fishery length and retained data, implying that short series would probably not produce reliable estimates of reweighting factors. He suggested that a combined reweighting factor be applied to all the trawl and nontrawl fisheries data. For survey lengths, because of limited data points in the AFSC shelf and AFSC slope surveys (four data points for each survey), all the surveys were combined and one reweighting factor was estimated. For the trawl age-at-length data, one reweighting factor was estimated. Chris expressed concern that for the fisheries data the residuals indicated some lack of fit in the predicted mean ages-at-length (below). For the survey age-at-length data the fits to the mean age were acceptable, and one reweighting factor was estimated. Chris also computed estimated ranges for the reweighting factors based on bootstrapped estimates for the mean length or mean age-at-length.

Observed and predicted age-at-length for the trawl fishery.

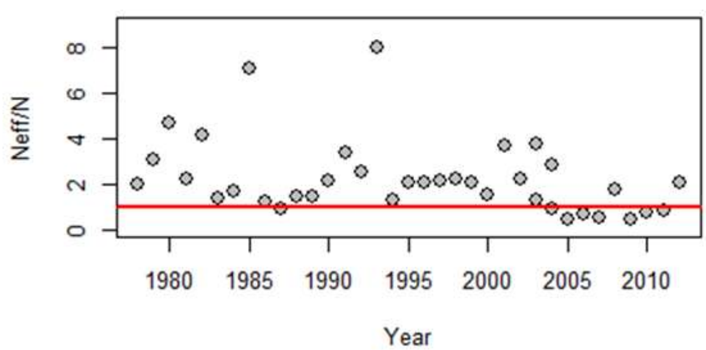



**Request 3:** Report the temporal trend in the ratio between input and effective sample sizes for each compositional data set.

Rationale: To see whether the calculation of the input N's is consistent over time.

Response: For most of the fleets the ratio of the effective N over the input N showed variability (as expected) but no time-trend. The one exception was the plot for the trawl fishery (below), for which the ratio was higher in the early years of the series. This suggests that the formula for calculating the input N values may need to be reconsidered.

Ratio of the effective N to the input N (Neff/N) for the trawl fishery composition data.



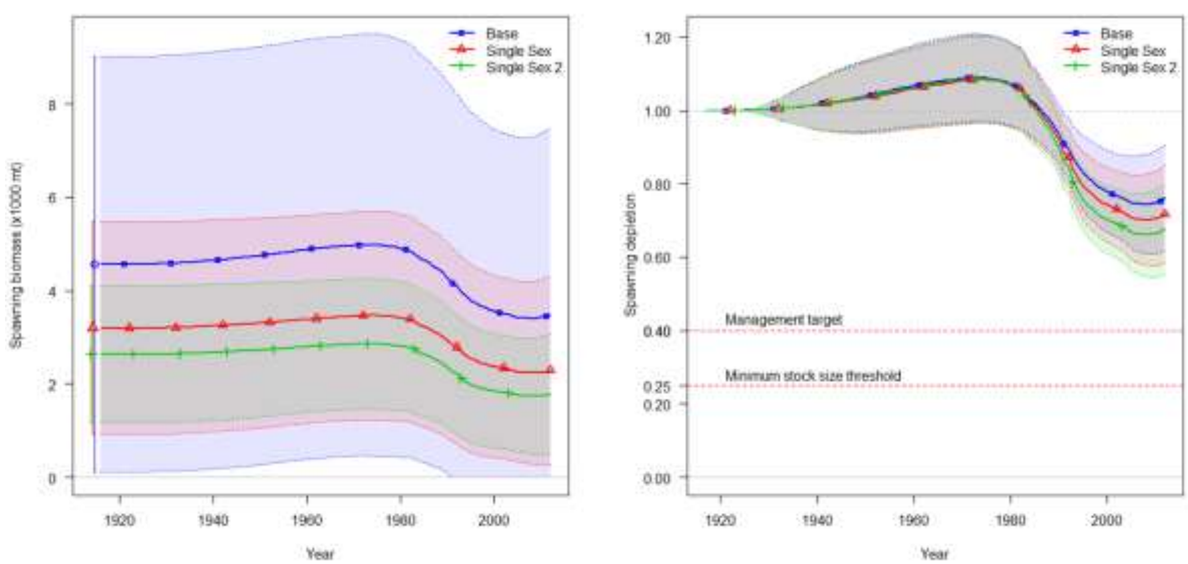

Also, because of differences in how the states collect their fishery samples, the relative number of samples coming from WA or OR may influence the combined length compositions. However, both the STAT and STAR after discussion realized that there was no clear "best approach" for combining the data.

**Request 4:** Develop a single-sex model.

Rationale: This is done in the interest of parsimony (minimizing the number of parameters), based largely on observation that growth and natural mortality are very similar between the two sexes.

Response: The STAT presented results from three models: (1) the base case model with two sexes plus some unsexed data; (2) a model with a single sex, but which leaves the unsexed data as in the base model; and (3) a model with a single sex that fully combined the sexed and unsexed data. There were surprisingly large differences in the estimated spawning biomass and depletion among the three models (below).

Base model (two sexes + unsexed) versus single sex + unsexed model ("Single Sex") versus model with sexes fully combined ("Single Sex 2").




The STAR and STAT agreed that model (a), which maintains the sex-structure as in the original base model, was the structure to go forward with.

**Request 5:** Develop a two (trawl+non-trawl, full retention) fishery model, in which the non-trawl length frequency data are removed.

Rationale: This is done in the interest of parsimony, and noting that non-trawl catches are very small and that the length frequency data for the non-trawl fishery are very noisy.

Response: This slight revision to the originally proposed base model resulted in slight increase in the scales of spawning biomass and current depletion, but the influence was less pronounced than the sex effect found in the response to Request 4.

**Request 6:** Develop models that begin around 1970. Start one model without recruitment deviations but with an equilibrium catch for the pre-1970 period, the other with recruitment deviations (estimated numbers at age in 1970) but without an equilibrium catch. Produce a plot of the age structure in 1970 from the base model and from the model that starts in 1970 (estimating age structure in that year).

Rationale: This is done in the interest of parsimony, and noting that catches prior to 1970 are minor. Also, the panel wants to better understand the cause of the unusual and implausible pattern in the estimated recruitment series of the proposed base model.

Response: The STAT showed results for three models: (1) the base model, which starts in 1916 from an unfished equilibrium; (2) a model which starts in 1970 from an unfished, non-equilibrium state; and (3) a model similar to (2) but that has a small historical average annual catch of 2.4 tons. Model (3) produced a sudden drop in spawning biomass that was implausible and taken as an indication that the model had not fully converged. Model (2) produced a spawning biomass trajectory that was essentially a scaled-up version of the spawning biomass trajectory from model (1). All three models produced nearly identical series of recruitment deviations for the period 1970 to 2011.

**Request 7:** Run the model both with no recruitment deviations (deterministic recruitment) as well as with recruitment deviations beginning later in the model (e.g., start main devs in 1970, 1980, 1990).

Rationale: The recruitment deviation patterns are somewhat unusual, with above average recruitment in the first 40 years of the model, followed by below average recruitment for ~25 years. The panel would like to better understand how these patterns improve the fit to the data, as well as how they affect model results.

Response: Several of the runs with short series of recruitment deviations produced implausibly large estimates for the scale of spawning biomass, which was taken as an indication that these models had not converged on the maximum likelihood estimates. The STAR and STAT discussed various hypotheses of the cause of the unusual pattern of recruitment deviations. One plausible hypothesis put forward by the STAT is that the historical fishery in California operated in shallow water, which would have resulted in dome-shaped fishery selectivity for these early removals, but the base model assumed asymptotic fishery selectivity for the entire catch series.

**Request 8:** Compare the size and age compositions in the northern (WA/OR) and southern regions (CA).

Rationale: The panel wants to better understand whether there are important geographical differences in size and age composition not accounted for in the model.

Response: The STAT produced a figure comparing the overall length frequency compositions from each of the three states. The fish landed in WA tend to be larger than the fished landed in OR, which in turn tend to be larger than the fish landed in CA. Because of the apparent differences in size among the states, there was discussion of whether the overall length frequency compositions for the coastwide fisheries had been generated by pooling the states' length frequency data based on their landing weights or on the estimated numbers of fish.

The STAT also produced a figure comparing the overall age compositions for samples from CA and OR, and similar comparison plots for the three years for which data were available (2003, 2008, and 2009). No age composition data were available from WA. It was evident that the age compositions could be quite different between CA and OR. The STAT commented that fishery selectivity might be changing over time because of changes in fishing patterns, and that retention was also likely to be changing over time.

**Request 9:** If possible, recalculate fishery length compositions with a numbers-based (rather than weight based) expansion factor, and use these composition data in the two-fleet model from Request 5. Include a comparison of the two runs.

Rationale: Given that length-frequencies are based on the numbers of fish (rather than their weight), and given that there are differences in size composition among states (noted in the response to Request 8), this is an appropriate change for the base model. This will also make the treatment of the fishery composition data consistent with the survey composition data, which supposedly were combined based on the numbers of fish caught rather than their weights.

Response: The fishery length-frequency data in the original base case model run turned out to have been combined based on the estimated numbers of fish. However, in checking out the methods they had used in preparing the data, the STAT found that the survey composition data had been combined according to weight rather than numbers. So, the STAT corrected the survey length composition data.

The STAT produced a spawning biomass trajectory plot that compared the two-fleet model from Request 5 with the same model based on the numbers-based survey length composition data. In the new model the STAT also corrected the discard rates to reflect that the trawl and non-trawl fleets had been combined. There were only minor differences between the spawning biomass trajectories from the two models, with the newer model having a slightly lower scale for the spawning biomass.

**Request 10:** Provide a comparison of the two-fleet model with tuning as done in the base model, and tuning consistent with Request 2.

Rationale: The rationale is the same as that for Request 2.

Response: The Francis reweighting approach resulted in a drastically higher spawning biomass that is implausible and that indicates a problem with model convergence.

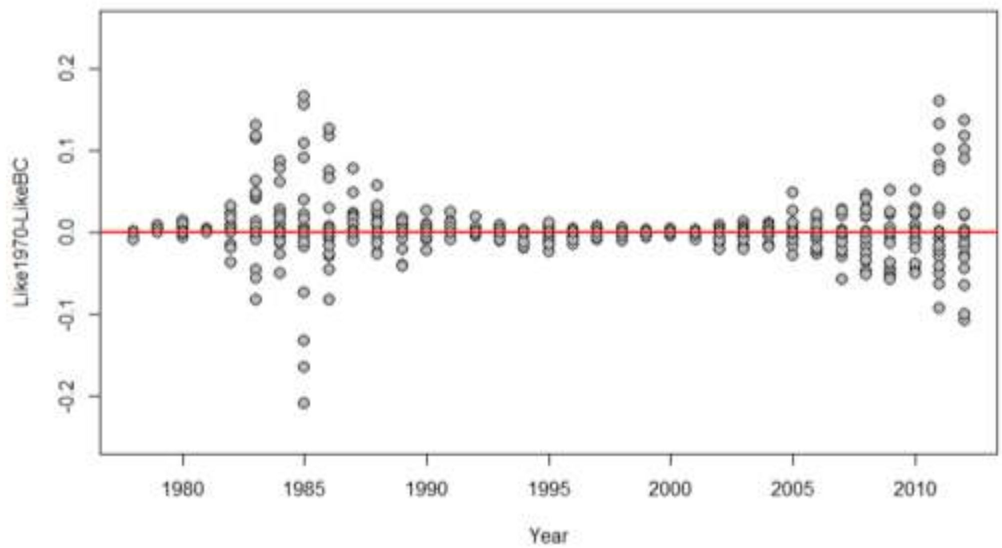
All these models fixed the natural mortality coefficient *M* at the mean value of the prior distribution (0.0405 $y^{-1}$ for females; 0.0429 $y^{-1}$ for males). The STAT recommended that the *M* values in the base model should be fixed at the median values of the prior distribution (0.0350 $y^{-1}$ for females; 0.0371 $y^{-1}$ for males) rather than at the mean values. The STAR concurred with this recommendation.

**Request 11:** Evaluate the differences in likelihoods of the year-specific compositional data (either, or both, age and length compositional data) in the two-fleet model (from Request 5) with full recruitment deviations (as in the original base model) versus a two-fleet model in which recruitment deviations begin in 1970.

Rationale: The STAR want to better understand the unusual recruitment pattern produced by the base model. For example, when recruitment deviations start in 1970 rather than 1916, there are comparable results in both the likelihoods and biomass trajectories, but very different results with respect to equilibrium recruitment. Differences in the likelihood components from the alternative recruitment scenarios may indicate the source of the odd recruitment pattern produced by the base model.

Response: The STAT provided plots by year and data source of individual log-likelihood ratios based on the two different models. It appears that the primary difference between the two models is in how they make the tradeoff between fitting the composition data from the mid-1980s versus fitting the composition data from the end of the time series (see figure below).

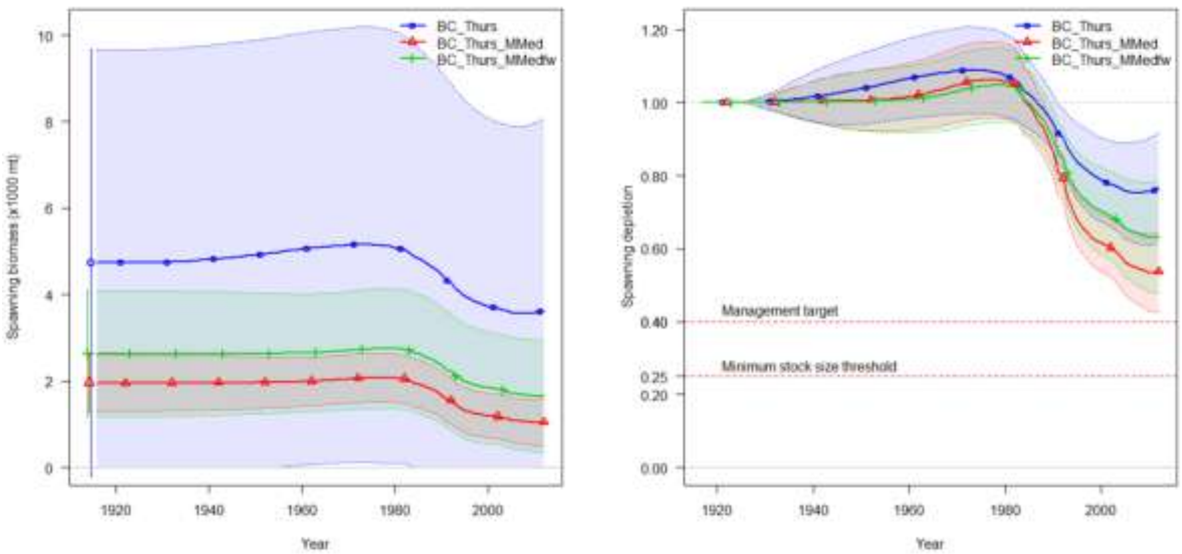
Difference in negative log-likelihood for fits to trawl + non-trawl fishery length composition data between the base model and a model that starts recruitment deviations in 1970.




## Description of the Base Model

Following the STAT's presentation of their response to Request 11 the STAT presented slides (below) that compared the spawning biomass and depletion trajectories of three candidate models that could be considered for use as the base model: (1) the model configuration that the STAT presented in their response to Request 9 (two sexes; two fleets, including combined discard data; full set of recruitment deviations; and *M* values - female *M* separate from male *M* - fixed at the means of the prior distribution); (2) the same configuration as in (1) but with the *M* values fixed at the medians of the prior distribution; and (3) the same configuration as in (2) but with the data reweighted using the Francis method. After discussion the STAT and STAR agreed that model (3) should be used as the final base model for the assessment and that the natural mortality rates (female *M*, male *M*) should form the major axis of uncertainty for constructing the decision table.

Candidate models (1-3, see text) considered for use as the new base model.
Model (1) = BC_Thurs; (2) = BC_Thurs_MMed; (3) = BC_Thurs_MMedfw.




The base model has the following structural characteristics.

- The stock is contained in one area, has no seasonality, and is modeled as having two sexes.
- The stock is at unfished equilibrium in 1915 and recruitment deviations start in 1916.
- The rate of natural mortality (*M*) is fixed at 0.035 $y^{-1}$ for females and 0.0371 $y^{-1}$ for males, based on the median values of the prior probability distributions.
- The steepness parameter (*h*) for the stock-recruitment function is fixed at the mean value (0.779) of the most recent version of the steepness prior probability distribution for rockfish. The recruitment variability parameter (*sigma-R*) is assumed to be 0.5.
- All parameters for the von Bertalanffy growth model are estimated freely. The parameters controlling variability in length-at-age for the males are assumed to be the same as those estimated for the females.
- There are two fishing fleets operating coastwide. One is conducted primarily with bottom trawl gear and is modeled as having discards. It includes some landings from a mixture of minor fisheries conducted primarily with hook-and-line gear (commercial and recreational). The other is a combination of two fisheries that are assumed to have produced no discards: the foreign fishery for Pacific ocean perch, the at-sea fishery for Pacific hake, and some research catches.
- Selectivity for both fleets is length-based, has a simple asymptotic form, and is assumed to be time-invariant. There is a single selectivity curve for both fleets, but the trawl + non-trawl fleet has a length-based logistic retention function for which the asymptote is estimated for 11 time-blocks (one block for 1916-1998, another for 1999-2001, annual blocks for 2002-2010, and a final block for 2011-2012).
- There are four fishery-independent trawl surveys: (1) the Triennial shelf survey; (2) the Alaska Fishery Science Center (AFSC) slope survey; (3) the Northwest Fisheries Science

Center (NWFSC) slope survey; and (4) the NWFSC shelf-slope survey. The surveys differ slightly from each other in survey design, survey gear, seasonal timing and geographic coverage.

- Selectivity for the surveys is length-based and is allowed to be dome-shaped (using the double-normal function), and the selection curves are independent of one another except for the NWFSC slope survey and the NWFSC shelf-slope survey, which are assumed to have the same selectivity. No length composition data are available from the NWFSC slope survey.
- The Francis method is used for reweighting the composition data from the different sources.

The base model is informed by the following data sources.

- Annual landings data from the two fishing fleets (trawl + non-trawl versus no-discard) for the period 1916-2012.
- Annual length composition data from the trawl fleet starting in the late 1970s. The length composition data from the non-trawl fleet had been included in the base model of the draft assessment, but were excluded from final base model. They were from limited very sampling and were quite variable.
- Annual conditional age-at-length composition data from the trawl fleet for three years (2003, 2008, and 2009).
- Annual discard biomass rates for the trawl fleet for 1985-1987 and 2002-2011.
- Annual mean weights of discarded fish for the trawl fleet for 2002-2011.
- Annual length compositions of discarded fish from the trawl fleet for 2002-2011.
- Annual biomass indices from the Triennial survey (1995, 1998, 2001, and 2004), the AFSC slope survey (1997, 1999, 2000, and 2001), the NWFSC slope survey (1999, 2000, 2001, and 2002), and the NWFSC shelf-slope survey (2003-2012).
- Annual length composition data from all surveys except the NWFSC slope survey.
- Annual conditional age-at-length composition data from the NWFSC shelf-slope survey (2003, 2005, 2007, and 2009-2012).

*Alternative Models for Bracketing Uncertainty*

The STAT, in the draft assessment document and in their opening presentation to the STAR, indicated that the results for this assessment were extremely sensitive to the assumed natural mortality coefficient (*M*). This sensitivity is clearly indicated in the last figure shown above. Changing female *M* from the mean value of the prior (0.0405 $y^{-1}$) to the median value (0.0350 $y^{-1}$) resulted in large changes in both spawning biomass and depletion. There was general agreement that *M* was the major axis of uncertainty. However, the best approach for quantifying the uncertainty associated with different values of *M* was not clear. The topic generated much discussion among all the STAR and STAT members. The STAT proposed the following method for selecting *M* values to characterize the low and high states of nature. The STAR endorsed this approach.

- Use the base model to produce a likelihood profile for $M$ and approximate this profile by a lognormal distribution for $M$.
- Combine this lognormal distribution with the prior distribution for $M$ based on Hoenig's method, which is also a lognormal distribution.
- Determine the 12.5 and 87.5 percentiles of spawning biomass in 2013 ($SB_{2013}$) based on this distribution.
- Determine the sets of fixed $M$ values that produce these low (female $M$ = 0.033 $y^{-1}$) and high (female $M$ = 0.037 $y^{-1}$) estimates of $SB_{2013}$.

One problem with this approach is that it only incorporates the uncertainty associated with the data measurement errors in the base model; the approach does not consider any of the uncertainties associated with the assumed model structure (e.g., the assumptions that steepness $h$ = 0.779 and that the data weightings are correct).

## Comments on Technical Merits and/or Deficiencies

*Technical Merits*

This is the first assessment for this stock and as such it provides a significant improvement on the previous data-poor view of the stock's potential productivity and current status. The preliminary concerns, based on the Council's productivity and susceptibility analysis, that the stock might be in poor condition proved to be unfounded.

The STAT produced a good quality assessment document, presented it clearly to the STAR, and was very responsive at addressing the questions and points raised by the STAR.

*Technical Deficiencies*

Because there were limited age-composition data available and because the stock had not previously been assessed, our state of knowledge regarding this stock is not fully mature. While the natural mortality rate remains the major source of uncertainty regarding this stock, there are several other potential sources of uncertainty that have not yet been fully explored or accounted for (e.g., the catch history and the assumption that fishery selectivity is time-invariant). The current assessment almost certainly underestimates the uncertainty of the stock's status and its ability to support harvest.

## Areas of Disagreement

*Between the STAR Panel and STAT*

There were no areas of disagreement between the STAT and the STAR Panel regarding the technical aspects or results of the assessment.

*Among STAR Panel Members*

There were no disagreements among the members of the STAR Panel regarding the technical aspects or results of the assessment.

Concerns Raised by the GMT.

The GMT did not raise any concerns regarding the technical aspects of the assessment.

Concerns Raised by the GAP.

The GAP did not raise any concerns regarding the technical aspects of the assessment.

## Unresolved Problems and Major Uncertainties

Numerous results presented by the STAT in the draft assessment document and during the review illustrated that the assessment results for aurora rockfish are very sensitive to the values chosen for the female and male natural mortality coefficients. Natural mortality is always a very problematic parameter for stock assessments, but with very long-lived species such as aurora rockfish, the presence of very old individuals in composition data can provide strong information regarding the implausibility of large values for *M*. Future assessments of this stock would greatly benefit from an increase in the number of conditional age-at-length observations and a validation of the ageing method.

Both draft assessments reviewed by the STAR Panel had used the SS3 estimates of effective sample size to iteratively reweight the different data sources. Although this reweighting approach has become a standard feature of most US West Coast assessments, Francis (2011, and in person at the review) provided compelling evidence that this standard approach resulted in implausible residual patterns for the aurora rockfish assessment and for the rougheye rockfish assessment. The Francis approach to reweighting, in contrast, for the most part eliminated these “bad” residual patterns. The Panel endorsed the use of the Francis approach for both assessments. However, it remains to be determined whether the Francis approach is the “best” general approach for deriving reweighting factors. The STAR Panel recommends that a scientific workshop be sponsored to review the state of the art for reweighting stock assessment data, with the aim of preparing a guide to good practices for future assessments.

The assessment model produced a rather implausible pattern of historical recruitments in which an extended period of positive deviations (roughly for the years 1940-1965) was followed by an extended period of negative deviations (roughly 1966-1987). Possible causes for this unusual pattern are likely related to one or more structural limitations in the model, which created systematic departures from an equilibrium age composition. However, despite attempts by the STAR and STAT to uncover the mechanism(s) that might be responsible (e.g., Requests 7 and 11), the exact cause(s) remain unknown. These structural limitations in the assessment model remain a source of uncertainty that should be explored more fully the next time this stock is assessed.

Another issue that generated considerable discussion amongst the STAR and STAT was how to adequately quantify and balance uncertainty when constructing the decision table. An initial attempt by the STAT conducting the rougheye rockfish assessment used the lognormal prior distribution for *M*, but this resulted in low and high states of nature that seemed implausibly asymmetric with respect to spawning biomass and projected catches. Future stock assessments and STAR Panels would likely benefit if they were provided with more detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

**Issues Raised by the GMT or GAP Representatives**

The GMT and GAP did not raise any data or management issues regarding this assessment.

**Prioritized Recommendations for Future Research and Data Collection**

*General (affecting more than one assessment)*

1. A workshop should be held to evaluate (a) methods for the iterative reweighting of composition data (e.g., current approach based on SS3 calculation of effective N versus Francis approach) and (b) methods for developing initial weightings (the initial input N values).

2. A workshop should be held to evaluate methods for constructing survey GLMM estimates. Topics that should be explored include: (a) the effect of treating vessels as random when in fact the vessels hardly vary from one year to the next; (b) possible aliasing of the index values with the *Vessel* x *Year* interactions; and (c) using information from the GLMM for combining length composition data collected by different vessels. One goal for the workshop should be to provide adequate documentation of the GLMM methods that will be used to produce survey biomass indices for future assessments and guidelines on how the analyses, including diagnostics, should be presented in stock assessment reports.

3. Port sampling programs should continue their routine collection of otoliths of slope rockfish species. A catalog of historical collections that have not been aged should be developed.

4. The series of historical catches of individual rockfish species, which are important sources of uncertainty in stock assessments of rockfish, should be explored in more detail. The STAR Panel agrees with the statement in the draft assessment document for rougheye rockfish that "*A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for"*.

   Furthermore, catch reconstructions should not just develop best estimates of rockfish catch by species, but should also characterize the uncertainty of historical catch estimates by identifying periods of greater and lesser uncertainty. For example, rockfish species compositions taken during early years when there were limited slope fisheries should be very different from species compositions taken during later years when fisheries on the slope were more prevalent.

5. The SSC should develop detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

6. Investigate better fishery-independent data collection methods for slope rockfish and other species living in untrawlable habitats (e.g., surveys using submersibles or remotely operated vehicles).

7. To lessen the potential for confusion in assessment documents and presentations, STATS in the future should be encouraged to develop and use consistent nomenclature for

identifying standard data sets. For example, during the Review the "AFSC triennial shelf survey" was also described as the "triennial survey" and as "AKSHLF".

*Specific to aurora rockfish*

1. The STAR Panel agrees with the STAT regarding the importance of (a) producing additional age-reading data for use in the next assessment of aurora rockfish and (b) validating the ageing method and age readings.
2. The STAR Panel agrees with the STAT regarding the importance of collecting additional information on reproductive biology (maturity, fecundity, and mass atresia) in aurora rockfish. This will allow analyses that better establish the relationship between effective fecundity and length, and between effective fecundity and weight.
3. The STAR Panel agrees with the STAT regarding the need for further development of the meta-analysis for steepness, including "*consideration of fixed and estimated parameters, assumptions, and the quality of the information on maturity and fecundity in the component assessments, as well as correlations in recruitments among assessments due to environmental drivers*".
4. The STAR Panel agrees with the STAT regarding the need for information on the stock structure of aurora rockfish with the aim of evaluating the assumption that the US West Coast stock is isolated from aurora rockfish off Canada and Mexico.
5. The STAR Panel agrees with the STAT that there should be exploration of developing an index of larval abundance of aurora rockfish from the CalCOFI surveys.

*Suitability for an Update Assessment*

Given that this stock had not been previously assessed, and given the sensitivity of the assessment results to small structural changes and additional data, the Panel recommends that the next assessment of this stock be a conducted as a full assessment.

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Agenda Item G.3.a
Attachment 3 (Full Version, Electronic Only)
September 2013



**DRAFT**

# The status of rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) as a complex along the U.S. West Coast in 2013

Allan C. Hicks
Chantell Wetzel
John Harms

Northwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

Allan.Hicks@noaa.gov
Chantell.Wetzel@noaa.gov
John.Harms@noaa.gov

Post-STAR DRAFT SAFE
8/20/2013

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# Executive Summary

## Stock

This is an assessment of rougheye rockfish (*Sebastes aleutianus*) that reside in the waters off California, Oregon, and Washington from the U.S.-Canadian border in the north to the U.S.-Mexico border in the south. Rougheye rockfish are more common north of the California-Oregon border and are also harvested in waters off British Columbia and the Gulf of Alaska. Although catches north of the U.S.-Canada border were not included in this assessment, it is not certain if those populations contribute to the biomass of rougheye rockfish off of the U.S. West Coast possibly through adult migration and/or larval dispersion.

The depth and geographic distribution of blackspotted rockfish (*S. melanostictus*) overlaps with rougheye rockfish and it is very difficult to visually distinguish between the two species. It has only been from recent genetic studies in the early 2000's that two separate species have been identified and described. Consequently, the vast majority of data that are available include pooled contributions from both rougheye rockfish and blackspotted rockfish. Due to the difficulty in distinguishing these two species and the lack of historical separation of the species in all of the data, this assessment combines any data for blackspotted rockfish with rougheye rockfish and provides management advice for the two species combined. In this assessment, the term "rougheye rockfish" refers to rougheye and blackspotted rockfishes unless specified.

## Landings

Rougheye rockfish are landed as part of the minor slope rockfish species complex. Because landings from the complex need not be sorted into component species for purposes of fish-ticket reporting, species composition sampling of this 'market' category is required to determine the amount of landed catch. The uncertainty in species composition is greater in past years, thus landings of rougheye rockfish are not well known further back in history.

The historical reconstruction of landings for rougheye rockfish suggests that fixed gear fisheries have caught rougheye rockfish since the turn of the 20$^{th}$ century and landings in the trawl fishery are estimated to have increased into the 1940's. Landings remained relatively constant throughout the 1950's and into the 1960's before the foreign trawl fleet increased catches into the 1970's. The declaration of the exclusive economic zone resulted in the buildup of a domestic fleet and landings increased rapidly into the late 1980's and early 1990's. Subsequently, landings have declined in the late 1990's and have been between 100 and 200 metric tons in recent years. Trawl, long-line, and Pacific whiting at-sea trawl fisheries make up the majority of the catch.

Rougheye rockfish are a desirable market species and discarding has been low, historically. However, management restrictions (e.g., trip limits) have resulted in increased discarding since 2000. Trawl rationalization was introduced in 2011, and since then very little discarding of rougheye rockfish has occurred. Discards were estimated in the model with the assistance of observer data, and total catches are reported elsewhere, as opposed to landings.

**Table a: Recent landings for trawl and hook & line (mt) from Washington, Oregon, and California. Catches (mt) from the Pacific whiting at-sea fishery as determined by onboard observers are also shown.**

| | Trawl | | | Hook & Line | | | At-sea | Total |
|---|---|---|---|---|---|---|---|---|
| Year | WA | OR | CA | WA | OR | CA | | |
| 2003 | 9.96 | 45.25 | 0.69 | 18.33 | 2.32 | 1.25 | 2.16 | 79.95 |
| 2004 | 8.60 | 50.40 | 0.08 | 31.44 | 0.00 | 0.00 | 13.69 | 104.21 |
| 2005 | 7.15 | 38.43 | 0.05 | 40.59 | 5.31 | 3.12 | 35.95 | 130.59 |
| 2006 | 12.72 | 34.92 | 0.07 | 51.85 | 2.40 | 1.85 | 6.64 | 110.46 |
| 2007 | 12.42 | 49.35 | 0.56 | 48.55 | 2.79 | 3.11 | 29.08 | 145.85 |
| 2008 | 9.37 | 45.22 | 0.39 | 43.59 | 9.68 | 1.06 | 75.58 | 184.88 |
| 2009 | 17.16 | 51.45 | 0.30 | 76.87 | 19.60 | 5.23 | 9.30 | 179.90 |
| 2010 | 18.35 | 65.24 | 0.17 | 44.89 | 21.88 | 1.79 | 21.57 | 173.90 |
| 2011 | 10.32 | 46.79 | 0.19 | 39.67 | 17.95 | 1.95 | 80.95 | 197.83 |
| 2012 | 15.66 | 64.15 | 0.00 | 30.27 | 17.71 | 0.00 | 54.00 | 181.78 |



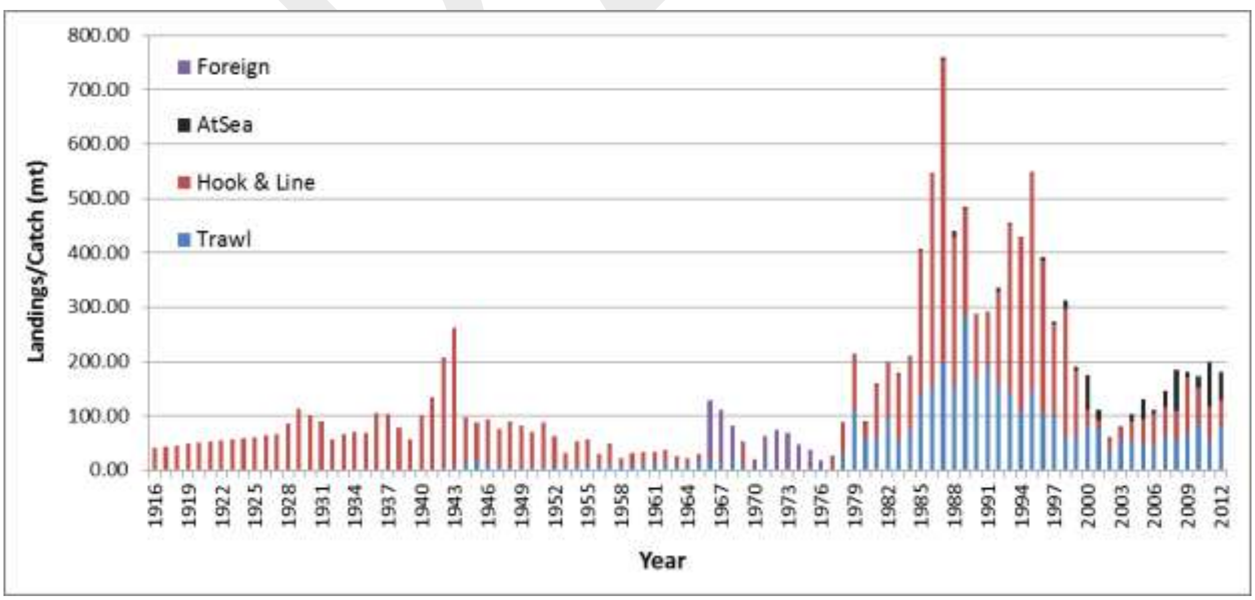


**Figure a: Landings of rougheye rockfish from 1916 to 2012 for the trawl and hook & line fisheries, and catches of rougheye rockfish for the foreign (1966–1976), and Pacific whiting at-sea fisheries.**

## Data and assessment

This assessment is the first formal assessment model for rougheye rockfish on the U.S. West Coast and was conducted using the length- and age-structured model called Stock Synthesis (version 3.24o, pers. comm. Richard Methot, NMFS). The coastwide population was modeled assuming parameters for combined sexes (a single sex model) from 1916 to 2013, and forecasted beyond 2013. Three fishing fleets were specified within the model: 1) a shore-based trawl fleet with foreign catches between 1966–1976 added to the domestic trawl catches, 2) a hook & line fleet, and 3) a foreign and at-sea fleet that targets Pacific whiting. Data from four fishery-independent surveys were also included in the model: 1) the triennial survey which was conducted from 1980–2004 in depths less than 500 meters, 2) a slope survey executed by the Alaska Fishery Science Center in 1996, 1997, and 1999-2001 which took place in waters north of 43° N latitude and between 183 and 1,280 meters in depth, 3) a Northwest Fishery Science Center (NWFSC) slope survey which occurred from 1999–2002 and included nearly the entire coastline in depths from 183 to 1280 meters, and 4) the NWFSC shelf/slope survey which has been surveying the entire U.S. West Coast in depths between 55 and 1,280 meters since 2003.

The data used in the assessment model consisted of survey abundance indices, length compositions, discard data, and ages. Model-based biomass indices and length compositions were determined for each survey, except for the NWFSC slope survey which did not record rockfish lengths. Length data were also available from the fisheries in recent years. Age data for all years of the NWFSC shelf/slope survey and the years 2008 and 2011 from the trawl and at-sea fisheries were input as age-at-length. Discard data for the trawl and hook & line fisheries were available for 2002–2011 in the form of discarded biomass, length compositions, and average weights. No data were available to inform discarding practices of rougheye rockfish prior to 2002, although anecdotal information suggests little discarding occurred before trip limits were implemented in the 1990's. The variances and sample sizes on all of the data were tuned to the expected variability in the model predictions.

The base model estimated parameters for selectivity and retention curves based on length for the trawl and hook & line fishing fleets, selectivity curves for the at-sea fleet and the four surveys, a length-at-age relationship, natural mortality, and recruitment deviations starting in 1900. A steepness parameter was fixed at 0.779 based on a steepness meta-analysis for west coast rockfishes (pers. comm. Jim Thorson, NWFSC) and was not estimated.

Uncertainty for the parameter estimates and derived quantities was determined in three ways. First, estimation uncertainty in the base model was determined using approximate asymptotic 95% confidence intervals based on maximum likelihood theory. Second, model uncertainty was investigated with various sensitivity runs where alternative model structures were implemented. Finally, the major axis of uncertainty was determined to define a range of states of nature and results are presented in a decision table.

Although there are many types of recent data available for rougheye rockfish, which were used in this assessment, there is little information about steepness, natural mortality, and historical recruitment. Estimates of steepness are uncertain partly because the stock has not been fished to low levels. Uncertainty in natural mortality is common in many fish stock assessments and because length and age data are available only for recent years there is little information to accurately estimate natural mortality, thus estimated spawning biomass is also uncertain. Finally, there is little information about the levels of historical recruitment mostly due to a lack of historical length or age data. This uncertainty was included in the predictions from this assessment.

## Stock biomass

The predicted spawning biomass from the base model generally showed a slight decline over the entire time series with a period of steeper decline during the 1980's and 1990's. Since 2000, the spawning biomass has stabilized and possibly increased because of reduced catches and above average recruitment in 1999. The 2013 spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass.

Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high. The standard deviation of the log of the spawning biomass in 2013 is 0.30.

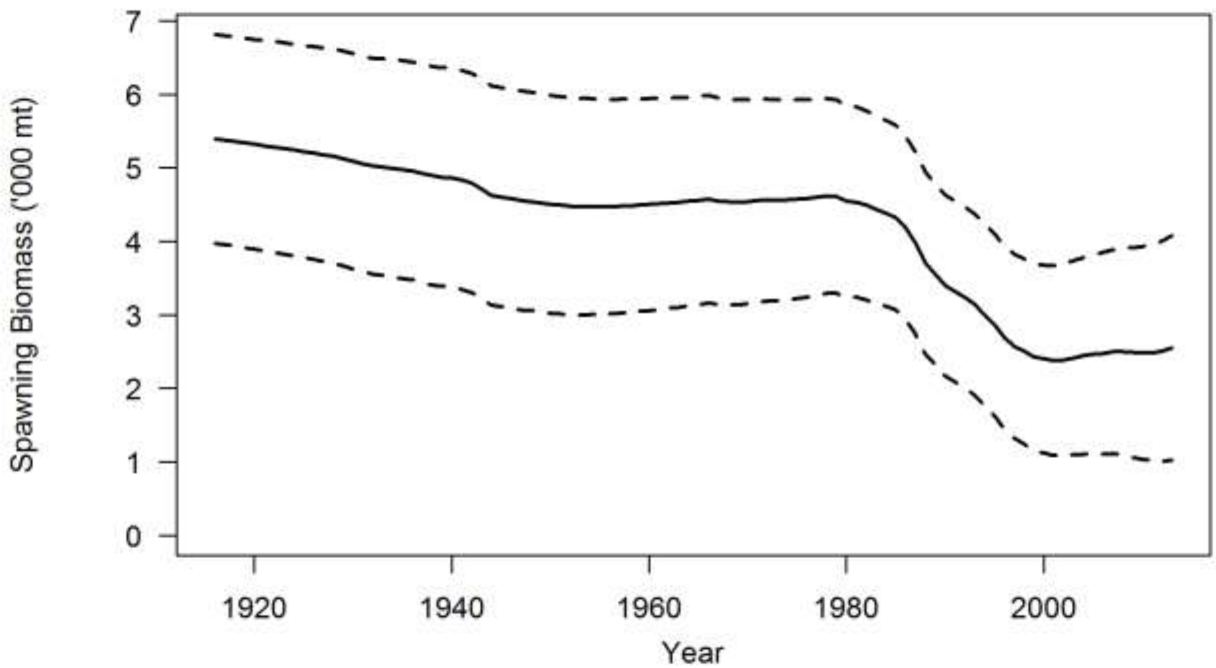


**Figure b: Estimated female spawning biomass time-series from the base model (solid line) with an approximate asymptotic 95% confidence interval (thick dashed lines).**

**Table b: Recent trend in estimated female spawning biomass and relative depletion of the spawning biomass.**

| Year | Spawning Biomass (mt) | ~95% confidence interval | Estimated depletion | ~95% confidence interval |
|---|---|---|---|---|
| 2004 | 2,444 | 1,108 – 3,780 | 45.31 | 31.4 – 59.3 |
| 2005 | 2,464 | 1,111 – 3,818 | 45.69 | 31.5 – 59.9 |
| 2006 | 2,477 | 1,106 – 3,847 | 45.92 | 31.5 – 60.3 |
| 2007 | 2,499 | 1,110 – 3,887 | 46.33 | 31.7 – 60.9 |
| 2008 | 2,498 | 1,092 – 3,904 | 46.32 | 31.4 – 61.2 |
| 2009 | 2,489 | 1,064 – 3,913 | 46.14 | 30.9 – 61.4 |
| 2010 | 2,483 | 1,038 – 3,929 | 46.04 | 30.4 – 61.7 |
| 2011 | 2,487 | 1,017 – 3,956 | 46.10 | 30.0 – 62.2 |
| 2012 | 2,511 | 1,014 – 4,008 | 46.56 | 30.1 – 63.0 |
| 2013 | 2,552 | 1,024 – 4,081 | 47.32 | 30.5 – 64.2 |

## Recruitment

Recruitment deviations were estimated for the entire time series modeled. There is little information regarding recruitment prior to 1980, and the uncertainty in these estimates is expressed in the model. Estimates of recruitment appear to oscillate between periods of low and high recruitment. The four largest recruitments were estimated in 1999, 1998, 2001, and 1988, and the four smallest recruitments were estimated in 2002, 2006, 2005, and 1995. Recruitment predictions since 2002 were all below the unfished average of 485,000 fish.

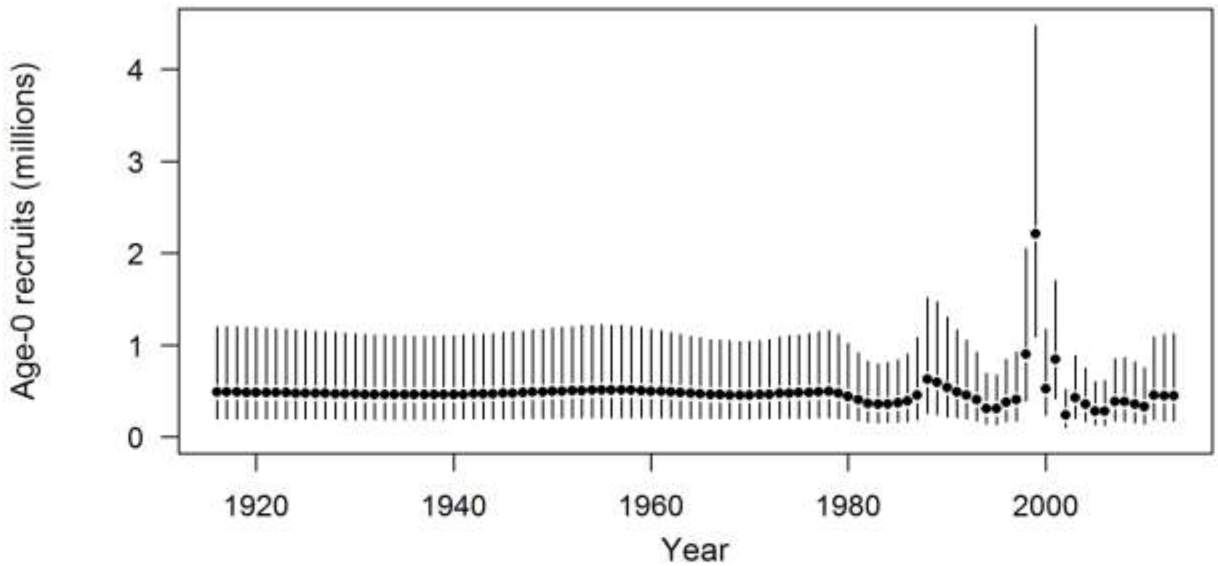


**Figure c: Time-series of estimated recruitments for the base case model (round points) with approximate asymptotic 95% confidence interval (vertical bars).**

**Table c: Recent estimated trend in rougheye rockfish recruitment with approximate 95% confidence intervals determined from the base model.**

| Year | Estimated recruitment (1,000's) | ~95% confidence interval |
|---|---|---|
| 2004 | 355.1 | 168–751 |
| 2005 | 282.4 | 132–605 |
| 2006 | 282.4 | 129–619 |
| 2007 | 385.2 | 174–855 |
| 2008 | 385.0 | 171–868 |
| 2009 | 357.8 | 157–816 |
| 2010 | 328.2 | 142–757 |
| 2011 | 452.3 | 188–1,090 |
| 2012 | 448.9 | 180–1,121 |
| 2013 | 449.9 | 180–1,123 |

## Exploitation status

The spawning biomass of rougheye rockfish reached a low in the late 1990's before stabilizing in the early 2000's and then slightly increasing during the last decade. The estimated depletion has remained above the 40% of unfished spawning biomass target and there is a small probability that the stock has fallen below this threshold in the last decade. Throughout the 1980's and 1990's the exploitation rate and (1-*SPR*) were mostly above target levels. Recent exploitation rates on rougheye rockfish were predicted to be near target levels.

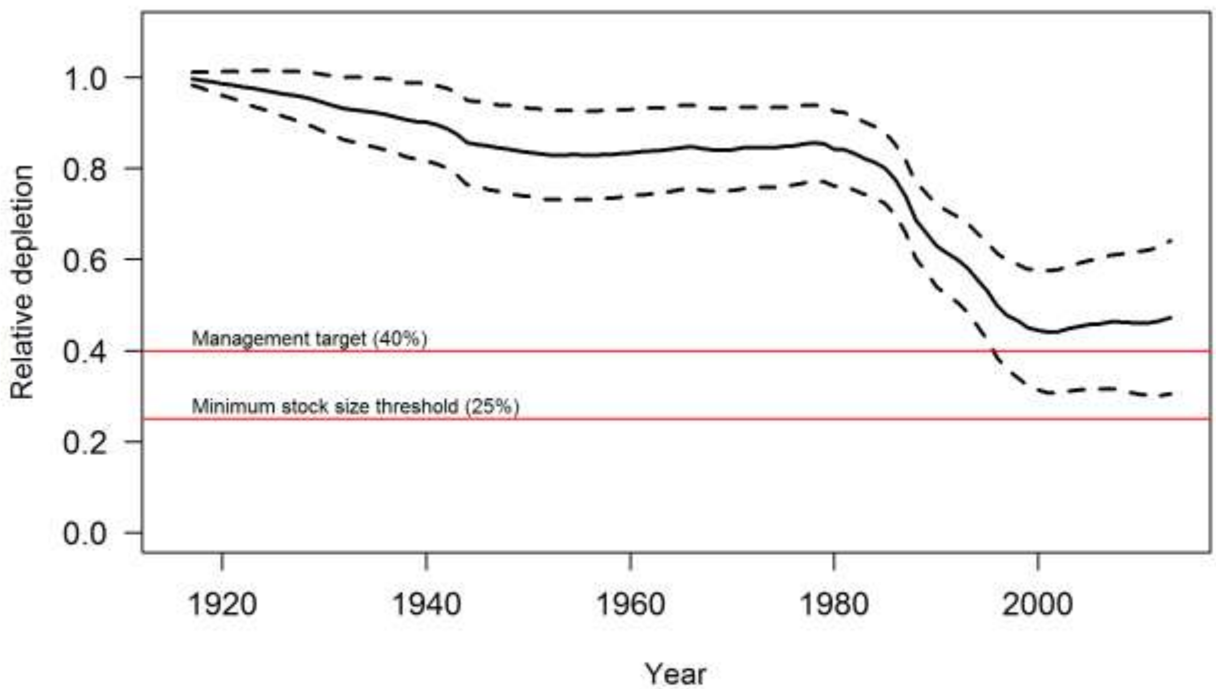


**Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.**

**Table d. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate.**

| Year | Estimated 1-SPR (%) | ~95% confidence interval | Harvest rate (proportion) | ~95% confidence interval |
|---|---|---|---|---|
| 2003 | 32.13 | 17.1–47.2 | 0.01261 | 0.006–0.019 |
| 2004 | 37.54 | 21.3–53.8 | 0.01612 | 0.008–0.025 |
| 2005 | 42.03 | 25.1–58.9 | 0.01977 | 0.009–0.030 |
| 2006 | 38.65 | 22.0–55.3 | 0.01702 | 0.008–0.026 |
| 2007 | 49.29 | 31.4–67.2 | 0.02618 | 0.012–0.040 |
| 2008 | 53.10 | 35.3–70.9 | 0.03049 | 0.014–0.047 |
| 2009 | 55.00 | 36.7–73.3 | 0.02923 | 0.013–0.045 |
| 2010 | 55.12 | 36.4–73.8 | 0.02904 | 0.013–0.045 |
| 2011 | 51.00 | 32.5–69.5 | 0.02506 | 0.011–0.039 |
| 2012 | 48.99 | 30.2–67.8 | 0.02291 | 0.010–0.036 |

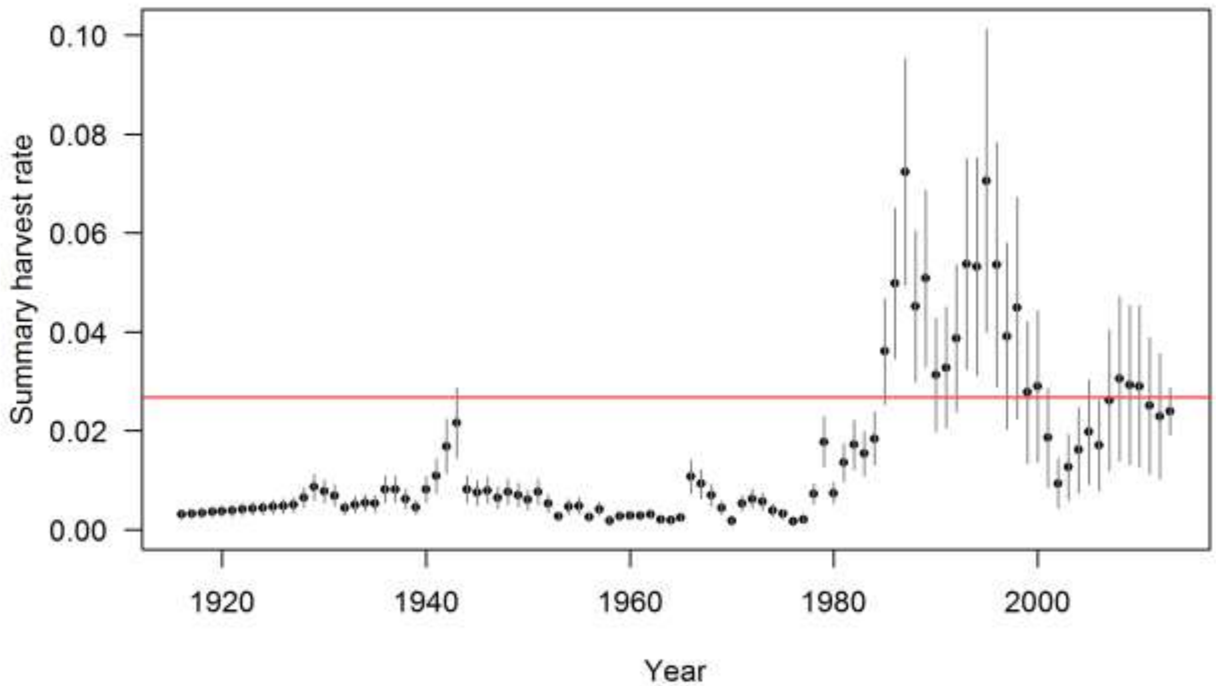


**Figure e. Time-series of estimated summary harvest rate for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines). The red line is the harvest rate at the overfishing proxy using $SPR_{50\%}$.**

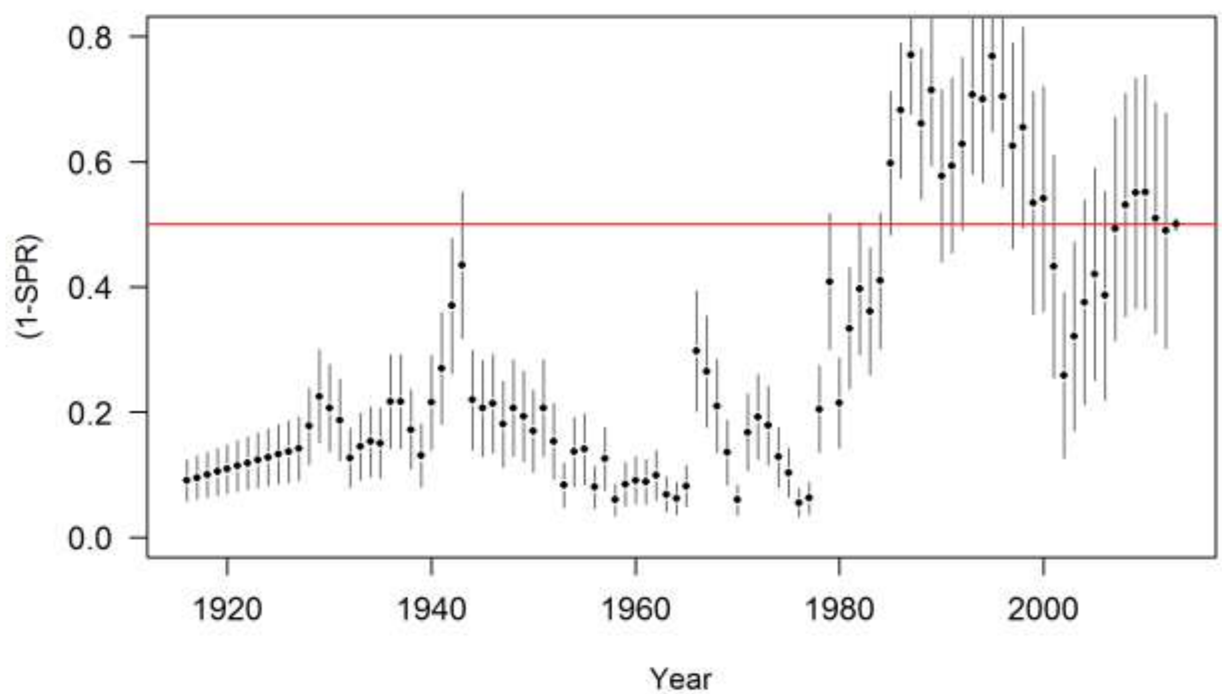


**Figure f. One minus the estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. One minus SPR is used so that higher exploitation rates occur on the upper portion of the y-axis. The relative management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.**

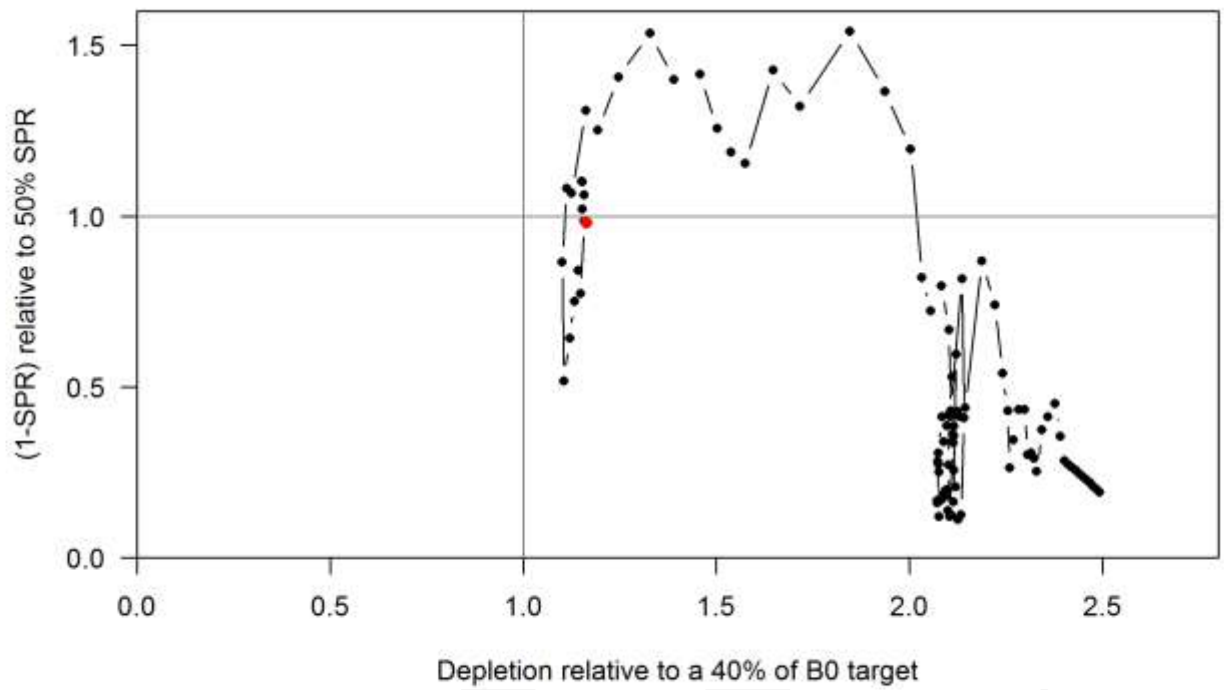


**Figure g. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 0.5 (one minus the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2012.**

## Ecosystem considerations

Rockfish are an important component of the California Current ecosystem along the U.S. West Coast, with its many dozens of species filling various niches in both soft and hard bottom habitats from the nearshore to the continental slope. Rougheye rockfish are one of the larger species of rockfishes and occupy shelf areas when they are young and move into deeper slope waters with age. As they age, they tend to become more solitary, but may form aggregations during the spawning season. Due to a paucity of life-history data for rougheye rockfish, most ecosystem considerations are implied from the understanding of rockfishes in general.

Recruitment is one mechanism by which the ecosystem may directly impact the population dynamics of rougheye rockfish. The 1999 cohort for many species of rockfish was larger – sometimes significantly so – from these species' long-term averages suggesting that environmental conditions may influence the spawning success and survival of larvae and juvenile rockfish, including rougheye rockfish. The specific pathways through which environmental conditions exert influence on rougheye rockfish dynamics are unclear, however, changes in water temperature and currents, distribution of prey and predators, and the amount and timing of upwelling are all possible linkages. Changes in the environment may also result in changes in age-at-maturity, fecundity, growth, and survival which can affect how the status of the stock and its susceptibility to fishing are determined. Unfortunately, there are no data for rougheye rockfish that provide insights into these effects.

Fishing has effects on both the age structure of a population as well as the habitat with which the target species is associated. Fishing often targets larger, older fish, and years of fishing mortality results in a truncated age-structure when compared to unfished conditions. Rockfish are often associated with habitats containing living structure such as sponges and corals, and fishing may alter that habitat to a less desirable state. This assessment provides a look at the effects of fishing on age structure, and recent studies on essential fish habitat are beginning to characterize important locations for rockfish throughout their life history, however there is little current information available to evaluate the specific effects of fishing on the population and ecosystem issues specific to rougheye rockfish.

## Reference points

Reference points were calculated using the estimated selectivities and catch distribution among fleets averaged across the last five years of the model (2008–2012). Sustainable total yields (landings plus discards) were 194 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 120 to 269 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished spawning output ($SB_{40\%}$) was 2,158 metric tons. The recent catches (landings plus discards) have been slightly greater than the point estimate of potential long-term yields calculated using an $SPR_{50\%}$ reference point. However, due to high predicted recruitment in 1999, the spawning biomass of the stock has been stable and slightly increasing over the last decade.

**Table e. Summary of reference points and management quantities for the base case model.**

| Quantity | Estimate | ~95% Confidence Interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 5,394 | 3,976–6,812 |
| Unfished age 10+ biomass (mt) | 13,756 | 9,883–17,629 |
| Unfished recruitment (R0, thousands) | 485 | 291–810 |
| Spawning biomass (2013) | 2,552 | 1,024 – 4,081 |
| SD of log Spawning Biomass (2013) | 0.30 | – |
| Depletion (2013) | 47.32 | 30.5–64.2 |
| ***Reference points based on $SB_{40\%}$*** | | |
| Proxy spawning biomass ($SB_{40\%}$) | 2,158 | 1,590–2,725 |
| SPR resulting in $SB_{40\%}$ | 44.3% | – |
| Exploitation rate resulting in $SB_{40\%}$ | 3.2% | 2.9–3.6% |
| Yield with *SPR* based on $SB_{40\%}$ (mt) | 210 | 129–290 |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 2,491 | 1,836–3,146 |
| $SPR_{proxy}$ | 50% | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 2.7% | 2.4–3.0% |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 194 | 120–269 |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 1,305 | 965–1,644 |
| $SPR_{MSY}$ | 29.6% | 29.2–30.0% |
| Exploitation rate corresponding to $SPR_{MSY}$ | 5.3% | 4.7–5.8% |
| *MSY* (mt) | 230 | 142–319 |

## Management performance

Exploitation rates on rougheye rockfish have exceeded *MSY* proxy target harvest rates during the 1980's and 1990's, and only slightly in the mid-2000's. Spawning biomass is predicted to have never fallen below the proxy management target of 40%. Exploitation rates decreased in the late 1990's due to management restrictions, and have increased in recent years. Rougheye rockfish are managed as part of the minor slope rockfish complex, and there were species specific contributions to the OFL catch levels set for the complex in 2011 and 2012. However, catch is measured on the complex as a whole and rougheye landings exceeded the rougheye contributions to the ABC's for the complex in 2011 and 2012. In retrospect, recent landings are predicted to have been only slightly above proxy harvest target levels.

**Table f. Recent trend in total catch and commercial landings (mt) relative to the management guidelines, given for minor slope rockfish and rougheye, north of 40° 10′ (N) and south of 40° 10′ (S). Estimated total catch reflects the commercial landings plus the model estimated discarded biomass.**

| | Minor Slope Rockfish Complex | | | Rougheye Rockfish | | | |
|---|---|---|---|---|---|---|---|
| Year | OFL (mt) N, S | ABC (mt) N, S | ACL (mt) N, S | OFL (mt) N, S | ABC (mt) N, S | Commercial Landings (mt) | Estimated Total Catch (mt) |
| 2003 | | | | | | 79.95 | 88.70 |
| 2004 | | | 1160, 639 | | | 104.21 | 114.12 |
| 2005 | | | 1160, 639 | | | 130.59 | 140.19 |
| 2006 | | | 1160, 639 | | | 110.46 | 120.89 |
| 2007 | | | 1160, 626 | | | 145.85 | 186.79 |
| 2008 | | | 1160, 626 | | | 184.88 | 221.61 |
| 2009 | | | 1160, 626 | | | 179.90 | 228.72 |
| 2010 | | | 1160, 626 | | | 173.90 | 229.39 |
| 2011 | 1462, 907 | 1324, 836 | 1160, 626 | 78.3, 0.5 | 65.3, 0.4 | 197.83 | 202.42 |
| 2012 | 1507, 903 | 1367, 832 | 1160, 626 | 78.3, 0.5 | 65.3, 0.4 | 181.78 | 185.51 |

## Unresolved problems and major uncertainties

This is the first full stock assessment for rougheye rockfish on the U.S. West Coast and although scientifically credible advice is provided by synthesizing many sources of data, there are still some data and structural assumptions that contribute to uncertainty in the estimates. Major sources of uncertainty include fishing mortality, natural mortality, and growth and are discussed below.

There is little information to accurately determine the catch history for rougheye rockfish. Historically, there are few observations to determine species compositions of landings and often little information to even determine if landings came from trawl or hook & line fisheries. It is uncertain if the landings used in the assessment are likely biased high or low. Recent landings are better determined than historical landings, but there still is uncertainty in the values used in this assessment. The landings of rougheye are not determined exactly, but are predicted by applying an estimated species composition to the landed catch. Furthermore, rougheye rockfish are often difficult to distinguish from blackspotted rockfish and sometimes shortraker rockfish (*S. borealis*). We combined blackspotted and rougheye rockfish catches, but did not make any assumptions about which fish labeled as rougheye may be shortraker and vice versa.

Discards of rougheye rockfish are even more uncertain than landings, but because rougheye rockfish is a marketable species commonly above average size, discard rates are likely lower than less desirable or smaller species. This assessment assumed that discarding was nearly negligible before management restrictions began in 2000. The few observations of rougheye in discarding studies corroborates that discarding was rare before 2000. For the years 2002–2010, the West Coast Groundfish Observer Program (WCGOP) has provided data on discards from vessels that were randomly selected for observer coverage, thus some uncertainty is present in the total amount discarded. The implementation of trawl rationalization in 2011 resulted in almost 100% observer coverage for the trawl fleet and very little incentive to discard rougheye rockfish. However, the fixed-gear fleet is not encompassed by the full observer coverage required under trawl rationalization and data show that discarding of rougheye rockfish is occurring on fixed gear vessels in recent years. Uncertainty in recent discards is greatly reduced because of observer coverage, but it is unknown what historical discarding may have been.

Rougheye rockfish are one of the longest lived species of rockfish on the West Coast and therefore natural mortality is likely to be lower than for other rockfish species. With length and age data available only for years after 1994, there are few observations available to monitor the long-term changes of aging cohorts. Therefore, estimates of natural mortality are uncertain. This assessment attempts to capture that uncertainty by estimating natural mortality and integrating that uncertainty into the derived biomass estimates.

Model sensitivities and profiles over $M$ showed that current stock status was highly sensitive to the assumption about natural mortality. The estimates of $M$ varied depending on the weight given to age and length data, or removing recent years of data. Profiles over natural mortality provide support for values from 0.037-0.047. The resulting current depletion ranges from 37–58%, depending upon the assumed natural mortality value.

## Decision table

Model uncertainty has been described by the estimated uncertainty within the base model and by the sensitivities to different model structure. The parameter that resulted in the most variability of predicted status and yield advice was natural mortality ($M$), which was also estimated with much more certainty than the prior distribution implied. In fact, the 95% confidence interval for $M$ was entirely greater than and did not include the point estimate from McDermott (1994), which was used in the assessment of rougheye and blackspotted rockfishes in the Gulf of Alaska assessment (Shotwell et al. 2011), and was greater than and did not include the value assumed in the analysis by Dick and MacCall (2010). There is the possibility that the base model and the approximate uncertainty intervals based on maximum likelihood theory may not entirely convey the actual uncertainty of this assessment. Preliminary (and non-converged) MCMC tests suggest that the uncertainty is greater than depicted by these results.

Therefore, to characterize uncertainty in the assessments, we used low and high values of natural mortality (0.037 and 0.047). These values closely corresponded to the 95% confidence interval from the likelihood profile, the 95% confidence interval of $M$ estimated from the asymptotic variance estimate (0.035–0.049), and the $M$ values of 0.037 and 0.047 respectively resulted in 2013 spawning biomass estimates that were near the 12.5% and 87.5% quantiles of spawning biomass from the base model when assuming a lognormal distribution. The 12.5% and 87.5% quantiles were chosen based on the groundfish terms of reference to give the base model a probability that is twice as likely as each alternative state of nature (12.5% and 87.5 are the central quantiles in the tails containing 25% probability).

**Table g. Projection of potential OFL, landings, and catch, summary biomass (age-10 and older), spawning biomass, and depletion for the base case model projected with total catch equal to the recent 5-year average in 2013 and 2014, and equal to the predicted ABC (adjusted by the 40:10 control rule and 0.956 to reflect the P* buffer) afterwards. The predicted OFL is the calculated total catch determined by $F_{SPR=50\%}$.**

| Year | Predicted OFL (mt) | ABC Catch (mt) | Landings (mt) | Age 10+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | | | 184 | 8,176 | 2,552 | 47.3% |
| 2014 | | | 184 | 8,220 | 2,600 | 48.2% |
| 2015 | 206 | 197 | 191 | 8,227 | 2,653 | 49.2% |
| 2016 | 210 | 201 | 196 | 8,211 | 2,703 | 50.1% |
| 2017 | 215 | 205 | 200 | 8,209 | 2,749 | 51.0% |
| 2018 | 219 | 209 | 203 | 8,194 | 2,787 | 51.7% |
| 2019 | 222 | 212 | 206 | 8,157 | 2,816 | 52.2% |
| 2020 | 224 | 215 | 209 | 8,098 | 2,835 | 52.6% |
| 2021 | 226 | 216 | 210 | 8,068 | 2,845 | 52.7% |
| 2022 | 227 | 217 | 211 | 8,032 | 2,846 | 52.8% |
| 2023 | 226 | 216 | 211 | 7,994 | 2,840 | 52.7% |
| 2024 | 226 | 216 | 210 | 7,955 | 2,829 | 52.4% |

**Table h. Summary table of 12-year projections beginning in 2015 for alternate states of nature based on the axis of uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained). Catches in 2013 and 2014 are determined from 5 year averages of the landings for each fleet (trawl, hook & line, and at-sea), and are also used as status quo catches.**

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low<br>*M* = 0.037 | | Base case<br>*M* estimated at 0.042 | | High<br>*M* = 0.047 | |
| **Relative probability of ln(SB_2013)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| ABC assuming σ = 0.36 | 2015 | 194 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 198 | 1,886 | 39% | 2,704 | 50% | 3,857 | 61% |
| | 2017 | 202 | 1,914 | 40% | 2,751 | 51% | 3,928 | 62% |
| | 2018 | 206 | 1,936 | 40% | 2,791 | 52% | 3,987 | 63% |
| | 2019 | 209 | 1,952 | 41% | 2,821 | 52% | 4,034 | 64% |
| | 2020 | 212 | 1,959 | 41% | 2,841 | 53% | 4,068 | 64% |
| | 2021 | 213 | 1,960 | 41% | 2,852 | 53% | 4,088 | 65% |
| | 2022 | 214 | 1,954 | 41% | 2,855 | 53% | 4,098 | 65% |
| | 2023 | 214 | 1,943 | 41% | 2,850 | 53% | 4,097 | 65% |
| | 2024 | 214 | 1,928 | 40% | 2,840 | 53% | 4,090 | 65% |
| Recent 5-year average of catches | 2015 | 189 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 189 | 1,888 | 39% | 2,706 | 50% | 3,859 | 61% |
| | 2017 | 189 | 1,919 | 40% | 2,756 | 51% | 3,933 | 62% |
| | 2018 | 189 | 1,946 | 41% | 2,801 | 52% | 3,997 | 63% |
| | 2019 | 189 | 1,968 | 41% | 2,837 | 53% | 4,051 | 64% |
| | 2020 | 189 | 1,983 | 41% | 2,865 | 53% | 4,091 | 65% |
| | 2021 | 189 | 1,992 | 42% | 2,884 | 53% | 4,120 | 65% |
| | 2022 | 189 | 1,995 | 42% | 2,895 | 54% | 4,138 | 65% |
| | 2023 | 189 | 1,993 | 42% | 2,900 | 54% | 4,147 | 65% |
| | 2024 | 189 | 1,987 | 41% | 2,899 | 54% | 4,148 | 65% |
| Catch that stabilizes equilibrium depletion at 40% in the base model | 2015 | 258 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 261 | 1,862 | 39% | 2,680 | 50% | 3,833 | 61% |
| | 2017 | 265 | 1,867 | 39% | 2,704 | 50% | 3,880 | 61% |
| | 2018 | 267 | 1,866 | 39% | 2,720 | 50% | 3,917 | 62% |
| | 2019 | 269 | 1,859 | 39% | 2,728 | 51% | 3,942 | 62% |
| | 2020 | 270 | 1,844 | 38% | 2,726 | 51% | 3,954 | 62% |
| | 2021 | 270 | 1,823 | 38% | 2,715 | 50% | 3,953 | 62% |
| | 2022 | 269 | 1,796 | 37% | 2,697 | 50% | 3,942 | 62% |
| | 2023 | 267 | 1,764 | 37% | 2,673 | 50% | 3,923 | 62% |
| | 2024 | 264 | 1,730 | 36% | 2,644 | 49% | 3,897 | 62% |

## Research and data needs

There are many areas of research that could be improved to benefit the understanding and assessment of rougheye and blackspotted rockfishes. Below, we specifically identify five topics that we believe are most important.

- **Historical landings and discards:** The historical landings and discards are uncertain for rougheye rockfish and improvements would increase the certainty that fishing removals are applied appropriately. Because landings are assumed to be known exactly in the assessment model, uncertainty in the predictions does not include uncertainty in the landings. A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for.

- **Natural mortality:** Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for rougheye rockfish. The collection of additional age data and improved understanding of the life-history of rougheye rockfish may reduce that uncertainty.

- **Maturity and fecundity:** There are few studies on the maturity of rougheye rockfish and only one has reported the results of a histological analysis. Further research on the maturity and fecundity of rougheye rockfish, the potential differences between areas, the possibility of changes over time, and differences between rougheye rockfish and blackspotted rockfish would greatly improve the assessment of these species.

- **Age data and error:** There is a considerable amount of error in the age data and the ageing of rougheye rockfish has not been validated. Investigating the ageing error and bias would help to understand the influences that the age data have on this assessment.

- **Understanding the stock structure and biology of rougheye and blackspotted rockfishes:** This assessment reports the status of rougheye and blackspotted rockfish as a pooled complex because it is extremely difficult to separate the catches of each species even in recent data, and attempting to do so would greatly increase the uncertainty in the predictions. Because little is known about the respective biology and catch histories of the two species, it is unclear whether managing them as a complex may place one species at disproportionate risk of overfishing relative to the other. We recommend additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species. Such an endeavor would like require the efforts of at sea observers in all fleets, biologists aboard fishery-independent surveys, and port samplers along the entire West Coast requiring broad, inter-agency collaboration.

- **Basin-wide understanding of stock structure, connectivity, and distribution:** This is a stock assessment for rougheye rockfish off of the west coast of the U.S. and does not consider data from British Columbia or Alaska. Further investigating and comparing the data and predictions from British Columbia and Alaska to determine if there are similarities with the U.S. West Coast observations would help to define the connectivity between rougheye rockfish north of the U.S.-Canada border.

**Table i. Summary table of results for the assessment of rougheye rockfish. OFL values are for rougheye specifically, which are managed within the minor slope rockfish complex.**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 79.95 | 104.21 | 130.59 | 110.46 | 145.85 | 184.88 | 179.90 | 173.90 | 197.83 | 181.78 | NA |
| Estimated Total catch (mt) | 88.70 | 114.12 | 140.19 | 120.89 | 186.79 | 221.61 | 228.72 | 229.39 | 202.42 | 185.51 | NA |
| OFL (mt) | — | — | — | — | — | — | — | — | 78.8 | 78.8 | 71.5 |
| ACL (mt) | — | — | — | — | — | — | — | — | — | — | — |
| 1-SPR | 0.32 | 0.38 | 0.42 | 0.39 | 0.49 | 0.53 | 0.55 | 0.55 | 0.51 | 0.49 | — |
| Exploitation rate | 1.3% | 1.6% | 2.0% | 1.7% | 2.6% | 3.0% | 2.9% | 2.9% | 2.5% | 2.3% | — |
| Age 10+ biomass (mt) | 7,036 | 7,079 | 7,093 | 7,102 | 7,134 | 7,268 | 7,825 | 7,899 | 8,077 | 8,097 | 8,176 |
| Spawning Biomass | 2,417 | 2,444 | 2,464 | 2,477 | 2,499 | 2,498 | 2,489 | 2,483 | 2,487 | 2,511 | 2,552 |
| ~95% Confidence Interval | 1,098–3,736 | 1,108–3,780 | 1,111–3,818 | 1,106–3,847 | 1,110–3,887 | 1,092–3,904 | 1,064–3,913 | 1,038–3,929 | 1,017–3,956 | 1,014–4,008 | 1,024–4,081 |
| Recruitment | 426 | 355 | 282 | 282 | 385 | 385 | 358 | 328 | 452 | 449 | 450 |
| ~95% Confidence Interval | 205–889 | 168–751 | 132–605 | 129–619 | 174–855 | 171–868 | 157–816 | 142–757 | 188–1090 | 180–1121 | 180–1123 |
| Depletion (%) | 44.8% | 45.3% | 45.7% | 45.9% | 46.3% | 46.3% | 46.1% | 46.0% | 46.1% | 46.6% | 47.3% |
| ~95% Confidence Interval | 31–59% | 31–59% | 32–60% | 32–60% | 32–61% | 31–61% | 31–61% | 30–62% | 30–62% | 30–63% | 31–64% |

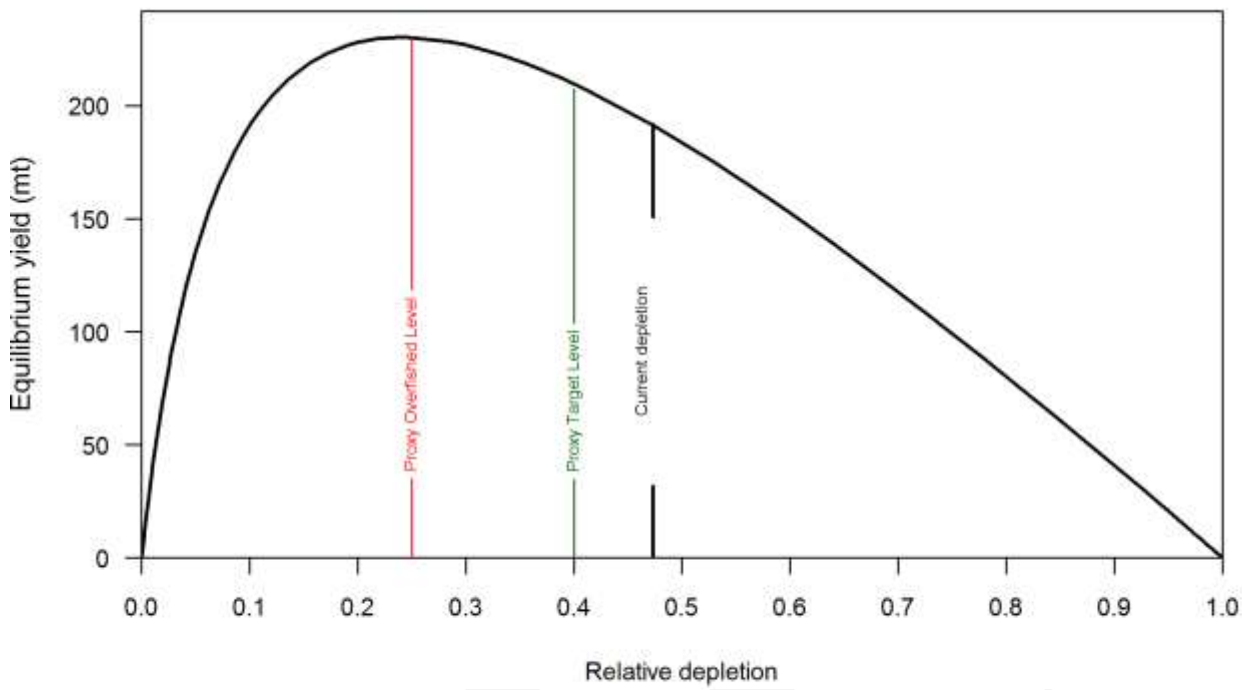


**Figure h. Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2012 fishery selectivity and distribution with steepness fixed at 0.779. The depletion is relative to unfished spawning biomass.**

# 1 Introduction

Rougheye rockfish (*Sebastes aleutianus*) are a long-lived rockfish named after a series of 2–10 spines along the lower rim of their eyes. They have also been called blackthroat or blacktip rockfish (Love et al. 2002, Love 2011). Recently, Gharrett et al. (2005) and Hawkins et al. (2005) described two sympatric species with similar characteristics, rougheye rockfish and blackspotted rockfish (*S. melanostictus*), although *S. melanostictus* was first described in the 1930's (Orr and Hawkins 2008). These two species may hybridize on occasion (Love 2011). These species are closely related to shortraker rockfish (*S. borealis*) and are sometimes difficult to distinguish from shortraker rockfish without looking at the gill rakers.

Blackspotted rockfish are distributed in similar locations as rougheye rockfish and it is very difficult to visually distinguish the two species. It has only been from recent genetic studies that these two separate species have been identified (Gharrett et al. 2005, Hawkins et al. 2005) and have had phenotypic characteristics useful for identifying the species in the field identified (Gharrett et al. 2005, Orr and Hawkins 2008). Before then, data are available for one species called rougheye rockfish which included rougheye rockfish and blackspotted rockfish. Due to the difficulty in distinguishing these two species and the lack of historical separation of the species in all of the data, this assessment combines any data for blackspotted rockfish with rougheye rockfish and provides management advice for the two species combined. In this assessment, the term "rougheye rockfish" refers to rougheye/blackspotted rockfish unless specified.

Therefore, this assessment is focused on the population of rougheye and blackspotted rockfishes on the outer West Coast of the United States. This includes waters off of California, Oregon, and Washington, but does not include Puget Sound or Canadian waters (Figure 1).

## 1.1 Distribution and stock structure

The earliest description of what would come to be known as rougheye rockfish date to 1811 with the identification of *Perca variabilis* by German zoologist Peter Simon Pallas (Jordan and Evermann 1898). It has subsequently been described and assigned to various taxa at least 15 times (Love et al. 2002). Some descriptions noted both light and dark color morphs, which, along with possible confusion with several morphologically similar co-occurring species (e.g., *S. borealis* and *S. melanostomus*) have contributed to the persistent ambiguity in formal descriptions of rougheye rockfish (Orr and Hawkins 2008). The first genetic studies conducted in the late 1960s and early 1970s (e.g., Tsuyuki et al. 1968, Tsuyuki and Westrheim 1970) observed diversity suggestive of two genetic types within specimens identified as rougheye rockfish. Allozyme studies conducted over the next two decades (e.g., Seeb 1986, Hawkins et al. 1997, Hawkins et al. 2005) provided additional evidence suggesting two separate genetic types within field-identified rougheye rockfish. Genetic variation between the two types, as manifested by divergence within both nuclear and mitochondrial DNA, was determined to be sufficiently conclusive of two separate species by Gharrett et al. (2005) which proposed a delineation of "Type I" and "Type II" rougheye rockfish. Meristic and morphometric comparisons of the two species suggested certain characters such as gill raker counts and length, snout length, anal base length, and pectoral fin base were significantly different, and in combination could reliably, though not definitively, distinguish between the species (Gharrett et al. 2006). The two separate species were formally re-described by Orr and Hawkins (2008) with the Type II group retaining the rougheye rockfish common name and *S. aleutianus* taxon. Blackspotted rockfish was proposed as the common name for the Type I group along with the scientific name of *S. melanostictus*, re-establishing nomenclature from one of the species complex's earlier descriptions (cf. Matsubara 1934).

Rougheye and blackspotted rockfish share broad overlap in their depth and geographic distributions from the Eastern Aleutian Islands along the North American continental margin to southern Oregon, with blackspotted rockfish's range extending east beyond the Aleutian chain to the Pacific Coast of Japan (Gharrett et al. 2005, Hawkins et al. 2005, Orr and Hawkins 2008). Both species are encountered at depths shallower than 100 m to at least 439 m, however, blackspotted rockfish tend to be more prevalent in deeper waters (Hawkins et al. 2005, Orr and Hawkins 2008). Genetic information is not available to provide positive species identification in historical survey and landings information, but these data indicate that density of the nominal rougheye rockfish complex decreases sharply south of the Oregon-California border (42° N). Studies suggest that rougheye rockfish account for a greater proportion of the species complex along the coast of Washington and Oregon than in Alaskan waters (Gharrett et al. 2005, Hawkins et al. 2005, Orr and Hawkins 2008). Recent discussions with port samplers in southern Oregon suggest that both rougheye and blackspotted rockfish are encountered with some regularity in the commercial trawl and fixed-gear landings in Charleston, Port Orford, and Brookings, with blackspotted rockfish composing approximately one third to one half of identified specimens (C. Good and N. Wilsman, ODFW, pers. comm.).

The west coast of the U.S. is the southern portion of the range of rougheye rockfish, and it is likely that the population north of the U.S.-Canada border is not a separate stock. The connectivity of rougheye populations throughout its range is unknown.

## 1.2 Life History and Ecosystem Interactions

Compared with other rockfish species on the west coast of the U.S., rougheye rockfish life-history is poorly described and the recent resurrection of two species (rougheye and blackspotted rockfishes) has further complicated the understanding of life-history characteristics. Rougheye rockfish are often associated with boulders and steep habitats, and are typically found alone or in small aggregations (Love et al. 2002). Younger fish may school and are often found in shallower waters on the shelf, and larger fish may form larger aggregations in the Pacific Northwest during the autumn and winter.

Rougheye rockfish give birth to live young with larvae released between February and June and at lengths between 4.5-5.3 mm (Love et al. 2002). There are no studies on the fecundity of rougheye rockfish on the west coast of the U.S.

A wide range of prey items make up the diet of rougheye rockfish. Crangid and pandalid shrimps make up the majority of their diets, and larger individuals, greater than 30 cm, feeding upon other fishes (Love 2011). They are also known to feed upon gammarid amphipods; mysids, crabs, polychaetes, and octopuses (Love et al. 2002, Love 2011).

## 1.3 Historical and Current Fishery

Rougheye rockfish are not often targeted by a specific fishery, but are desirable and marketable, thus are typically retained when captured. They are often captured in bottom trawl, mid-water trawl, and longline fisheries. Small numbers have been observed in pot, shrimp, and recreational fisheries.

After many attempts to start trawl fisheries off the west coast of the United States in the late 1800's, the availability of the otter trawl and the diesel engine in the mid-1920's helped the trawl fisheries expand (Douglas 1998). The trawl fisheries really became established during World War II when demand increased for shark livers and bottomfish. A mink food fishery also developed during World War II (Jones and Harry 1960). Foreign fleets began fishing for rockfish in the mid 1960's until the EEZ was implemented in 1977 (Rogers 2003). Since 1977, landings of rockfish were high until management restrictions were implemented in 2000. Longline catches of rougheye rockfish are present from the turn of the century and continue in recent years, targeting sablefish and halibut. The catches by state for the trawl and hook & line fleets as well as for the Pacific whiting at-sea fleet are shown in Table 1.

A long-term directed fishery has not occurred for rougheye rockfish and historical discarding practices are not well known. Rougheye rockfish inhabit deeper water as adults, which were fished less often historically. More detailed information of the fisheries by state is given in Section 2.2.1 where the reconstructed landings are discussed.

## 1.4 Management History and Performance

Rougheye rockfish has been a small component of groundfish fisheries and has not had the species specific attention other rockfishes have been given over the last 30 years. The catch of rougheye rockfish have been governed by restrictions on assemblages of species, of which rougheye was a member. However, the distribution of fishing effort in areas where rougheye might often be caught has also been affected by catch restrictions on co-occurring, rebuilding species, as well as associated area closures instituted to promote rebuilding.

Limits on select rockfishes, which include co-occurring species, were established in 1982. The first imposed landings limits on a coastwide *Sebastes* complex (rougheye rockfish being one of the 50 rockfishes in the complex) were instituted in 1983. This complex was divided in to two management areas north and south of 43º 00’ N (separating the Eureka and Columbia INPFC areas) in 1994. Ongoing concern that shelf and slope rockfishes may be undergoing overfishing led the attempt by Rogers et al. (1996) to describe the status of most rockfishes contained in the Sebastes complex. Rougheye rockfish information content was low, and using the Triennial survey to calculate an average biomass and assuming that fishing mortality equals natural mortality provided estimates of exploitation rates that indicated the stock was undergoing very high exploitation rates in both management areas.

The dividing line between the northern and southern management areas was shifted to 40º 10’ N latitude in 1999 and the *Sebastes* complex was subsequently divided into nearshore, shelf, and slope complexes in 2000. Rougheye rockfish has since been managed under trip limits for minor slope rockfish complex in both north and south management areas. Table 2 summarizes management guidelines since 1999. Some important events are the gear restrictions implemented in 2000, implementation of Rockfish Conservation Areas (RCA’s) in 2002, seasonal changes to the RCA’s in 2007, and the beginning of trawl rationalization in 2011.

While stock-specific OFLs/ABCs were not historically set for rougheye rockfish specifically, the reauthorized Magnuson-Stevens Act of 2006 required OFLs for all species in a management plan. The first of the OFL contributions were calculated using DB-SRA in 2010 for the 2011-2012 management cycle. Figure 2 compares the 2011–2012 OFL contribution for each management area to historical total removals of rougheye rockfish for those areas. Most years in the northern management areas and several years in the southern area indicate that removals were higher than the estimated OFL contributions. The observation that recent catches had frequently exceeded the OFL contribution estimated using data-poor, catch-only methods provided a strong indication that a more thorough evaluation of rougheye stock status and sustainable harvest levels be undertaken, using all available data.

## 1.5 Fisheries and assessments in Canada and Alaska

Rougheye rockfish are distributed throughout Canada and Alaska and are commonly caught in trawl and hook & line fisheries. Alaska conducts assessments biennial for the rougheye/blackspotted complex, but Canada has not completed a formal assessment of this species. The fisheries and assessments for each country are described below.

Rougheye rockfish have been managed as a bycatch only species in Alaska since 1991 with catches ranging between 130 and 2,418 mt (Shotwell et al. 2011). In 2011, 65% of the catch was from bottom trawls, 29% from longline fisheries, and the remaining 6% from pelagic trawls. The rougheye/blackspotted complex in Alaska had total allowable catch (TAC) levels established in 2005, which have generally been between 30% and 40% of the potential quota.

The last full assessment for rougheye rockfish in Alaska was done in 2011 (Shotwell et al. 2011), although was updated in 2012 with recent catch information. The assessment used catches, fishery age and size compositions, trawl and longline survey biomass estimates, trawl survey age compositions, and longline survey size compositions. Natural mortality was estimated using a prior with a mean of 0.03 (from McDermott (1994)) and an arbitrary small coefficient of variation of 10%. The estimated natural mortality was 0.034. Female spawning biomass was well above the target of $B_{40\%}$ and the allowable biological catch (ABC) for 2012 was 1,223 mt. The stock is not estimated to be overfished and it is not likely that overfishing is occurring.

Canada identified two species of rougheye rockfish (Type I and Type II) in 2007 and designated both species of special concern, which means that they may become threatened or endangered because of a combination of biological characteristics and identified threats (COSEWIC 2007). This designation was given because biomass estimates are uncertain and no strong trends are observed, there is evidence of truncation of the age distribution and overall mortality has doubled, it is a long-lived, low-fecundity *Sebastes* species, which is susceptible to population collapse and slow recovery, and because the difficulty in separating the two species may result in potential impacts on one of the species going unnoticed. Subsequently, the species were identified as rougheye rockfish and blackspotted rockfish and a management plan was created in 2012 with a goal of sustaining the populations of rougheye and blackspotted rockfishes (Fisheries and Oceans Canada 2012). Five high priority and seven low priority actions have been identified to address the threats to the populations and support the management goal.

The species pair is targeted in some areas of British Columbia waters and occurs frequently in the bottom trawl and hook & line fisheries. Recent catches have fluctuated around 1,000 mt and the coastwide Total Allowable Catch (TAC) for 2012 was 1,140 mt.

# 2 Data

## 2.1 Fishery-independent data

Data from four surveys were used in this assessment: 1) the AFSC/NWFSC triennial Pacific Coast Bottom Trawl Survey (hereafter, "triennial survey"; 2) the AFSC Pacific Coast Upper Continental Slope Trawl Survey (hereafter, "AFSC slope survey"); 3) the NWFSC Pacific Coast Upper Continental Slope Trawl Survey (hereafter, "NWFSC slope survey"), and 4) the NWFSC Pacific Coast Groundfish Bottom Trawl Survey (hereafter, "NWFSC shelf/slope survey"). These surveys employed different designs and sampling methodologies, were conducted during different years and time periods within years, and included coverage over different areas of the coast. In some instances, the survey frequency, depths, and geographic areas covered were not internally consistent within surveys. A brief description of each survey is provided below.

Strata were defined by latitude and depth to analyze the catch-rates, length compositions, and age compositions using stratified random sampling theory. The latitude and depth breaks were chosen based on the design of the survey as well as by looking at biological patterns with latitude and depth.

Indices of abundance for all of the surveys were derived using a delta-generalized linear mixed model (GLMM) following the methods of Thorson and Ward (2013). The surveys were stratified by latitude and depth, and vessel-specific differences in catchability (via inclusion of random effects for the NWFSC surveys and fixed effects for the AFSC and Triennial survey) were estimated for each survey time series. The Delta-GLMM approach explicitly models both the zero and non-zero catches and allows for skewness in the distribution of catch rates. Lognormal and gamma errors structures were considered for the positive tows, including the option to model extreme catch events (ECEs), defined as hauls with extraordinarily large catches, as a mixture distribution (Thorson et al. 2011). There were therefore four total positive tow error structures considered: gamma or lognormal with or without ECEs mixture distributions. Model convergence was evaluated using the effective sample size of all estimated parameters (typically >500 of more than 1000 kept samples would indicate convergence), while model goodness-of-fit was evaluated using Bayesian Q-Q plots and deviance. The resultant coefficient of variations (CVs) of each model were also considered when determining viable indices (i.e., CVs consistently >2 in each year were deemed uninformative and not used).

### 2.1.1 AFSC/NWFSC Triennial Bottom Trawl Survey

The triennial survey was first conducted by the AFSC in 1977 and spanned the timeframe from 1977–2004. The survey's design and sampling methods are most recently described in Weinberg et al. (2002). Its basic design was a series of equally-spaced transects from which searches for tows in a specific depth range were initiated (Figure 5). The survey design has changed slightly over the period of time (Table 4, Figure 3). In general, all of the surveys were conducted in the mid-summer through early fall: the 1977 survey was conducted from early July through late September; the surveys from 1980 through 1989 ran from mid-July to late September; the 1992 survey spanned from mid-July through early October; the 1995 survey was conducted from early June to late August; the 1998 survey ran from early June through early August; and the 2001 and 2004 surveys were conducted in May-July (Figure 4).

Haul depths ranged from 91–457 m during the 1977 survey with no hauls shallower than 91 m. The surveys in 1980, 1983, and 1986 covered the West Coast south to 36.8°N latitude and a depth range of 55–366 meters. The surveys in 1989 and 1992 covered the same depth range but extended the southern range to 34.5°N (near Point Conception). From 1995 through 2004, the surveys covered the depth range 55–500 meters and surveyed south to 34.5°N. In the final year of the triennial series (2004), the NWFSC's Fishery Resource and Monitoring division (FRAM) conducted the survey and followed very similar protocols as the AFSC.

Given the different depths surveyed during 1977, the data from that year were not included in this assessment. Water hauls (Zimmermann et al. 2003) and tows located in Canadian waters were also excluded from the analysis of this survey. The survey was analyzed as an early series (1980–1992) and a late series (1995–2004), as has been done in other West Coast rockfish assessments.

The indices for the early and late series of this survey were estimated separately using a GLMM with the stratifications shown in Table 5. Boxplots of the deviance for the late and early triennial survey series are shown in Figure 5 and show that the lognormal distribution had the lowest median deviance for both series. Random or fixed strata-year effects produced similar deviance, and the random strata-year effects were chosen as the final models. Selection of using the extreme catch event mixture distribution (ECE) was done by investigating the Q-Q plots in Figure 6. The Q-Q plot for no ECE does not show any departures from the assumed distribution, and the ECE Q-Q plot did not show improvement. Therefore, the lognormal distribution without the ECE mixture distribution and random effects on the year-strata interaction were used to estimate the indices shown in Figure 7and Table 6. The early series suggests a possible slightly increasing trend in biomass from 1983–1992, while the late series showed no discernible trend and alternated between high and low estimates from 1995–2004. The design-based estimates (average density expanded to the stratum area then summed over strata) are compared to the model-based estimates in Figure 8. Similar trends are seen for both sets of estimates, but the design-based estimates are consistently greater than the model-based estimates by more than a factor of 2. This suggests that the scale of the model-based estimates may be low, which may be caused by incorrect expansion to the proper area. This is not an issue with the assessment because a catchability coefficient relating the survey biomass to the assessment model biomass is estimated without any prior assumption on what value that catchability coefficient should be. Therefore, caution is advised if attempting to interpret the value of that estimated catchability coefficient.

Length frequencies for each year were expanded using the same stratification as the GLMM, except that no observations were available for 1983 (Figure 9). Because sex ratios showed no discernible trend across years and surveys, and rougheye rockfish show no tendency toward sexual dimorphism (see sections below), we pooled male, female, and unsexed length data in this analysis. There was considerable variability in length frequencies in the triennial survey data. Mean length in the triennial survey declined during the period 1986–1992 from 31.0 cm to 21.9 cm, and there was no clear trend in mean length from 1995–2004. Mean length in the late period (1995–2004) was larger than mean length in the early period (1980–1992), except in 2004. This further supports the split into early and late periods.

### 2.1.2 AFSC slope survey

The AFSC slope survey operated during autumn (October-November) aboard the R/V *Miller Freeman*. Partial survey coverage of the U.S. west coast occurred during 1988–96 and complete coverage (north of 34° 30’ S) during 1997, 1999, 2000, and 2001. Only the four years of consistent and complete surveys plus 1996, which surveyed north of 43° N latitude to the U.S.-Canada border, were used in this assessment. The number of tows ranged from 8 in 2001 to 26 in 1996 (Table 7). The numbers of tows with length data for rougheye rockfish are also shown in Table 7. Because a large number of positive tows occurred in 1996, we decided to include that year, which surveyed from 43° N latitude to the U.S.-Canada border. Therefore, only tows from 43° N latitude to the U.S.-Canada border were used.

The indices for this survey were developed using a GLMM with the stratification shown in Table 5. Boxplots of the deviance for this survey (Figure 5) show that the lognormal distribution had a lower median deviance than the gamma distribution. Random or no strata-year effects produced similar deviance, and the no strata-year effects were chosen as the final model. Selection of using the extreme catch event mixture distribution (ECE) was done by investigating the Q-Q plots in Figure 6. The Q-Q plot for no ECE does not show any departures from the assumed distribution, and the ECE Q-Q plot did not show improvement. Therefore, the lognormal distribution without the ECE mixture distribution and no effects on the year-strata interaction were used to estimate the indices shown in Figure 7and Table 6.

The final two years of the series (2000–2001) are much higher than the first three. The design-based indices (Figure 8) were similar in trend to the model-based indices, but were typically more than 2 times greater indicating that the scale may not be correct. This is not an issue with the assessment because a catchability coefficient relating the survey biomass to the assessment model biomass is estimated without any prior assumption on what value that catchability coefficient should be. Therefore, caution is advised if attempting to interpret the value of that estimated catchability coefficient.

Length frequencies for each year were expanded using the same stratification as the GLMM (Table 5) and are shown in Figure 10. No age data were available for the AFSC slope survey.

### 2.1.3 NWFSC Slope Survey

The NWFSC slope survey covered waters throughout the summer from 183 m to 1280 m north of 34° 30’ S, which is near Point Conception. The survey strata used to expand the biomass data for this assessment are shown in Table 5. There were no length data from this survey for rougheye rockfish.

Boxplots of the deviance for this survey (Figure 5) show that the gamma and lognormal distributions had similar deviance. Random or no strata-year effects produced similar deviance, and the no strata-year effects were chosen as the final model. Selection of using the extreme catch event mixture distribution (ECE) was not possible for this survey due to errors in the algorithm when assuming an ECE mixture distribution. The Q-Q plot for the non ECE model is shown in Figure 6 and does not display any alarming inconsistencies. Therefore, the lognormal distribution without the ECE mixture distribution and no effects on the year-strata interaction were used to estimate the indices shown in Figure 7and Table 6.

The index for this short series is quite variable and shows no consistent trend (Figure 7).

### 2.1.4 NWFSC Shelf/Slope Survey

The NWFSC shelf/slope survey is based on a random-grid design; covering the coastal waters from a depth of 55 m to 1,280 m (Keller et al. 2007). This design uses four chartered industry vessels in most years, assigned to a roughly equal number of randomly selected grid cells. The survey, which has been conducted from late-May to early-October each year, is divided into two 2-vessel passes of the coast, which are executed from north to south. This design therefore incorporates both vessel-to-vessel differences in catchability as well as variance associated with selecting a relatively small number (~700) of cells from a very large population of possible cells (greater than 11,000) distributed from the Mexican to the Canadian border. Much effort has been expended on appropriate analysis methods for this type of data, culminating in the West Coast trawl survey workshop held in Seattle in November 2006.

Rougheye rockfish are not commonly caught in the shelf/slope survey. Higher catch rates occur north of 42° N latitude and catches are rare south of 40° 10′ N latitude (Figure 11 & Figure 12). Very few large fish are found on the shelf and few small fish are found in the deeper water of the slope (Figure 13). There is no clear trend in length with latitude, but there appears to be two areas of more frequent catches: near 45° N latitude and near 48° N latitude. Larger fish are caught in these two areas. Age shows a similar pattern with depth and latitude (Figure 14). The oldest fish observed on the shelf (depth less than 183 m) was 13 years.

The indices for this survey were developed using a GLMM with the stratification shown in Table 5. Boxplots of the deviance for this survey (Figure 5) show that the lognormal distribution with random strata-year effects had the lowest median deviance and was chosen as the final model. Selection of using the extreme catch event mixture distribution (ECE) was done by investigating the Q-Q plots in Figure 6. The Q-Q plot for no ECE does not show any departures from the assumed distribution, and the ECE Q-Q plot did not showed only a very slight improvement. Therefore, the lognormal distribution without the ECE mixture distribution and random effects on the year-strata interaction were used to estimate the indices shown in Figure 7and Table 6.

The indices for the NWFSC shelf/slope survey are quite variable and show no consistent trend (Figure 7). The design-based estimates are similar to the model-based estimates (Figure 8) except that the model-based estimates shows dampened fluctuations, which are likely a result of assuming a lognormal distribution.

Expanded length frequencies from this survey show years with high proportions of small fish and years with high proportions of large fish (Figure 15). It appears that length frequencies may be affected by process error and dependent on whether or not they encounter fish in certain areas within a year. From 2003 to 2009, few fish were seen in the 30–40 cm range. Age compositions (Figure 16) show a high proportion of the 1999 year class from 2003 to 2010. In 2012, there was a high proportion of very young fish. Conditional age-at-length proportions (Figure 17) show that at young ages and small lengths the data are mostly consistent, but at larger lengths and older ages, the variability increases.

### 2.1.5 Fishery-Independent Surveys not used in this Analysis

The International Pacific Halibut Commission (IPHC) has conducted an annual longline survey for Pacific halibut off the coast of Oregon and Washington (IPHC area "2A") since 1999 with a fixed station design. Approximately 1,800 hooks are deployed at 84 locations each year (Figure 18). Rockfish bycatch is routinely recorded during this survey, and originally estimates of rockfish bycatch in area 2A were based on subsampling the first 20 hooks of each 100-hook skate. Recently, though, all rockfish are tagged and recorded for later sampling by WDFW and ODFW biologists (see http://www.iphc.int/publications/rara/2012/rara2012503_ssa_survey.pdf). Some variability in exact sampling location is practically unavoidable, and leeway is given in the IPHC methods to center the set on the target coordinates but to allow wind and currents to dictate the actual direction in which the gear is deployed. This can result in different habitats accessed at each fixed location among years.

The IPHC longline survey fishes in suitable habitat for rougheye rockfish, but the majority of the rockfish catch is yelloweye rockfish (*S. ruberrimus*). In 2012, 169 rockfish were observed in area 2A, and consisted of eleven different species. Of those 169 rockfish, 115 were yelloweye, and 13 were rougheye. Based on the low numbers of rougheye rockfish, the data were not used in this assessment.

## 2.2 Fishery-dependent data

Rougheye rockfish have been caught in trawl and hook & line fisheries since the early part of the 20th century. Rougheye rockfish are a large and desirable rockfish, and are not likely to be discarded for market reasons. However, smaller rougheye are found at shallower depths and discarding practices in the early 1900's are uncertain. Few rougheye have been observed in recreational, commercial pot, and commercial shrimp fisheries, thus only trawl and hook & line landings were used in this assessment.

Since 2000, rougheye rockfish have been landed as part of the minor slope rockfish species complex, and previously, they were commonly landed as part of the 'Other *Sebastes*' complex. Therefore, the results of species-composition sampling are relied upon to determine the landed catch of rougheye. The uncertainty in species composition is greater in past years, with less systematic and extensive sampling occurring prior to 1980. Consequently, the precision with which landings of rougheye rockfish can be estimated likely decreases for earlier years. A description of the methods used to determine the historical and current landings is provided below.

### 2.2.1 Commercial catch reconstruction

PacFIN serves as a clearinghouse for commercial landings data since the early 1980's, and before that, landings for each state were reconstructed using the assumptions described below. The at-sea trawl fleet calculates catches are calculated from observer data stored in the NORPAC database, maintained by the AFSC.

#### *2.2.1.1 Washington*

Historical commercial landings of two gear types, trawl and longline, were reconstructed for rougheye rockfish landed in Washington. It was assumed that landings from other gears constitute a negligible amount of the total mortality.

**Washington's trawl fishery**

Washington's coastal trawl fishery began in the early 1930's off of Cape Flattery and landings increased substantially by the 1940's (Tagart and Kimura 1982). In 1946, rockfish landings experienced a sharp decline, presumably in response to weakened market demand following World War II. After a period of steady landings of around 5,000 metric tons (mt) annually, landings rapidly increased in the 1960's, followed by a decline in the mid-1970's and a further increase in the late 1970's. Before the mid-1970's, most of the rockfish and POP catch came from Canadian waters. The implementation of the EEZ brought higher landings in Washington from U.S. waters and U.S. landings rose to over 10,000 mt up until 1983. After that time, rockfish landings declined to around 500 mt in the late 1990's.

Most of the rockfish landed in the Washington trawl fishery were historically categorized into two market categories: "Pacific Ocean Perch" (POP) or "other rockfish" (URCK). Additional market categories were added in the mid-1980's, but only POP and URCK were used to determine the landings of rougheye rockfish prior to the 1980's. Figure 19 shows the amount landed in each category before proportioning out the species.

Theresa Tsou (pers comm., WDFW) provided species composition data from landings for 1967–2009. From these data, the years 1968–1994 were used to calculate average proportions of rougheye rockfish in the UPOP and URCK market categories. These proportions were then applied to historical landings of each category to determine historical rougheye rockfish landings. These years were chosen because landings in these two market categories were consistently sampled for species compositions. The average proportion of rougheye rockfish in UPOP landings from 1968–1994 was 0.00661 and the average proportion of rougheye rockfish in URCK landings from 1968–1994 was 0.00160. The average proportion of rougheye rockfish in the sum of UPOP and URCK landings between 1968 and 1994 was 0.00236.

A database of historical Washington landings (Greg Lippert, WDFW, pers comm.) contained landings from Puget Sound and was used to calculate a proportion of the U.S. and Canadian rockfish landings (without POP) that were not from Puget Sound. POP was excluded because it was assumed all POP were caught outside of Puget Sound. From 1949 to 1969, the proportion of landings outside of Puget Sound were greater than 0.95. These estimates agreed closely with estimates calculated using data from research reports on the Washington trawl fishery (Holmberg et al. 1962, Holmberg et al. 1967). Prior to 1949, when POP and rockfish landings were not separated, it was assumed that 99% of the landings came from outside of Puget Sound.

Catches from U.S. waters were derived from Forrester (1967) and Tagart and Kimura (1982). Forrester (1967) reports the separate U.S. vessel and Canadian vessel catches of POP and rockfish for PSMFC areas near British Columbia in the years 1954–1965. Catches south of PSMFC area 3B were not reported, but it is likely that a large proportion of the catch south of 3B came from Oregon vessels. The proportion of Washington landings caught in US waters was calculated as the ratio between the US vessel catch in area 3B and the total catch by US vessels. It is unclear if area 3C as used by Forrester (1967) includes a portion of U.S. waters. Tagart and Kimura (1982) report catches by PSMFC area for the years 1966–1979 and there was little catch in the areas south of 3B.

Historical landings from trawl fisheries of rougheye rockfish were determined as follows for the periods shown.

**< 1930:** Assumed no catch of rougheye rockfish.

**1930–1934:** The Pacific Fisherman Yearbook rockfish landings were used and it was assumed that all landings were caught in U.S. waters. It was assumed that 1% of the total catch was from Puget Sound, thus was removed (1% was used because POP could have been aggregated with rockfish). The proportion of rougheye rockfish used was 0.00236.

**1935–1941:** Dept. of Fisheries WA reported landings (1955 Commercial Fishing Statistics, WA Dept Fisheries) were used instead of the Pacific Fisherman Yearbook. The sources are quite different, and the Pacific Fisherman Yearbook states it is reporting foodfish only (there was a substantial mink food fishery). We used 0.00236 as the proportion of rougheye rockfish in the landings since POP landings were not separated. For U.S. catches, we assumed a linear decrease from 100% of the catches in U.S. waters in 1934 to 17.65% catches from U.S. waters in 1946 (calculated from the average percentage of catch of rockfish+POP in U.S. waters between 1954-1974, see Forrester (1967) and Tagart and Kimura (1982). However, it is likely that fishing vessels stayed closer to home during the war years. Puget Sound catches were assumed to comprise 1% of the total landings and were removed.

**1942–1948:** Fish & Wildlife Service reports (Pacific Coast Fisheries) were used to determine rockfish landings instead of the Pacific Fisherman Yearbook or Dept of Fisheries WA reported landings (1955 Commercial Fishing Statistics, WA Dept Fisheries). The Pacific Fisherman Yearbook was typically less than the other two sources, which were not much different. The value 0.00236 was used as the proportion of rougheye rockfish in the landings. For U.S. catches, the linear decrease to 17.65%, as above, was used and it was furthermore assumed that 17.65% of the catch came from U.S. waters from 1946–1948. It was also assumed that 1% of the total catch came from Puget Sound.

**1949–1951:** A database of Washington landings provided by Greg Lippert (pers comm., WDFW) was used to determine landings of combined rockfish and POP for these years. The value 0.00236 was used as the proportion of rougheye rockfish in the landings. For U.S. catches, it was furthermore assumed that 17.65% of the catch came from U.S. waters from 1946–1948. The proportion of landings that occurred outside of Puget Sound were determined from the database and ranged between 99.2% and 99.7% for these years.

**1952–1965:** The database of Washington landings was used for separated rockfish and POP landings. Values of 0.00160 and 0.00661 were used as the proportion of rougheye rockfish in the other rockfish and POP categories, respectively. The proportion of landings from U.S. waters were determined for the years 1954–1965 using data reported by Forrester (1967) and ranged from 3.1–40.2% for rockfish landings and 9.9–46.4% for POP landings. The proportions of rockfish and POP landings from US waters for the years 1952–1953 were 0.215 and 0.143, respectively, which were the averages of the proportions from U.S. waters in the years 1954–1974 (before the proportion of landings caught in U.S. waters began steadily increasing). Tagart and Kimura (1982)report that prior to 1968, POP landings were invariably 100% Pacific Ocean perch and species composition does not need to be applied. However, after discussions with Fish & Wildlife Biologists and noticing that rougheye rockfish have been landed with POP catches after 1968, it was considered unreasonable given the large catch of POP prior to 1968 that no rougheye rockfish would have been caught or landed in this category.

**1966–1968** Tagart and Kimura (1982) report area specific landings, thus catches of rougheye rockfish from U.S. waters were determined directly. The estimated landings of rougheye rockfish increase rapidly near the end of this series, which is due to the domestic fleet taking more catch from U.S. waters.

**1969–1980:** The estimate of rougheye rockfish landings for this set of years was obtained from a spreadsheet supplied to me by Vlada Gertsvena (pers comm., NWFSC, NOAA) which was supplied to her by Jack Tagart. This spreadsheet is called ROCKFI~2.xls and has the catch of rougheye rockfish listed. Therefore, no proportions needed to be applied.

**1981–2012:** The rougheye rockfish landings were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated May 30, 2013, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org). Puget Sound catches were removed and only non-shrimp trawl gear was used.

The landings of rougheye rockfish in the Washington trawl fishery were low until the late 1970's when the EEZ was implemented and US vessels fished more often in US waters (Figure 20).

**Washington's longline fishery**

The longline fishery contributes a major portion of annual rougheye rockfish landings. Total rockfish landings for longline gear were available from the Washington landings database for the years from 1949 to 1969, and from the Washington fish ticket data between 1970 and 1980 (pers comm., Theresa Tsou, WDFW). Jack Tagart provided Vlada Gertsvena (NWFSC, NOAA Fisheries) with a spreadsheet containing species-composition data for longline gear (called LLSPP~2.xls). Using these data from the period 1994–1998, the proportion of rougheye rockfish observed in longline landings was 0.5042.

Historical longline catches were determined as follows for the periods shown.

**1897–1926:** Assumed a linear increase in catch of rougheye rockfish from zero to the value in 1927, following the Oregon catch reconstruction of longline catch.

**1927–1948:** Assumed that Washington longline catches of rougheye rockfish followed the same pattern as Oregon longline catches of rougheye rockfish. Without any other data, we simply added the average difference between Washington and Oregon longline catches of rougheye rockfish between 1949 and 1958 (36.9677 mt) to the Oregon longline landings of rougheye rockfish for each year.

**1949–1969:** Longline landings of all rockfish were obtained from a Washington landings database supplied by Theresa Tsou and Greg Lippert (pers. comm, WDFW, 2009) and a proportion of 0.5042 was applied to estimate rougheye landings.

**1970–1980:** A database of Washington fish tickets supplied by Theresa Tsou and Greg Lippert (pers. comm, WDFW, 2009) was used to determine all rockfish landed. A proportion of 0.5042 was applied to estimate rougheye landings.

**1981–1999:** Total hook and line landings for rockfish in Washington were taken from the Fisheries Statistics website (http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/index). A proportion of 0.5042 was used to estimate the rougheye landings.

**2000–2012**: The estimated landings of rougheye rockfish from hook and line gear were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated May 30, 2013, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org).

Hook & line fisheries in Washington are predicted to have caught a considerable amount of rougheye prior to 1960. Catches were low in the 1970's but increased quickly in the 1980's and 1990's. Catches are similar to historical levels in the 2000's (Figure 20).

#### *2.2.1.2 Oregon*

Historical reconstructed trawl and hook & line landings of rougheye rockfish from Oregon for the years 1927–1986 were obtained from Vladlena Gertseva (NWFSC, NOAA). A description of the methods can be found in Karnowski et al. (2012). Recent landings for these two gear types were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated May 30, 2013, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org).

#### *2.2.1.3 California*

Historical commercial fishery landings of rougheye rockfish were obtained from the California Cooperative Groundfish Survey, also known as CALCOM (pers. comm, Don Pearson) for the years 1916–1968. However, the catches were classified as "other" gear, and because they were small compared to Oregon and Washington landings (a total of 3.73 mt over 53 years) we decided to exclude them from the total catch history. Recent landings by trawl and hook & line gear types were obtained from PacFIN (Pacific Fisheries Information Network (PacFIN) retrieval dated May 30, 2013, Pacific States Marine Fisheries Commission, Portland, Oregon; www.psmfc.org) and are a small proportion of the total landings (Figure 20).

#### *2.2.1.4 At-sea*

Catches of rougheye rockfish are determined aboard the vessel by observers in the At-Sea hake Observer program (ASHOP). Observers use a spatial sample design, based on weight, to randomly choose a portion of the haul to sample for species composition. For the last decade, this is typically 30-50% of the total weight. The total weight of the sample is determined by all catch passing over a flow scale. All species other than hake are removed and weighed, by species, on a motion compensated flatbed scale. Observers record the weights of all non-hake species. Non-hake species total weights are expanded (in the database) by using the proportion of the haul sampled to the total weight of the haul. The catches of non-hake species in unsampled hauls is determined using bycatch rates determined from sampled hauls. Table 8 provides a summary of the total number of hauls, the total number of unsampled hauls, the total sampled weight of all of the hauls, and the median tow expansion factor used to expand from the sample to the haul. Since 2001, more than 97% of the hauls have been observed and sampled.

The at-sea fleet consists of catcher-processor vessels (CP) and mother-ship vessels (MS). The CP fleet typically catches more rougheye rockfish than the MS fleet (Table 9) and catches have fluctuated to reach high amounts since 2000 for the CP fleet (Figure 21). From 2009 to 2012, the MS fleet has shown an increase in rougheye rockfish catches while the CP fleet has shown high catches within the range of recent fluctuations.

### 2.2.2 Fishery-Catch-Per-Unit-Effort

Fishery catch-per-unit-effort (CPUE) was not used in this assessment because management restrictions have likely resulted in changes in catch-rates that are not reflective of rougheye rockfish abundance and difficulty with species identification may result in erroneous information. Additionally, trawl logbook data, which are available since the 1980s, do not identify retained amounts of rougheye. However, raw catch-per-tow was calculated for the at-sea fleet and plotted in Figure 22 to determine if there are any significant trends in catch-rates. Overall, trends in catch-per-tow for the at-sea fleet has been mostly stable, although from 1990 to 2000 there appears to be a general increase in catch-rate, which drops in 2002 and again increases slightly to 2012. Somewhat lower rates in the 2000s may reflect efforts by the at-sea fleet to reduce their bycatch of rebuilding species, such as widow and darkblotched rockfishes, and rockfish excluders began being used by some vessels in 2009.

### 2.2.3 Fishery Biological Data

Biological data from commercial fisheries that caught rougheye rockfish were extracted from PacFIN (PSMFC) on June 7, 2013 and from the NORPAC database on June 10, 2013. Lengths taken during port sampling in California, Oregon, and Washington were used to calculate length compositions, and ages were determined from rougheye rockfish sampled from Oregon landings in 2008 and 2011. The data were classified as groundfish trawl (TWL), shrimp trawl (TWS), hook and line (HKL), or net (NET). There were no hauls outside of US waters in this extraction.

Table 10 shows the number of landings sampled as well as the number of lengths taken for each year since 1995 for trawl and non-trawl gear from the three states, and the number of tows from the at-sea fleet. California has few sampled landings during this time period because landings of rougheye rockfish are small in that state. The numbers of lengths sampled by gear are shown in Table 11.

Length frequencies for trawl and hook & line gears were estimated using these data (Figure 23). Samples were expanded up to the total landing then combined into state specific length frequencies. Washington did not have the total weight of the landing recorded, therefore they were expanded to the total landing weight by a factor of 5.18, which is the median expansion for the Oregon landings. Expansion factors were calculated in a way such that large expansions would not occur and based on ideas first presented by Owen Hamel (pers. comm., NWFSC). First the expansion factor ($E_k$) was the total catch weight ($W_k$) divided by the sample weight ($w_k$), and raised to 0.9 to account for non-homogeneity within a trip. Then, expansion factors greater than 30 were assigned a value of 30 to reduce the influence of small samples (i.e., a few fish representing a large catch). The predicted total numbers at length weighted by landings for each state were added to create a coast-wide length frequency. The effective sample size of the state combined length frequencies were determined by weighting the sample sizes within each state relative to the proportion of the total landings that were sampled.

Expanded at-sea length compositions are shown in Figure 24. Observed lengths were expanded to the tow from At-Sea Hake Observer Program samples. Tows are typically well sampled, thus expansion factors were not modified from what was calculated. Lengths from the at-sea fleet were most often greater than 40 cm.

Conditional age-at-length show a large amount of variability mostly because larger fish were observed (Figure 25 and Figure 26).

### 2.2.4 Discards

The West Coast Groundfish Observer Program (WCGOP) has been collecting on-vessel data since 2002 to mainly record discard information. Their data are current through 2011 and are summarized here. A proportion of the fleet for various gear types has been observed in each year and the data collected are used to estimate the total mortality to various species. In 2011, under trawl rationalization, 100% observer coverage is required for some sectors, which resulted in a large increase in data and ability to determine discard behavior. However, given the change in management, it is likely that there has been a change in discarding behavior.

Table 13 shows discard totals in metric tons for each year since the WCGOP has been collecting data. Figure 27 shows the discard totals by year for the trawl and fixed gear fisheries. Discard totals ranged from around 1 to 20 metric tons between 2002 and 2006 for the trawl fleet, and increased to around 30–60 mt from 2007 to 2010. In the first year of trawl rationalization (2011), the discard total was the lowest observed value of 0.04 mt. Prior to the implementation of catch shares, two main reasons for discarding practices were trip limits and area closures. Discard totals for the fixed gear fishery varied between 1 and 21 mt per year between 2002 and 2011.

Table 14 and Figure 28 show the observed mean body weights of discarded rougheye rockfish for the trawl and fixed gear fisheries. The mean body weight of discarded rougheye rockfish ranged between 0.53-1.84 kg between 2002 and 2010 for the trawl fishery. In 2011, under catch shares, the mean body weight of discarded fish was 0.53kg. The mean body weight of discarded rougheye rockfish ranged between 1.38-2.7 kg between 2002 and 2011 for the fixed gear fishery. On average, the fixed gear fleet appeared to discard larger rougheye rockfish relative to the trawl fleet during the comparable years of 2002-2010.

Length compositions of the discards for the trawl and hook & line fleets were quite different from each other (Figure 29). The hook & line fleet did not observe the small fish that were observed in the trawl fleet. The trawl fleet observed small fish from 2004 to 2006 in high proportion, which then was reduced from 2007 to 2010, but strong again in 2011. The hook & line fleet rarely observed fish less than 40 cm.

These discards were estimated in the model and estimated total catches, as opposed to landings, are reported where necessary.

## 2.3 Biological data

### 2.3.1 Weight-Length Relationship

Weight-at-length data collected by the NWFSC shelf/slope trawl survey was used to estimate a weight-length relationship for rougheye rockfish. Weight-at-length was very similar between females and males (Figure 30). The following relationships between weight and length for females, males, and all sexes were estimated:

| | |
|---|---|
| Females | $\text{weight} = 8.384\text{E-}6 \cdot \text{Length}^{3.161}$ |
| Males | $\text{weight} = 1.005\text{E-}5 \cdot \text{Length}^{3.110}$ |
| Combined | $\text{weight} = 9.595\text{E-}5 \cdot \text{Length}^{3.123}$ |

where weight is measured in grams and length in cm.

### 2.3.2 Maturity schedule

McDermott (1994) estimated the probability that rougheye were mature at different lengths using histological techniques. Samples were collected along the coast from Oregon to the Gulf of Alaska and the small number of samples from Oregon, Washington, and British Columbia showed a slightly smaller length at 50% mature (42.88 cm) than the samples from Alaska (44.87 cm). Figure 31 shows the maturity-at-length.

### 2.3.3 Fecundity

Fecundity in rockfish is often not a linear function of weight, but increases faster at larger weights (Dick 2009). Therefore, this relationship is often accounted for in assessments of rockfish and spawning output is used to determine current status. We were unable to find published studies of the fecundity of rougheye rockfish that were useful for this assessment. However, it has been noted that rougheye rockfish do not experience senescence (de Bruin et al. 2004).

### 2.3.4 Natural Mortality

Natural mortality (*M*) is a parameter that is often highly uncertain in fish stocks. There are few published estimates of natural mortality for rougheye rockfish. Malecha et al. (2007) used samples from Alaska to calculate estimates of *M* that ranged from 0.013 to 0.063 using methods developed by Alverson and Carney (1975) and Hoenig (1983). McDermott (1994) analyzed samples collected from Alaska to Oregon and used the method developed by Gunderson and Dygert (1988) that relates the gonad somatic index (GSI) to natural mortality rate. Natural mortality rates of 0.0304 and 0.039 were reported with a high amount of uncertainty. The Gulf of Alaska assessment of rougheye rockfish (Shotwell et al. 2011) used 0.03 as the mean of a prior distribution for *M*.

In this assessment, natural mortality was estimated. A lognormal prior distribution based upon a maximum age of 130 years (as seen in the survey data) was developed and had a median of 0.03365 and a coefficient of variation (CV) of 0.58 (pers comm, Owen Hamel, NWFSC, NOAA). Two other prior distributions were developed. One assumed a maximum age of 205 (Munk 2001) resulting in a median of 0.02134 and a CV of 0.60. The other assumed a maximum age of 130 and an asymptotic weight-at-age of 3.92 kg, resulting in a median *M* of 0.0605 and a CV of 0.44. Figure 32 shows that these prior distributions are wide and not highly informative.

### 2.3.5 Length-at-age

In 2013, the Cooperative Ageing Project (CAP) in Newport, Oregon aged 962 rougheye rockfish otoliths collected from the NWFSC shelf/slope survey, 722 rougheye rockfish otoliths collected from Oregon port samples in 2008 and 2011, and 1065 rougheye rockfish otoliths collected by observers from the Pacific hake at-sea fleet in 2008 and 2011. All but 9 of these otoliths had a sex assigned to them. Figure 33 shows the lengths and ages for all years of the NWFSC shelf/slope survey as well as predicted von Bertalanffy fits to the data. Females and males grow at similar rates with sex specific growth parameters estimated at the following values:

| | |
|---|---|
| Females | $L_\infty = 58.3,\ k = 0.071,\ t_0 = -1.69$ |
| Males | $L_\infty = 57.7,\ k = 0.068,\ t_0 = -2.26$ |
| Combined | $L_\infty = 57.9,\ k = 0.069,\ t_0 = -2.00$ |

Figure 34 shows the observations of length at age as well as predicted von Bertalanffy curves for each year of the data collected from the NWFSC shelf/slope survey. Large differences are apparent between years, which are likely due to smaller sizes within each year.

The length-at-age data collected from the Oregon commercial samples are shown in Figure 35 with the year-specific data shown in Figure 36. The estimates of the von Bertalanffy parameters using both years of data are:

| | |
|---|---|
| Females | $L_\infty = 61.2,\ k = 0.032,\ t_0 = -25.98$ |
| Males | $L_\infty = 60.5,\ k = 0.032,\ t_0 = -25.16$ |
| Combined | $L_\infty = 60.7,\ k = 0.032,\ t_0 = -25.40$ |

The length-at-age data collected from the Pacific hake at-sea commercial samples are shown in Figure 37with the year-specific data shown in Figure 38. The estimates of the von Bertalanffy parameters using both years of data are:

| | |
|---|---|
| Females | $L_\infty = 60.1,\ k = 0.038,\ t_0 = -24.21$ |
| Males | $L_\infty = 57.6,\ k = 0.046,\ t_0 = -19.04$ |
| Combined | $L_\infty = 58.7,\ k = 0.042,\ t_0 = -21.14$ |

Fewer smaller/younger fish were present in the commercial data, and estimates of $k$ and $t_0$ are likely uncertain for those fleets. $L_\infty$ was larger for the females when using data from the commercial fleets, and the Oregon samples showed a larger $L_\infty$ for males. Even with samples sizes greater than 150, the sex-specific parameters were variable across years (e.g., see males in the Oregon samples in Figure 36).

Compared to the estimated growth curve using combined sex data from the NWFSC shelf/slope survey, the estimated growth curve from McDermott (1994) predicted smaller fish at ages less than 10, similar sized fish from about ages 10–30, and smaller fish at older ages. McDermott (1994) used data from Oregon, Washington, British Columbia, and Alaska collected in the early 1990's, while the NWFSC survey data is collected from California, Oregon, and Washington and collected in the 2000's.

### 2.3.6 Sex ratios

Males and females grow to similar lengths and it is expected that the proportion of females across all lengths or ages would be 50% unless mortality differs by sex. Figure 40 shows that the proportion of females at length or age from survey data is near 50% but typically slightly less than 50%. A trend would suggest differential mortality rates by sex, but instead the proportion of females appears to be consistently less than 50%. This may be a result of differential selectivity by sex and males are more vulnerable than females across all lengths or ages, or a bias in sex determination. Conversely, Figure 40 also shows the proportion of females for data from the trawl fleet and data from the at-sea fleet. There are a larger number of length observations and the proportions are much closer to 0.5 across all lengths and ages.

### 2.3.7 Ageing Bias and Imprecision

Uncertainty surrounding the ageing-error process for rougheye rockfish was incorporated by estimating ageing error by age. All age-composition data used in the model were from break-and-burn reads and were aged by the Cooperative Ageing Project (CAP) in Newport, Oregon.

Age validation has not been done for rougheye rockfish otoliths and there is likely a considerable amount of error in age determination, especially with very old fish. For example, the CAP lab initially aged an otolith at 210 years, but upon further investigation it was revised to be 153 (pers. comm., Patrick McDonald, NWFSC). Also, Munk (2001) reported a rougheye rockfish that was aged at 205 years, which has been referenced many times since. However, it was noted that there were ambiguous regions of the otolith and that the age of the fish could be younger than 205, but was at least 170 years.

Break-and-burn double reads of 604 otoliths were performed by CAP (unpublished data). An ageing error estimate was made based on these double reads using a computational tool specifically developed for estimating ageing error (Punt et al. 2008), which produces a standard deviation in estimated age as a function of true age. A non-linear standard error was estimated by age where there is more variability in the estimated age of older fish (Table 17, Figure 41). Bias was not estimated because there were no validated ages to provide a benchmark.

## 2.4 History of Modeling Approaches Used for this Stock

A previous data-limited, category-three, evaluation was conducted for the U.S. Pacific Coast stock of rougheye rockfish in 2010 by Dick and MacCall (2010) using depletion-based stock reduction analysis (DB-SRA). They estimated that the population had greater than a 50% probability of exceeding the estimated proxy overfishing level in 2010 if the harvest remained at the observed levels. DB-SRA estimated a proxy OFL for rougheye rockfish of 78.7 mt with a 95% confidence interval between 4.7-587 metric tons.

The results from DB-SRA and from this assessment vary for multiple reasons. First, the overall modeling structure, DB-SRA is a delay-difference modeling approach using only catch data and terminal-depletion assumptions, whereas this assessment applied an age-structured analysis which integrated catch, index, and compositional data. Secondly, the catch history has been substantially updated for rougheye, although it is still highly uncertain (Figure 42). The last main reason, and perhaps the most critical, is the assumption about natural mortality. DB-SRA assumed a distribution about a low value of *M* relative to the value that was estimated with the base model of this assessment. Model sensitivity analyses were conducted for the base model in which *M* was fixed at a low value similar to the median applied in DB-SRA. The mean long-term yield at $SPR_{50\%}$ was estimated to be 79 mt, a similar result to that resulting from the Dick and MacCall (2010) analysis.

### 2.4.1 Pre-assessment webinar

A pre-assessment webinar was held on May 28, 2013 to present preliminary analyses of data and potential modeling methods. Participants included representatives from federal and state agencies, as well as representatives from trawl and at-sea industries. The webinar was extremely useful to help understand the fishery and management concerns, to learn more about the fishery, and to meet people interested in this assessment for further consultation. We greatly appreciate the time that everyone took to attend the webinar and provide comments, advice, and insight used in this assessment.

After a short presentation on the data and methods used to assess rougheye rockfish, a discussion took place where many things were learned. Some of the more important concepts were

- This is the southern range of the stock.
- Rougheye rockfish are a desirable species and discards likely occur at the end of the trip limit period.
- Discard rates should have been low when slope rockfish limits were not constraining.
- The Pacific whiting shoreside trawl fishery interaction with rougheye rockfish (included with the trawl fleet here) is likely similar to the Pacific whiting mothership at-sea fleet.
- In 2009, excluders started being used in the at-sea fleet, and in 2013 many vessels were using excluder devices.

# 3 Assessment

An age-structured stock assessment model was used to predict the biomass trajectory of rougheye rockfish with an approach of balancing parsimony with complexity. This allowed for the determination of general trends in the biomass over time without introducing extraneous data partitions that explain little additional variation.

Despite the recent formal recognition of two separate species (Orr and Hawkins 2008), we modeled and assessed rougheye and blackspotted rockfish as a pooled complex in this analysis. The primary reason for this is the lack of information specific to the two species. As a result of over two centuries of taxonomic ambiguity, the information that is available for rougheye and blackspotted rockfish including depth and geographic distribution, abundance, age and growth, reproductive characteristics, and landings history reflect contributions from both species. A pooled approach was also taken by the AFSC in its most recent assessment of rougheye and blackspotted rockfish in the Gulf of Alaska (Shotwell et al. 2011). The authors cited the difficulty in correctly distinguishing between the two species during at-sea research and the high likelihood that most historical data include a combination of both species as rationale for their approach.

## 3.1 General Model Specifications and Assumptions

Stock Synthesis v3.24O was used to estimate the parameters in the model. R4SS, revision 1.20, along with R version 2.15.3 were used to investigate and plot model fits. A summary of the data sources used in the model (details discussed above) is shown in Figure 43.

Stock Synthesis has many options when setting up a model and the assessment model for rougheye rockfish was set up in the following manner.

### 3.1.1 Summary of Fleets and Areas

Rougheye rockfish are most frequently observed in Oregon and Washington waters, however, they are observed along the entire U.S. West Coast in survey and fishery observations. Multiple fisheries encounter rougheye rockfish. Trawl, fixed gear (mainly longline), and the at-sea (mid-water) hake fisheries account for the majority of the rougheye rockfish landings both historically and currently.

The trawl fishery was combined into a coast-wide fleet. For the period from 1916 to 2000, prior to the introduction of trip limits for rockfish, little to no discarding of rougheye rockfish was assumed based upon the Enhanced Data Collection Program (EDCP) (Methot et al. 2000). There were limited observations of rougheye rockfish in thePikitch et al. (1988) data (1986-1987) which prevented a formal analysis of discard rates from this data set. Foreign trawl catches (1966-1976) were added to the main trawl fleet. The fixed gear fishery is primarily a hook and line fishery and was modeled as a coast-wide fleet. The at-sea fishery operates as a mid-water fishery targeting Pacific whiting but encounters rougheye rockfish as a bycatch species. This fleet was also modeled as a single fleet.

### 3.1.2 Other specifications

The specifications of the assessment are listed in Table 15. The model is a single-sex, age-structured model starting in 1916 with an accumulated age group at 140 years. Growth and natural mortality were estimated. The lengths in the population were tracked by 2 cm intervals and the length data were binned into 2cm intervals. A curvilinear ageing imprecision relationship was estimated and used to model ageing error. Fecundity was assumed to be proportional to body weight, thus spawning biomass was used as the measure of spawning output.

The Triennial survey was split into an early and a late series, based mostly on the shift to deeper depths and the timing of the survey (see section 2.1.1), by estimating different catchability parameters and selectivity parameters for each period. Only years in which the AFSC slope survey covered the entire coast north of 43° N latitude were used (1996, 1997, 1999–2001). The NWFSC survey was split at 2003 with 1998–2002 representing just the slope area and 2003–2010 representing the shelf and slope areas. Age data were not available for the Triennial, AFSC slope, or the NWFSC slope surveys, but were available for the NWFSC shelf/slope survey and entered into the model as age-at-length. Length-frequencies were calculated for the Triennial, AKFSC slope, and the NWFSC shelf/slope surveys. There were no length frequencies available for the NWFSC slope survey, and selectivity was assumed to equal the estimated selectivity of the AFSC slope survey.

The specification of when to estimate recruitment deviations is an assumption that likely affects model uncertainty. It was decided to estimate recruitment deviations from 1900–2012 to appropriately quantify uncertainty. The earliest length-composition data occur in 1980, however the earliest age data were much later (2003-2012). The most informed years for estimating recruitment deviations were from about 1980 to the mid-2000's. Therefore, the period from 1900-1979 was fit using an early series with no bias adjustment, the main period of recruitment deviates occurred from 1980–2011 with an upward and downward ramping of bias adjustment, and 2012 onward was fit using forecast recruitment deviates with no bias adjustment. Methot and Taylor (2011) summarize the reasoning behind varying levels of bias adjustment based on the information available to estimate the deviates. Recruitment deviation was assumed to be 0.40, based on iteratively tuning to a value slightly less than the observed variability of recruitment deviations in the period 1980–2011.

The recommended selectivity type in Stock Synthesis is the double normal and was used in this assessment for the fleets and surveys. The model was allowed to estimate a shift in selectivity for the Triennial survey between the early and the late period of the time series. Shifts in selectivity and retention curves were estimated for the trawl and fixed gear fisheries.

Time blocks for the trawl fishery selectivity were set from 1916–2001, 2002–2012, based on the implementation of the RCAs. The time block on the retention curves for the trawl fishery were set from 1916–1999, 2000–2006, 2007–2010, 2011–2012, based on changes in trip limits and area closures that likely resulted in changes to discarding patterns for rougheye rockfish. The early period (1916-1999) of the model and the final two years (2011-2012) were mirrored and assumed to have little discards from the trawl fishery. There were insufficient observations of rougheye rockfish in the Pikitch data (1986-1987) to estimate a discard ratio, the EDCP data set estimated little to no discard of large rockfish (Methot et al. 2000), and the WCGOP data from 2011, under catch shares management, indicated very little discarding of rougheye rockfish (0.7%). Time blocks for the hook & line selectivity were set from 1916–2002 and 2003–2012, based on the implementation of RCAs for fixed-gear. Retention for the fixed gear fleet was blocked into two periods 1916-1999 and 2000-2012 where the recent period was based upon trip limits and estimated using data collected by the WCGOP, and the early period assuming no discards.

The following distributions were assumed for data fitting. Survey indices were lognormal, total discards were lognormal, and mean weight-at-age followed a t-distribution with 30 degrees of freedom. The variability around length at age was also lognormal.

### 3.1.3 Priors

Prior distributions were developed for the natural mortality parameter from an analysis of maximum age and $W_\infty$. The analysis was performed by Owen Hamel (pers comm, NWFSC, NOAA) and used a combination of methods to provide a lognormal distribution for natural mortality. The medians of the lognormal priors were 0.021, 0.034 and 0.065 when assuming maximum age is 130, maximum age is 205, or maximum age is 130 and $W_\infty$ is 3.92 kg, respectively. The distributions are shown in Figure 32.

The prior for steepness (*h*) assumes a beta distribution with parameters based on an update of the Dorn rockfish prior (commonly used in past West Coast rockfish assessments) conducted by J. Thorson (pers. Comm, NWFSC, NOAA)) which was reviewed and accepted by the SSC in March 2013 (a beta distribution with $\mu$=0.779 and $\sigma$=0.152).

### 3.1.4 Sample weights

Initially, the base case assessment model was iteratively reweighted such that the various data sources were mostly consistent with each other in terms of the relationship between input and effective sample sizes. Age-at-length compositions were fit along with length compositions for the fishery fleets and the NWFSC shelf/slope survey. Length data started with a sample size of the number of port samples for the trawl and fixed gear fleets, the number of tows for the at-sea fleet, and the number of tows for survey samples (Table 10). Age-at-length data assumed that each age was a random sample within the length bin and started with a sample size equal to the number of fish in that length bin . One extra variability parameter that was added to the input variance was estimated for each survey index series. Vessels present in the WCGOP data were bootstrapped to provide uncertainty of the total discards (Table 13) and a small amount was added to the standard deviation to make the confidence intervals of the data consistent with the predictions. The variability for the mean weight of the discards (Table 14) was determined from the sample variation and not tuned since the estimated variability was already quite large.

During the STAR panel, an alternative method was proposed to determine weights for the different data sources, which was based on equation TA1.8 in Francis (2011). This formulation looks at the mean length or age and the variance of the mean to determine if across years, the variability is explained by the model. If the variability around the mean does not encompass the model predictions, then that data source should be down-weighted. This method does account for correlation in the data (i.e., the multinomial distribution) as opposed to the McAllister and Ianelli (1997) method of looking at the difference between individual observations and predictions. Code written in R by Chris Francis (pers. comm.) was provided and ultimately used to determine the weighting of the fleet specific length and age data sets. The length data were given less weight than the method of comparing effective and input sample sizes.

### 3.1.5 Estimated and Fixed Parameters

There were 173 estimated parameters in the base case model. These included one parameter for $R_0$, 5 parameters for growth, a single natural mortality parameter, 4 parameters for extra variability on the survey indices, two parameters for the catchability of the two series of the Triennial survey (the catchability for other surveys was calculated analytically), 24 parameters for selectivity, retention, and time blocking of the fleets, 11 parameters for survey selectivity, 113 recruitment deviations, and 12 forecast recruitment deviations.

Fixed parameters in the model were as follows. Steepness was fixed at 0.779, which is the mean of the current rockfish prior. A sensitivity analysis and a likelihood profile were done for steepness. The standard deviation of recruitment deviates was fixed at 0.40. Maturity at length was fixed with a length at 50% mature at 43.87 cm (Figure 31) based upon McDermott (1994). Length-weight parameters were fixed at estimates from the NWFSC shelf/slope survey data (Figure 30 and Table 16). There were no length data associated with NWFSC slope survey, so the selectivity was mirrored to match the selectivity of the AFSC slope survey.

Dome-shaped selectivity was explored for both the fishery and the surveys. Older rougheye rockfish are often found in deeper waters and may move into areas that limit their availability to fishing gear, especially trawl gear. Little evidence was found for domed shape selectivity, except for the Triennial survey, which was mostly a shelf survey. The final base model assumed asymptotic selectivity for each fishery and for all surveys expect the Triennial survey.

## 3.2 Model selection and evaluation

The base case assessment model for rougheye rockfish was developed to balance parsimony and realism, and the goal was to estimate a biomass trajectory for the population of rougheye rockfish on the west coast of the United States. The model contains many assumptions to achieve parsimony and uses many different sources of data to estimate reality. A series of investigative model runs were done to achieve the final base case model.

### 3.2.1 Key assumptions and structural choices

The key assumptions in the model were that the assessed population is a single stock, maturity at length has remained constant over the period modeled, weight-at-length has remained constant over the period modeled, the standard deviation in recruitment deviation is 0.40, and steepness is 0.779. These are simplifying assumptions that unfortunately cannot be verified or disproven. Sensitivity analyses were conducted for most of these assumptions to determine their effect on the results.

Structurally, the model assumed that the catches from each fleet were representative of the coast-wide population, instead of specific areas, and fishing mortality prior to 1916 was negligible. It was also assumed that discards were low prior to 2000.

### 3.2.2 Alternate models explored

The exploration of models began by fixing *M* at the median of the prior distribution to understand the general behavior of the model. After initial investigations allowed us to better understand the model and fits to the data, *M* was estimated to determine a base model by further exploring selectivity types and blocking of time periods. Ultimately, decisions regarding specific blocks for selectivity and retention were made, primarily, through consideration of changes in management and relating those changes to patterns seen in the data. In the spirit of parsimony, we used as few blocks as possible, and added new blocks when we felt they were justified by changes in management and they improved the fit to the data.

A simple production type model was fit to the data during the initial explorations where recruitment, growth, and natural mortality were fixed and only length data were used. This simple model was not chosen as a base model because there is some indication of recruitment strengths in the length and age data, and uncertainty is very small given so many fixed parameters. We felt that these assumptions could be relaxed with a more complicated model, and poor residual patterns were explained much better with this slightly more complicated model.

### 3.2.3 Convergence status

Proper convergence was determined by starting the minimization process from dispersed values of the maximum likelihood estimates to determine if the model found a better minimum. This was repeated 100 times and a better minimum was not found. The model did experience some convergence issues, but through the jittering done as explained above and likelihood profiles, we are confident that the base case as presented represents the best fit to the data given the assumptions made. There were no difficulties in inverting the Hessian to obtain estimates of variability, although much of the early model investigation was done without attempting to estimate a Hessian.

## 3.3 Response to STAR panel review and recommendations

The stock assessment review (STAR) panel for this assessment was held at the NWFSC in Seattle from July 8–12, 2013. David Sampson chaired the review, Yan Jiao, Chris Francis, and John Field were reviewers, Colby Brady was the GMT representative, Gerry Richter was the GAP representative, and John Devore was Council staff. Other stakeholder representatives as well as scientists participated in the review and were very helpful with insights into various issues.

A number of requests were made by the reviewers during the review. The requests mainly addressed understanding the model-based GLMM estimates of survey indices, determining if the paucity of rougheye observations in the surveys between 250–300 m was due to poor gear performance, and determining appropriate weighting between data sets. No serious issues were identified with the data or the assessment, other than an alternative method was used to determine the weighting of the data sets (see Section 3.1.4 above). Specific outcomes to all of the requests are given in the STAR panel report for this assessment.

A list of recommendations for future consideration came out of the review and specific responses to those recommendations are given here.

General recommendations

1. *A workshop should be held to evaluate methods (a) for the iterative reweighting of composition data (e.g., current approach based on SS3 calculation of effective N versus the Francis approach) and (b) for developing initial weightings (the initial input N values).*

   **Response:** We were initially concerned with the differences in relative weightings that the two methods resulted in, but feel that the Francis method was less arbitrary and produced reasonable results. However, we support the further investigation of both of the methods to determine the pros and cons of each.

2. *A workshop should be held to evaluate methods for constructing survey GLMM estimates. Topics that should be explored include: (a) the effect of treating vessels as random when in fact the vessels hardly vary from one year to the next; (b) possible aliasing of the index values with the Vessel x Year interactions; and (c) the using information from the GLMM for combining length composition data collected by different vessels. One goal for the workshop should be to provide adequate documentation of the GLMM methods that will be used to produce survey biomass indices for future assessments and guidelines on how the analyses, including diagnostics, should be presented in stock assessment reports.*

   **Response:** A considerable amount of work was done to improve these methods in the last year, and significant gains have been made. This is an ongoing project and future improvements are planned. We are grateful to the STAR panel for providing guidance of what should be the focus of this work.

3. *Port sampling programs should continue their routine collection of otoliths of slope rockfish species. A catalog of historical collections that have not been aged should be developed.*

   **Response:** We agree that one of the most important data sources for this assessment is the age data, and it is crucial to continue the collection of otoliths, even if they are not aged immediately. It would also be useful to age any otoliths from the past to provide a better picture of historical stock composition.

4. *The series of historical catches of individual rockfish species, which are important sources of uncertainty in stock assessments of rockfish, should be explored in more detail. The STAR Panel agrees with the statement in the draft assessment document that "A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for".*

   *Furthermore, catch reconstructions should not just develop best estimates of rockfish catch by species, but should also characterize the uncertainty of historical catch estimates by identifying periods of greater and lesser uncertainty. For example, rockfish species compositions taken during early years when there limited slope fisheries should be very different from species compositions taken during later years when fisheries on the slope were more prevalent.*

   **Response:** This is a key issue for many assessments of West Coast groundfish species. Identifying uncertainty in historical estimates of catch would provide the ability for assessors to develop appropriate sensitivities to alternative historical catch levels.

5. *Investigate better fishery-independent data collection methods for slope rockfish and other species living in untrawlable habitats (e.g., surveys using submersibles or remotely operated vehicles).*

   **Response:** Surveys in areas that are not accessible by the trawl survey would greatly improve the ability to detect changes in the population biomass of many West Coast groundfish species. Currently, AUV research is ongoing, and a hook & line survey is being performed annually in the Southern California Bight. It may be worthwhile to investigate the opportunities for expansion of the hook & line survey into areas off of Central and Northern California, as well as Oregon and Washington to increase the number of species for which that survey could provide indices of abundance.

<u>Specific to rougheye rockfish</u>

1. *The STAR Panel agrees with the STAT regarding the importance of collecting additional age data and other information that will improve our understanding of the life-history characteristics of rougheye and blackspotted rockfish, with the aim of reducing the uncertainty regarding natural mortality.*

   **Response:** We agree, as noted in the list of recommendations provided in this document.

2. *The survey and port sampling efforts should collect genetic material in association with otolith sampling to provide a clear basis for distinguishing between rougheye and blackspotted rockfish. Also, researchers in the PFMC arena should collaborate with ongoing AFSC and DFO genetic studies of rougheye and blackspotted rockfish.*

   **Response:** We agree that groundtruthing species identification as well as collecting additional information for the two species would be beneficial.

3. *The STAR Panel agrees with the STAT regarding the importance of "understanding the stock structure of rougheye and blackspotted rockfishes".*

   **Response:** NA

4. *Prior to the next assessment of either rougheye or blackspotted rockfish (or their complex), there should be targeted studies or analyses to investigate what caused the lack 30-44 cm fish caught in the 250-300 m depth zone by the NWFSC shelf/slope survey.*

   **Response:** This is one of unresolved issues of this assessment and further investigation would be useful. Collecting detailed information from the commercial fisheries or from alternative surveys may help to understand this observation.

5. *The STAR Panel agrees with the STAT regarding the importance of additional studies of the maturity and fecundity of rougheye and blackspotted rockfish. Further, any fish used for maturity and fecundity studies should be subjected to genetic analysis to definitively identify what species it is.*

   **Response:** We were unable to find any specific information on fecundity, and the maturity curve included data from Canada and Alaska. More specific studies of maturity and fecundity of each species off of the West Coast would provide insight into area differences as well as differences between species. Additionally, the collection of data from various years could provide insight into temporal changes in maturity. All of this information is necessary for an accurate assessment of each species.

6. *The STAR Panel agrees with the STAT regarding the importance of validating the ageing method for rougheye and blackspotted rockfish. Further, any fish used for age-validation studies should be subjected to genetic analysis to definitively identify what species it is.*

   **Response:** For long-lived species, it is very important to validate the ageing methods. The ageing error determined in this assessment was large for older ages, and the age of one fish was initially determined to be over 200 years, but was subsequently determined to be 153 years old. Munk (2001) reported a rougheye rockfish of 205 years old, but admitted that it was at least 170 years old. Based on the methods of Hoenig (1983), a fish that lives to 200 should have a natural mortality value slightly greater than 0.02, but the estimated natural mortality in this assessment was more than double that. It would be useful to verify that rougheye and blackspotted rockfishes actually do live to 200 years.

7. *The STAR Panel agrees with the STAT regarding the importance of "understanding the stock structure and biology of rougheye and blackspotted rockfishes" and their recommendation for "… additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species".*

   **Response:** As above.

8. *The STAR Panel agrees with the STAT regarding the importance of "basin-wide understanding of stock structure, connectivity, and distribution" for rougheye and blackspotted rockfish, with the aim of defining "the connectivity between rougheye [and blackspotted] rockfish north of the U.S.-Canada border".*

   **Response:** Rougheye rockfish is distributed mainly in the northern area of the West Coast of the U.S., with higher densities observed near the U.S./Canada border. Very little is known about the connectivity between rougheye in the U.S. and Canada, and understanding this connectivity may help to explain some of the unusual observations as well as provide a more complete assessment.

## 3.4 Base-model results

The base model parameter estimates along with approximate asymptotic standard errors are shown in Table 18 and the likelihood components are shown in Table 19. Estimates of key derived parameters and approximate 95% asymptotic confidence intervals are shown in Table 20.

### 3.4.1 Parameter estimates

The estimates of natural mortality were higher than has typically been assumed in the past, and were also higher than suggested by the median of the prior distribution (0.00365) that was used. McDermott (1994) estimated *M* at either 0.030 or 0.039 using two different methods, but both produced a large amount of uncertainty (the upper 95% confidence interval was greater than 0.2). The assessment of rougheye and blackspotted rockfishes in the Gulf of Alaska assumed that *M* was 0.03 with a tight prior that had very little probability above 0.04. (Dick and MacCall 2010) assumed that *M* was 0.024 based on a maximum age of 170. All of these previous assumptions are less than the 95% estimated confidence interval of *M* from this assessment (0.0353–0.0487).

Estimating *M* is difficult in stock assessments, and the parameters may represent model misspecification instead of the actual life-history trait. However, when investigating models leading up to the base case model, the estimates of M were rarely less than 0.04. The uncertainty in the estimated *M* was also much less than the range of the prior (Figure 44).

Selectivity curves were estimated for commercial and survey fleets. The estimated selectivity, retention, and keep (the product of selectivity and retention) curves for the trawl and hook & line fleets are shown in Figure 45. The selectivity curves showed a shift to larger fish in 2002 and 2003 for the trawl and hook & line fleets, respectively. The trawl shift is consistent with the introduction of the RCA and gear restrictions (shoreward of the RCA) that virtually eliminated fishing in rocky shelf habitats where smaller rougheye would more likely be encountered. Around this same time, the fixed-gear RCA specifications began preventing fishing between 30 and 100 fm. The retention curves showed a shift to retaining a lower percentage of fish in recent years (since 2000), except that the trawl fisheries retain nearly all fish in 2011 and on. This is likely the result of very restrictive trip limits for the minor shelf rockfish complex, which were used to reduce mortality on darkblotched rockfish (which has been under rebuilding during most of the 2000s). Estimated selectivity for the at-sea fleet was similar to the selectivity of the fixed gear fleet, where mostly fish larger than 40% were selected (Figure 46). The estimated selectivity for the Triennial survey was dome-shaped (Figure 47), which is expected given that the survey mainly covers the shelf area. Estimated selectivity of larger fish is higher in the late triennial survey, which coincides with a move to include deeper water (Table 4). The slope surveys showed a selectivity curve shifted to the right of the NWFSC shelf/slope survey (Figure 47), which is also expected since the shelf/slope survey likely encounters more smaller fish on the shelf than the slope-only surveys.

Additional survey variability (process error added directly to each year's input variability) was estimated in the model and resulted in a modest addition to the Triennial survey (0.104), small additions to the AFSC slope and NWFSC slope surveys (0.051 and 0.054, respectively), and effectively no addition to the NWFSC shelf/slope survey. It is not surprising that the slope and Triennial surveys require extra variability since they do not survey the entire stock. The NWFSC shelf/slope survey covers much more range of the stock and the GLMM is used to obtain reasonable estimates of variance.

The estimates of maximum size for both females and males were slightly less than anticipated when looking at the survey data alone. This is not uncommon, especially when using a lognormal distribution for length-at-age, which is skewed and able to explain larger fish. The estimates of the maximum size were slightly larger than the estimate used in the assessment of rougheye and blackspotted rockfishes in the Gulf of Alaska.

### 3.4.2 Fits to the data

There are four types of data for which the fits are discussed: survey abundance indices, discard data (biomass and average weight estimates), length composition data, and conditional age-at-length observations.

The fits to the five survey series are shown in Figure 48. Extra standard error was estimated for all of the series (Table 18), but was zero for the NWFSC shelf/slope survey. None of the series showed consistent trends, and with the large amount of error, none of the series showed serious lack of fit.

Fitting the total observed discard amounts required the time blocks used in the base case model (Figure 49). Fits to the trawl discards from 2002–2006 were low in 3 of the 5 years, but it was not possible to fit the discards without making additional assumptions that did not have much reasoning. The fits to the trawl discards from 2007–2010 and in 2011 were quite good and followed the trend observed from 2008–2010. There were no strong *a priori* reasons for additional blocks on retention for the hook & line fleet after 2000, thus it was difficult to fit all of the observations, especially in later years when an increase seemed to occur, and the estimated discards were less than the observed discards. Fits to the mean weight of the discards were reasonable only because they did not show any serious departures from the observations and the variability around them (Figure 50).

Fits to the length-composition data are displayed in two different ways: the Pearson residuals-at-length are shown for each year for all types of length compositions, and the fits to aggregates of all years are also shown. More detailed plots of fitted lines drawn over the plotted proportions at length are shown in Appendix A. Pearson residuals for the fisheries (Figure 51) show a consistent pattern of underfitting lengths between 40 and 50 cm for both the trawl and hook & line fisheries. The length compositions from the at-sea fleet did not show a consistent pattern, but some years had poor fits. The fit to the length frequency combined for all years (Figure 52) for the at-sea fleet was very good indicating that the lack of fit in individual years may be due to process error and the model is fitting the general pattern of length observations very well. The combined fit to the hook & line fishery was good, but there was a slight underfitting of lengths around 45–50 cm and overfitting of lengths between 50 and 60 cm. The trawl fit showed a similar pattern except that there was slight overfitting at smaller and larger fish than 50 cm.

The discard length frequencies for the trawl and hook & line fleets were highly variable and showed some large residuals in some years (Figure 53). The fits to hook & line discard length frequencies were worse in recent years. When combining all years of discard length frequencies by fishery, the variability was still evident, but the model fit the distribution reasonably well given small sample sizes (Figure 54). The predicted trawl discard length frequency did not fully captured the peak for smaller fish, and the hook & line fleet predicted a steep increase on frequency starting at 40 cm, but under-predicted discarding of older fish.

The residuals for the fits to the survey length frequencies were smaller than the residuals for the fishery length data (Figure 55). The triennial and NWFSC shelf/slope surveys length frequencies were often bimodal with a valley around 40 cm, and the model showed an indication of a bimodal distribution but was unable to adequately capture both peaks (Figure 56). Therefore, a pattern in the residuals was apparent across some years for these two surveys (Figure 55). The fits to the length frequencies for the AFSC survey showed an opposite pattern where there was a single peak around 30–40 cm and the model underfit that peak. Therefore, the residuals showed filled circles (underfitting) in the middle of the length range.

Age data were entered as conditional age-at-length, which was simply the raw proportion of ages in each length bin. This assumes that within each length bin, the observed ages were a random sample of fish. The observed and expected age-at-length are shown in Figure 57 for the two years of the trawl fishery observations. The fits generally match the observations. The at-sea fleet showed similar results, except that slightly older ages were predicted in both 2008 and 2011 between lengths 40 and 50 cm (Figure 58). The survey data observed smaller fish than the fisheries (Figure 59). Expected ages-at-length were very good for the survey data, except that there were a few length bins that showed potential outliers. The standard deviation of age-at-length was variable and often the expectation was much higher than the observations at larger lengths.

Plots with the residuals for individual observations showed how variable the data were. Residuals for the trawl fishery were often larger than 2 and indicated that there were potentially some outliers at the smaller lengths (Figure 60). However, where the bulk of the data were (40–60 cm) the residuals were mostly smaller than 2 and did not show any significant pattern. The residuals from fits to the age-at-length data for the at-sea fleet were similar, except that no small fish were observed and the very large residuals seen in the trawl data (potential outliers) were not seen. Some years of the NWFSC shelf/slope survey age-at-length data were very consistent between expectations and observations, while others showed some lack of fit to the smaller and younger fish. Residuals were occasionally large and it appears that there may be outliers present. The years 2004, 2005, and 2009 had very good fits, while 2008 and 2010 data did not.

### 3.4.3 Population trajectory

The predicted spawning biomass (in metric tons) is given in Table 21 and plotted in Figure 63. The trajectory shows a slight initial decline followed by a flat trend from 1940 to around 1980. A steeper decline occurred in the 1980's and early 1990's before stabilizing at the start of the 21st century and then slightly increasing. The trajectory of the age 10+ biomass shows a very similar pattern, except with more increase recently (Figure 64), due to the predicted size of the 1999 year class. Estimated depletion never dips below the management target of 40% of unfished biomass and has recently stabilized near 47% of unfished equilibrium spawning biomass (Figure 65).

Recruitment deviations were estimated for the entire time series that was modeled (Figure 66). There is little information regarding recruitment prior to 1980, and the uncertainty in these estimates is expressed in the model. Estimates of recruitment appear to oscillate between periods of low recruitment and periods of high recruitment. The four largest recruitments (in descending order) were predicted in the years 1999, 1998, 2001, and 1988. The four smallest recruitments (in ascending order) were estimated to have occurred in 2002, 2006, 2005, and 1995. Recruitment predictions from 2002 to 2010 were all below average. Many other stock assessments of rockfish along the west coast of the U.S. have estimated a large recruitment event in 1999 (e.g., greenstriped rockfish (Hicks et al. 2009), chilipepper rockfish (Field 2007), darkblotched rockfish (Gertseva and Thorson 2013)). It may be worthwhile to investigate the periods of strong and weak year classes further to see if it is an artifact of the data, a consistent autocorrelation, or a result of the environment.

The stock-recruit curve resulting from a fixed value of steepness is shown in Figure 67 with estimated recruitments also shown. The stock is predicted to have never fallen to low levels. Consequently, there is little contrast is spawning biomass, and little expectation that reasonable estimates of steepness could be obtained.

The population numbers-at-age for each year are shown in Appendix B.

## 3.5 Uncertainty and sensitivity analyses

Three types of uncertainty are presented for the assessment of rougheye rockfish. First, uncertainty in the parameter estimates was determined using approximate asymptotic estimates of the standard error. These estimates were based on the maximum likelihood theory that the inverse of the Hessian matrix (the second derivative of the log-likelihood function with respect to the parameter vector) approaches the true uncertainty of the parameter estimates as the sample size approaches infinity. This approach takes into account the uncertainty in the data and supplies correlation estimates between parameters, but does not capture possible skewness in the error distribution of the parameters and may not accurately estimate the standard error in some cases (see Stewart et al. 2013).

The second type of uncertainty that is presented is related to modeling and structural error. This uncertainty cannot be captured in the base model as it is related to errors in the assumptions used in specifying the base model. Therefore, sensitivity analyses were conducted where assumptions were modified to reveal the effect they have on the model results.

Lastly, a major axis of uncertainty was determined from a parameter or structural assumption that results in the greatest change in stock status and advice, and projections were made for different states of nature based upon that parameter or structural assumption.

### 3.5.1 Parameter uncertainty

Parameter estimates are shown in Table 18 along with approximate asymptotic standard errors. Some selectivity parameters showed large uncertainty, indicating that they were poorly estimated. Most correlations between parameters were below an absolute value of 0.95, except for two selectivity parameters for the AFSC slope survey. Estimates of key derived parameters are given in Table 20 along with approximate 95% asymptotic confidence intervals. There is a considerable amount of uncertainty in the estimates of biomass and the coefficient of variation (CV) of the spawning biomass in 2013 and 2014 is 0.30, slightly below the default value used to calculate P* (Ralston et al. 2011). The CV of the 2013 estimate of depletion is 18.2% and 80% of the approximate normal distribution describing uncertainty around depletion is above the management target of 40% of the unfished spawning biomass.

### 3.5.2 Sensitivity analysis

Sensitivity analysis was performed to determine the model behavior under different assumptions than those of the base case model. Eight sensitivity analyses were conducted to explore the potential differences in model structure and assumptions, including

1. Downweighted age data by a factor of 0.50.
2. Downweighted age data by a factor of 0.25.
3. Allowed the model to estimate domed selectivity for fishery and surveys.
4. Specified a lognormal prior for natural mortality with a median of 0.021.
5. Specified a lognormal prior for natural mortality with a median of 0.061.
6. Fixed natural mortality at 0.021.
7. Fixed natural mortality at 0.034
8. Fixed natural mortality at 0.061.

Likelihood values and estimates of key parameters are shown in Table 22. Predicted depletion trajectories and target yield comparisons are shown in in Figure 68 and Figure 69.

The current stock status ranged from 13.7-91.1% across the sensitivity runs, with the fixed *M* sensitivities resulting in the extreme values. Downweighting the age data by a factor of 0.50 did not result in estimates that differed from the base model. This is due to the data-weighting structure in the base model which downweights the length data significantly compared to the age data. Downweighting the age data by a factor of 0.25 resulted in a depletion value of 57.5% with *M* estimated at 0.0448. This sensitivity was done to provide a comparison between the new base model with a weighting structure that resembled the initial base model prior to the updating of the sampling weights to the new preferred Francis (2011) method. The ability to estimate domed selectivity did not greatly improve the fits to the data. Allowing *M* to be estimated, but with alternative priors resulted in estimates that were similar to the base model. The results were the most sensitive to fixing natural mortality at the medians of the low and high prior distributions.

### 3.5.3 Retrospective analysis

A 5-year retrospective analysis was conducted by running the model using data only through 2008, 2009, 2010, 2011, and 2012, progressively (Table 23 and Figure 70). The scale of spawning population size was generally reduced as sequential years of data were removed until the $5^{th}$ year of data were removed, at which point the biomass increased to a very large value. This was related to changing estimates of *M* and growth as well as the considerable reduction of biological and index data in the base model. As commonly observed in other first time assessments, the bulk of the composition data (especially age data) occurs in the final years of the model. The estimates of depletion follow the same general trajectory as the base model but in the 2009-2012 retrospective runs, the estimates suggest a more depleted stock as data are removed from the model. The 2008 retrospective resulted in the highest estimates of natural mortality and maximum sizes, which resulted in population estimates of a much larger and less depleted stock than in other runs.

### 3.5.4 Likelihood profiles over key parameters

Likelihood profiles were conducted for steepness (even though it was not estimated in the base case) and over a range of natural mortality values. These likelihood profiles were conducted by fixing the parameter at specific values and removing the prior on the parameter being profiled. Without the original prior distribution the MLE estimates from the base case will likely be different than the MLE in the likelihood profile. For steepness, the negative log-likelihood was minimized near 1, but the 95% confidence interval extends down to near 0.45 (Table 24 and Figure 71). Likelihood components by data source for various values of steepness show that all but the fishery and triennial length compositions support a high steepness (Figure 72). Age data were the most influential on the estimate of steepness.

For natural mortality, the likelihood profile showed that values between 0.037 and 0.049 were within the 95% confidence interval (Table 25 and Figure 73). The change of stock status and potential yield from the upper and lower bounds of the interval covers the possibility of 37.2% depletion and yield of 153 mt to 63.0% depletion and a yield of 299 mt annually. Overall, age composition data favored natural mortality values between 0.040-0.050, except for age data from the NWFSC shelf/slope survey which favored lower values (Figure 74).

### 3.5.5 Overall assessment uncertainty

Model uncertainty has been described by the estimated uncertainty within the base model and by the sensitivities to different model structure. The parameter that resulted in the most variability of predicted status and yield advice was natural mortality (*M*), which was also estimated with much more certainty than the prior distribution implied. In fact, the 95% confidence interval for *M* was greater than and did not include the point estimate from McDermott (1994), which was used in the assessment of rougheye and blackspotted rockfishes in the Gulf of Alaska assessment (Shotwell et al. 2011), and greater than and did not include the value assumed in the analysis by Dick and MacCall (2010). There is the possibility that the base model and its approximate uncertainty intervals based on maximum likelihood theory may not entirely convey the actual uncertainty of this assessment. Preliminary (and non-converged) MCMC tests suggest that the uncertainty is greater than depicted by these results.

Therefore, to characterize uncertainty in the assessments, we used the 12.5% and 87.5% quantiles of natural mortality using a lognormal distribution with the uncertainty of the prior distribution for *M* and the base model estimated value as the median to bracket the uncertainty in the assessment (*M*= 0.0245 and 0.0853). The uncertainty from the prior distribution was chosen to ensure that it encompassed previously assumed values, and the estimate from the base model was used as the median value of the distribution so that the base model was central in the probability of these states-of-nature. The 12.5% and 87.5% quantiles were chosen based on the groundfish terms of reference to give the base model a probability that is twice as likely as the alternative states of nature (12.5% and 87.5 are the central quantiles in the tails containing 25% probability).

# 4 Reference points

Reference points were calculated using the estimates of selectivity and a fleet distribution based on the last year with catch observations (2012) and are show in Table 20. Sustainable total yields (landings plus discards) were 194 mt when using an $SPR_{50\%}$ reference harvest rate with a 95% confidence interval from 120 to 269 mt. The value for 40% of the unfished spawning biomass (analogous to $B_{40\%}$) was 2,158 metric tons. The recent catches (landings plus discards) have been below or near the estimated long-term yield calculated using an $SPR_{50\%}$ reference point. As a result, the spawning biomass of the stock has been slightly increasing over the last decade.

The predicted spawning biomass from the base model generally showed a slight decline over the entire time series with a period of steeper decline during the 1980's and 1990's (Figure 63). Since 2000, the spawning biomass has stabilized and possibly increased because of reduced catches and above average recruitment in 1999. The 2013 spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass (Figure 64). However, in the 1980's the exploitation rate and *SPR* exceeded the current estimates of the harvest rate limit ($SPR_{50\%}$), as seen in Figure 75. Recent exploitation rates on rougheye rockfish were predicted to be near target levels. In recent years, the stock has experienced exploitation rates that have been higher and lower than the target while the biomass level has remained above the target level (Figure 76).

The equilibrium yield plot is shown in Figure 77, based on a steepness value fixed at 0.779. The predicted maximum sustainable yield under the assumptions of this assessment occurs near 25% of equilibrium unfished spawning biomass.

# 5 Harvest projections and decision tables

A twelve year projection of the base model with catches in 2013 and 2014 determined from a recent 5-year average and catches from 2015–2024 based on the predicted allowable biological catch (ABC) suggests that the spawning biomass will increase over the projection period as the large estimated 1999 year class enters the fishery in higher proportions with ABCs over 200 mt by 2024. A decision table expands upon this by showing projections from 2015–2024 under ABC catches for three states of nature (defined on *M* as described in Section 3.5.5) and with status quo catches (recent 5-year average) for three states of nature. The low state of nature begins with a depletion level below the target at 39%, while the high state of nature is at more than 60% of unfished biomass in 2015, but biomass in both states of nature increases over the projection period due to the estimated high 1999 year class.

# 6 Regional management considerations

Currently, rougheye rockfish are managed as part of the minor slope rockfish complex, which has separate limits north and south of 40° 10′ N latitude. Rougheye rockfish are rare south of 40° 10′ N, but occasionally catches occur in this area. Therefore, species specific catch limits greater than zero should be determined for south of 40° 10′ N, and currently the OFL for rougheye rockfish is 0.5 mt, or less than 1% of the total 78.8 mt OFL.

In only four of the 10 years of data from the NWFSC shelf/slope survey were rougheye rockfish observed south of 40° 10′ N. In these years (2004, 2006, 2009, and 2011), the proportion of biomass estimated south of 40° 10′ N was 0.764%, 0.029%, 2.35%, and 0.022%, respectively.

Landings from the trawl and hook & line commercial fleets are broken down by state in Table 1. Since 1985, an average of 1.03 % of the landings of rougheye rockfish occurred in California with a maximum of 5.97% in 1994. For the hook & line fleet, since 1985, the average percentage of landings of rougheye rockfish in California is 2.11% with a maximum of 15.17% in 2001. This type of analysis may be misleading for a number of reasons. First, the California border is at 42° N and a majority of the landings in California occurs north of 40° 10′ N. Second, the proportion of the biomass in California may not be represented by the proportion of the coastwide landings since many other factors determine how much catch is taken. Nevertheless, these averages are an indication that at most and likely less, the proportion of biomass south of 40° 10′ N latitude is 2%. It may be worthwhile to do a more detailed analysis using the limited entry trawl fleet with 100% observer coverage, although this information is still subject to differential fishing effort by area.

The effect of the management line at 40° 10′ N latitude for rougheye rockfish is that catches south of 40° 10′ N may be seriously limited due to the small perceived rougheye rockfish biomass south of that line. Conversely, setting catch levels high enough to not be limiting south of 40° 10′ N may result in limiting catches north of 40° 10′ N. An adaptive approach of assessing the efficacy of the north and south management targets over time by monitoring survey biomass, length, and age data, while also paying attention to catch levels in each area may assist in eventually determining the proper allocation of the OFL to each area.

# 7 Research and data needs

There are many areas of research that could be improved to benefit the understanding and assessment of rougheye and blackspotted rockfishes. Below, we specifically identify five topics that we believe are most important.

- **Historical landings and discards:** The historical landings and discards are uncertain for rougheye rockfish and improvements would increase the certainty that fishing removals are applied appropriately. Because landings are assumed to be known exactly in the assessment model, uncertainty in the predictions does not include uncertainty in the landings. A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for.

- **Natural mortality:** Uncertainty in natural mortality translates into uncertain estimates of status and sustainable fishing levels for rougheye rockfish. The collection of additional age data and improved understanding of the life-history of rougheye rockfish may reduce that uncertainty.

- **Maturity and fecundity:** There are few studies on the maturity of rougheye rockfish and only one has reported the results of a histological analysis. Further research on the maturity and fecundity of rougheye rockfish, the potential differences between areas, the possibility of changes over time, and differences between rougheye rockfish and blackspotted rockfish would greatly improve the assessment of these species.

- **Age data and error:** There is a considerable amount of error in the age data and the ageing of rougheye rockfish has not been validated. Investigating the ageing error and bias would help to understand the influences that the age data have on this assessment.

- **Understanding the stock structure and biology of rougheye and blackspotted rockfishes:** This assessment reports the status of rougheye and blackspotted rockfish as a pooled complex because it is extremely difficult to separate the catches of each species even in recent data, and attempting to do so would greatly increase the uncertainty in the predictions. Because little is known about the respective biology and catch histories of the two species, it is unclear whether managing them as a complex may place one species at disproportionate risk of overfishing relative to the other. We recommend additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species. Such an endeavor would like require the efforts of at sea observers in all fleets, biologists aboard fishery-independent surveys, and port samplers along the entire West Coast requiring broad, inter-agency collaboration.

- **Basin-wide understanding of stock structure, connectivity, and distribution:** This is a stock assessment for rougheye rockfish off of the west coast of the U.S. and does not consider data from British Columbia or Alaska. Further investigating and comparing the data and predictions from British Columbia and Alaska to determine if there are similarities with the U.S. West Coast observations would help to define the connectivity between rougheye rockfish north of the U.S.-Canada border.

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# 10 Tables

**Table 1: Landings for trawl and hook & line (mt) from Washington, Oregon, and California. Catches (mt) from the Pacific whiting at-sea fishery as determined by onboard observers are also shown.**

| | TWL | | | HKL | | | At-sea | Total |
|---|---|---|---|---|---|---|---|---|
| Year | WA | OR | CA | WA | OR | CA | | |
| 1916 | 0.00 | 0.00 | 0.00 | 32.61 | 9.25 | 0.00 | 0.00 | 41.85 |
| 1917 | 0.00 | 0.00 | 0.00 | 34.32 | 9.72 | 0.00 | 0.00 | 44.04 |
| 1918 | 0.00 | 0.00 | 0.00 | 36.04 | 10.20 | 0.00 | 0.00 | 46.24 |
| 1919 | 0.00 | 0.00 | 0.00 | 37.76 | 10.67 | 0.00 | 0.00 | 48.43 |
| 1920 | 0.00 | 0.00 | 0.00 | 39.47 | 11.15 | 0.00 | 0.00 | 50.62 |
| 1921 | 0.00 | 0.00 | 0.00 | 41.19 | 11.62 | 0.00 | 0.00 | 52.81 |
| 1922 | 0.00 | 0.00 | 0.00 | 42.90 | 12.10 | 0.00 | 0.00 | 55.00 |
| 1923 | 0.00 | 0.00 | 0.00 | 44.62 | 12.57 | 0.00 | 0.00 | 57.19 |
| 1924 | 0.00 | 0.00 | 0.00 | 46.34 | 13.05 | 0.00 | 0.00 | 59.39 |
| 1925 | 0.00 | 0.00 | 0.00 | 48.05 | 13.52 | 0.00 | 0.00 | 61.58 |
| 1926 | 0.00 | 0.00 | 0.00 | 49.77 | 14.00 | 0.00 | 0.00 | 63.77 |
| 1927 | 0.00 | 0.00 | 0.00 | 51.48 | 14.52 | 0.00 | 0.00 | 66.00 |
| 1928 | 0.00 | 0.00 | 0.00 | 61.19 | 24.23 | 0.00 | 0.00 | 85.42 |
| 1929 | 0.00 | 0.00 | 0.00 | 75.30 | 38.33 | 0.00 | 0.00 | 113.63 |
| 1930 | 0.00 | 0.00 | 0.00 | 69.12 | 32.15 | 0.00 | 0.00 | 101.26 |
| 1931 | 0.00 | 0.00 | 0.00 | 63.21 | 26.24 | 0.00 | 0.00 | 89.44 |
| 1932 | 0.00 | 0.00 | 0.00 | 46.63 | 9.66 | 0.00 | 0.00 | 56.30 |
| 1933 | 0.00 | 0.00 | 0.00 | 51.30 | 14.33 | 0.00 | 0.00 | 65.63 |
| 1934 | 0.01 | 0.00 | 0.00 | 53.30 | 16.34 | 0.00 | 0.00 | 69.65 |
| 1935 | 0.29 | 0.00 | 0.00 | 52.38 | 15.42 | 0.00 | 0.00 | 68.09 |
| 1936 | 0.48 | 0.01 | 0.00 | 70.63 | 33.66 | 0.00 | 0.00 | 104.77 |
| 1937 | 0.40 | 0.02 | 0.00 | 70.33 | 33.36 | 0.00 | 0.00 | 104.11 |
| 1938 | 0.46 | 0.00 | 0.00 | 57.38 | 20.41 | 0.00 | 0.00 | 78.25 |
| 1939 | 0.43 | 0.02 | 0.00 | 46.73 | 9.76 | 0.00 | 0.00 | 56.95 |
| 1940 | 0.42 | 0.50 | 0.00 | 68.98 | 32.02 | 0.00 | 0.00 | 101.92 |
| 1941 | 0.62 | 0.77 | 0.00 | 85.38 | 48.41 | 0.00 | 0.00 | 135.18 |
| 1942 | 0.86 | 1.44 | 0.00 | 121.47 | 84.50 | 0.00 | 0.00 | 208.27 |
| 1943 | 2.37 | 5.02 | 0.00 | 146.25 | 109.28 | 0.00 | 0.00 | 262.91 |
| 1944 | 3.35 | 8.80 | 0.00 | 61.20 | 24.23 | 0.00 | 0.00 | 97.58 |
| 1945 | 6.62 | 13.67 | 0.00 | 52.67 | 15.70 | 0.00 | 0.00 | 88.65 |
| 1946 | 2.40 | 8.43 | 0.00 | 59.95 | 22.99 | 0.00 | 0.00 | 93.77 |
| 1947 | 1.25 | 5.23 | 0.00 | 53.54 | 16.57 | 0.00 | 0.00 | 76.60 |
| 1948 | 2.04 | 3.47 | 0.00 | 60.69 | 23.72 | 0.00 | 0.00 | 89.92 |
| 1949 | 2.38 | 3.24 | 0.00 | 69.02 | 7.93 | 0.00 | 0.00 | 82.57 |
| 1950 | 2.28 | 3.80 | 0.00 | 45.31 | 18.99 | 0.00 | 0.00 | 70.38 |
| 1951 | 1.87 | 3.53 | 0.00 | 69.66 | 13.72 | 0.00 | 0.00 | 88.78 |
| 1952 | 2.24 | 4.66 | 0.00 | 48.64 | 6.44 | 0.00 | 0.00 | 61.98 |

**Table 2: continued**

| Year | TWL WA | TWL OR | TWL CA | HKL WA | HKL OR | HKL CA | At-sea | Total |
|---|---|---|---|---|---|---|---|---|
| 1953 | 1.94 | 3.40 | 0.00 | 20.25 | 5.68 | 0.00 | 0.00 | 31.28 |
| 1954 | 3.97 | 4.47 | 0.00 | 36.71 | 8.83 | 0.00 | 0.00 | 53.98 |
| 1955 | 3.43 | 4.18 | 0.00 | 42.17 | 6.30 | 0.00 | 0.00 | 56.08 |
| 1956 | 3.29 | 5.93 | 0.00 | 15.06 | 5.22 | 0.00 | 0.00 | 29.50 |
| 1957 | 4.46 | 7.16 | 0.00 | 25.58 | 11.45 | 0.00 | 0.00 | 48.65 |
| 1958 | 5.02 | 5.57 | 0.00 | 7.45 | 3.15 | 0.00 | 0.00 | 21.20 |
| 1959 | 2.74 | 5.37 | 0.00 | 18.05 | 5.52 | 0.00 | 0.00 | 31.68 |
| 1960 | 4.85 | 6.96 | 0.00 | 20.14 | 2.05 | 0.00 | 0.00 | 34.00 |
| 1961 | 6.14 | 7.06 | 0.00 | 11.05 | 8.73 | 0.00 | 0.00 | 32.99 |
| 1962 | 5.81 | 8.42 | 0.00 | 12.71 | 10.30 | 0.00 | 0.00 | 37.24 |
| 1963 | 4.74 | 5.79 | 0.00 | 8.23 | 6.23 | 0.00 | 0.00 | 25.00 |
| 1964 | 5.93 | 5.39 | 0.00 | 10.73 | 0.55 | 0.00 | 0.00 | 22.60 |
| 1965 | 2.18 | 16.60 | 0.00 | 8.10 | 3.01 | 0.00 | 0.00 | 29.89 |
| 1966 | 15.38 | 7.19 | 0.00 | 4.89 | 2.92 | 0.00 | 0.00 | 30.37 |
| 1967 | 7.02 | 6.37 | 0.00 | 4.18 | 7.93 | 0.00 | 0.00 | 25.50 |
| 1968 | 23.72 | 4.16 | 0.00 | 2.12 | 5.91 | 0.00 | 0.00 | 35.91 |
| 1969 | 1.10 | 8.35 | 0.00 | 6.75 | 21.22 | 0.00 | 0.00 | 37.41 |
| 1970 | 0.10 | 0.12 | 0.00 | 0.27 | 3.54 | 0.00 | 0.00 | 4.02 |
| 1971 | 3.20 | 10.55 | 0.00 | 0.00 | 0.85 | 0.00 | 0.00 | 14.60 |
| 1972 | 0.00 | 5.03 | 0.00 | 0.01 | 1.43 | 0.00 | 0.00 | 6.47 |
| 1973 | 2.80 | 2.02 | 0.00 | 0.08 | 0.16 | 0.00 | 0.00 | 5.06 |
| 1974 | 0.00 | 1.31 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 | 1.91 |
| 1975 | 2.00 | 3.11 | 0.00 | 2.01 | 0.55 | 0.00 | 3.24 | 10.91 |
| 1976 | 6.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 7.31 |
| 1977 | 0.30 | 0.00 | 0.00 | 22.98 | 0.00 | 0.00 | 1.22 | 24.50 |
| 1978 | 5.70 | 26.25 | 0.00 | 38.70 | 16.17 | 0.00 | 0.38 | 87.20 |
| 1979 | 96.60 | 14.13 | 0.00 | 41.25 | 60.26 | 0.00 | 0.78 | 213.03 |
| 1980 | 28.30 | 28.14 | 0.00 | 15.15 | 15.91 | 0.00 | 0.19 | 87.69 |
| 1981 | 15.87 | 43.68 | 0.00 | 49.00 | 47.47 | 2.09 | 2.13 | 160.25 |
| 1982 | 42.49 | 50.84 | 0.00 | 59.49 | 48.12 | 0.00 | 0.00 | 200.94 |
| 1983 | 10.27 | 44.27 | 0.00 | 72.09 | 49.45 | 0.00 | 1.23 | 177.31 |
| 1984 | 28.49 | 44.67 | 0.00 | 97.10 | 37.66 | 0.00 | 2.28 | 210.20 |
| 1985 | 40.93 | 95.48 | 0.05 | 200.35 | 69.32 | 0.00 | 0.91 | 407.05 |
| 1986 | 16.32 | 136.13 | 0.11 | 217.29 | 174.93 | 0.10 | 1.21 | 546.10 |
| 1987 | 64.92 | 130.22 | 1.00 | 337.64 | 222.12 | 0.00 | 4.23 | 760.11 |
| 1988 | 24.87 | 126.14 | 0.00 | 180.89 | 96.85 | 0.00 | 15.85 | 444.60 |
| 1989 | 44.20 | 238.23 | 0.49 | 160.12 | 40.02 | 0.14 | 0.27 | 483.48 |
| 1990 | 10.17 | 153.75 | 2.41 | 118.48 | 0.00 | 0.38 | 0.73 | 285.92 |
| 1991 | 18.67 | 169.39 | 1.27 | 97.61 | 2.10 | 0.00 | 3.99 | 293.03 |
| 1992 | 26.80 | 125.14 | 1.74 | 165.97 | 8.10 | 1.07 | 9.12 | 337.94 |

**Table 2: continued**

| | TWL | | | HKL | | | At-sea | Total |
|---|---|---|---|---|---|---|---|---|
| Year | WA | OR | CA | WA | OR | CA | | |
| 1993 | 2.46 | 140.28 | 0.00 | 279.91 | 31.24 | 0.00 | 1.50 | 455.39 |
| 1994 | 5.32 | 97.92 | 6.55 | 290.40 | 18.84 | 6.91 | 5.01 | 430.95 |
| 1995 | 42.85 | 97.68 | 4.98 | 277.19 | 122.56 | 0.70 | 2.65 | 548.62 |
| 1996 | 24.80 | 81.46 | 1.89 | 207.16 | 70.47 | 0.76 | 6.71 | 393.25 |
| 1997 | 33.54 | 64.24 | 0.21 | 156.04 | 12.69 | 0.36 | 9.73 | 276.82 |
| 1998 | 17.29 | 41.78 | 1.80 | 159.67 | 75.73 | 0.83 | 17.21 | 314.30 |
| 1999 | 18.69 | 40.78 | 0.99 | 117.77 | 4.23 | 0.00 | 8.96 | 191.42 |
| 2000 | 23.46 | 56.16 | 2.36 | 25.58 | 2.22 | 1.00 | 71.37 | 182.16 |
| 2001 | 11.53 | 63.68 | 0.37 | 13.00 | 0.81 | 2.47 | 20.69 | 112.56 |
| 2002 | 8.57 | 21.93 | 0.40 | 23.18 | 3.26 | 0.55 | 0.73 | 58.63 |
| 2003 | 9.96 | 45.25 | 0.69 | 18.33 | 2.32 | 1.25 | 2.16 | 79.95 |
| 2004 | 8.60 | 50.40 | 0.08 | 31.44 | 0.00 | 0.00 | 13.69 | 104.21 |
| 2005 | 7.15 | 38.43 | 0.05 | 40.59 | 5.31 | 3.12 | 35.95 | 130.59 |
| 2006 | 12.72 | 34.92 | 0.07 | 51.85 | 2.40 | 1.85 | 6.64 | 110.46 |
| 2007 | 12.42 | 49.35 | 0.56 | 48.55 | 2.79 | 3.11 | 29.08 | 145.85 |
| 2008 | 9.37 | 45.22 | 0.39 | 43.59 | 9.68 | 1.06 | 75.58 | 184.88 |
| 2009 | 17.16 | 51.45 | 0.30 | 76.87 | 19.60 | 5.23 | 9.30 | 179.90 |
| 2010 | 18.35 | 65.24 | 0.17 | 44.89 | 21.88 | 1.79 | 21.57 | 173.90 |
| 2011 | 10.32 | 46.79 | 0.19 | 39.67 | 17.95 | 1.95 | 80.95 | 197.83 |
| 2012 | 15.66 | 64.15 | 0.00 | 30.27 | 17.71 | 0.00 | 54.00 | 181.78 |

**Table 2: A subset of management actions of importance to the fisheries that caught rougheye rockfish.**

| Year | Management action |
|---|---|
| 1982 | Per-trip limits for bocaccio, chilipepper, splitnose, and yellowtail rockfishes |
| 1983 | Per-trip and per-week limits implemented for *Sebastes* complex coastwide (north and south of 40° N) |
| 1997 | Per-trip limits changed to monthly or bi-monthly cumulative vessel limits |
| 1999 | Dividing line between north and south management areas moved to 40° 10’ N |
| 2000 | Minor slope rockfish complex formed north and south of 40° 10’ N and is subject to bi-monthly vessel limits. New limited entry trawl gear restrictions implemented for large footrope trawl gear, small footrope trawl gear, and midwater trawl gear. |
| 2002 | Rockfish Conservation Areas (RCA) established. Large footrope gear prohibited inside 275 m. Open access trip limits revised for the minor slope rockfish complex. |
| 2005 | Selective flatfish trawl required shoreward of the RCA north of 40° 10’ N |
| 2006 | Ammendment 19 established essential fish habitat (EFH) boundaries and conservation areas. |
| 2007 | Seasonal changes of trawl RCA boundaries and periodic closures within certain latitude boundaries (e.g., north of Cape Alava at 48°10’ N. latitude to the U.S.- Canada border) started in 2007. |
| 2011 | Trawl rationalization began, establishing the IFQ fishery. |

**Table 3: Management guidelines for minor slope rockfish and rougheye rockfish north of 40° 10′ (N) and south of 40° 10′ (S). Commercial landings not including discards (mt) for rougheye rockfish are also shown.**

| | Minor Slope Rockfish Complex | | | Rougheye Rockfish | | |
|---|---|---|---|---|---|---|
| Year | OFL (mt) N, S | ABC (mt) N, S | ACL (mt) N, S | OFL (mt) N, S | ABC (mt) N, S | Commercial Landings (mt) |
| 2000 | | | | | | 182.16 |
| 2001 | | | | | | 112.56 |
| 2002 | | | | | | 58.63 |
| 2003 | | | | | | 79.95 |
| 2004 | | | 1160, 639 | | | 104.21 |
| 2005 | | | 1160, 639 | | | 130.59 |
| 2006 | | | 1160, 639 | | | 110.46 |
| 2007 | | | 1160, 626 | | | 145.85 |
| 2008 | | | 1160, 626 | | | 184.88 |
| 2009 | | | 1160, 626 | | | 179.90 |
| 2010 | | | 1160, 626 | | | 173.90 |
| 2011 | 1462, 907 | 1324, 836 | 1160, 626 | 78.3, 0.5 | 65.3, 0.4 | 197.83 |
| 2012 | 1507, 903 | 1367, 832 | 1160, 626 | 78.3, 0.5 | 65.3, 0.4 | 181.78 |

**Table 4: Depth ranges and limits of the southern latitude in the Triennial survey for the different years.**

| Years | Depth range (m) | Southern latitude |
|---|---|---|
| 1977 | 91–457 | 34.05 |
| 1980–1986 | 55–366 | 36.8 |
| 1989–1992 | 55–366 | 34.5 |
| 1995–2004 | 55–500 | 34.5 |

**Table 5. Stratifications used for the various surveys.**

**Triennial**

| Strata | Area (km2) | Depth1 | Depth2 | Latitude1 | Latitude2 |
|---|---|---|---|---|---|
| A | 20,817 | 55 | 183 | 42 | 49 |
| B | 10,687 | 183 | 549 | 42 | 49 |

**AFSC slope**

| Strata | Area (km2) | Depth1 | Depth2 | Latitude1 | Latitude2 |
|---|---|---|---|---|---|
| A | 6,885 | 183 | 549 | 43 | 46 |
| B | 2,776 | 183 | 549 | 46 | 49 |

**NWFSC slope**

| Strata | Area (km2) | Depth1 | Depth2 | Latitude1 | Latitude2 |
|---|---|---|---|---|---|
| A | 7,911 | 183 | 549 | 42 | 46 |
| B | 2,776 | 183 | 549 | 46 | 49 |

**NWFSC shelf/slope**

| Strata | Area (km2) | Depth1 | Depth2 | Latitude1 | Latitude2 |
|---|---|---|---|---|---|
| A | 20,817 | 55 | 183 | 42 | 49 |
| B | 10,687 | 183 | 549 | 42 | 49 |

**Table 6: Survey indices of abundance used in the base case model. The NWFSC consists of the NWFSC slope from 1999–2002 and the NWFSC shelf/slope from 2003–2012.**

| | Triennial | | AFSC | | NWFSC | |
|---|---|---|---|---|---|---|
| Year | Estimate (B) | SE(logB) | Estimate (B) | SE(logB) | Estimate (B) | SE(logB) |
| 1980 | 325.77 | 0.459 | | | | |
| 1981 | | | | | | |
| 1982 | | | | | | |
| 1983 | 125.38 | 0.308 | | | | |
| 1984 | | | | | | |
| 1985 | | | | | | |
| 1986 | 423.90 | 0.320 | | | | |
| 1987 | | | | | | |
| 1988 | | | | | | |
| 1989 | 326.62 | 0.301 | | | | |
| 1990 | | | | | | |
| 1991 | | | | | | |
| 1992 | 429.25 | 0.360 | | | | |
| 1993 | | | | | | |
| 1994 | | | | | | |
| 1995 | 1078.99 | 0.289 | | | | |
| 1996 | | | 427.78 | 0.302 | | |
| 1997 | | | 406.20 | 0.528 | | |
| 1998 | 579.97 | 0.326 | | | | |
| 1999 | | | 258.75 | 0.426 | 496.27 | 0.490 |
| 2000 | | | 1036.92 | 0.413 | 536.45 | 0.553 |
| 2001 | 999.44 | 0.322 | 584.98 | 0.551 | 1113.27 | 0.476 |
| 2002 | | | | | 228.42 | 0.550 |
| 2003 | | | | | 512.50 | 0.359 |
| 2004 | 761.36 | 0.325 | | | 1130.91 | 0.395 |
| 2005 | | | | | 1366.46 | 0.392 |
| 2006 | | | | | 727.52 | 0.360 |
| 2007 | | | | | 780.51 | 0.335 |
| 2008 | | | | | 1063.01 | 0.334 |
| 2009 | | | | | 1181.97 | 0.374 |
| 2010 | | | | | 1008.90 | 0.366 |
| 2011 | | | | | 1136.46 | 0.350 |
| 2012 | | | | | 681.45 | 0.410 |

**Table 7: Number of positive tows in each year for each survey. The NWFSC survey consists of the slope survey (1998–2002) and the shelf/slope survey (2003–2010).**

| | Number of tows with rougheye | | | Number of tows with lengths | | | Number of tows with ages | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | AFSC slope | Triennial | NWFSC | AFSC slope | Triennial | NWFSC | AFSC slope | Triennial | NWFSC |
| 1980 | | 18 | | | 2 | | | | |
| 1981 | | | | | | | | | |
| 1982 | | | | | | | | | |
| 1983 | | 36 | | | | | | | |
| 1984 | | | | | | | | | |
| 1985 | | | | | | | | | |
| 1986 | | 54 | | | 10 | | | | |
| 1987 | | | | | | | | | |
| 1988 | | | | | | | | | |
| 1989 | | 48 | | | 24 | | | | |
| 1990 | | | | | | | | | |
| 1991 | | | | | | | | | |
| 1992 | | 46 | | | 17 | | | | |
| 1993 | | | | | | | | | |
| 1994 | | | | | | | | | |
| 1995 | | 61 | | | 59 | | | | |
| 1996 | 26 | | | | | | | | |
| 1997 | 10 | | | 10 | | | | | |
| 1998 | | 50 | | | 50 | | | | |
| 1999 | 11 | | 15 | 11 | | | | | |
| 2000 | 12 | | 13 | 12 | | | | | |
| 2001 | 8 | 53 | 20 | 8 | 53 | | | | |
| 2002 | | | 13 | | | | | | |
| 2003 | | | 33 | | | 33 | | | 17 |
| 2004 | | 49 | 26 | | 48 | 25 | | | 25 |
| 2005 | | | 27 | | | 27 | | | 27 |
| 2006 | | | 36 | | | 34 | | | 34 |
| 2007 | | | 36 | | | 36 | | | 36 |
| 2008 | | | 37 | | | 36 | | | 36 |
| 2009 | | | 28 | | | 26 | | | 26 |
| 2010 | | | 30 | | | 29 | | | 29 |
| 2011 | | | 33 | | | 29 | | | 29 |
| 2012 | | | 24 | | | 22 | | | 21 |

**Table 8: Summary of the data from the at-sea hake observer program used to determine the catches of rougheye.**

| Year | Total Hauls | Unsampled | % Unsampled | Total Sampled Wt | Median within tow expansion factor |
|---|---|---|---|---|---|
| 1991 | 5167 | 2713 | 52.51% | 2.6185 | 1.00 |
| 1992 | 3568 | 1407 | 39.43% | 6.5402 | 1.00 |
| 1993 | 1802 | 796 | 44.17% | 1.0397 | 2.62 |
| 1994 | 3743 | 1919 | 51.27% | 3.3123 | 2.57 |
| 1995 | 2229 | 1046 | 46.93% | 1.8056 | 1.73 |
| 1996 | 2617 | 1077 | 41.15% | 4.7535 | 2.39 |
| 1997 | 2861 | 835 | 29.19% | 7.5304 | 2.53 |
| 1998 | 2969 | 573 | 19.3% | 14.4241 | 5.33 |
| 1999 | 3012 | 736 | 24.44% | 7.1991 | 2.31 |
| 2000 | 2431 | 250 | 10.28% | 64.7230 | 2.48 |
| 2001 | 2212 | 56 | 2.53% | 20.1781 | 2.71 |
| 2002 | 1764 | 10 | 0.57% | 0.7248 | 2.90 |
| 2003 | 1843 | 18 | 0.98% | 2.1349 | 2.64 |
| 2004 | 2699 | 6 | 0.22% | 13.6631 | 2.77 |
| 2005 | 3006 | 4 | 0.13% | 35.8976 | 2.03 |
| 2006 | 2933 | 48 | 1.64% | 6.5345 | 1.97 |
| 2007 | 2872 | 15 | 0.52% | 28.9273 | 1.93 |
| 2008 | 3613 | 23 | 0.64% | 75.1063 | 2.02 |
| 2009 | 1908 | 4 | 0.21% | 9.2771 | 2.03 |
| 2010 | 2493 | 1 | 0.04% | 21.5634 | 1.98 |
| 2011 | 3010 | 6 | 0.2% | 80.7842 | 2.01 |
| 2012 | 2055 | 21 | 1.02% | 53.4815 | 1.99 |

**Table 9: Mothership (MS) and catcher-processor (CP) catches (mt) of rougheye rockfish from the at-sea fleet.**

| Year | MS | CP |
|---|---|---|
| 1991 | 0.13 | 3.86 |
| 1992 | 3.07 | 6.05 |
| 1993 | 0.00 | 1.50 |
| 1994 | 0.42 | 4.59 |
| 1995 | 0.59 | 2.06 |
| 1996 | 0.43 | 6.28 |
| 1997 | 6.63 | 3.10 |
| 1998 | 1.60 | 15.61 |
| 1999 | 3.97 | 4.98 |
| 2000 | 0.87 | 70.49 |
| 2001 | 0.35 | 20.34 |
| 2002 | 0.39 | 0.34 |
| 2003 | 0.16 | 2.00 |
| 2004 | 0.02 | 13.67 |
| 2005 | 5.70 | 30.24 |
| 2006 | 0.58 | 6.06 |
| 2007 | 1.78 | 27.30 |
| 2008 | 5.93 | 69.65 |
| 2009 | 1.01 | 8.28 |
| 2010 | 4.61 | 16.95 |
| 2011 | 6.45 | 74.49 |
| 2012 | 11.58 | 42.42 |

**Table 10: Number of landings sampled for length data by gear and state. Number of tows are shown for the at-sea fleet .**

| | Trawl | | | Hook & Line | | | At-sea |
|---|---|---|---|---|---|---|---|
| Year | CA | OR | WA | CA | OR | WA | |
| 1995 | 4 | 1 | 0 | 1 | 1 | 0 | |
| 1996 | 6 | 2 | 21 | 3 | 5 | 0 | |
| 1997 | 1 | 1 | 36 | 1 | 0 | 5 | |
| 1998 | 1 | 0 | 29 | 1 | 2 | 11 | |
| 1999 | 2 | 1 | 19 | 0 | 3 | 18 | |
| 2000 | 4 | 2 | 28 | 1 | 1 | 42 | |
| 2001 | 2 | 5 | 20 | 1 | 1 | 29 | |
| 2002 | 5 | 1 | 26 | 3 | 0 | 22 | |
| 2003 | 4 | 8 | 36 | 3 | 1 | 52 | 66 |
| 2004 | 1 | 20 | 14 | 0 | 0 | 37 | 425 |
| 2005 | 1 | 20 | 9 | 13 | 5 | 42 | 461 |
| 2006 | 5 | 29 | 9 | 9 | 10 | 49 | 305 |
| 2007 | 13 | 53 | 21 | 4 | 4 | 26 | 572 |
| 2008 | 15 | 42 | 14 | 8 | 7 | 33 | 893 |
| 2009 | 11 | 64 | 14 | 11 | 14 | 27 | 284 |
| 2010 | 8 | 59 | 8 | 14 | 38 | 21 | 380 |
| 2011 | 9 | 41 | 16 | 12 | 42 | 34 | 1091 |
| 2012 | 16 | 65 | 18 | 2 | 34 | 26 | 591 |

**Table 11: Number of lengths used to calculate length compositions for each fleet and state.**

| | Trawl | | | Hook & Line | | | At-sea |
|---|---|---|---|---|---|---|---|
| Year | CA | OR | WA | CA | OR | WA | |
| 1995 | 5 | 22 | 0 | 2 | 21 | 0 | |
| 1996 | 15 | 44 | 163 | 7 | 123 | 0 | |
| 1997 | 1 | 24 | 591 | 2 | 0 | 237 | |
| 1998 | 3 | 0 | 591 | 8 | 44 | 678 | |
| 1999 | 3 | 33 | 419 | 0 | 69 | 692 | |
| 2000 | 11 | 40 | 575 | 9 | 23 | 803 | |
| 2001 | 2 | 111 | 386 | 5 | 24 | 474 | |
| 2002 | 5 | 5 | 388 | 15 | 0 | 413 | |
| 2003 | 6 | 46 | 885 | 9 | 2 | 967 | 300 |
| 2004 | 1 | 318 | 315 | 0 | 0 | 798 | 1735 |
| 2005 | 1 | 258 | 186 | 57 | 22 | 1171 | 2485 |
| 2006 | 5 | 254 | 297 | 113 | 177 | 1338 | 941 |
| 2007 | 17 | 815 | 718 | 9 | 58 | 690 | 4084 |
| 2008 | 32 | 660 | 673 | 47 | 121 | 971 | 6022 |
| 2009 | 16 | 888 | 458 | 92 | 177 | 1123 | 919 |
| 2010 | 12 | 725 | 354 | 109 | 521 | 743 | 2253 |
| 2011 | 13 | 394 | 268 | 51 | 494 | 1111 | 6961 |
| 2012 | 24 | 869 | 614 | 11 | 319 | 847 | 4284 |



**Table 12: Number of landings sampled for ages from the Oregon trawl fleet, the number of tows sampled from the at-sea fleet, and the number of ages by fleet used to calculate age-at-length proportions.**

| | Number of samples | | Number of ages | |
|---|---|---|---|---|
| Year | Trawl | At-sea | Trawl | At-sea |
| 2008 | 11 | 170 | 330 | 555 |
| 2011 | 40 | 305 | 392 | 509 |

**Table 13: Discard totals (mt) for the trawl and fixed gear fishery from 2002 to 2011. The standard error (SE) is given in log space.**

| Year | Fleet | Value | SE log |
|---|---|---|---|
| 2002 | Trawl | 14.462 | 0.3815 |
| 2003 | Trawl | 19.8433 | 0.2937 |
| 2004 | Trawl | 1.6134 | 0.6049 |
| 2005 | Trawl | 0.9774 | 0.4243 |
| 2006 | Trawl | 14.7902 | 0.4337 |
| 2007 | Trawl | 30.252 | 0.3714 |
| 2008 | Trawl | 31.6008 | 0.3128 |
| 2009 | Trawl | 51.7018 | 0.2774 |
| 2010 | Trawl | 60.2267 | 0.4091 |
| 2011 | Trawl | 0.0383 | 0.0300 |
| 2002 | Fixed | 0.7106 | 0.4634 |
| 2003 | Fixed | 2.0126 | 0.5212 |
| 2004 | Fixed | 4.1077 | 0.7641 |
| 2005 | Fixed | 6.0832 | 0.3532 |
| 2006 | Fixed | 1.2622 | 0.4824 |
| 2007 | Fixed | 8.6847 | 0.5849 |
| 2008 | Fixed | 16.8214 | 0.5212 |
| 2009 | Fixed | 1.8543 | 0.4514 |
| 2010 | Fixed | 21.3752 | 0.8215 |
| 2011 | Fixed | 7.2975 | 0.6950 |

**Table 14: Discard mean weight (kg) for the trawl and fixed gear fishery from 2002 to 2011. The coefficient of variation (CV) was determined from the samples.**

| Year | Fleet | Value | CV |
|---|---|---|---|
| 2002 | Trawl | 1.84 | 1.16 |
| 2003 | Trawl | 1.80 | 0.65 |
| 2004 | Trawl | 1.51 | 0.9 |
| 2005 | Trawl | 0.53 | 0.71 |
| 2006 | Trawl | 1.34 | 0.84 |
| 2007 | Trawl | 1.40 | 0.59 |
| 2008 | Trawl | 1.60 | 0.74 |
| 2009 | Trawl | 1.58 | 0.53 |
| 2010 | Trawl | 1.57 | 0.49 |
| 2011 | Trawl | 0.55 | 0.86 |
| 2002 | Fixed | 1.99 | 0.31 |
| 2003 | Fixed | 2.31 | 0.45 |
| 2004 | Fixed | 1.43 | 0.33 |
| 2005 | Fixed | 2.15 | 0.28 |
| 2006 | Fixed | 1.77 | 0.8 |
| 2007 | Fixed | 1.79 | 0.25 |
| 2008 | Fixed | 2.16 | 0.56 |
| 2009 | Fixed | 2.33 | 0.59 |
| 2010 | Fixed | 1.38 | 0.33 |
| 2011 | Fixed | 2.70 | 0.29 |

**Table 15: Specifications of the base assessment model for rougheye rockfish.**

| | |
|---|---|
| Starting year | 1916 |
| | |
| *Population characteristics* | |
| Maximum age | 140 |
| Genders | 1 |
| Population lengths | 10-80 cm by 2 cm bins |
| Summary biomass (mt) | Age 10+ |
| | |
| *Data characteristics* | |
| Data lengths | 10-80 cm by 2 cm bins |
| Data ages | 1-100 |
| Minimum age for growth calcs | 2 |
| Maximum age for growth calcs | 80 |
| First mature age | 5 |
| Starting year of estimated recruitment | 1900 |
| | |
| *Fishery characteristics* | |
| Fishery timing | 0.5 |
| Triennial survey timing | 0.55 |
| AFSC slope survey timing | 0.825 |
| NWFSC slope survey timing | 0.65 |
| NWFSC combo survey timing | 0.65 |
| Fishing mortality method | Discrete |
| Maximum F | 0.9 |
| Catchability | Analytical estimate |
| Fishery Selectivity | Asymptotic Double Normal |
| Triennial Survey Selectivity | Double Normal |
| AFSC Survey Selectivity | Asymptotic Double Normal |
| NWFSC Slope Survey Selectivity | Asymptotic Double Normal |
| NWFSC Combo Survey Selectivity | Asymptotic Double Normal |

**Table 16: Description of biological parameters in the base case assessment model. The lognormal (LN) prior distribution is specified with the median of the parameter and the standard deviation of the log of the parameter.**

| Parameter | Initial value | Number estimated | Bounds (low, high) | Prior distribution |
|---|---|---|---|---|
| *Biological* | | | | |
| Females: | | | | |
| Natural mortality (*M*) | 0.03365 | 1 | (0.001-0.20) | LN(0.034, 054) |
| Length at age 2 | 11 | 1 | (1-25) | |
| Length at age 80 | 57 | 1 | (40-90) | |
| von Bertalanffy K | 0.069 | 1 | (0.01-0.15) | |
| ln(SD) of length at age 2 | 0.09 | 1 | (0.03-0.20) | |
| ln(SD) of length at age 80 | 0.09 | 1 | (0.03-0.20) | |
| Maturity inflection | 43.87 | 0 | — | |
| Maturity slope | -0.3 | 0 | — | |
| Fecundity intercept | 1 | 0 | — | |
| Fecundity slope | 0 | 0 | — | |
| Length-weight intercept | 3.123 | 0 | — | |
| Length-weight slope | 9.60E-06 | 0 | — | |

**Table 17: Ageing error used in the base case model**

| True Age | Standard Deviation | True Age | Standard Deviation | True Age | Standard Deviation | True Age | Standard Deviation |
|---|---|---|---|---|---|---|---|
| **1** | 0.0873 | **41** | 5.9126 | **81** | 10.3128 | **121** | 13.6366 |
| **2** | 0.2537 | **42** | 6.0383 | **82** | 10.4078 | **122** | 13.7083 |
| **3** | 0.4190 | **43** | 6.1631 | **83** | 10.5020 | **123** | 13.7796 |
| **4** | 0.5831 | **44** | 6.2871 | **84** | 10.5957 | **124** | 13.8503 |
| **5** | 0.7461 | **45** | 6.4102 | **85** | 10.6887 | **125** | 13.9205 |
| **6** | 0.9079 | **46** | 6.5324 | **86** | 10.7810 | **126** | 13.9903 |
| **7** | 1.0686 | **47** | 6.6538 | **87** | 10.8727 | **127** | 14.0595 |
| **8** | 1.2282 | **48** | 6.7743 | **88** | 10.9637 | **128** | 14.1283 |
| **9** | 1.3866 | **49** | 6.8940 | **89** | 11.0542 | **129** | 14.1966 |
| **10** | 1.5440 | **50** | 7.0129 | **90** | 11.1439 | **130** | 14.2644 |
| **11** | 1.7002 | **51** | 7.1309 | **91** | 11.2331 | **131** | 14.3318 |
| **12** | 1.8554 | **52** | 7.2481 | **92** | 11.3216 | **132** | 14.3986 |
| **13** | 2.0094 | **53** | 7.3645 | **93** | 11.4095 | **133** | 14.4650 |
| **14** | 2.1624 | **54** | 7.4801 | **94** | 11.4968 | **134** | 14.5310 |
| **15** | 2.3144 | **55** | 7.5948 | **95** | 11.5835 | **135** | 14.5965 |
| **16** | 2.4652 | **56** | 7.7088 | **96** | 11.6696 | **136** | 14.6615 |
| **17** | 2.6150 | **57** | 7.8219 | **97** | 11.7551 | **137** | 14.7261 |
| **18** | 2.7638 | **58** | 7.9343 | **98** | 11.8400 | **138** | 14.7902 |
| **19** | 2.9115 | **59** | 8.0459 | **99** | 11.9242 | **139** | 14.8538 |
| **20** | 3.0582 | **60** | 8.1567 | **100** | 12.0079 | **140** | 14.9171 |
| **21** | 3.2039 | **61** | 8.2667 | **101** | 12.0911 | | |
| **22** | 3.3485 | **62** | 8.3760 | **102** | 12.1736 | | |
| **23** | 3.4922 | **63** | 8.4845 | **103** | 12.2555 | | |
| **24** | 3.6348 | **64** | 8.5922 | **104** | 12.3369 | | |
| **25** | 3.7764 | **65** | 8.6992 | **105** | 12.4177 | | |
| **26** | 3.9171 | **66** | 8.8055 | **106** | 12.4980 | | |
| **27** | 4.0567 | **67** | 8.9110 | **107** | 12.5777 | | |
| **28** | 4.1954 | **68** | 9.0157 | **108** | 12.6568 | | |
| **29** | 4.3331 | **69** | 9.1197 | **109** | 12.7354 | | |
| **30** | 4.4699 | **70** | 9.2230 | **110** | 12.8134 | | |
| **31** | 4.6057 | **71** | 9.3256 | **111** | 12.8909 | | |
| **32** | 4.7405 | **72** | 9.4275 | **112** | 12.9679 | | |
| **33** | 4.8745 | **73** | 9.5286 | **113** | 13.0443 | | |
| **34** | 5.0074 | **74** | 9.6291 | **114** | 13.1201 | | |
| **35** | 5.1395 | **75** | 9.7288 | **115** | 13.1955 | | |
| **36** | 5.2706 | **76** | 9.8279 | **116** | 13.2703 | | |
| **37** | 5.4008 | **77** | 9.9262 | **117** | 13.3446 | | |
| **38** | 5.5301 | **78** | 10.0239 | **118** | 13.4184 | | |
| **39** | 5.6585 | **79** | 10.1209 | **119** | 13.4916 | | |
| **40** | 5.7860 | **80** | 10.2172 | **120** | 13.5644 | | |

**Table 18: Parameter estimates and approximate asymptotic standard deviations for the base case model (from the final year for the commercial selectivity).**

| **Parameter** | **Estimate** | **SD** | | | | |
|---|---|---|---|---|---|---|
| *Stock and recruitment* | | | | | | |
| Ln(R0) | 6.19 | 0.266 | | | | |
| *Surveys* | *Catchability ln(q)* | | Extra SE | | | |
| Early triennial | 0.374 | | 0.104 | | | |
| Late triennial | | | | | | |
| AFSC | 0.068 | | 0.051 | | | |
| NWFSC Slope | 0.076 | | 0.054 | | | |
| NWFSC Combo | 0.113 | | 0.000 | | | |
| *Fisheries* | **Trawl** | | **Fixed Gear** | | **At Sea** | |
| | **Est** | **SD** | **Est** | **SD** | **Est** | **SD** |
| Length at peak selectivity | 51.01 | 1.778 | 48.39 | 1.139 | 56.03 | 2.359 |
| Ascending width | 4.06 | 0.397 | 3.20 | 0.362 | 4.20 | 0.351 |
| Initial Selectivity | -3.30 | 0.300 | -5.79 | 0.879 | NA | |
| *Surveys* | **Triennial** | | **Slope** | | **NWFSC Combo** | |
| | **Est** | **SD** | **Est** | **SD** | **Est** | **SD** |
| Length at peak selectivity | 19.51 | 2.411 | 21.63 | 16.052 | 18.24 | 4.054 |
| Width of top | -3.26 | 2.817 | | | | |
| Ascending width | 2.54 | 1.184 | -1.70 | 51.206 | 2.70 | 1.641 |
| Descending width | 3.99 | 1.069 | | | | |
| Initial selectivity | -3.01 | 1.186 | | | | |
| Final selectivity | -3.32 | 1.1724 | | | | |
| *Biological* | **Est** | **SD** | | | | |
| Natural mortality (M) | 0.0420 | 0.0034 | | | | |
| Length at age 2 | 11.1963 | 0.3346 | | | | |
| Length at age 80 | 55.1636 | 0.4979 | | | | |
| Von Bertalanffy K | 0.0812 | 0.0026 | | | | |
| SD (log) at age 2 | 0.0691 | 0.0045 | | | | |
| SD (log) at age 80 | 0.1094 | 0.0080 | | | | |

**Table 19: Likelihood components and other quantities related to the minimization of the base case model.**

| Description | Values |
|---|---|
| Nparameters | 173 |
| | |
| *Negative log-likelihoods* | |
| Total | 2299.59 |
| Indices | -11.65 |
| Length-frequency data | 220.68 |
| Age-frequency data | 2076.94 |
| Discard biomass | 14.00 |
| Discard mean weight | 0.78 |
| Recruitment | -1.28 |
| Priors | 0.08 |
| Parameter Softbound | 0.02 |

**Table 20: Estimates of key derived parameters and reference points with approximate 95% asymptotic confidence intervals.**

| **Quantity** | **Estimate** | **~95% Confidence Interval** |
|---|---|---|
| Unfished Spawning biomass (mt) | 5,394 | 3,976–6,812 |
| Unfished age 10+ biomass (mt) | 13,756 | 9,883–17,629 |
| Unfished recruitment (R0, thousands) | 485 | 291–810 |
| Depletion (2013) | 47.32 | 30.5–64.2 |
| ***Reference points based on $SB_{40\%}$*** | | |
| Proxy spawning biomass ($SB_{40\%}$) | 2,158 | 1,590–2,725 |
| SPR resulting in $SB_{40\%}$ | 44.3% | – |
| Exploitation rate resulting in $SB_{40\%}$ | 3.2% | 2.9–3.6% |
| Yield with *SPR* based on $SB_{40\%}$ (mt) | 210 | 129–290 |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 2,491 | 1,836–3,146 |
| $SPR_{proxy}$ | 50% | |
| Exploitation rate corresponding to $SPR_{proxy}$ | 2.7% | 2.4–3.0% |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 194 | 120–269 |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 1,305 | 965–1,644 |
| $SPR_{MSY}$ | 29.6% | 29.2–30.0% |
| Exploitation rate corresponding to $SPR_{MSY}$ | 5.3% | 4.7–5.8% |
| *MSY* (mt) | 230 | 142–319 |

**Table 21: Time-series of population estimates from the base case model.**

| Year | Total biomass (mt) | Spawning Biomass | Total Biomass 10+ (mt) | Depletion | Age-0 recruits | Total catch (mt) | 1-SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1916 | 14,306 | 5,395 | 13,763 | 100.0% | 489 | 41.87 | 0.091 | 0.0030 |
| 1917 | 14,267 | 5,377 | 13,724 | 99.7% | 488 | 44.06 | 0.095 | 0.0032 |
| 1918 | 14,227 | 5,360 | 13,684 | 99.4% | 488 | 46.26 | 0.100 | 0.0034 |
| 1919 | 14,186 | 5,341 | 13,643 | 99.0% | 487 | 48.45 | 0.105 | 0.0036 |
| 1920 | 14,145 | 5,322 | 13,601 | 98.7% | 486 | 50.64 | 0.109 | 0.0037 |
| 1921 | 14,102 | 5,303 | 13,559 | 98.3% | 484 | 52.83 | 0.114 | 0.0039 |
| 1922 | 14,058 | 5,283 | 13,515 | 98.0% | 483 | 55.02 | 0.119 | 0.0041 |
| 1923 | 14,014 | 5,263 | 13,471 | 97.6% | 481 | 57.21 | 0.123 | 0.0042 |
| 1924 | 13,968 | 5,243 | 13,427 | 97.2% | 479 | 59.41 | 0.128 | 0.0044 |
| 1925 | 13,922 | 5,222 | 13,381 | 96.8% | 477 | 61.60 | 0.132 | 0.0046 |
| 1926 | 13,875 | 5,201 | 13,335 | 96.4% | 475 | 63.79 | 0.137 | 0.0048 |
| 1927 | 13,826 | 5,179 | 13,288 | 96.0% | 473 | 66.02 | 0.142 | 0.0050 |
| 1928 | 13,777 | 5,158 | 13,240 | 95.6% | 471 | 85.44 | 0.178 | 0.0065 |
| 1929 | 13,710 | 5,128 | 13,174 | 95.1% | 469 | 113.65 | 0.225 | 0.0086 |
| 1930 | 13,617 | 5,088 | 13,083 | 94.3% | 466 | 101.28 | 0.207 | 0.0077 |
| 1931 | 13,537 | 5,054 | 13,006 | 93.7% | 465 | 89.46 | 0.188 | 0.0069 |
| 1932 | 13,471 | 5,026 | 12,941 | 93.2% | 463 | 56.31 | 0.126 | 0.0044 |
| 1933 | 13,438 | 5,012 | 12,910 | 92.9% | 462 | 65.65 | 0.145 | 0.0051 |
| 1934 | 13,396 | 4,994 | 12,870 | 92.6% | 461 | 69.66 | 0.153 | 0.0054 |
| 1935 | 13,350 | 4,976 | 12,827 | 92.3% | 460 | 68.10 | 0.151 | 0.0053 |
| 1936 | 13,306 | 4,959 | 12,786 | 91.9% | 460 | 104.79 | 0.217 | 0.0082 |
| 1937 | 13,228 | 4,926 | 12,709 | 91.3% | 460 | 104.12 | 0.217 | 0.0082 |
| 1938 | 13,150 | 4,895 | 12,634 | 90.8% | 461 | 78.26 | 0.172 | 0.0062 |
| 1939 | 13,099 | 4,875 | 12,585 | 90.4% | 462 | 56.95 | 0.131 | 0.0045 |
| 1940 | 13,069 | 4,864 | 12,556 | 90.2% | 464 | 101.93 | 0.215 | 0.0081 |
| 1941 | 12,996 | 4,834 | 12,484 | 89.6% | 465 | 135.19 | 0.270 | 0.0108 |
| 1942 | 12,892 | 4,791 | 12,380 | 88.8% | 468 | 208.29 | 0.370 | 0.0168 |
| 1943 | 12,719 | 4,719 | 12,207 | 87.5% | 470 | 262.94 | 0.434 | 0.0215 |
| 1944 | 12,497 | 4,625 | 11,985 | 85.7% | 473 | 97.60 | 0.219 | 0.0081 |
| 1945 | 12,440 | 4,600 | 11,927 | 85.3% | 476 | 88.69 | 0.206 | 0.0074 |
| 1946 | 12,393 | 4,580 | 11,879 | 84.9% | 480 | 93.79 | 0.214 | 0.0079 |
| 1947 | 12,342 | 4,558 | 11,827 | 84.5% | 483 | 76.61 | 0.181 | 0.0065 |
| 1948 | 12,311 | 4,543 | 11,793 | 84.2% | 488 | 89.93 | 0.207 | 0.0076 |
| 1949 | 12,268 | 4,523 | 11,747 | 83.8% | 492 | 82.59 | 0.193 | 0.0070 |
| 1950 | 12,234 | 4,506 | 11,711 | 83.5% | 496 | 70.40 | 0.170 | 0.0060 |
| 1951 | 12,214 | 4,495 | 11,688 | 83.3% | 500 | 88.80 | 0.206 | 0.0076 |
| 1952 | 12,179 | 4,477 | 11,649 | 83.0% | 503 | 62.00 | 0.154 | 0.0053 |
| 1953 | 12,172 | 4,470 | 11,638 | 82.9% | 506 | 31.30 | 0.084 | 0.0027 |

| Year | Total biomass (mt) | Spawning Biomass | Total Biomass 10+ (mt) | Depletion | Age-0 recruits | Total catch (mt) | 1-SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1954 | 12,197 | 4,476 | 11,659 | 83.0% | 509 | 53.99 | 0.137 | 0.0046 |
| 1955 | 12,202 | 4,474 | 11,659 | 82.9% | 511 | 56.11 | 0.141 | 0.0048 |
| 1956 | 12,206 | 4,471 | 11,660 | 82.9% | 511 | 29.52 | 0.080 | 0.0025 |
| 1957 | 12,239 | 4,479 | 11,688 | 83.0% | 510 | 48.66 | 0.126 | 0.0042 |
| 1958 | 12,254 | 4,480 | 11,700 | 83.1% | 508 | 21.22 | 0.060 | 0.0018 |
| 1959 | 12,298 | 4,494 | 11,740 | 83.3% | 505 | 31.70 | 0.085 | 0.0027 |
| 1960 | 12,333 | 4,503 | 11,773 | 83.5% | 500 | 34.01 | 0.091 | 0.0029 |
| 1961 | 12,368 | 4,512 | 11,805 | 83.6% | 494 | 33.01 | 0.089 | 0.0028 |
| 1962 | 12,404 | 4,522 | 11,840 | 83.8% | 488 | 37.27 | 0.099 | 0.0031 |
| 1963 | 12,437 | 4,530 | 11,872 | 84.0% | 482 | 25.01 | 0.068 | 0.0021 |
| 1964 | 12,482 | 4,545 | 11,918 | 84.3% | 476 | 22.62 | 0.062 | 0.0019 |
| 1965 | 12,529 | 4,561 | 11,968 | 84.6% | 470 | 29.92 | 0.082 | 0.0025 |
| 1966 | 12,568 | 4,575 | 12,011 | 84.8% | 465 | 128.51 | 0.298 | 0.0107 |
| 1967 | 12,509 | 4,552 | 11,956 | 84.4% | 461 | 110.62 | 0.265 | 0.0093 |
| 1968 | 12,466 | 4,537 | 11,920 | 84.1% | 459 | 83.00 | 0.210 | 0.0070 |
| 1969 | 12,451 | 4,532 | 11,910 | 84.0% | 457 | 52.45 | 0.136 | 0.0044 |
| 1970 | 12,464 | 4,539 | 11,930 | 84.1% | 458 | 21.06 | 0.060 | 0.0018 |
| 1971 | 12,507 | 4,559 | 11,978 | 84.5% | 460 | 63.68 | 0.168 | 0.0053 |
| 1972 | 12,504 | 4,562 | 11,982 | 84.6% | 466 | 74.56 | 0.192 | 0.0062 |
| 1973 | 12,489 | 4,562 | 11,971 | 84.6% | 474 | 68.14 | 0.178 | 0.0057 |
| 1974 | 12,479 | 4,564 | 11,964 | 84.6% | 479 | 46.97 | 0.128 | 0.0039 |
| 1975 | 12,487 | 4,573 | 11,975 | 84.8% | 481 | 37.94 | 0.103 | 0.0032 |
| 1976 | 12,503 | 4,585 | 11,991 | 85.0% | 483 | 19.34 | 0.056 | 0.0016 |
| 1977 | 12,536 | 4,604 | 12,023 | 85.4% | 491 | 24.50 | 0.063 | 0.0020 |
| 1978 | 12,562 | 4,619 | 12,047 | 85.6% | 495 | 87.23 | 0.205 | 0.0072 |
| 1979 | 12,526 | 4,609 | 12,008 | 85.4% | 476 | 213.14 | 0.408 | 0.0178 |
| 1980 | 12,367 | 4,547 | 11,844 | 84.3% | 445 | 87.75 | 0.215 | 0.0074 |
| 1981 | 12,332 | 4,535 | 11,805 | 84.1% | 404 | 160.30 | 0.334 | 0.0136 |
| 1982 | 12,227 | 4,493 | 11,697 | 83.3% | 367 | 201.05 | 0.397 | 0.0172 |
| 1983 | 12,082 | 4,434 | 11,553 | 82.2% | 355 | 177.37 | 0.361 | 0.0154 |
| 1984 | 11,964 | 4,384 | 11,438 | 81.3% | 359 | 210.27 | 0.410 | 0.0184 |
| 1985 | 11,812 | 4,321 | 11,294 | 80.1% | 371 | 407.20 | 0.598 | 0.0361 |
| 1986 | 11,469 | 4,179 | 10,962 | 77.5% | 393 | 546.27 | 0.682 | 0.0498 |
| 1987 | 10,995 | 3,982 | 10,506 | 73.8% | 456 | 760.34 | 0.771 | 0.0724 |
| 1988 | 10,322 | 3,702 | 9,855 | 68.6% | 628 | 444.77 | 0.661 | 0.0451 |
| 1989 | 9,964 | 3,554 | 9,519 | 65.9% | 598 | 483.81 | 0.714 | 0.0508 |
| 1990 | 9,568 | 3,397 | 9,139 | 63.0% | 536 | 286.11 | 0.577 | 0.0313 |
| 1991 | 9,374 | 3,319 | 8,945 | 61.5% | 494 | 293.26 | 0.594 | 0.0328 |
| 1992 | 9,179 | 3,240 | 8,733 | 60.1% | 454 | 338.12 | 0.629 | 0.0387 |

| Year | Total biomass (mt) | Spawning Biomass | Total Biomass 10+ (mt) | Depletion | Age-0 recruits | Total catch (mt) | 1-SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1993 | 8,950 | 3,144 | 8,476 | 58.3% | 406 | 455.56 | 0.707 | 0.0537 |
| 1994 | 8,616 | 3,000 | 8,109 | 55.6% | 312 | 431.08 | 0.699 | 0.0532 |
| 1995 | 8,318 | 2,867 | 7,775 | 53.1% | 307 | 548.79 | 0.768 | 0.0706 |
| 1996 | 7,916 | 2,689 | 7,339 | 49.8% | 381 | 393.39 | 0.704 | 0.0536 |
| 1997 | 7,674 | 2,574 | 7,083 | 47.7% | 404 | 276.95 | 0.626 | 0.0391 |
| 1998 | 7,558 | 2,507 | 7,004 | 46.5% | 898 | 314.40 | 0.654 | 0.0449 |
| 1999 | 7,432 | 2,428 | 6,895 | 45.0% | 2209 | 191.51 | 0.534 | 0.0278 |
| 2000 | 7,398 | 2,400 | 6,898 | 44.5% | 526 | 200.01 | 0.541 | 0.0290 |
| 2001 | 7,377 | 2,376 | 6,889 | 44.1% | 846 | 128.25 | 0.433 | 0.0186 |
| 2002 | 7,450 | 2,384 | 6,938 | 44.2% | 239 | 64.58 | 0.259 | 0.0093 |
| 2003 | 7,610 | 2,417 | 7,036 | 44.8% | 426 | 88.70 | 0.321 | 0.0126 |
| 2004 | 7,771 | 2,444 | 7,079 | 45.3% | 355 | 114.12 | 0.375 | 0.0161 |
| 2005 | 7,919 | 2,464 | 7,093 | 45.7% | 282 | 140.19 | 0.420 | 0.0198 |
| 2006 | 8,054 | 2,477 | 7,102 | 45.9% | 282 | 120.89 | 0.387 | 0.0170 |
| 2007 | 8,212 | 2,499 | 7,134 | 46.3% | 385 | 186.79 | 0.493 | 0.0262 |
| 2008 | 8,306 | 2,498 | 7,268 | 46.3% | 385 | 221.61 | 0.531 | 0.0305 |
| 2009 | 8,365 | 2,489 | 7,825 | 46.1% | 358 | 228.72 | 0.550 | 0.0292 |
| 2010 | 8,406 | 2,483 | 7,899 | 46.0% | 328 | 229.39 | 0.551 | 0.0290 |
| 2011 | 8,441 | 2,487 | 8,077 | 46.1% | 452 | 202.42 | 0.510 | 0.0251 |
| 2012 | 8,494 | 2,511 | 8,097 | 46.6% | 449 | 185.51 | 0.490 | 0.0229 |
| 2013 | 8,550 | 2,552 | 8,176 | 47.3% | 450 | NA | NA | NA |

**Table 22: Quantities of interest from the sensitivity analyses.**

| | Base | Age (0.50) | Age (0.25) | Domed Selectivity | Low Prior *M* | High Prior *M* | *M*=0.021 | *M*=0.034 | *M*=0.061 |
|---|---|---|---|---|---|---|---|---|---|
| Steepness (*h*) | 0.779 | 0.779 | 0.779 | 0.779 | 0.779 | 0.779 | 0.779 | 0.779 | 0.779 |
| Natural Mortality (*M*) | 0.0420 | 0.0415 | 0.0448 | 0.0419 | 0.0414 | 0.0432 | 0.0213 | 0.0337 | 0.0605 |
| lnR0 | 6.19 | 6.19 | 6.52 | 6.18 | 6.15 | 6.10 | 4.80 | 5.61 | 8.76 |
| SB0 | 5,394 | 5,379 | 6,384 | 5,412 | 5,321 | 4,869 | 4,165 | 4,542 | 33,412 |
| SB2013 | 2,552 | 2,545 | 3,711 | 2,566 | 2,478 | 2,429 | 571 | 1,417 | 30,431 |
| Depl2013 | 47.3% | 47.3% | 57.5% | 47.4% | 46.6% | 49.9% | 13.7% | 31.2% | 91.1% |
| Yield_SPR | 194 | 198 | 260 | 194 | 190 | 174 | 80 | 133 | 1715 |
| SPR2012 | 0.510 | 0.519 | 0.708 | 0.510 | 0.500 | 0.500 | 0.102 | 0.312 | 0.949 |
| Q Triennial Early | 0.374 | 0.387 | 0.279 | 0.337 | 0.320 | 0.321 | 1.136 | 0.613 | 0.028 |
| Q Triennial Late | 0.383 | 0.433 | 0.390 | 0.355 | 0.337 | 0.426 | 1.516 | 0.678 | 0.028 |
| Q AKFSC Slope | 0.068 | 0.066 | 0.045 | 0.105 | 0.069 | 0.067 | 0.180 | 0.108 | 0.006 |
| Q NWFSC Slope | 0.076 | 0.075 | 0.051 | 0.116 | 0.078 | 0.075 | 0.220 | 0.125 | 0.007 |
| Q NWFSC Slope/Shelf | 0.113 | 0.114 | 0.081 | 0.113 | 0.117 | 0.121 | 0.389 | 0.192 | 0.010 |
| Likelihood | 2,300 | 1,256 | 725 | 2,299 | 2,303 | 2,354 | 2,338 | 2,304 | 2,321 |
| Triennial | -3.11 | -3.24 | -3.54 | -3.12 | -3.13 | -3.28 | -2.39 | -2.82 | -3.73 |
| AKSC Slope | -1.15 | -1.16 | -1.19 | -1.22 | -1.15 | -1.14 | -0.74 | -1.03 | -1.29 |
| NWFSC Slope | -0.27 | -0.27 | -2.77 | -0.26 | -0.26 | -0.28 | -0.27 | -0.26 | -0.28 |
| NWFSC Shelf/Slope | -7.12 | -7.07 | -6.98 | -7.12 | -7.11 | -6.98 | -6.50 | -7.05 | -7.12 |
| Length TRAWL | 115.36 | 111.12 | 107.57 | 115.55 | 115.37 | 119.88 | 114.73 | 114.44 | 129.12 |
| Length FIXED | 45.27 | 40.05 | 36.13 | 45.60 | 44.92 | 87.43 | 47.01 | 45.31 | 45.56 |
| Length ASF | 8.19 | 7.63 | 7.43 | 8.15 | 8.19 | 8.46 | 8.42 | 8.22 | 8.25 |
| Length Triennial | 15.27 | 14.65 | 14.76 | 15.83 | 17.49 | 16.01 | 14.87 | 15.13 | 16.05 |
| Length AKFSC Slope | 4.46 | 4.25 | 4.19 | 3.67 | 4.66 | 4.79 | 4.53 | 4.46 | 4.60 |
| Length NWFSC Shelf/Slope | 32.13 | 31.06 | 32.21 | 31.90 | 32.21 | 30.09 | 33.16 | 32.47 | 31.71 |
| Age TRAWL | 330.63 | 333.51 | 334.32 | 330.65 | 330.81 | 329.49 | 340.77 | 332.74 | 329.87 |
| Age ASF | 356.15 | 364.18 | 371.28 | 356.10 | 356.26 | 355.56 | 368.47 | 357.73 | 358.20 |
| Age NWFSC Shelf/Slope | 1390.16 | 1405.26 | 1430.06 | 1389.85 | 1390.59 | 1389.99 | 1392.05 | 1389.56 | 1393.95 |
| Discards | 14.01 | 14.07 | 14.30 | 14.01 | 14.01 | 20.80 | 14.43 | 14.06 | 13.75 |
| Discard weights | 0.78 | 0.86 | 1.19 | 0.79 | 0.78 | 4.03 | 1.12 | 0.84 | 0.72 |

**Table 23: Results from retrospective runs, sequentially removing data over the last five years using the base case assumptions.**

| Year Assessed | Last year of data | Unfished Spawning Biomass | 2008 Spawning Biomass | 2008 Depletion | 2013 Depletion | Yield $SPR_{50\%}$ | *M* |
|---|---|---|---|---|---|---|---|
| 2013 | 2012 | 10,788 | 4,996 | 46.32% | 47.32% | 194 | 0.0420 |
| 2012 | 2011 | 10,427 | 4,642 | 44.73% | 45.66% | 189 | 0.0417 |
| 2011 | 2010 | 9,647 | 3,941 | 40.85% | 41.28% | 179 | 0.0413 |
| 2010 | 2009 | 9,893 | 4,293 | 43.40% | 44.06% | 192 | 0.0430 |
| 2009 | 2008 | 9,102 | 3,486 | 38.30% | 38.90% | 175 | 0.0420 |
| 2008 | 2007 | 18,160 | 13,286 | 73.16% | 75.72% | 462 | 0.0490 |

**Table 24: Quantities of interest when profiling over steepness values**

| *h* | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 | 0.99 |
|---|---|---|---|---|---|---|---|---|---|
| *M* | 0.0461 | 0.0451 | 0.0438 | 0.0431 | 0.0426 | 0.0422 | 0.0420 | 0.0418 | 0.0416 |
| lnR0 | 6.44 | 6.38 | 6.30 | 6.25 | 6.22 | 6.20 | 6.18 | 6.17 | 6.16 |
| SB0 | 5,876 | 5,751 | 5,596 | 5,508 | 5,452 | 5,415 | 5,389 | 5,370 | 5,356 |
| SB2013 | 2,062 | 2,179 | 2,320 | 2,409 | 2,472 | 2,521 | 2,560 | 2,591 | 2,615 |
| Depl2013 | 35.1% | 37.9% | 41.5% | 43.7% | 45.3% | 46.6% | 47.5% | 48.3% | 48.8% |
| Yield_SPR | 0 | 0 | 90 | 146 | 172 | 187 | 196 | 203 | 207 |
| SPR2012 | 0.483 | 0.491 | 0.498 | 0.503 | 0.506 | 0.508 | 0.510 | 0.512 | 0.513 |
| Q Triennial Early | 0.375 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.374 | 0.373 |
| Q Triennial Late | 0.487 | 0.460 | 0.429 | 0.410 | 0.398 | 0.388 | 0.381 | 0.376 | 0.372 |
| Q AKFSC Slope | 0.073 | 0.071 | 0.070 | 0.069 | 0.068 | 0.068 | 0.068 | 0.067 | 0.067 |
| Q NWFSC Slope | 0.083 | 0.081 | 0.079 | 0.078 | 0.077 | 0.077 | 0.076 | 0.076 | 0.075 |
| Q NWFSC Slope/Shelf | 0.137 | 0.131 | 0.124 | 0.119 | 0.117 | 0.115 | 0.113 | 0.112 | 0.111 |
| | | | | | | | | | |
| Likelihood | 2,304 | 2,303 | 2,301 | 2,301 | 2,300 | 2,300 | 2,300 | 2,299 | 2,299 |
| Triennial | -2.91 | -2.97 | -3.03 | -3.06 | -3.08 | -3.10 | -3.11 | -3.12 | -3.12 |
| AKSC Slope | -1.06 | -1.09 | -1.11 | -1.13 | -1.14 | -1.15 | -1.16 | -1.16 | -1.16 |
| NWFSC Slope | -0.28 | -0.28 | -0.27 | -0.27 | -0.27 | -0.27 | -0.27 | -0.26 | -0.26 |
| NWFSC Shelf/Slope | -6.91 | -6.97 | -7.04 | -7.07 | -7.10 | -7.11 | -7.12 | -7.13 | -7.14 |
| Length TRAWL | 115.21 | 115.26 | 115.32 | 115.35 | 115.36 | 115.36 | 115.36 | 115.36 | 115.36 |
| Length FIXED | 45.92 | 45.77 | 45.57 | 45.44 | 45.36 | 45.30 | 45.26 | 45.23 | 45.21 |
| Length ASF | 8.15 | 8.15 | 8.17 | 8.18 | 8.18 | 8.19 | 8.19 | 8.20 | 8.20 |
| Length Triennial | 15.33 | 15.32 | 15.30 | 15.29 | 15.28 | 15.27 | 15.27 | 15.26 | 15.26 |
| Length AKFSC Slope | 4.51 | 4.50 | 4.48 | 4.47 | 4.46 | 4.46 | 4.46 | 4.46 | 4.45 |
| Length NWFSC Shelf/Slope | 31.56 | 31.59 | 31.72 | 31.85 | 31.97 | 32.06 | 32.14 | 32.21 | 32.26 |
| Age TRAWL | 330.29 | 330.35 | 330.45 | 330.52 | 330.57 | 330.61 | 330.64 | 330.66 | 330.68 |
| Age ASF | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Age NWFSC Shelf/Slope | 357.43 | 357.16 | 356.78 | 356.54 | 356.36 | 356.23 | 356.14 | 356.06 | 356.00 |
| Discards | 1,390.21 | 1,390.18 | 1,390.16 | 1,390.15 | 1,390.15 | 1,390.15 | 1,390.16 | 1,390.16 | 1,390.16 |
| Discard weights | 13.96 | 13.97 | 13.99 | 13.99 | 14.00 | 14.00 | 14.01 | 14.01 | 14.01 |

**Table 25: Quantities of interest when profiling over natural mortality values.**

| *M* | 0.036 | 0.038 | 0.040 | 0.042 | 0.044 | 0.046 | 0.048 | 0.05 |
|---|---|---|---|---|---|---|---|---|
| lnR0 | 5.77 | 5.90 | 6.04 | 6.18 | 6.34 | 6.50 | 6.67 | 6.87 |
| SB0 | 4,709 | 4,888 | 5,112 | 5,391 | 5,743 | 6,195 | 6,788 | 7,589 |
| SB2013 | 1,668 | 1,916 | 2,206 | 2,549 | 2,962 | 3,470 | 4,114 | 4,961 |
| Depl2013 | 35.4% | 39.2% | 43.2% | 47.3% | 51.6% | 56.0% | 60.6% | 65.4% |
| Yield_SPR | 147 | 160 | 176 | 194 | 216 | 243.614 | 278 | 324 |
| SPR2012 | 0.365 | 0.412 | 0.460 | 0.510 | 0.560 | 0.610 | 0.660 | 0.710 |
| Q Triennial Early | 0.539 | 0.481 | 0.426 | 0.374 | 0.326 | 0.280 | 0.237 | 0.197 |
| Q Triennial Late | 0.581 | 0.508 | 0.442 | 0.383 | 0.330 | 0.281 | 0.236 | 0.195 |
| Q AKFSC Slope | 0.096 | 0.086 | 0.077 | 0.068 | 0.059 | 0.051 | 0.044 | 0.037 |
| Q NWFSC Slope | 0.110 | 0.098 | 0.087 | 0.076 | 0.067 | 0.057 | 0.049 | 0.041 |
| Q NWFSC Slope/Shelf | 0.167 | 0.147 | 0.130 | 0.113 | 0.099 | 0.085 | 0.072 | 0.056 |
| | | | | | | | | |
| Likelihood | 2,301.46 | 2,300.35 | 2,299.72 | 2,299.50 | 2,299.63 | 2300.04 | 2300.70 | 2301.57 |
| Triennial | -2.90 | -2.97 | -3.04 | -3.11 | -3.17 | -3.24 | -3.31 | -3.38 |
| AKSC Slope | -1.07 | -1.10 | -1.13 | -1.15 | -1.18 | -1.19 | -1.21 | -1.22 |
| NWFSC Slope | -0.26 | -0.26 | -0.26 | -0.27 | -0.27 | -0.27 | -0.27 | -0.27 |
| NWFSC Shelf/Slope | -7.08 | -7.10 | -7.11 | -7.12 | -7.13 | -7.13 | -7.13 | -7.13 |
| Length TRAWL | 114.69 | 114.91 | 115.14 | 115.36 | 115.58 | 115.79 | 116.01 | 116.21 |
| Length FIXED | 45.24 | 45.22 | 45.23 | 45.27 | 45.32 | 45.39 | 45.48 | 45.58 |
| Length ASF | 8.21 | 8.20 | 8.20 | 8.19 | 8.19 | 8.19 | 8.19 | 8.19 |
| Length Triennial | 15.17 | 15.20 | 15.24 | 15.27 | 15.30 | 15.32 | 15.35 | 15.37 |
| Length AKFSC Slope | 4.45 | 4.45 | 4.46 | 4.46 | 4.46 | 4.47 | 4.47 | 4.48 |
| Length NWFSC Shelf/Slope | 32.38 | 32.30 | 32.21 | 32.13 | 32.04 | 31.96 | 31.87 | 31.79 |
| Age TRAWL | 32.38 | 32.30 | 32.21 | 32.13 | 32.04 | 31.96 | 31.87 | 31.79 |
| Age ASF | 331.97 | 331.44 | 330.99 | 330.64 | 330.35 | 330.12 | 329.94 | 329.81 |
| Age NWFSC Shelf/Slope | 357.02 | 356.60 | 356.32 | 356.16 | 356.10 | 356.13 | 356.23 | 356.40 |
| Discards | 1389.61 | 1389.73 | 1389.92 | 1390.15 | 1390.43 | 1390.75 | 1391.10 | 1391.48 |
| Discard weights | 14.04 | 14.02 | 14.01 | 14.01 | 14.00 | 14.00 | 14.00 | 14.00 |

**Table 26: Projection of potential OFL, landings, and catch, summary biomass (age-10 and older), spawning biomass, and depletion for the base case model projected with total catch equal to the recent 5-year average in 2013 and 2014, and equal to the predicted OFL afterwards. The predicted OFL is the calculated total catch determined by $F_{SPR=50\%}$.**

| Year | Predicted OFL (mt) | ABC Catch (mt) | Landings (mt) | Age 10+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | | | 184 | 8,176 | 2,552 | 47.3% |
| 2014 | | | 184 | 8,220 | 2,600 | 48.2% |
| 2015 | 206 | 197 | 191 | 8,227 | 2,653 | 49.2% |
| 2016 | 210 | 201 | 196 | 8,211 | 2,703 | 50.1% |
| 2017 | 215 | 205 | 200 | 8,209 | 2,749 | 51.0% |
| 2018 | 219 | 209 | 203 | 8,194 | 2,787 | 51.7% |
| 2019 | 222 | 212 | 206 | 8,157 | 2,816 | 52.2% |
| 2020 | 224 | 215 | 209 | 8,098 | 2,835 | 52.6% |
| 2021 | 226 | 216 | 210 | 8,068 | 2,845 | 52.7% |
| 2022 | 227 | 217 | 211 | 8,032 | 2,846 | 52.8% |
| 2023 | 226 | 216 | 211 | 7,994 | 2,840 | 52.7% |
| 2024 | 226 | 216 | 210 | 7,955 | 2,829 | 52.4% |

**Table 27: Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis of uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained). Catches in 2013 and 2014 are determined from 5 year averages of the landings for each fleet (trawl, hook & line, and at-sea), and are also used as status quo catches.**

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low *M* = 0.037 | | Base case *M* estimated at 0.042 | | High *M* = 0.047 | |
| **Relative probability of ln(SB_2013)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| ABC assuming σ = 0.36 | 2015 | 194 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 198 | 1,886 | 39% | 2,704 | 50% | 3,857 | 61% |
| | 2017 | 202 | 1,914 | 40% | 2,751 | 51% | 3,928 | 62% |
| | 2018 | 206 | 1,936 | 40% | 2,791 | 52% | 3,987 | 63% |
| | 2019 | 209 | 1,952 | 41% | 2,821 | 52% | 4,034 | 64% |
| | 2020 | 212 | 1,959 | 41% | 2,841 | 53% | 4,068 | 64% |
| | 2021 | 213 | 1,960 | 41% | 2,852 | 53% | 4,088 | 65% |
| | 2022 | 214 | 1,954 | 41% | 2,855 | 53% | 4,098 | 65% |
| | 2023 | 214 | 1,943 | 41% | 2,850 | 53% | 4,097 | 65% |
| | 2024 | 214 | 1,928 | 40% | 2,840 | 53% | 4,090 | 65% |
| Recent 5-year average of catches | 2015 | 189 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 189 | 1,888 | 39% | 2,706 | 50% | 3,859 | 61% |
| | 2017 | 189 | 1,919 | 40% | 2,756 | 51% | 3,933 | 62% |
| | 2018 | 189 | 1,946 | 41% | 2,801 | 52% | 3,997 | 63% |
| | 2019 | 189 | 1,968 | 41% | 2,837 | 53% | 4,051 | 64% |
| | 2020 | 189 | 1,983 | 41% | 2,865 | 53% | 4,091 | 65% |
| | 2021 | 189 | 1,992 | 42% | 2,884 | 53% | 4,120 | 65% |
| | 2022 | 189 | 1,995 | 42% | 2,895 | 54% | 4,138 | 65% |
| | 2023 | 189 | 1,993 | 42% | 2,900 | 54% | 4,147 | 65% |
| | 2024 | 189 | 1,987 | 41% | 2,899 | 54% | 4,148 | 65% |
| Catch that stabilizes equilibrium depletion at 40% in the base model | 2015 | 258 | 1,855 | 39% | 2,653 | 49% | 3,779 | 60% |
| | 2016 | 261 | 1,862 | 39% | 2,680 | 50% | 3,833 | 61% |
| | 2017 | 265 | 1,867 | 39% | 2,704 | 50% | 3,880 | 61% |
| | 2018 | 267 | 1,866 | 39% | 2,720 | 50% | 3,917 | 62% |
| | 2019 | 269 | 1,859 | 39% | 2,728 | 51% | 3,942 | 62% |
| | 2020 | 270 | 1,844 | 38% | 2,726 | 51% | 3,954 | 62% |
| | 2021 | 270 | 1,823 | 38% | 2,715 | 50% | 3,953 | 62% |
| | 2022 | 269 | 1,796 | 37% | 2,697 | 50% | 3,942 | 62% |
| | 2023 | 267 | 1,764 | 37% | 2,673 | 50% | 3,923 | 62% |
| | 2024 | 264 | 1,730 | 36% | 2,644 | 49% | 3,897 | 62% |

## 11 Figures

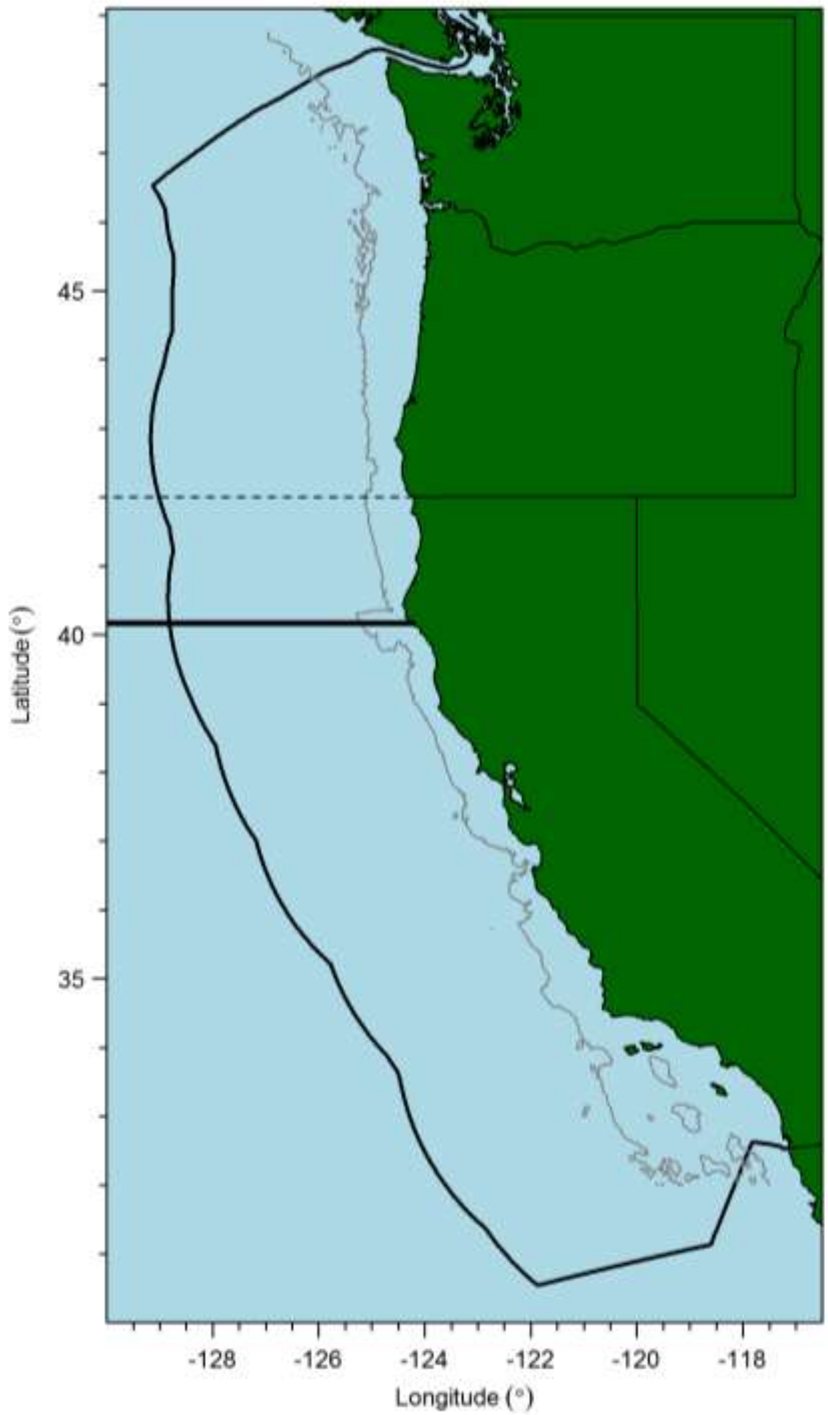



**Figure 1: A map of the west coast of the U.S. with the EEZ and the 40° 10' line that divides rougheye management into northern and southern regions. Survey data north of the dashed line at 42° were used to create an index of abundance for rougheye rockfish.**

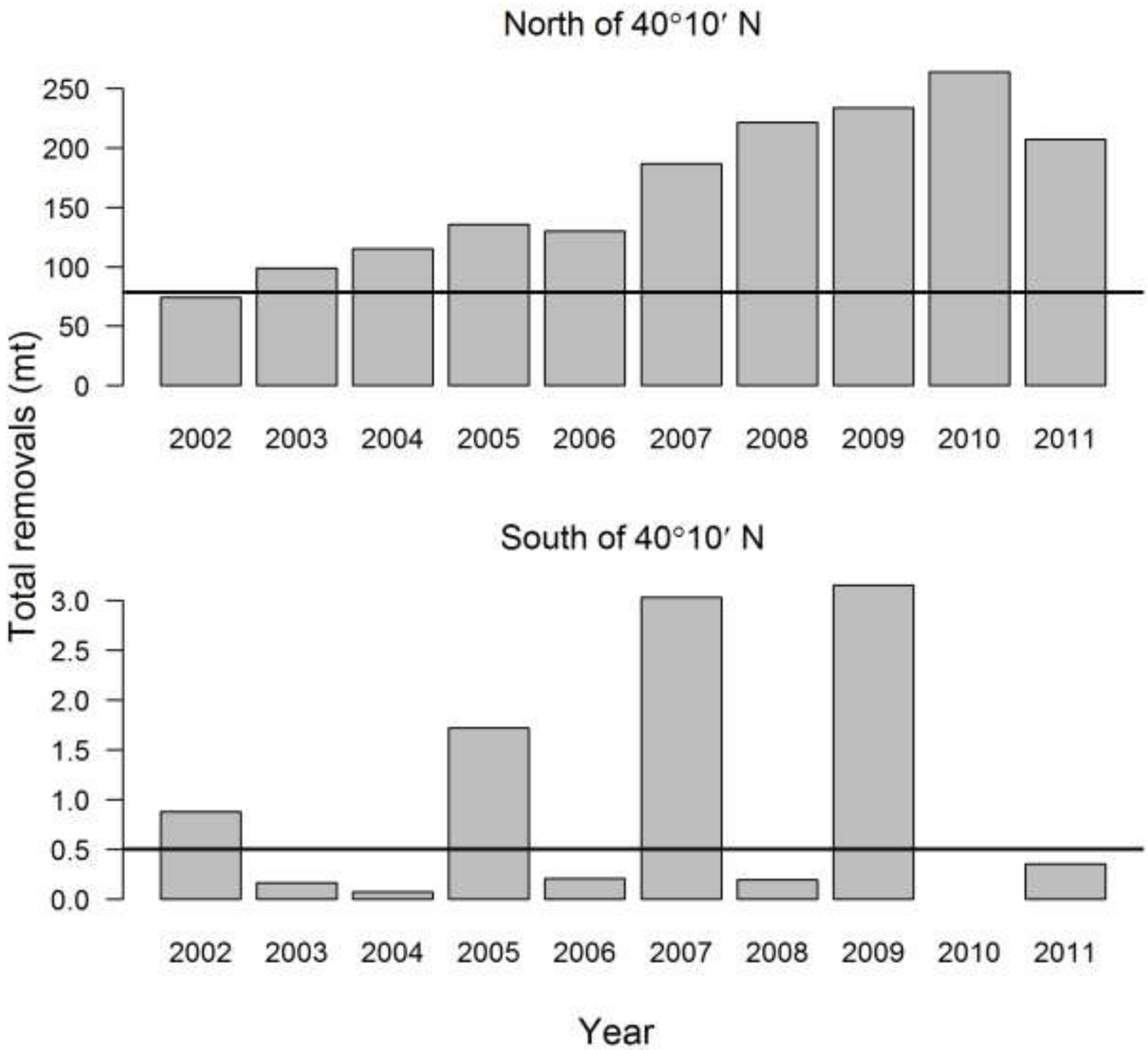



**Figure 2: Total removals north of 40° 10' N (top) and south of 40° 10' N (bottom) as estimated in the groundfish mortality report (pers. comm., Marlene Bellman, NWFSC) for 2002 to 2011. The horizontal line represents the rougheye specific OFL for 2011 and 2012.**

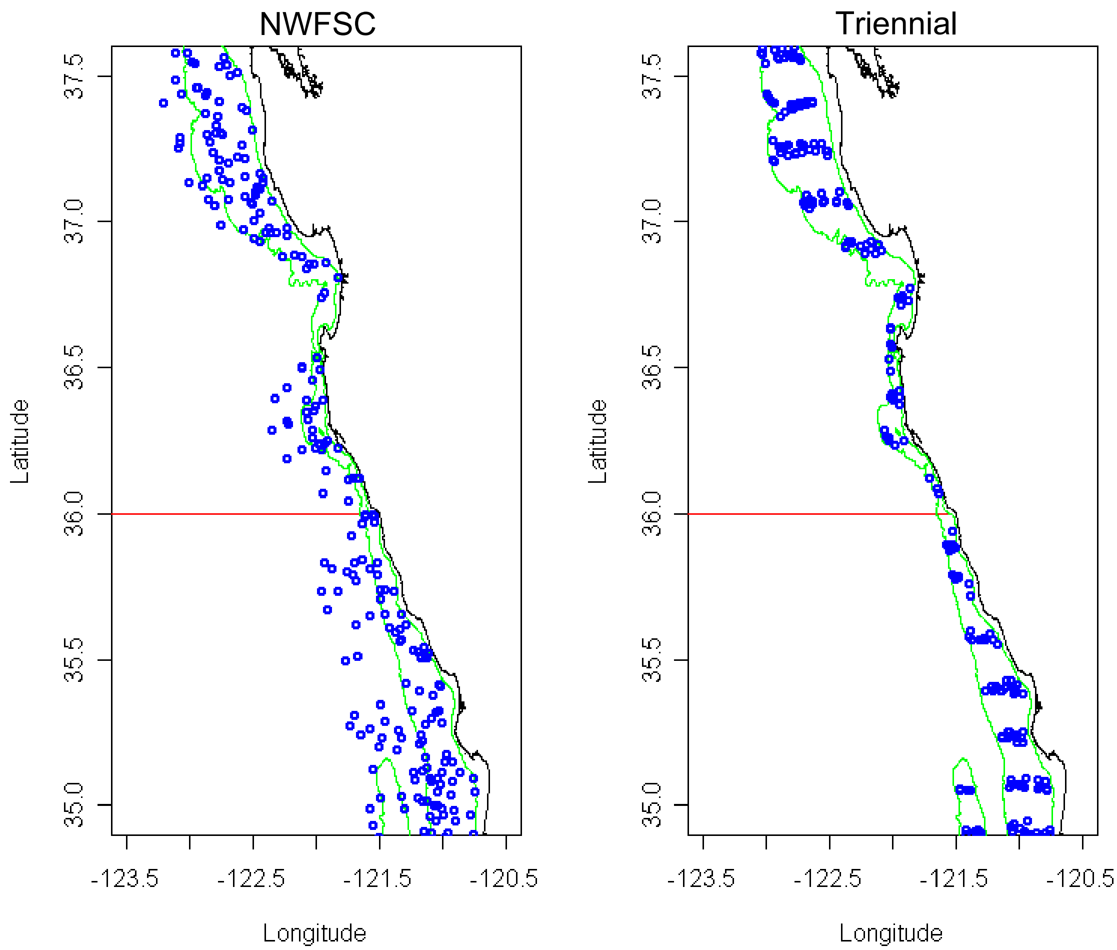


**Figure 3: Survey tow locations in 2004, showing the difference in station design for the NWFSC survey relative to the Triennial trawl survey (Figure from Stewart (2007)).**

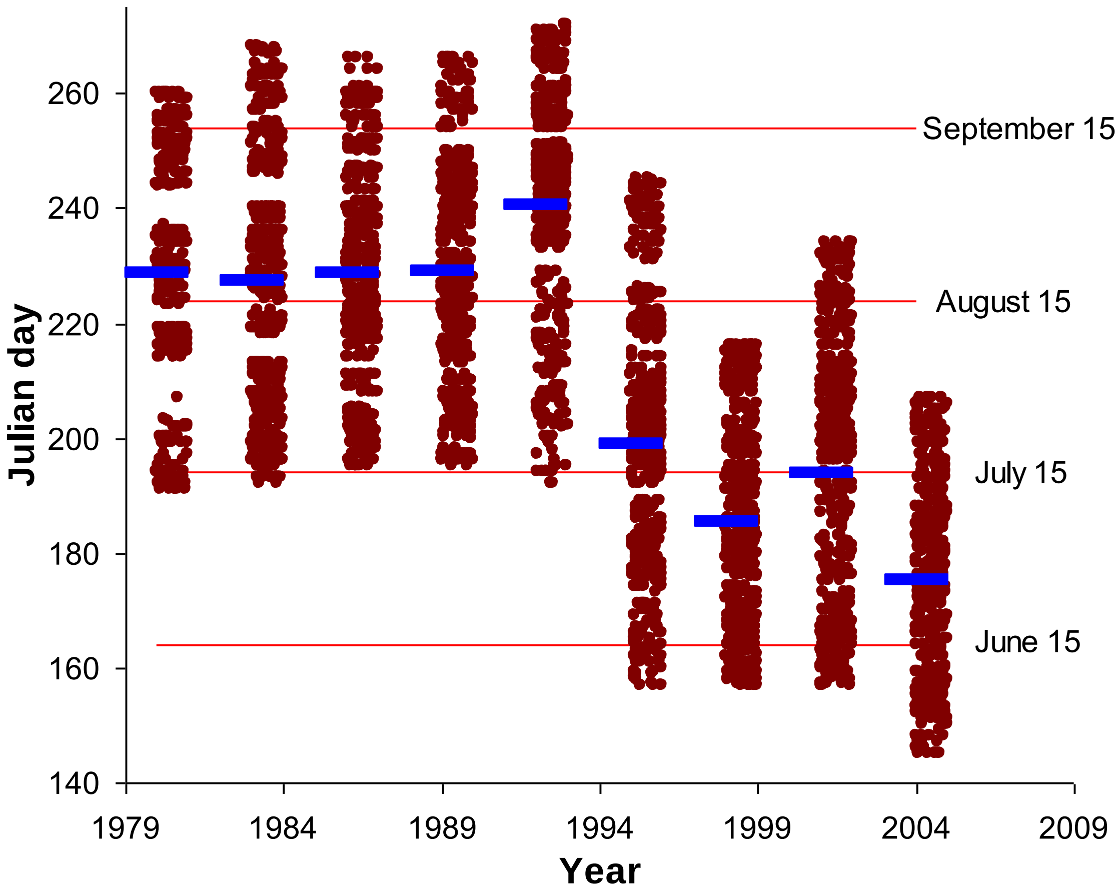



**Figure 4: Distribution of dates of operation for the triennial survey (1980-2004). Solid bars show the mean date for each survey year, points represent individual hauls dates, but are jittered to allow better delineation of the distribution of individual points (Figure from (Stewart 2007)).**

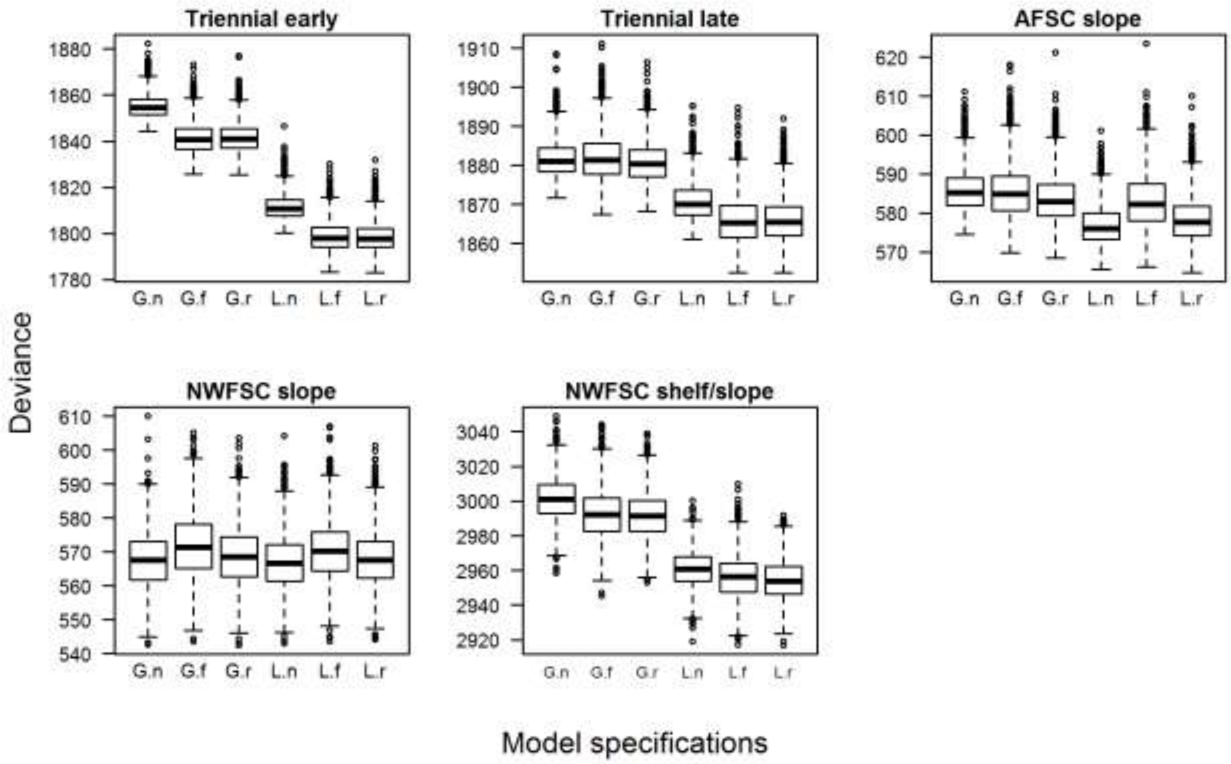



**Figure 5: Deviance from six assumptions in the GLMM model for the five surveys. "G" refers to the gamma distribution and "L" refers to the lognormal distribution. No stratum effects, fixed stratum effects, and random stratum effects are notated with "n", "f", "r", respectively.**

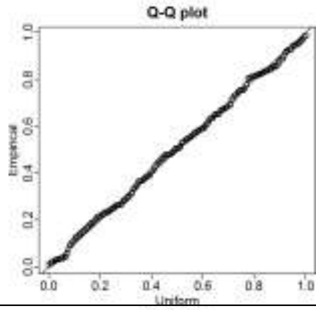
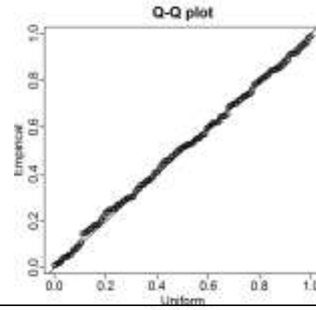
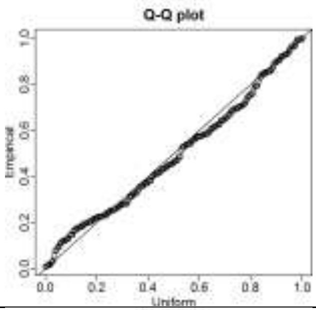
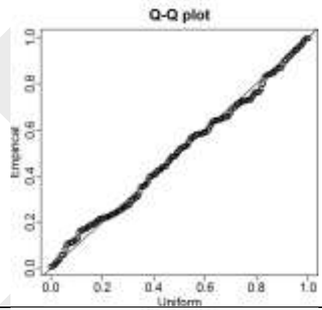
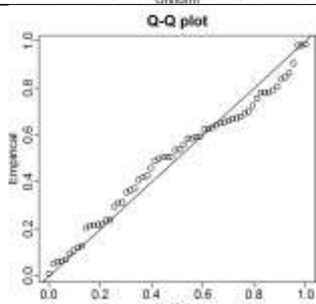
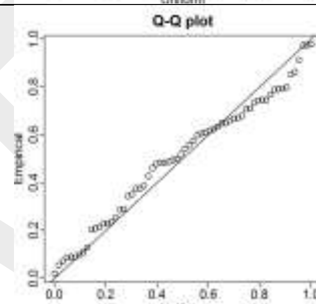
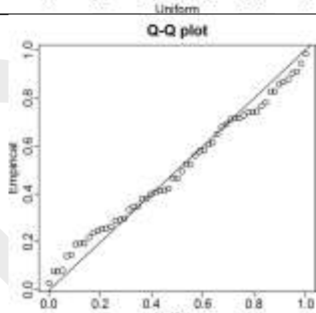
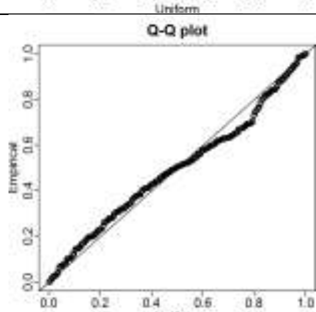
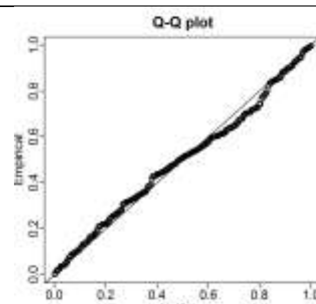
| | No ECE mixture distribution | ECE mixture distribution |
| --- | --- | --- |
| **Triennial Early** |   |   |
| **Triennial Late** |   |   |
| **AFSC Slope** |   |   |
| **NWFSC Slope** |   | Not available |
| **NWFSC shelf/slope** |   |   |

**Figure 6: Q-Q plots for models without an extreme catch event (ECE) mixture distribution (left column) and with an ECE mixture distribution (right column) for the five survey series.**

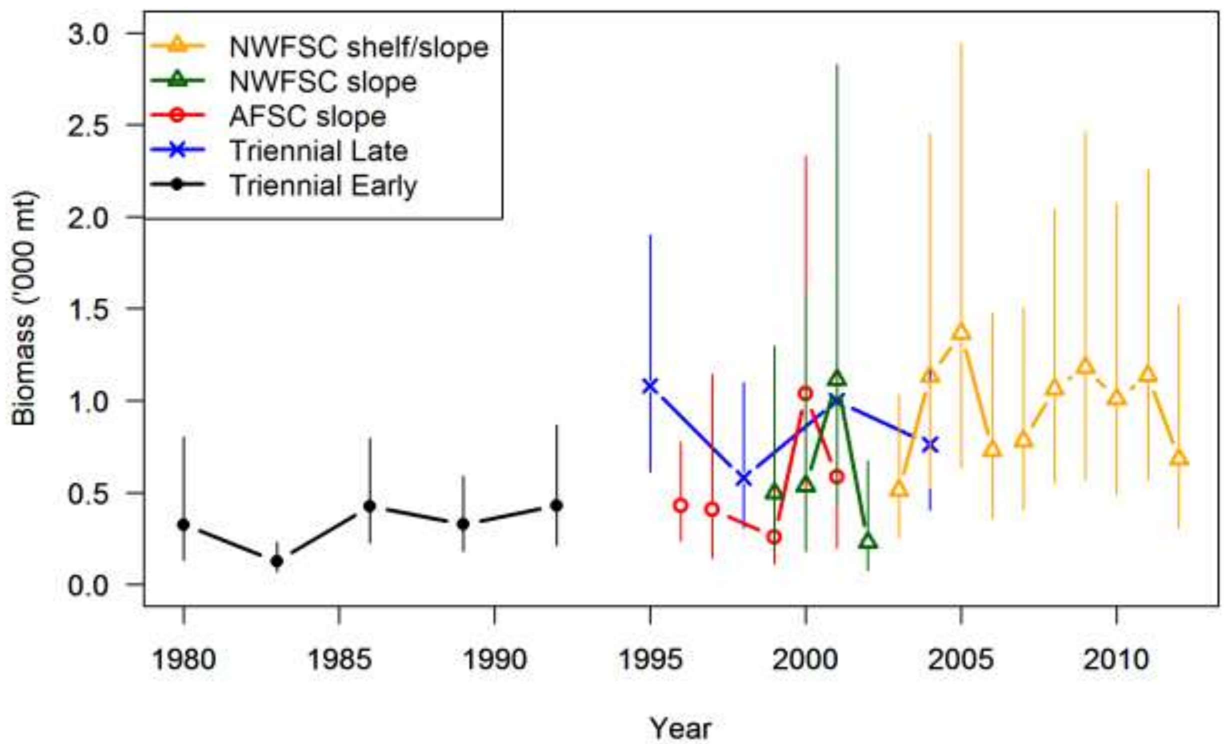



**Figure 7: Model-based survey estimates for the four surveys with estimated 95% confidence intervals.**

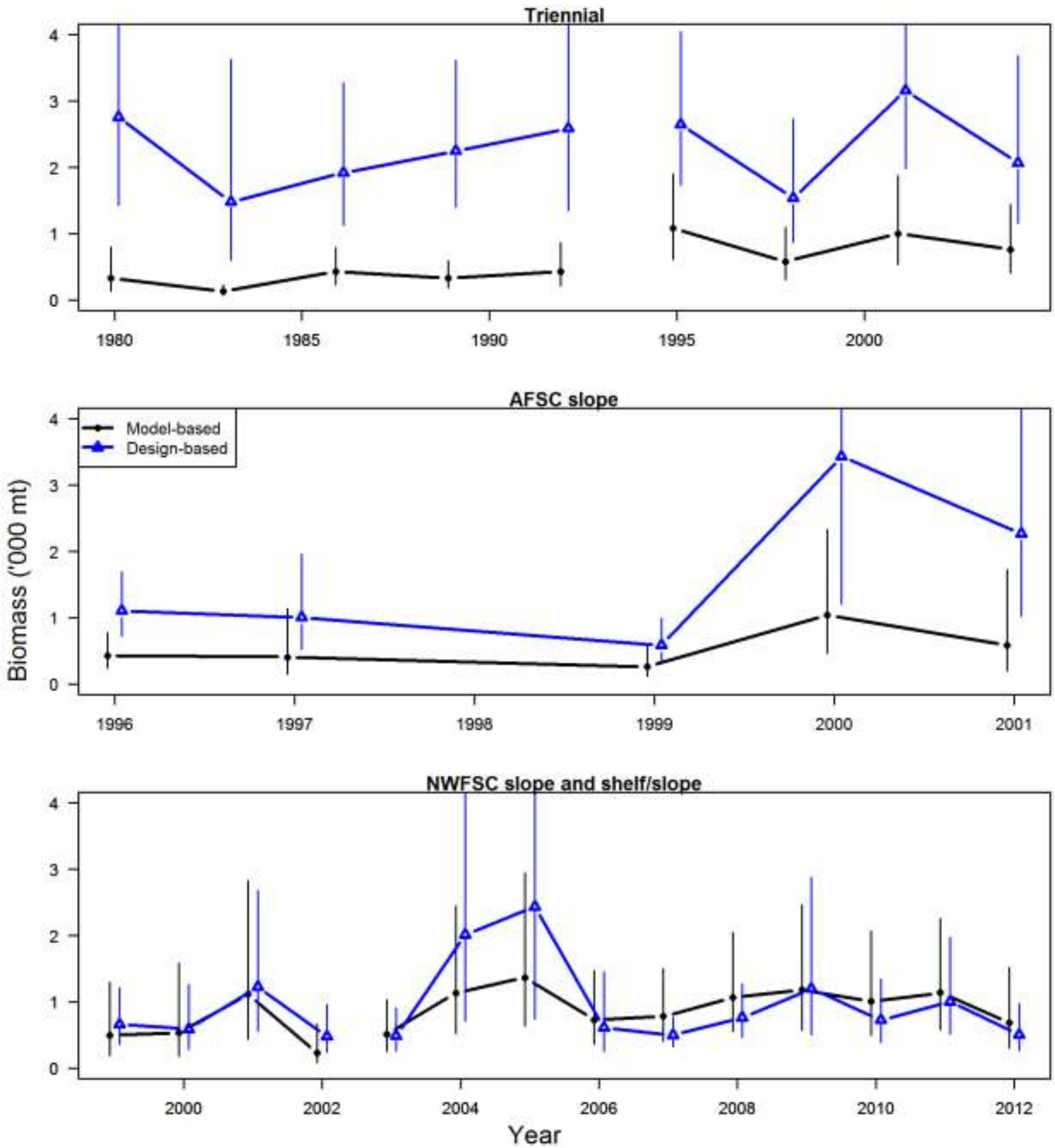



**Figure 8: A comparison of the design-based estimates and the model-based estimates for each survey.**

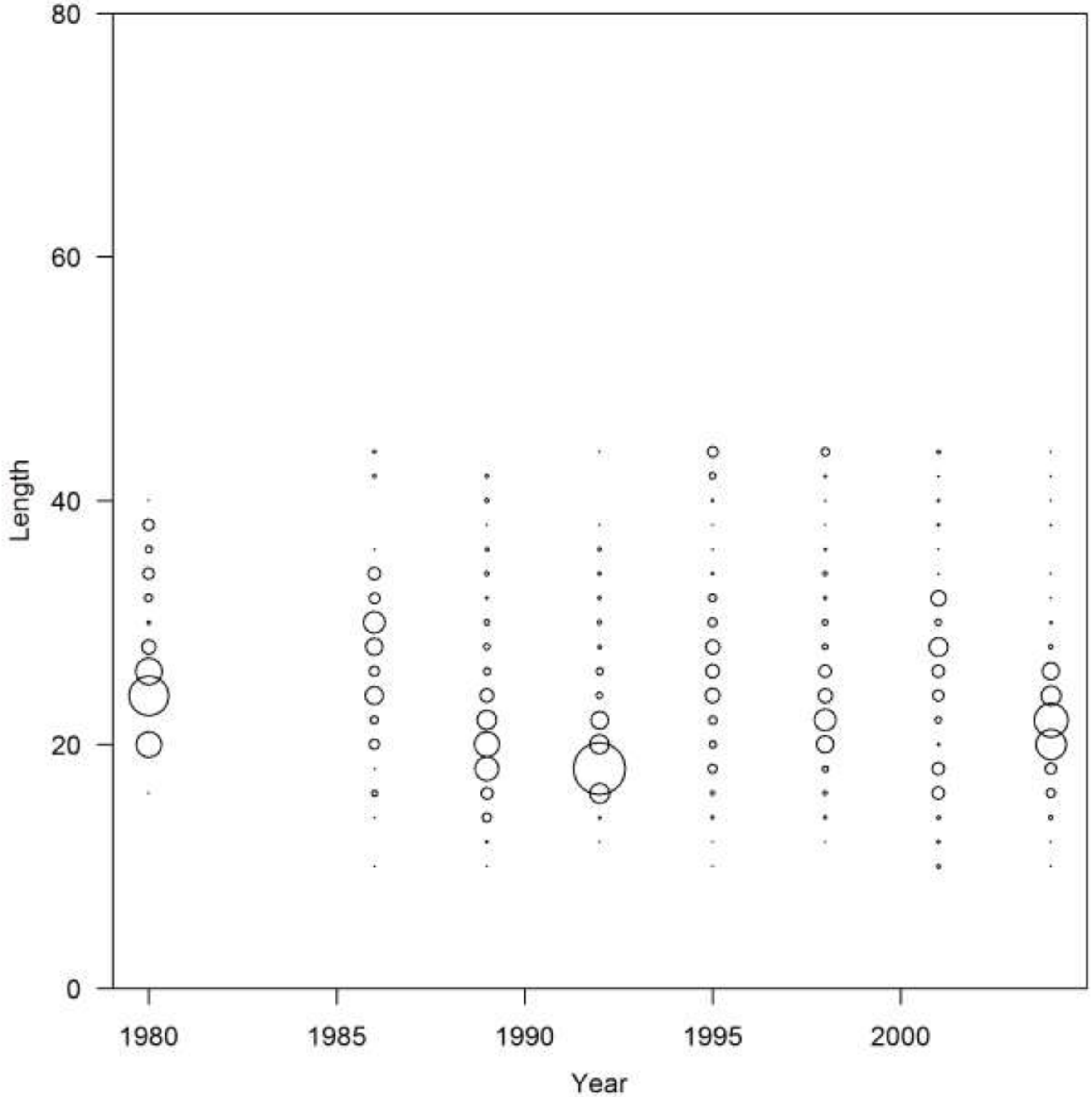



**Figure 9: Expanded length compositions for the Triennial survey.**

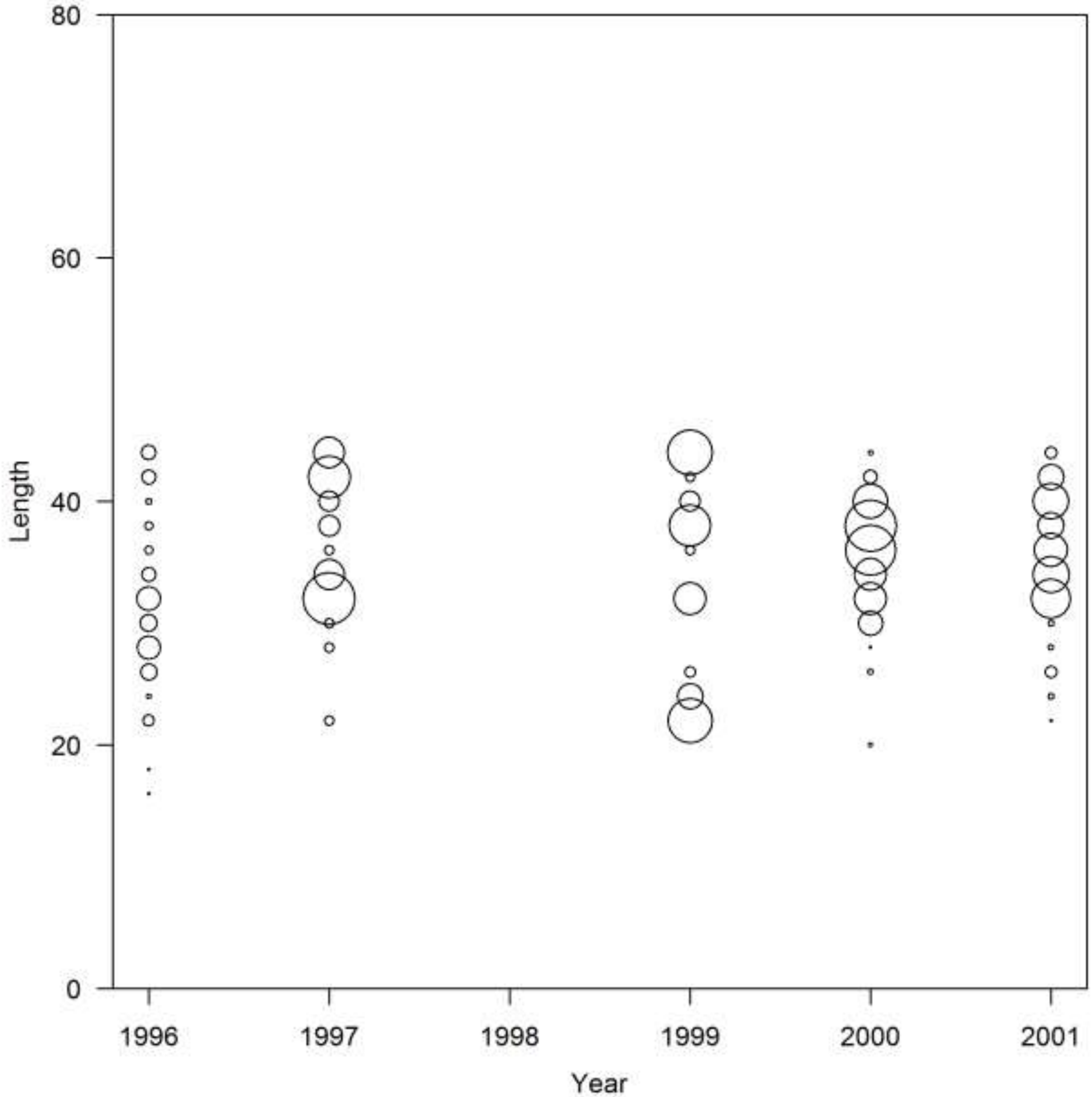



**Figure 10: Expanded length compositions for the AFSC slope survey.**

**Figure 11: Catch-rates (pink circles) of rougheye rockfish north of 40° 10' N for all years of the NWFSC shelf/slope survey.**



**Figure 12: Catch-rates (pink circles) of rougheye rockfish south of 40° 10' N for all years of the NWFSC shelf/slope survey.**

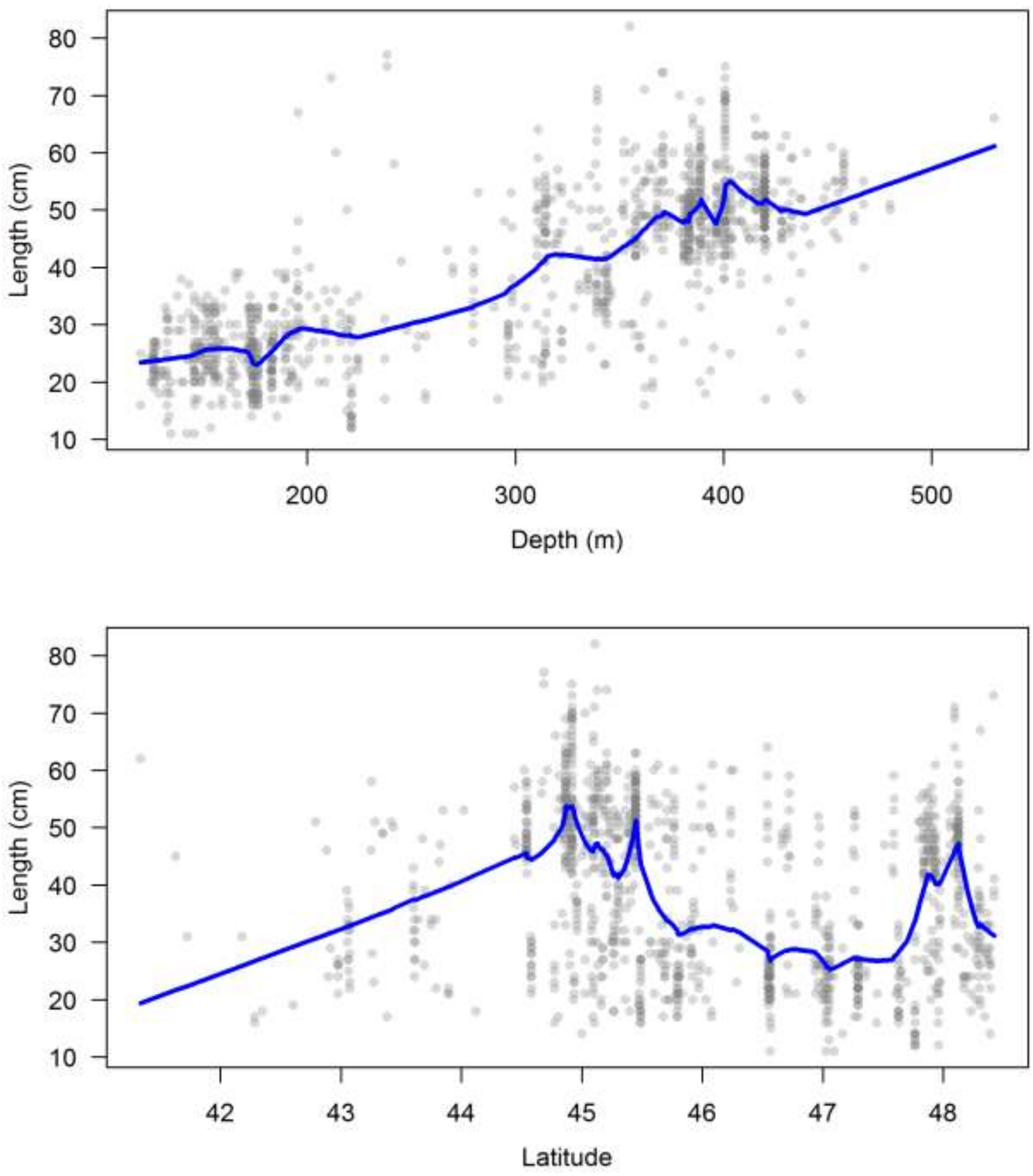



**Figure 13: Observed rougheye rockfish lengths (cm) plotted against depth (top) and latitude (bottom). The blue line is a smoothed line through the observations.**

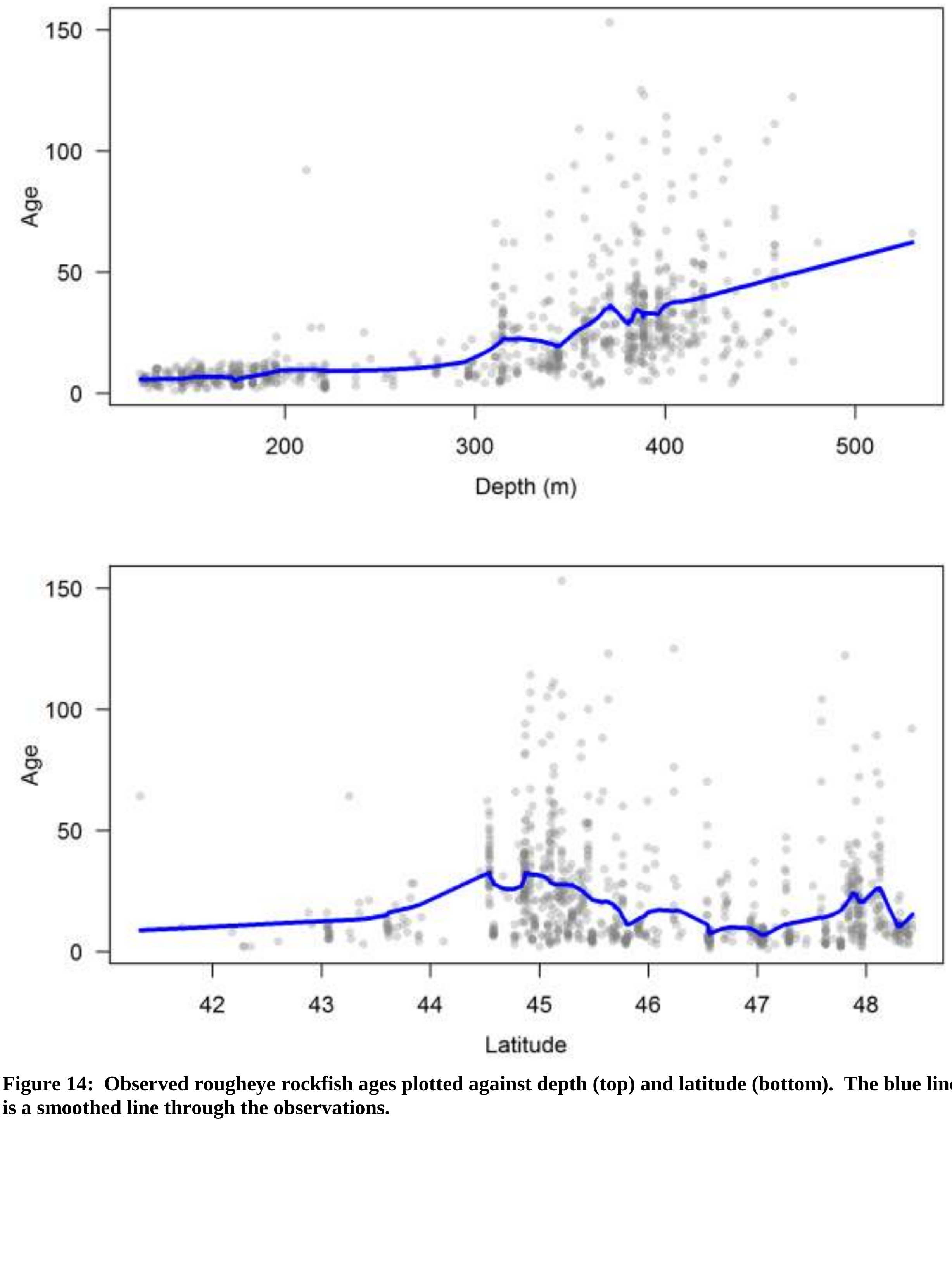



**Figure 14: Observed rougheye rockfish ages plotted against depth (top) and latitude (bottom). The blue line is a smoothed line through the observations.**

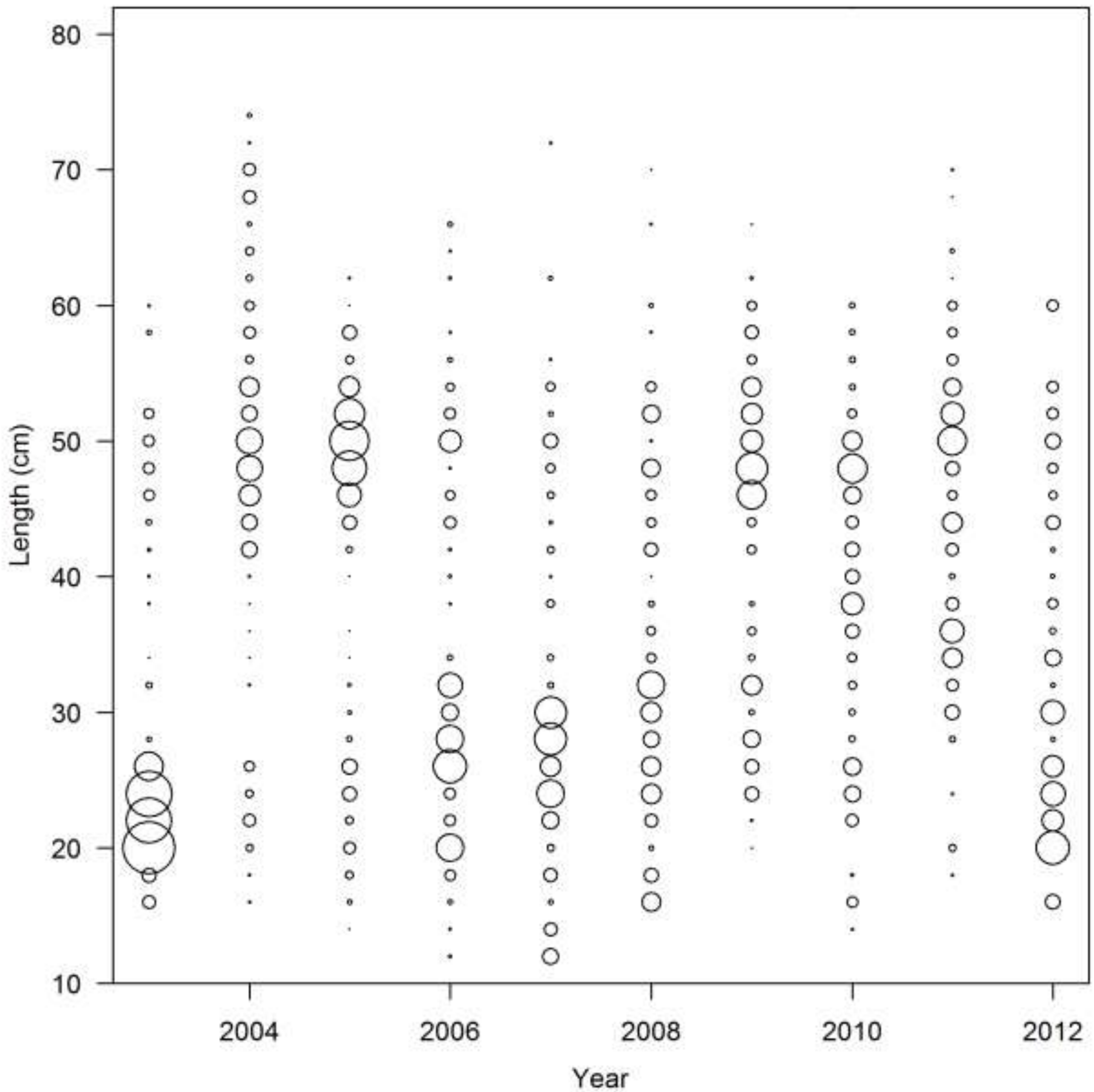



**Figure 15: Expanded length compositions for the NWFSC shelf/slope survey.**

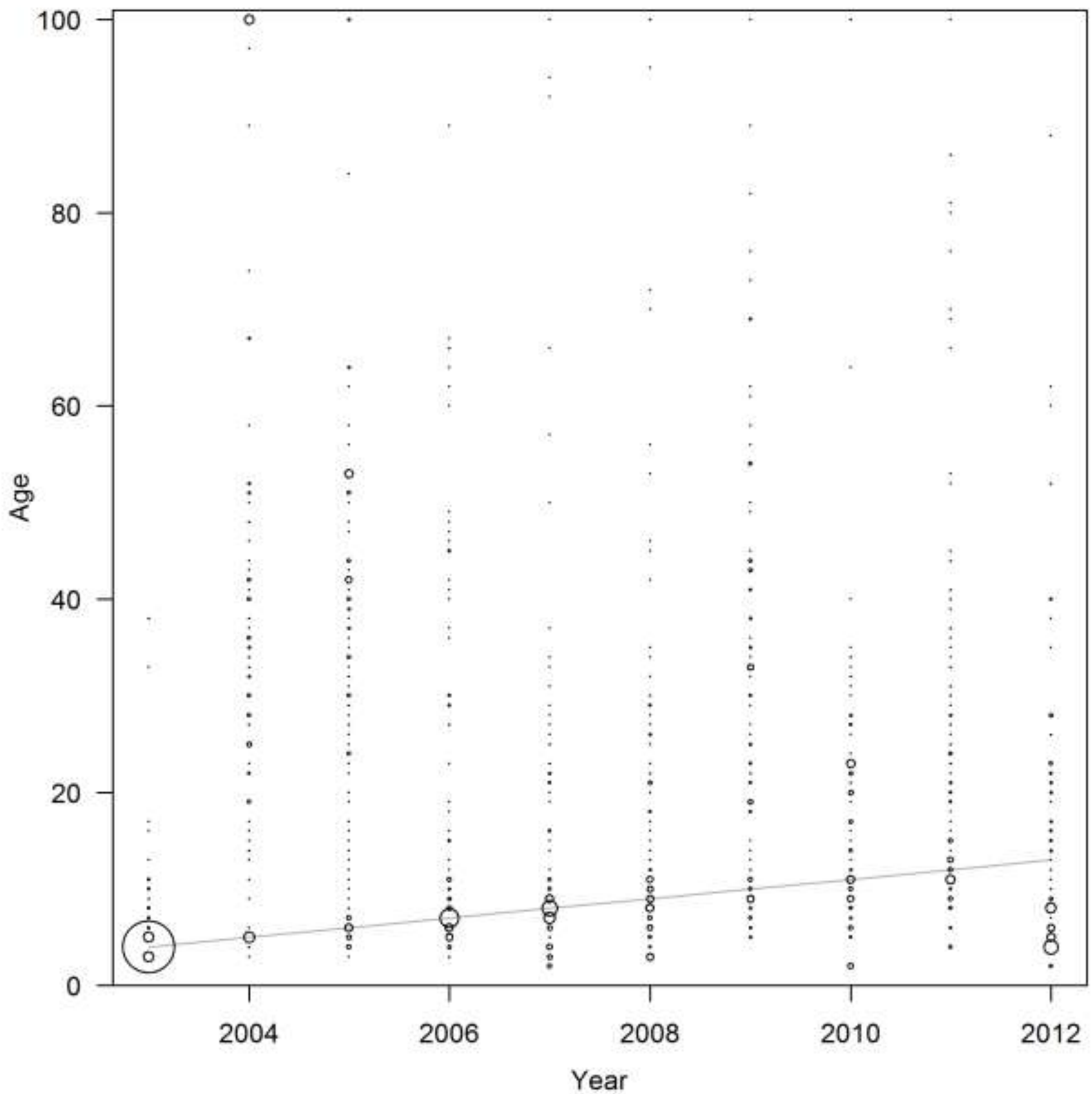



**Figure 16: Expanded age compositions from the NWFSC shelf/slope survey. The grey line follows the 1999 cohort, which was estimated to be a strong cohort for many different species of rockfish.**

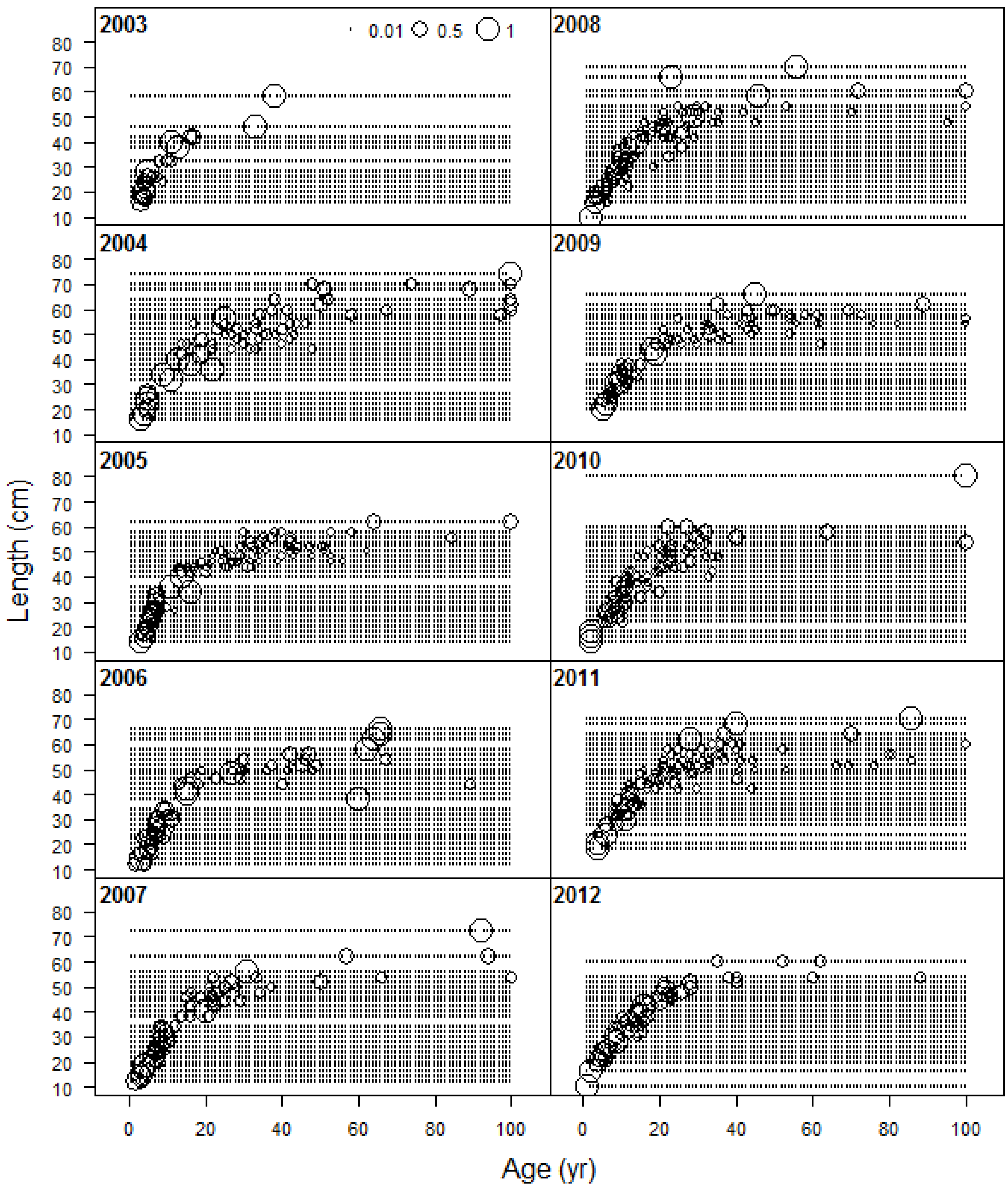



**Figure 17: Conditional age-at-length from NWFSC shelf/slope observations.**

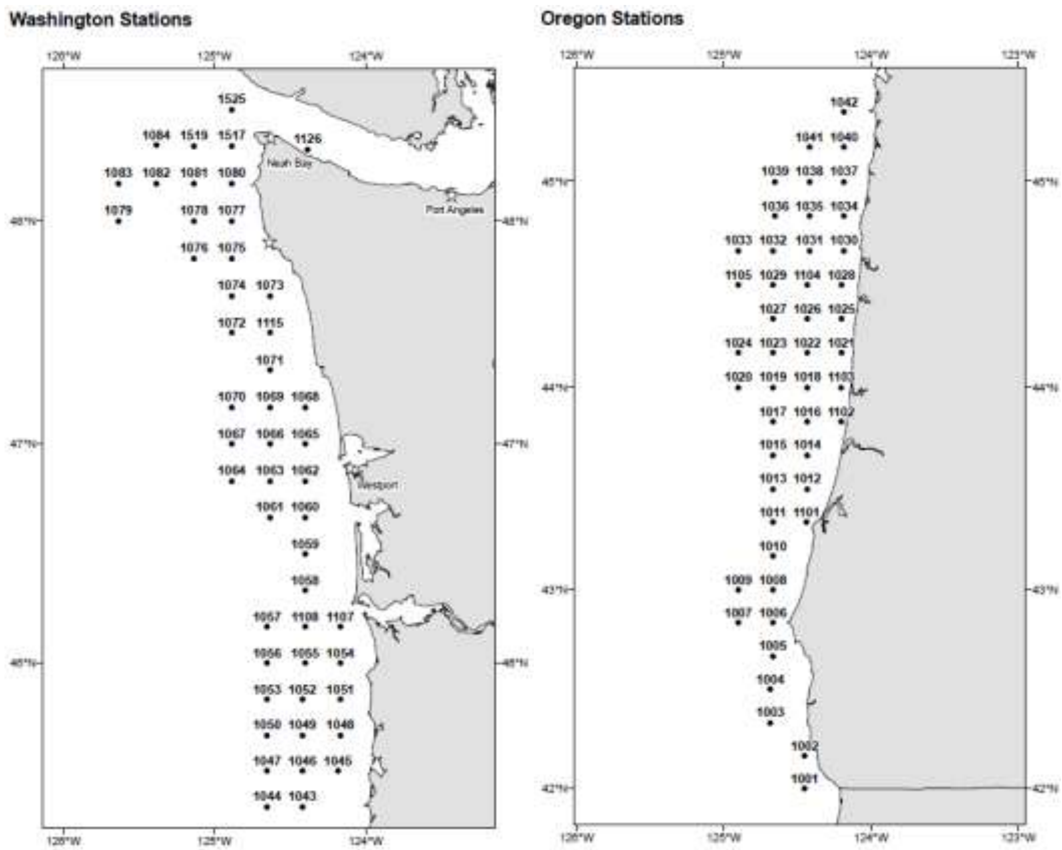



**Figure 18: Station locations for the International Pacific Halibut Commission longline survey in Washington (left) and Oregon (right).**

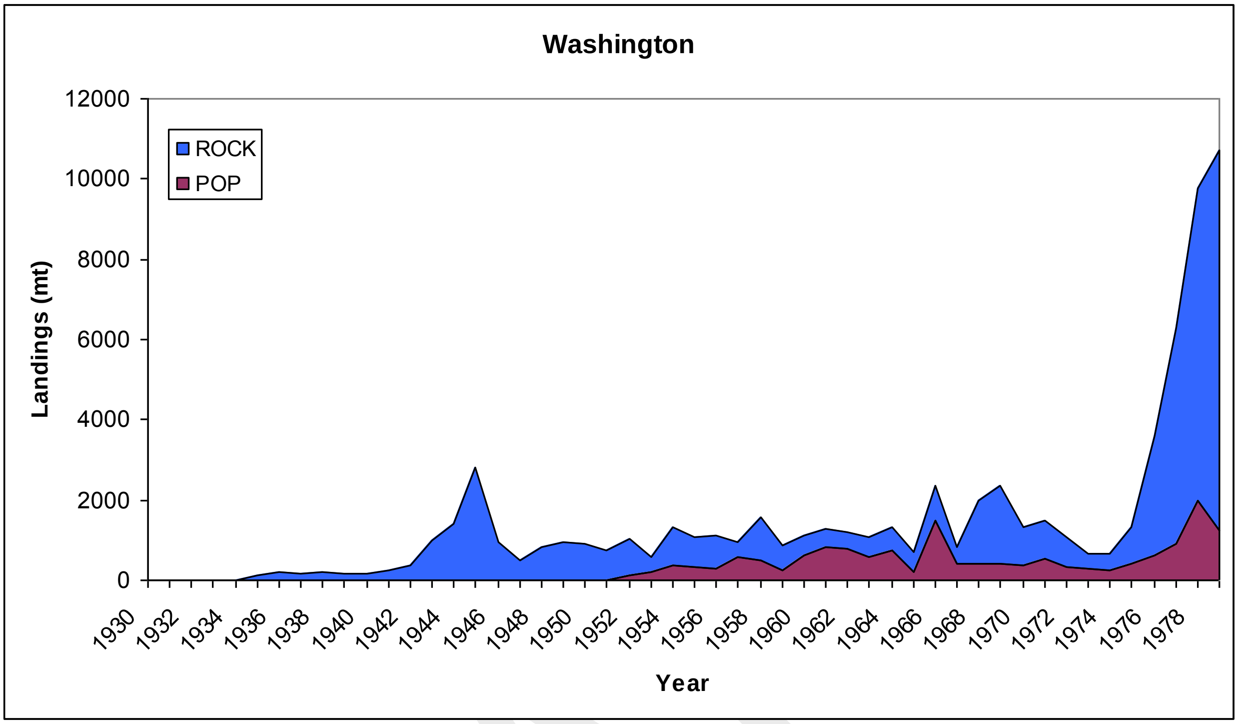



**Figure 19: Trawl landings in Washington of each market category used in the historical catch reconstruction. Different proportions were applied to each market category to estimate the landings of rougheye rockfish.**

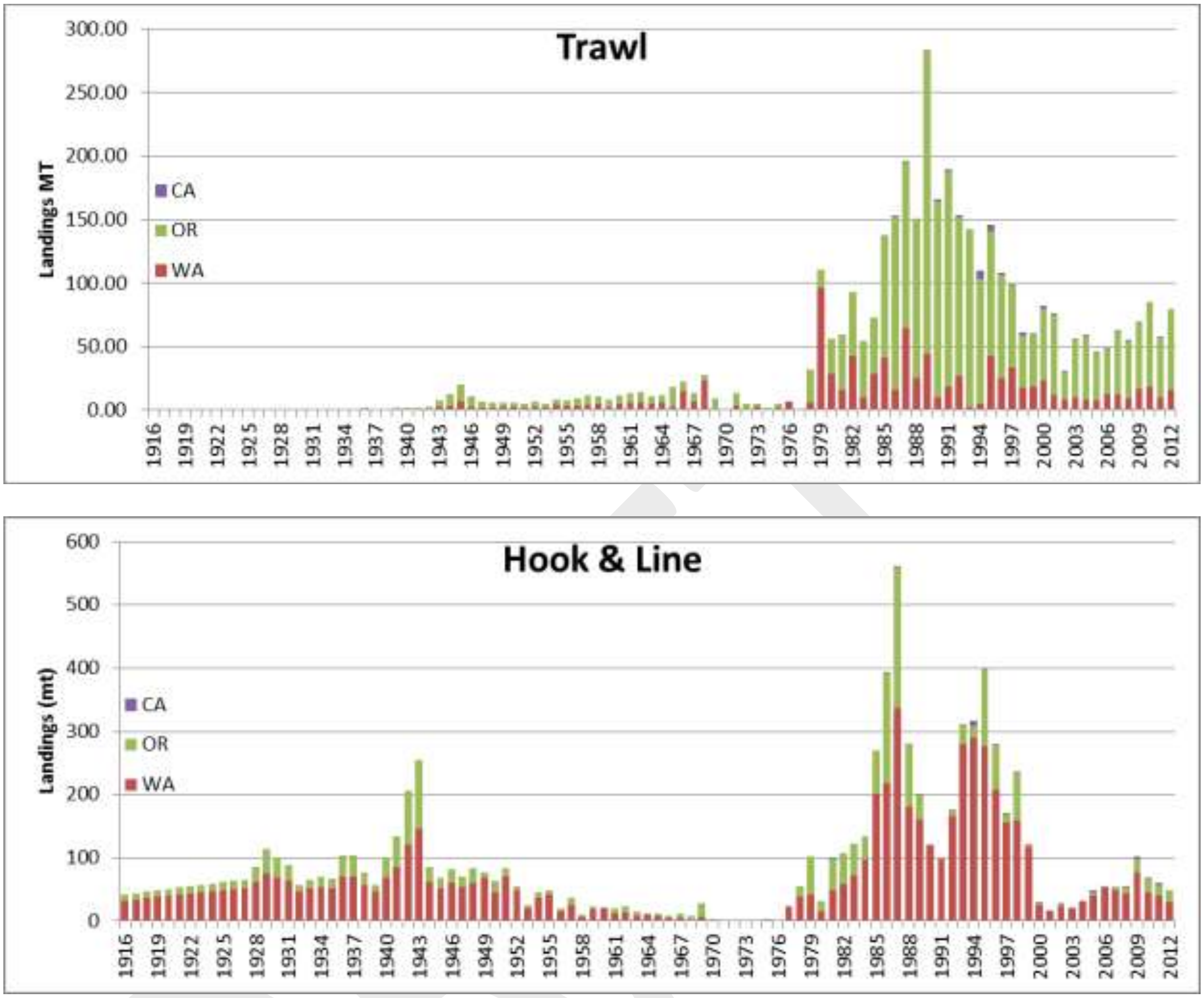


Figure 20: Trawl landings (top) and hook & line landings (bottom) by state of rougheye rockfish.

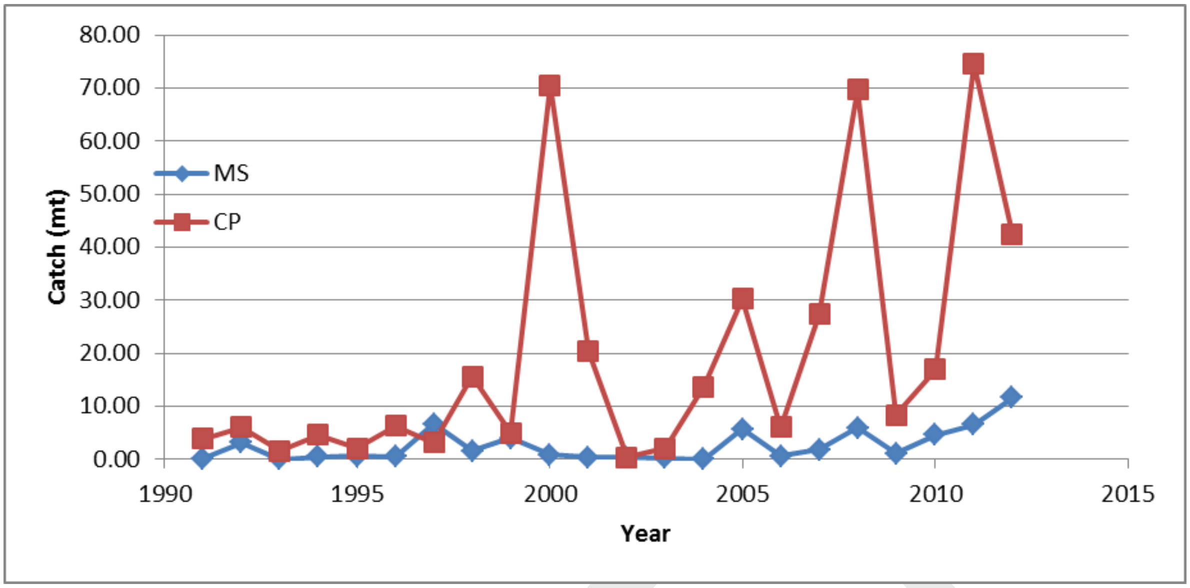


**Figure 21: Catches of rougheye rockfish for the mothership (MS) and catcher-processor (CP) fleets.**

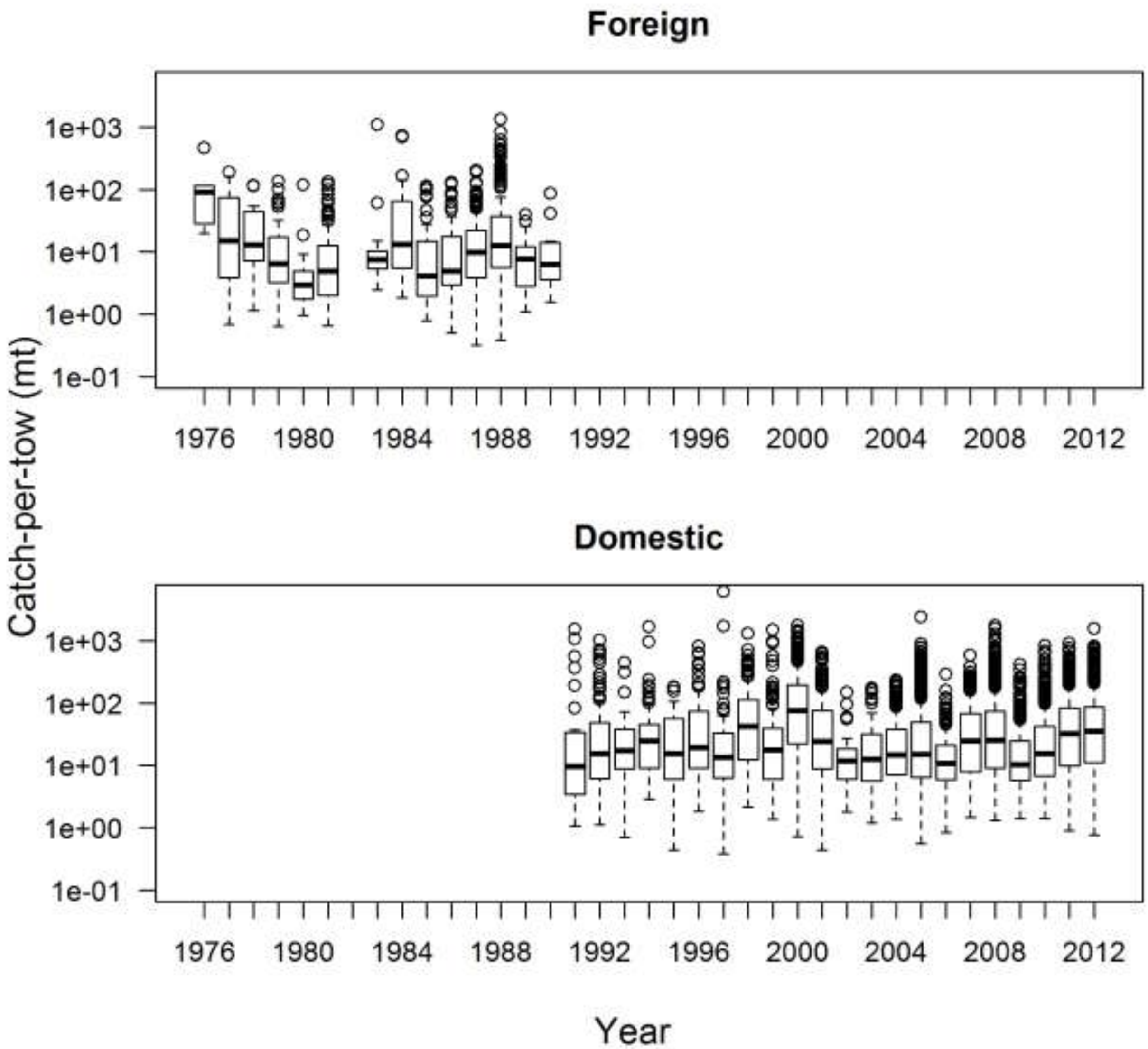



**Figure 22: Catch-per-tow in metric tons for the at-sea foreign fleet (top) and at-sea domestic fleet (bottom).**

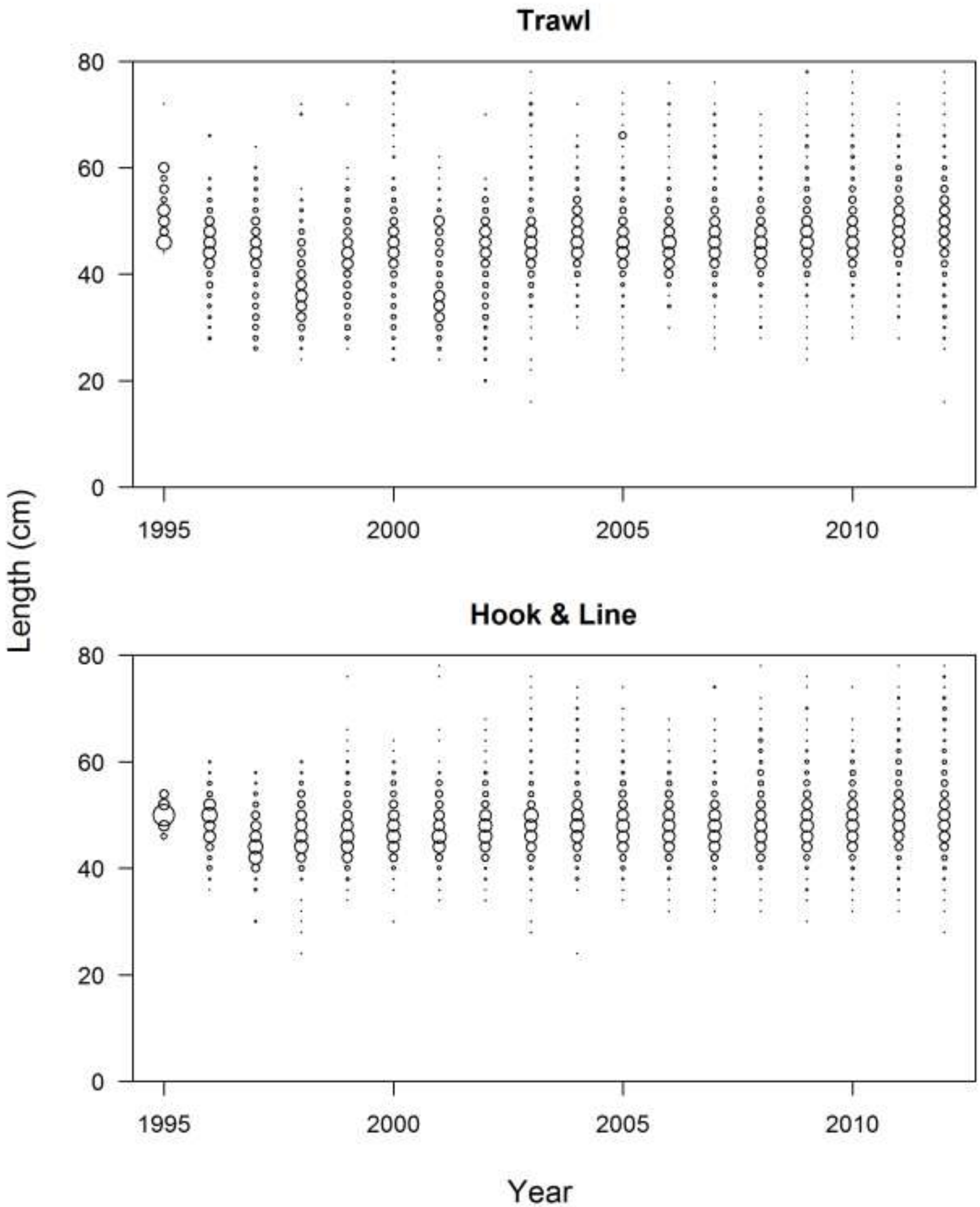



**Figure 23: Expanded length compositions for trawl and hook & line fisheries. The area of the circles are proportional to the proportion-at-length, and are consistent for the two fleets.**

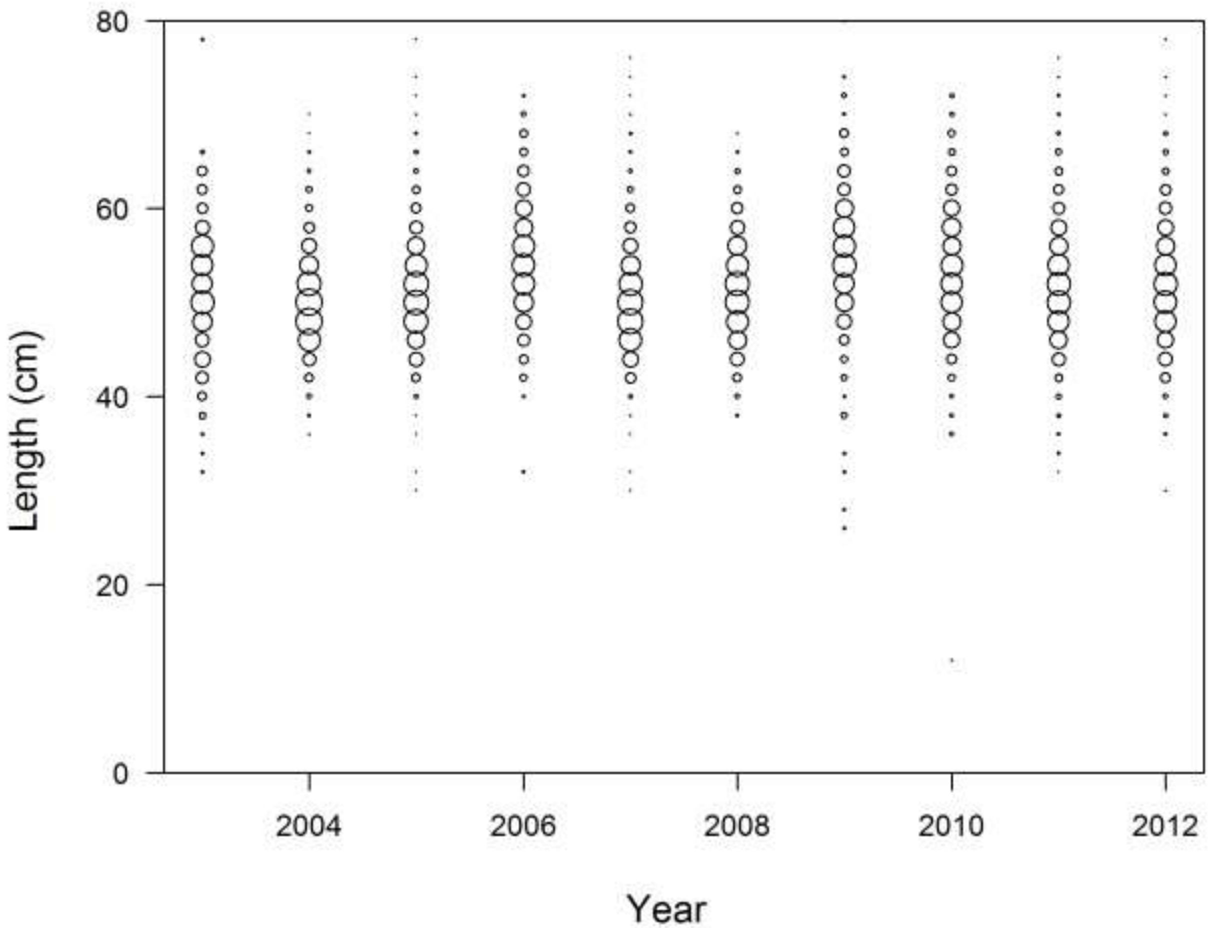



**Figure 24: Expanded length compositions for Pacific whiting at-sea fishery. The area of the circles is proportional to the proportion-at-length.**

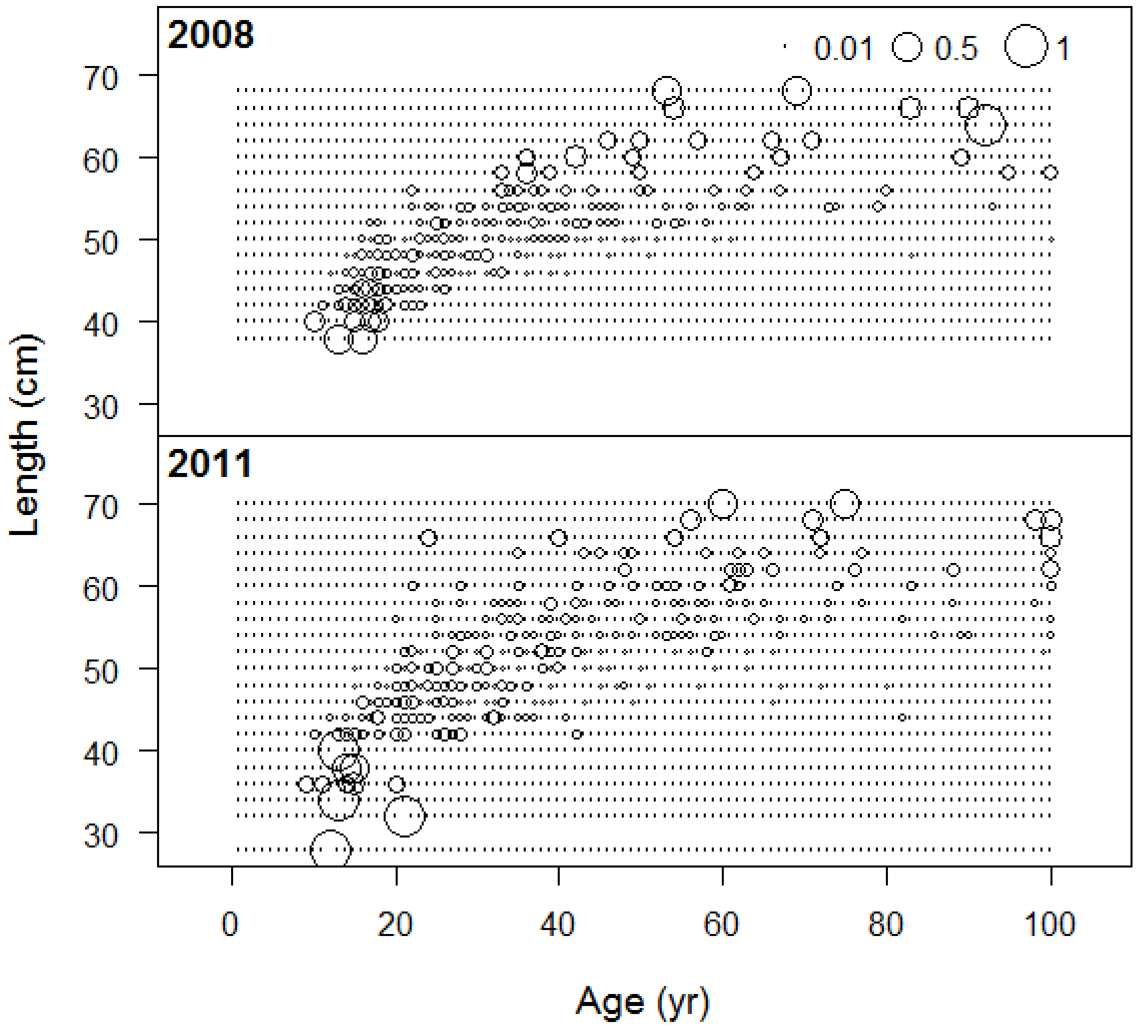



**Figure 25: Conditional age-at-length from Oregon trawl fishery observations.**

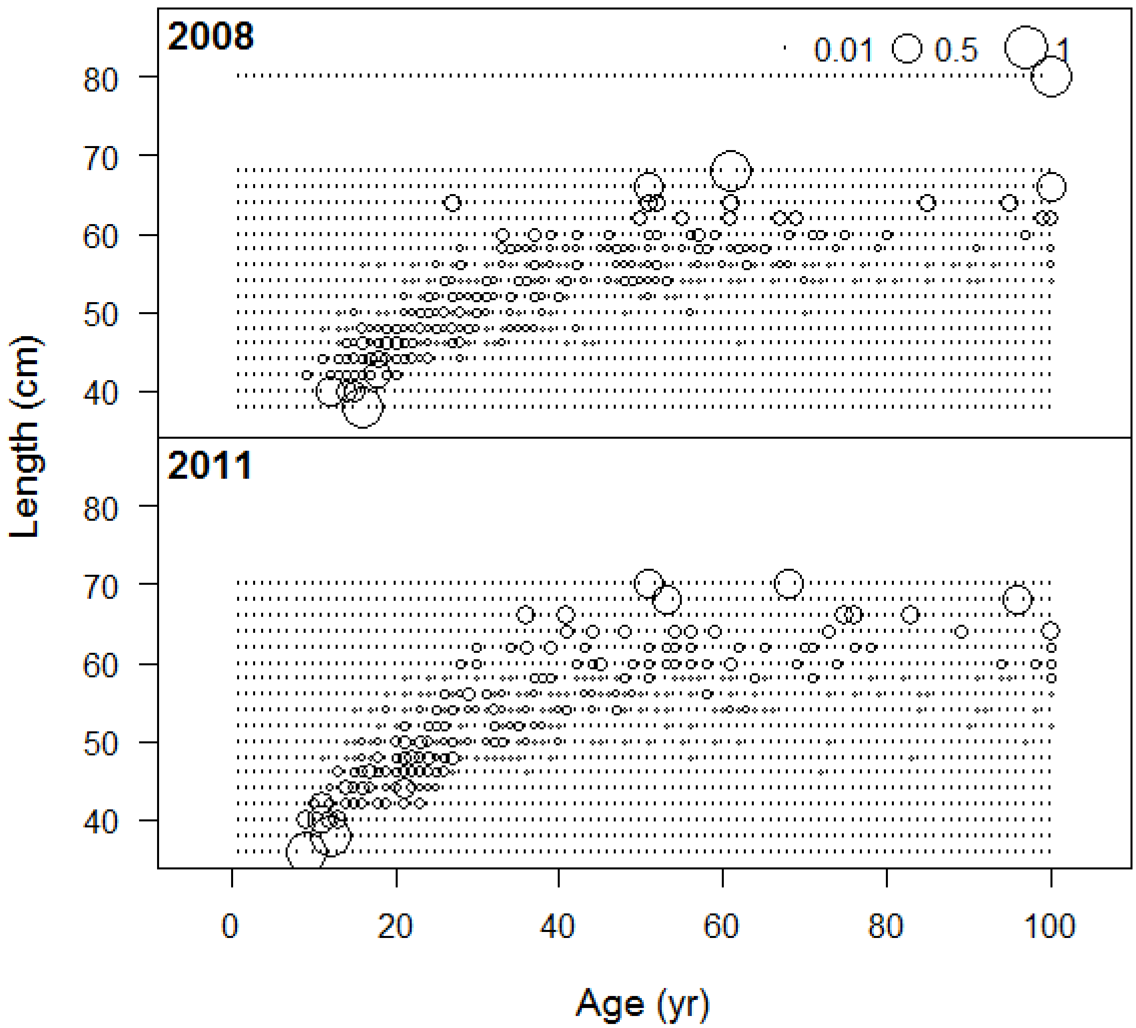



**Figure 26: Conditional age-at-length from Pacific whiting at-sea fishery observations.**

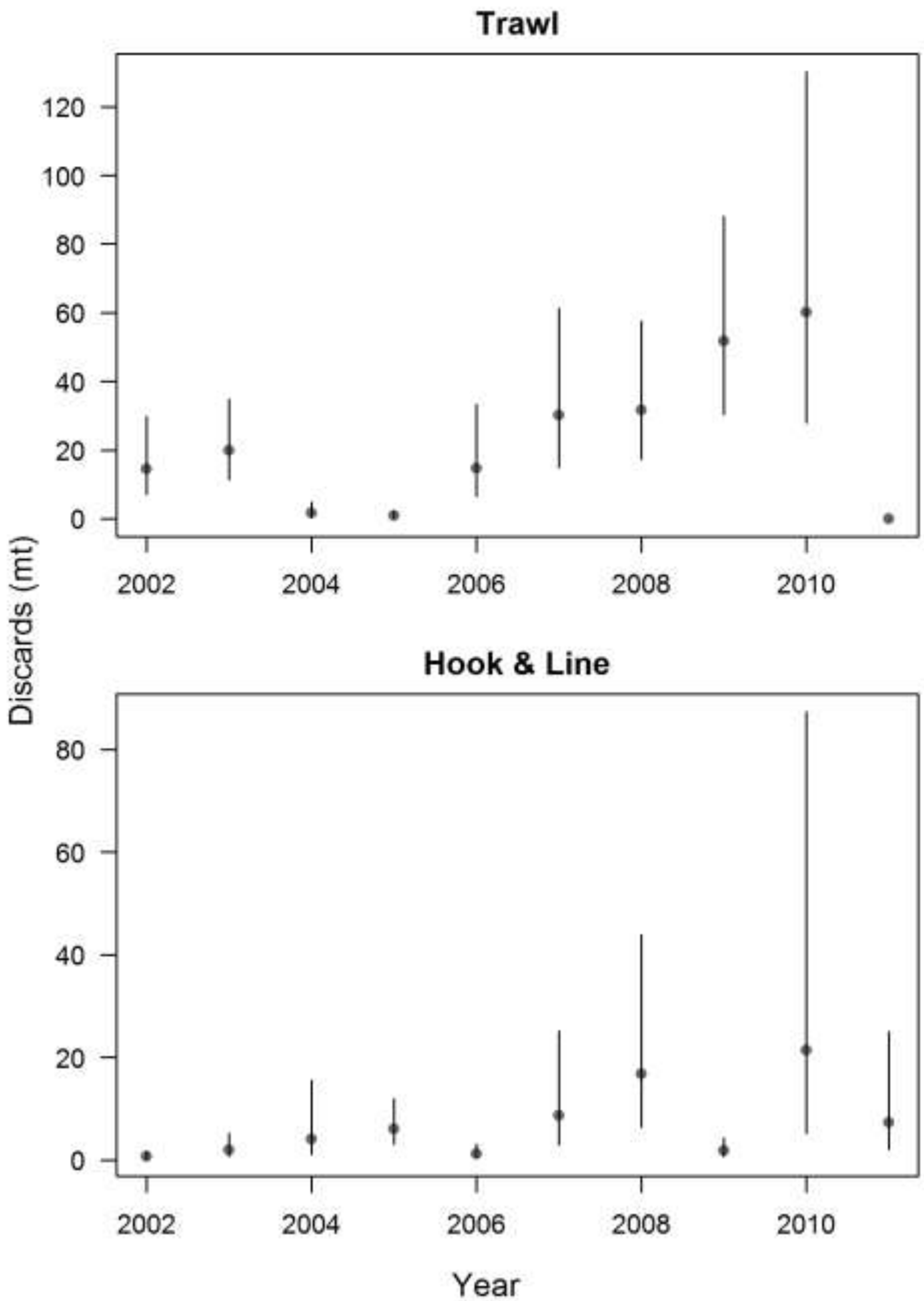



**Figure 27: Total discards (mt) from 2002 to 2011 for the trawl and hook & line fleets. Vertical lines show 95% confidence intervals determined by bootstrapping vessels in each year and fleet.**

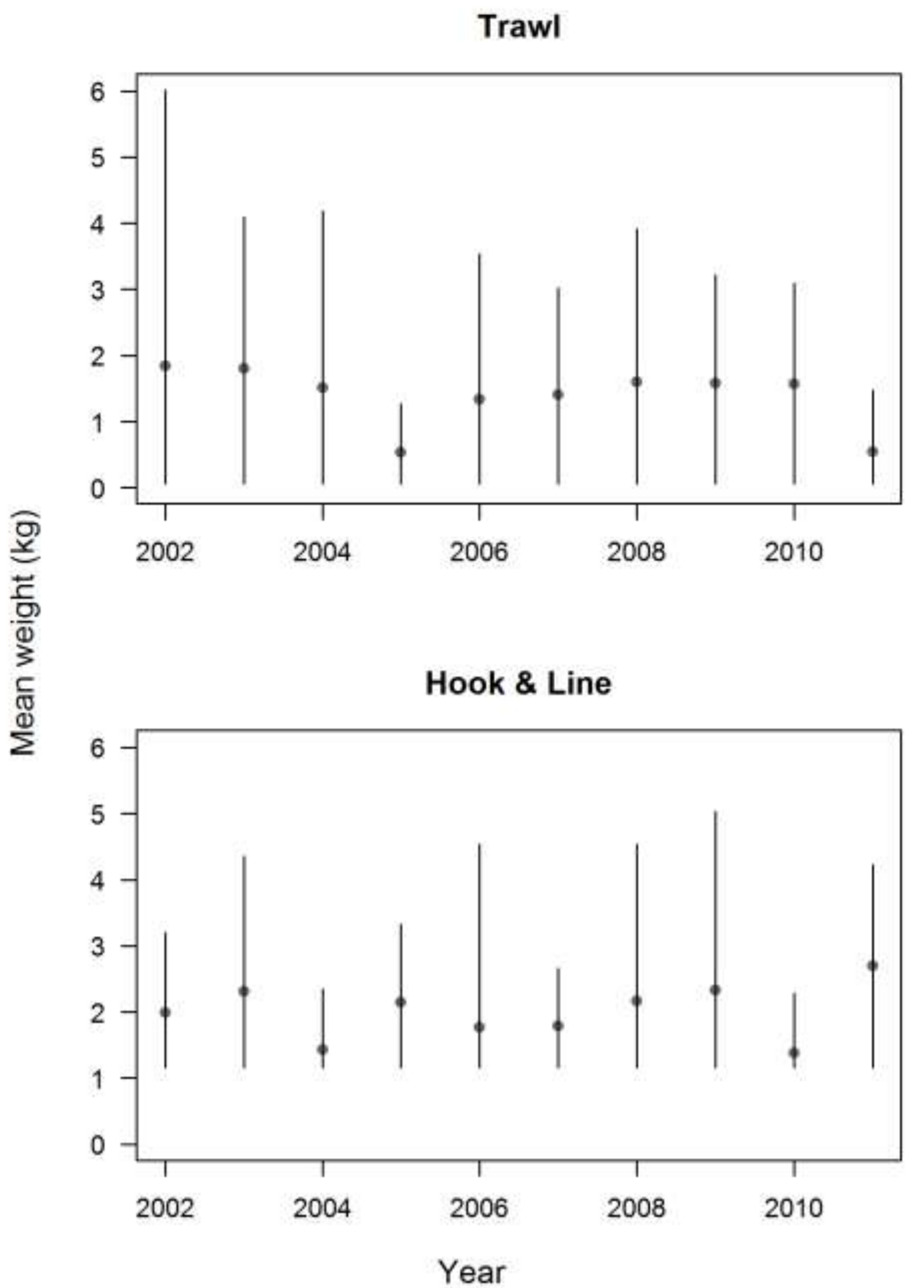



**Figure 28: Mean weights of discards for 2002–2011 as determined by the WCGOP. 95% confidence intervals are determined from variability between observations.**

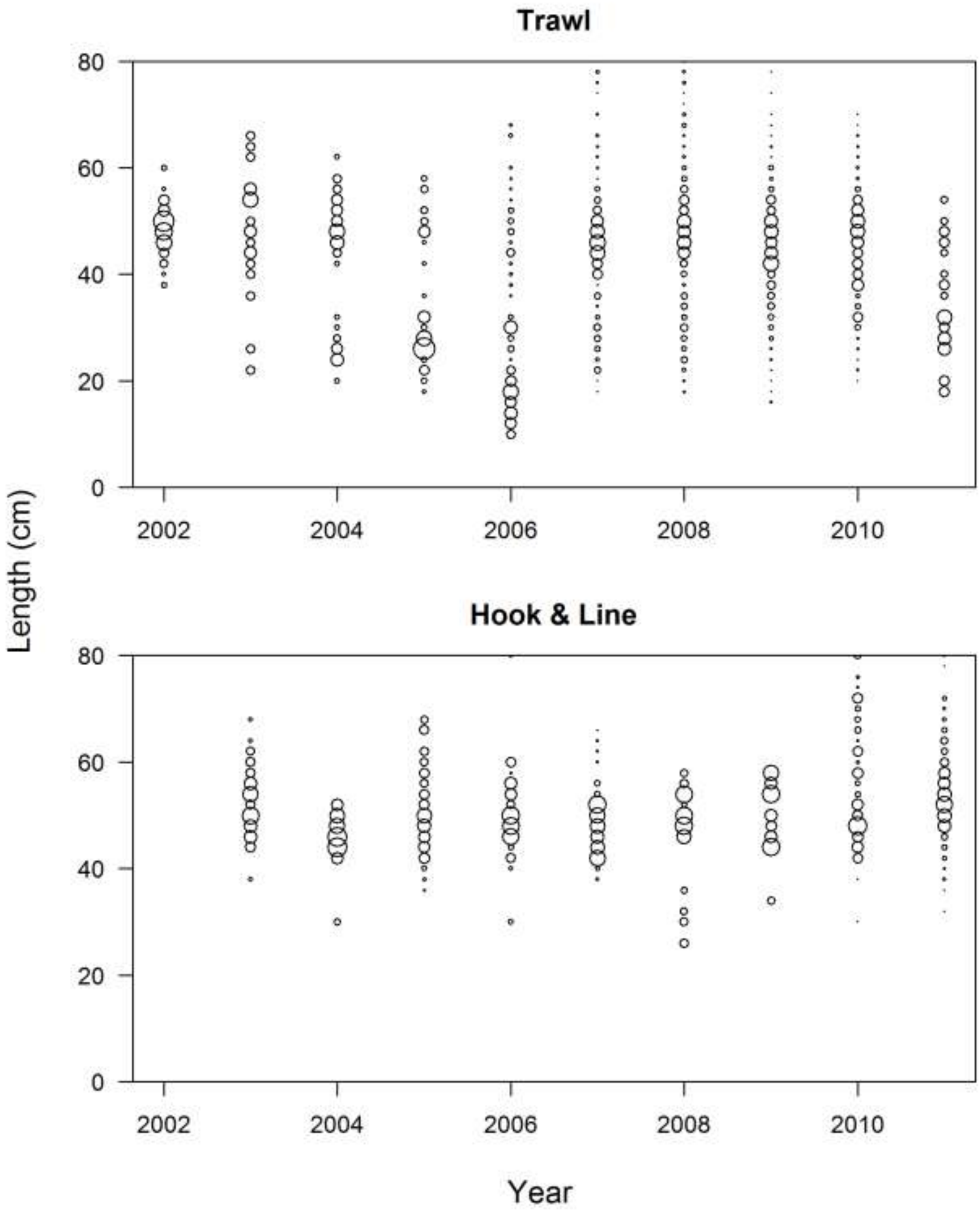



**Figure 29: Length compositions of the discards for the trawl and hook & line fleets.**

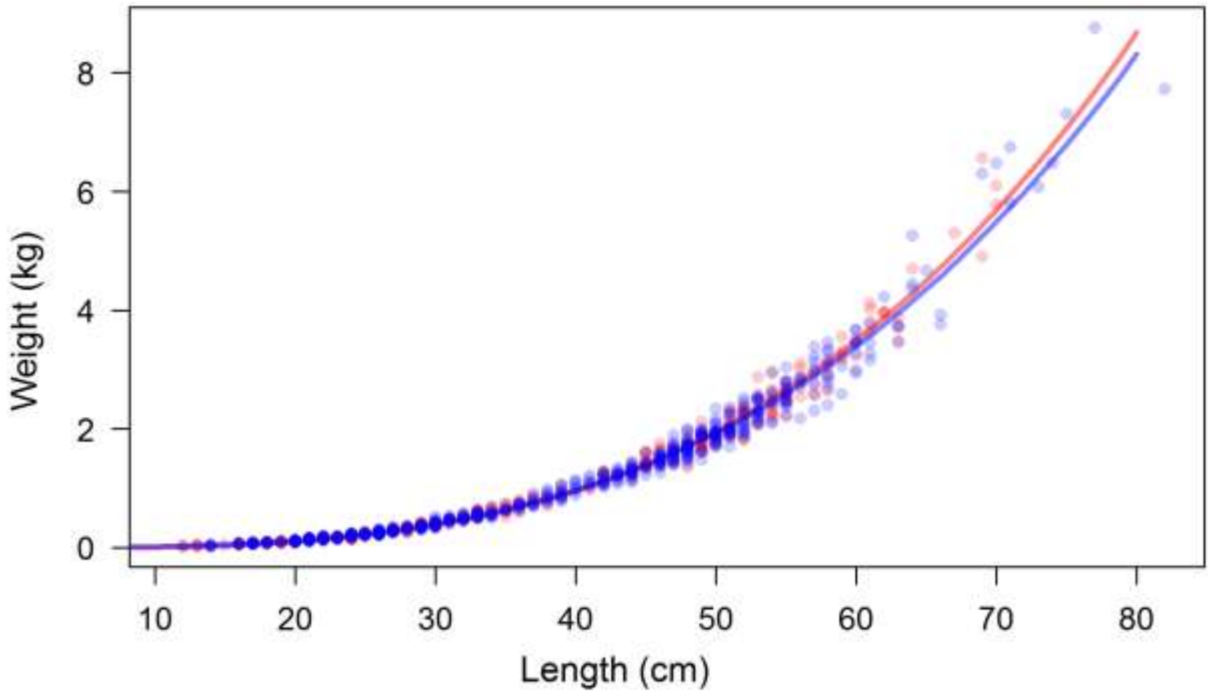



**Figure 30: Weight-at-length observations for females (red dots) and males (blue dots). Fitted lines to the sex specific observations from regression analysis are shown in red (females) and blue (males).**

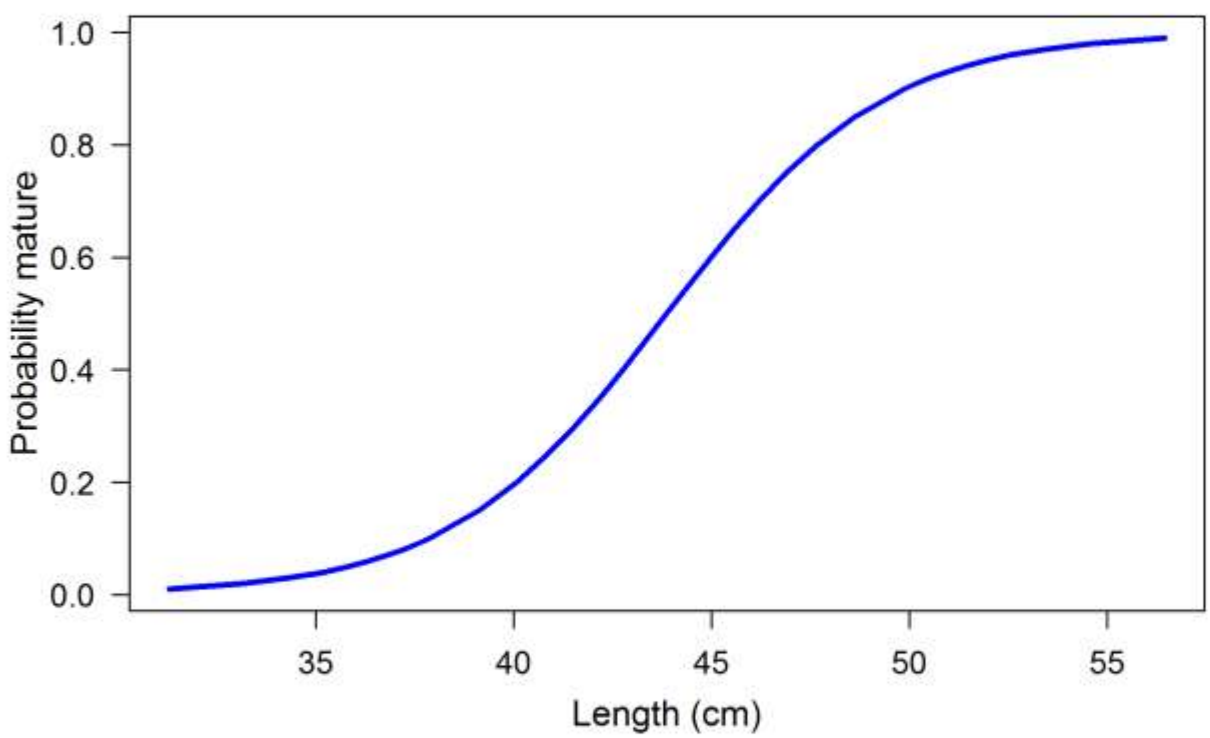



**Figure 31: Maturity at length estimated from (McDermott 1994) using all samples from Oregon to Alaska.**

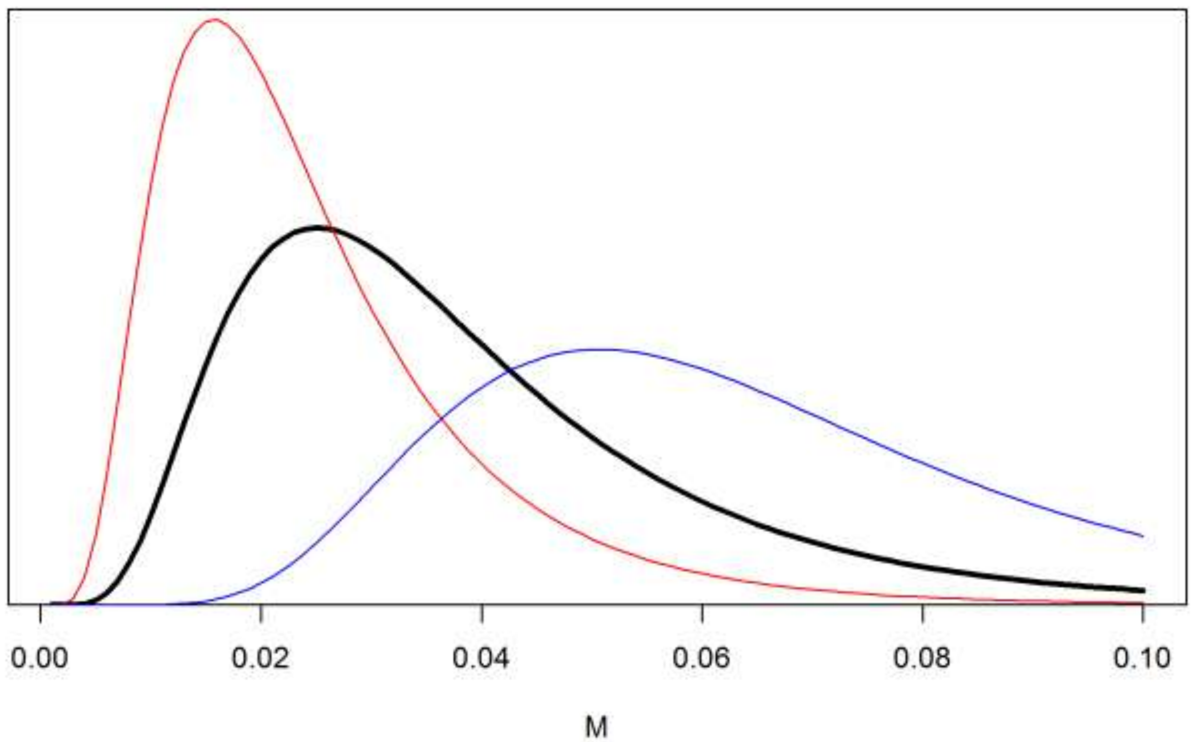



**Figure 32: Prior distributions for natural mortality (*M*). The prior used in the base model is shown by the thick black line.**

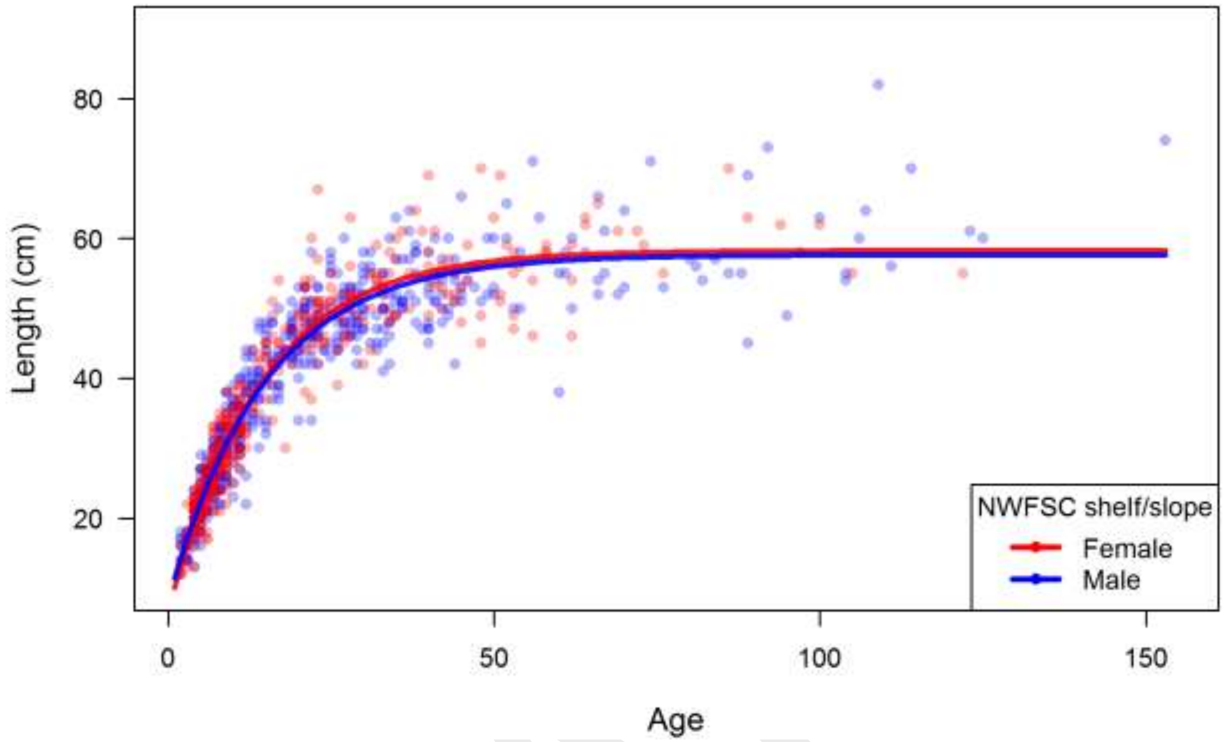



**Figure 33: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish collected from the NWFSC shelf/slope survey.**

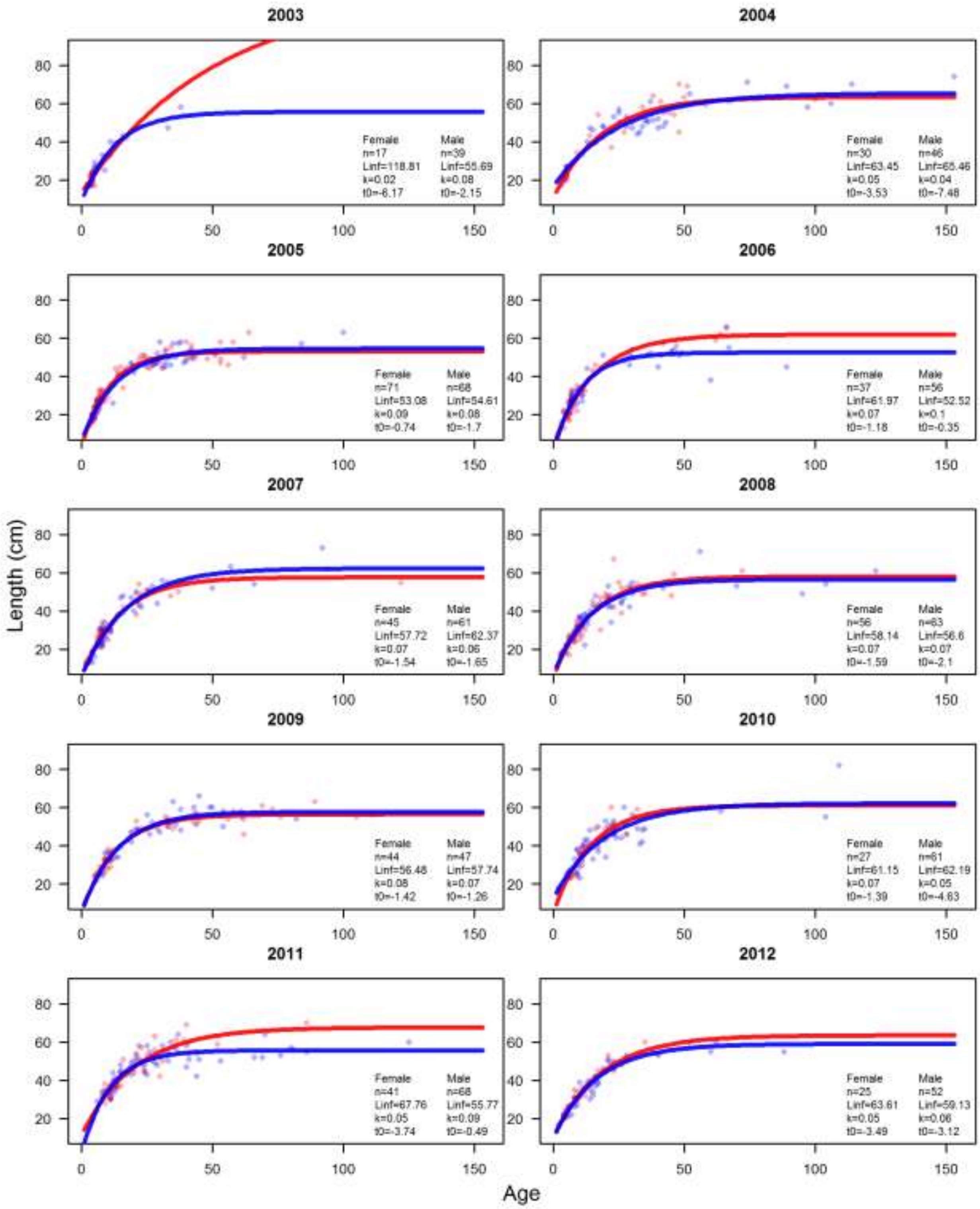



**Figure 34: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish by each year collected from the NWFSC shelf/slope survey.**

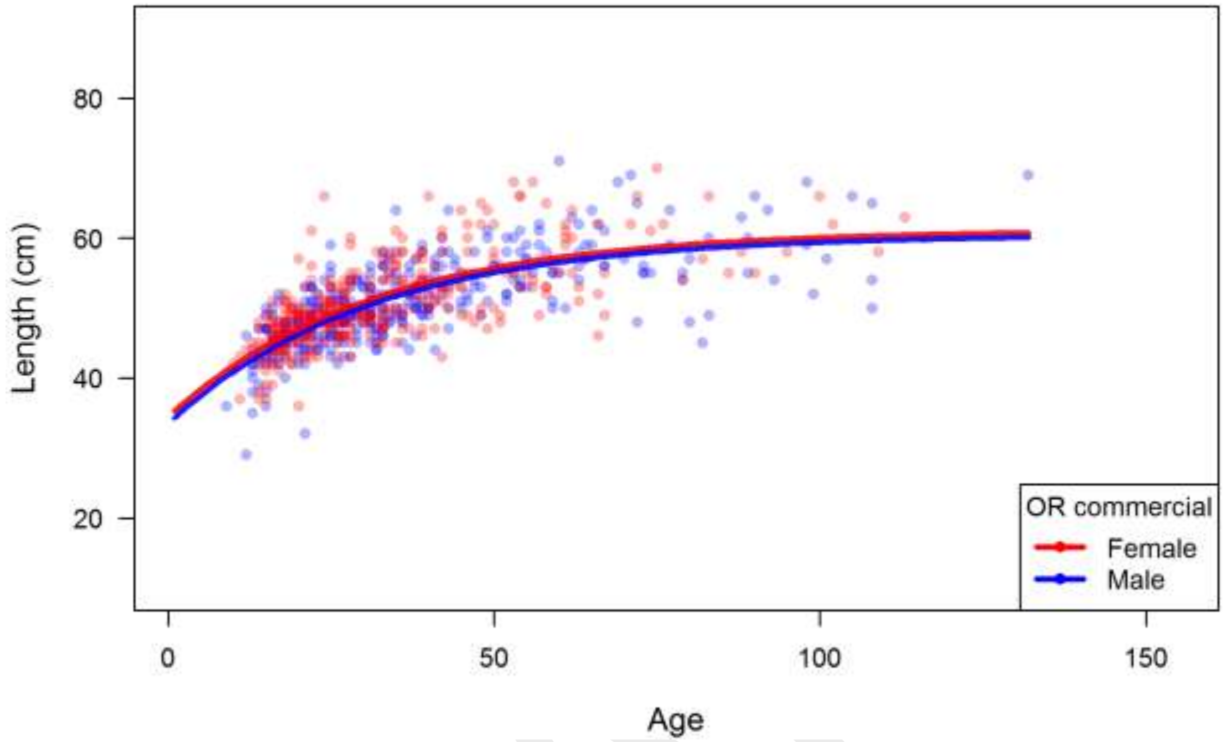


Figure 35: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish collected from Oregon port samples in 2008 and 2011.

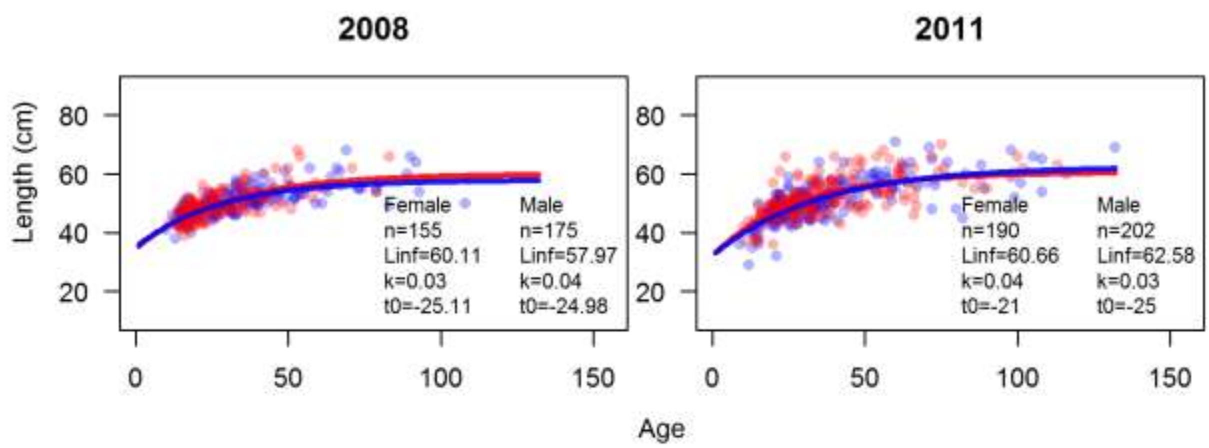


Figure 36: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish by each year collected from Oregon port samples in 2008 and 2011.

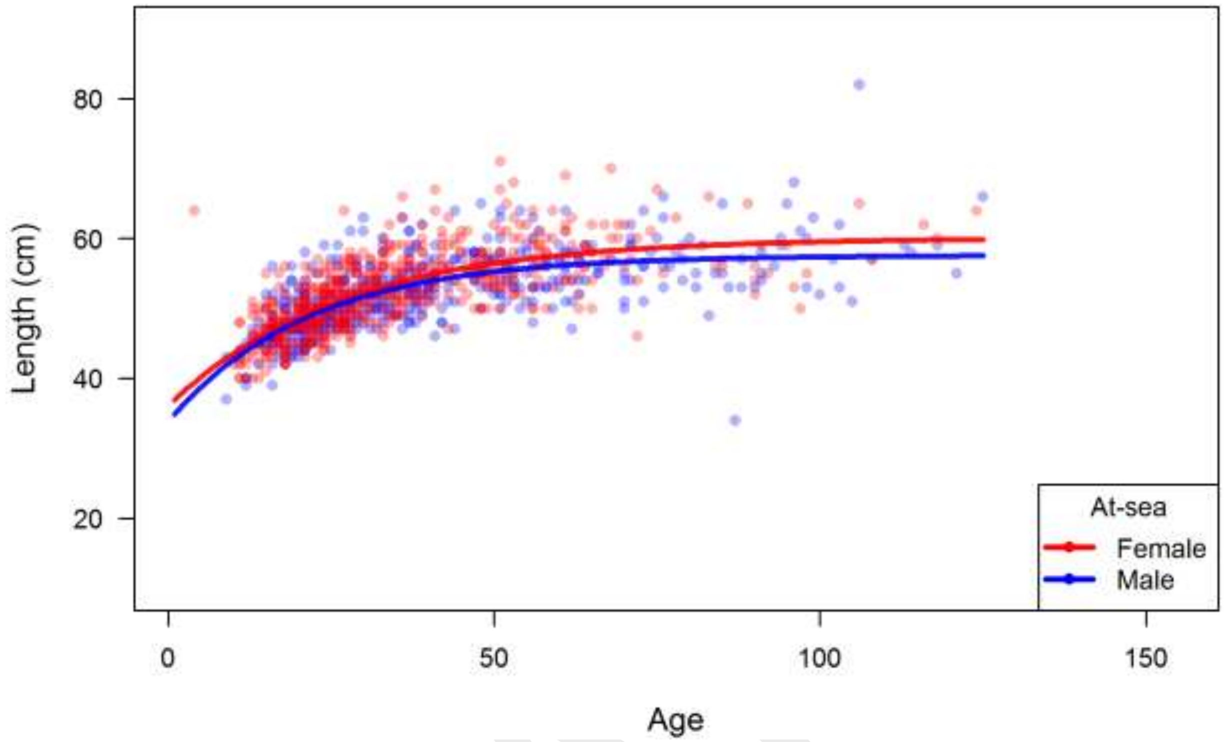



**Figure 37: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish collected from Pacific hake at-sea samples in 2008 and 2011.**

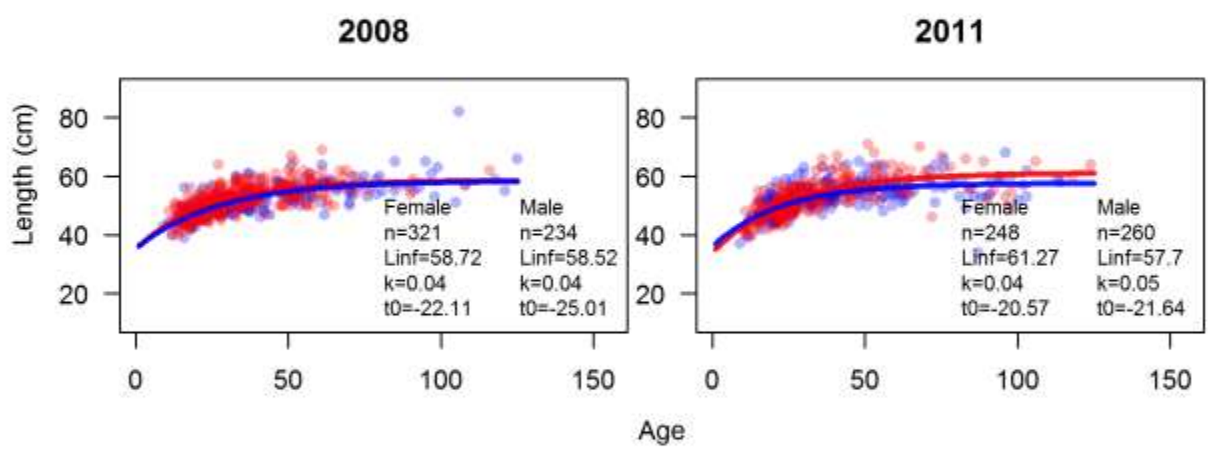



**Figure 38: Length-at-age observations (points) and predicted length-at-age von Betalanffy curves for female (red) and male (blue) rougheye rockfish by each year collected from Pacific hake at-sea port samples in 2008 and 2011.**

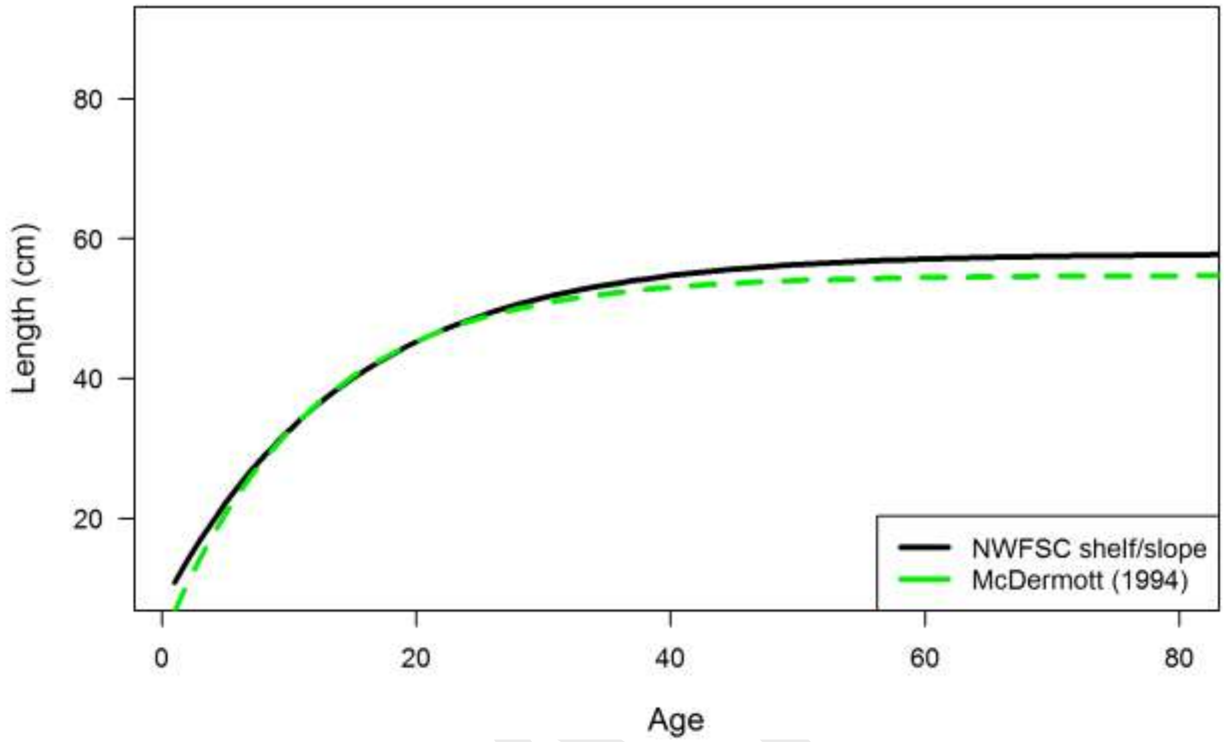



**Figure 39: Predicted growth curves for combined sexes using NWFSC survey data compared to predicted growth curves from (McDermott 1994).**

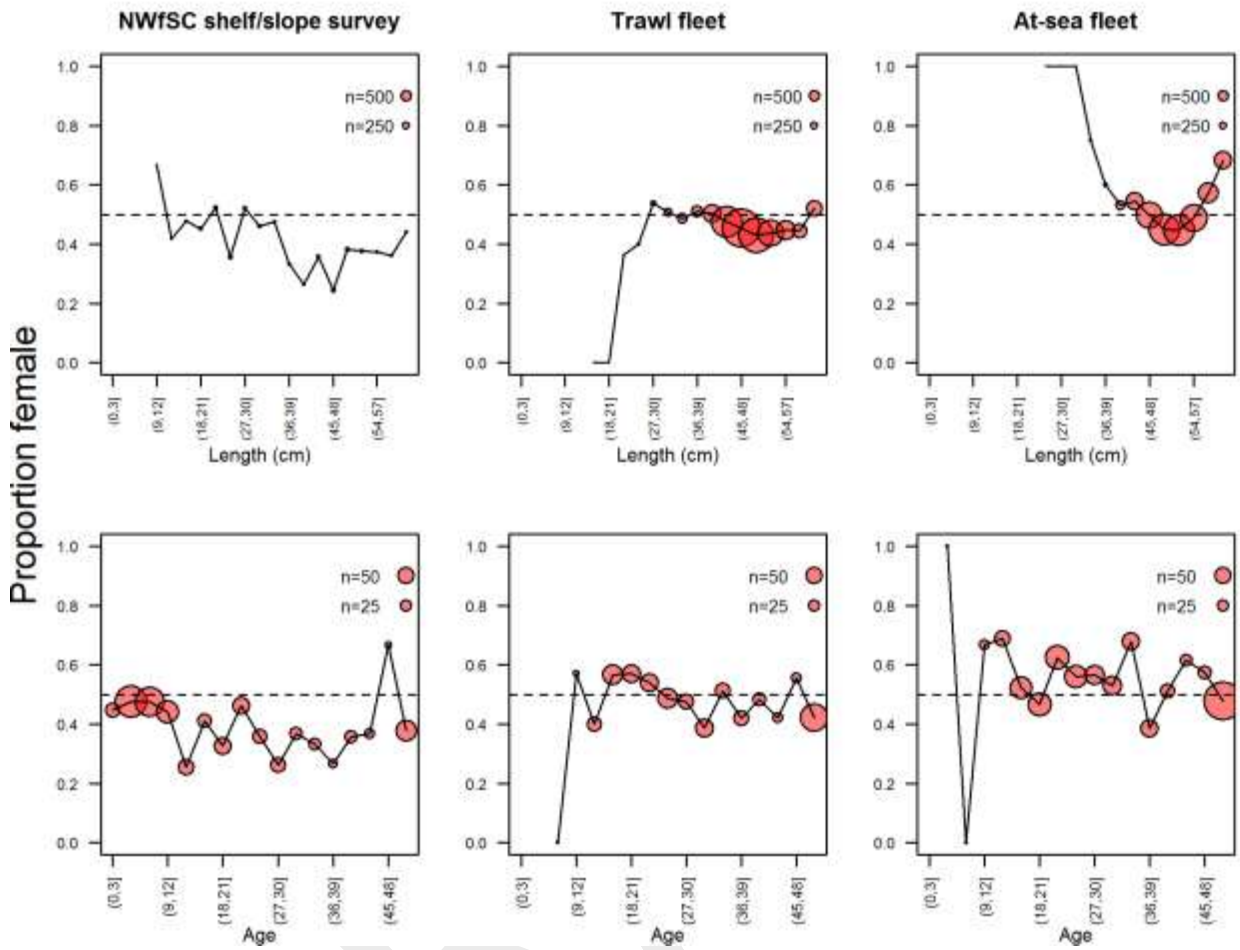



**Figure 40: Proportion of females plotted against fish length (top) and fish age (bottom). The area of the circle corresponds to the number of observations in that bin.**

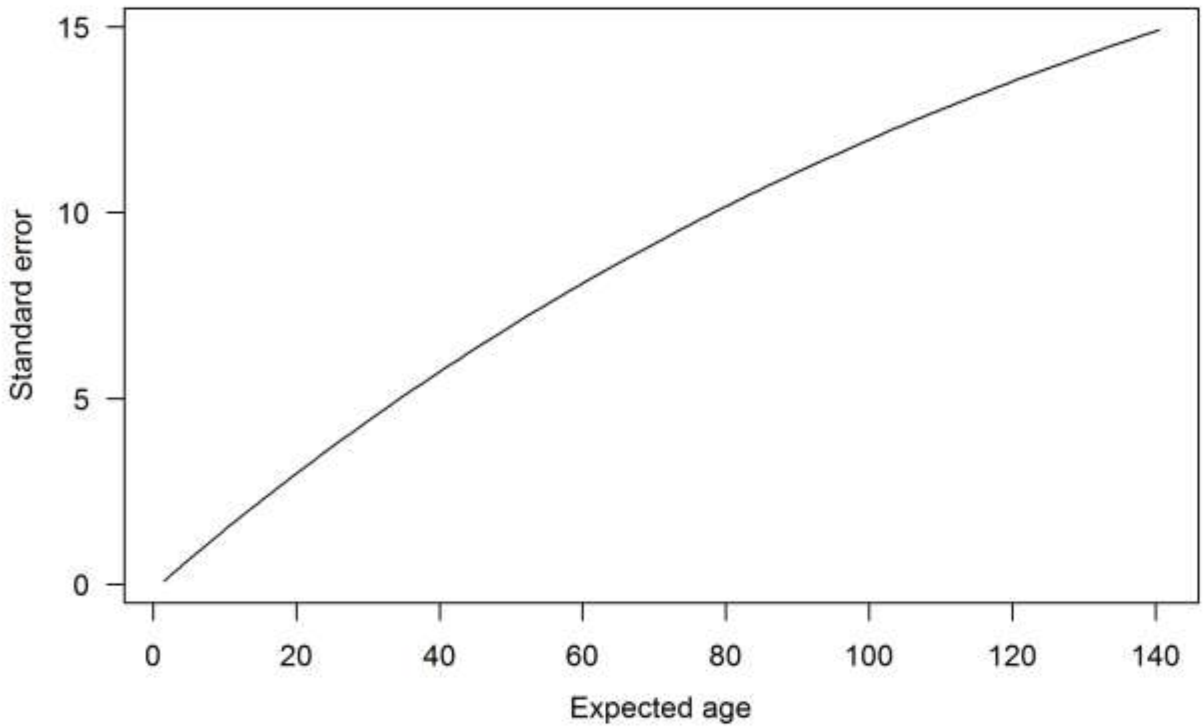



**Figure 41: Estimated ageing error used in the model.**

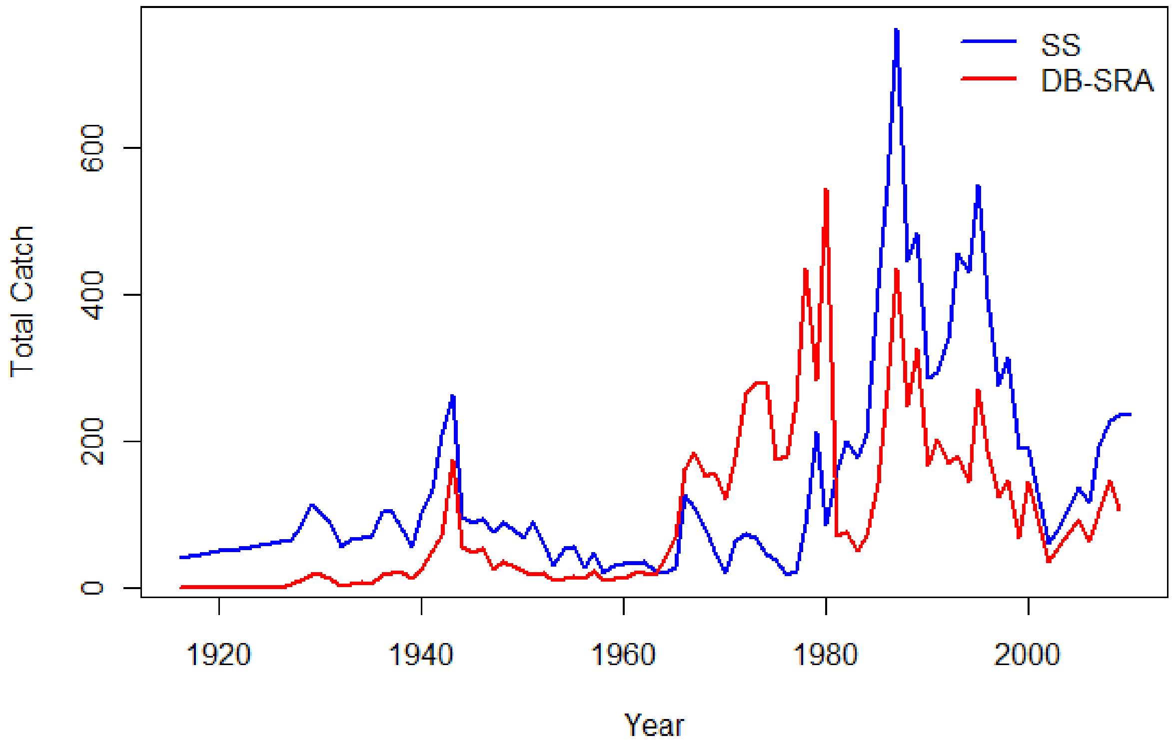



**Figure 42: Comparison of catches applied by (Dick and MacCall 2010) in 2010 to those used by the base model in this assessment for 1916-2010.**

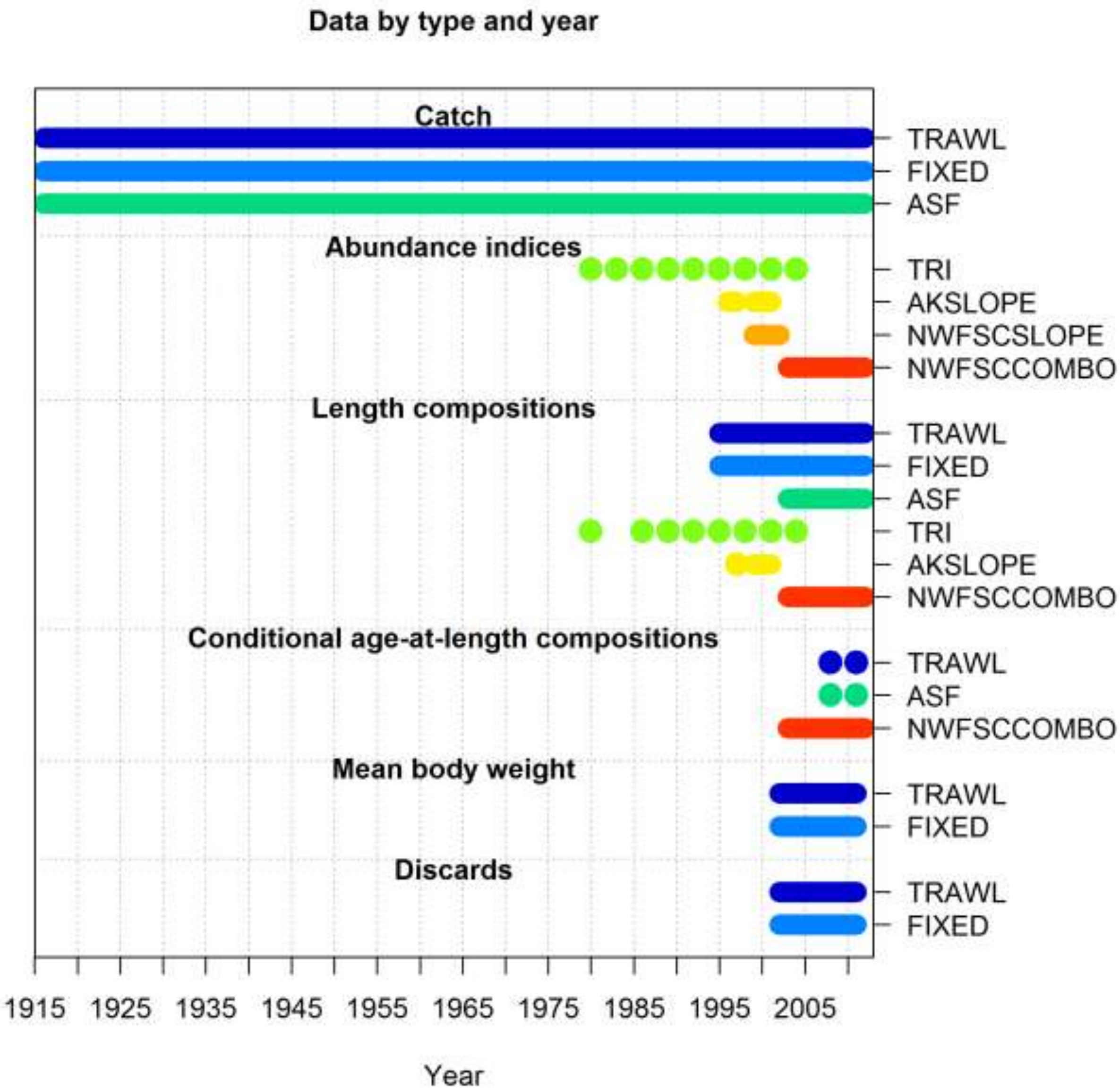



**Figure 43: Data sources by type and year that were used in the base model.**

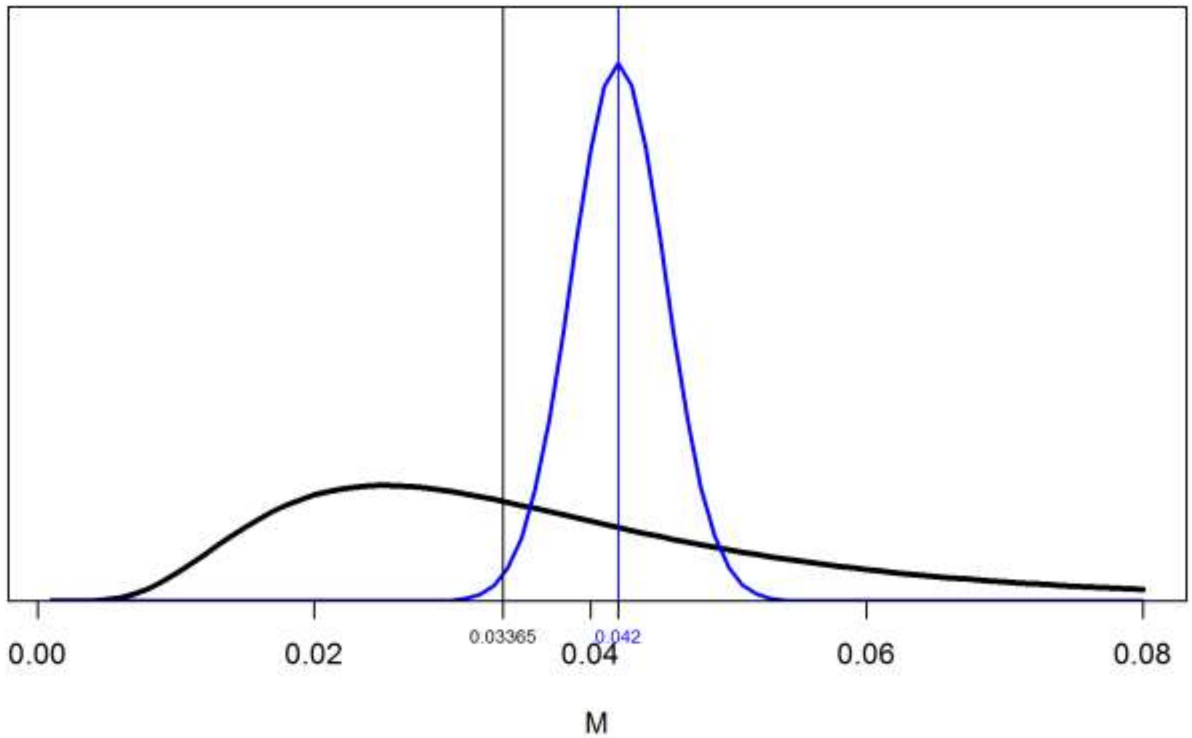



**Figure 44: The prior for natural mortality (*M*) and the estimated *M* with asymptotic uncertainty based on maximum likelihood theory. The median of the prior is shown by the vertical black line and the maximum likelihood estimate is shown by the vertical blue line.**

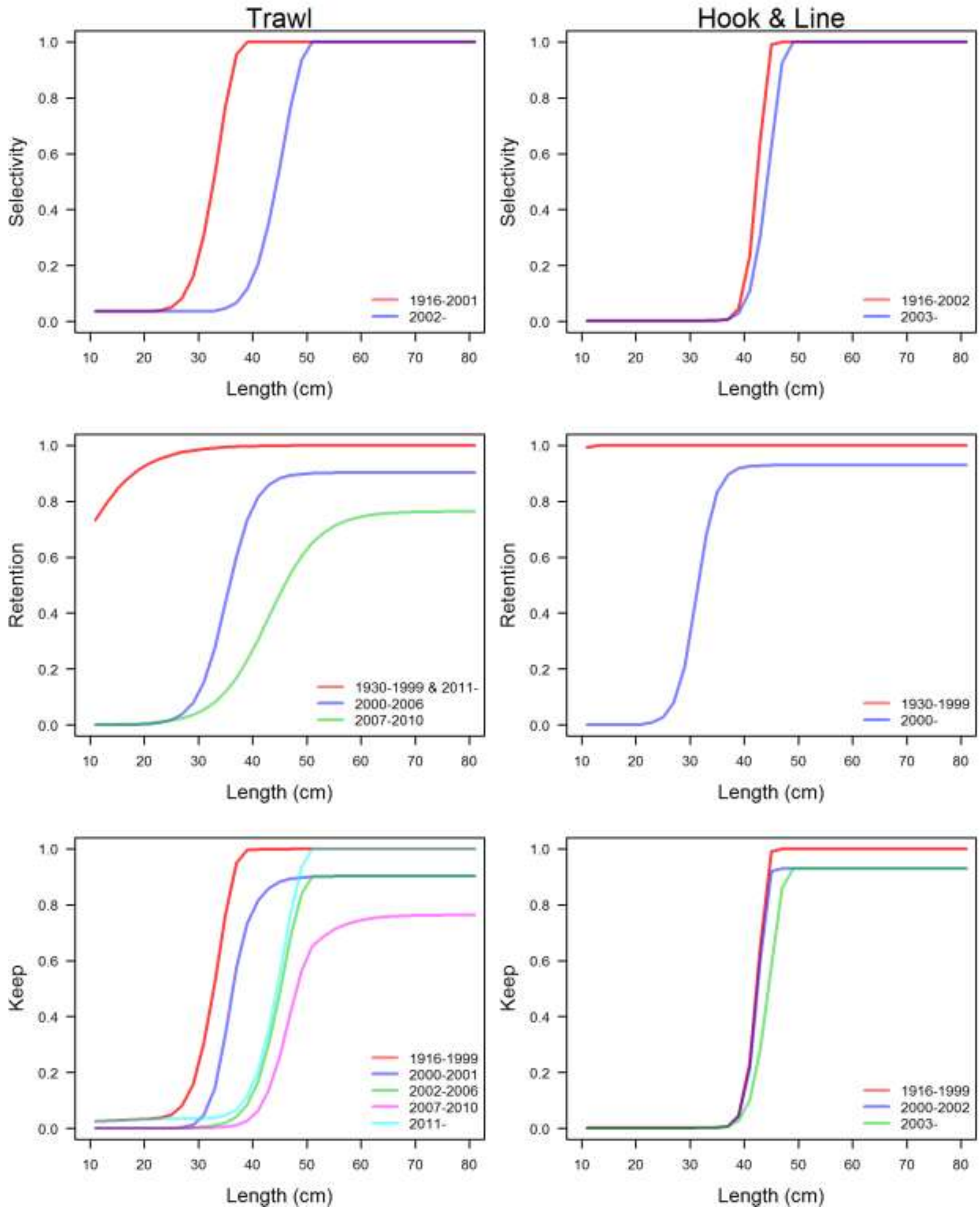


**Figure 45: Estimated selectivity (top), retention (middle), and keep (bottom) curves for different blocks and the trawl (left) and hook & line (right) fleets.**

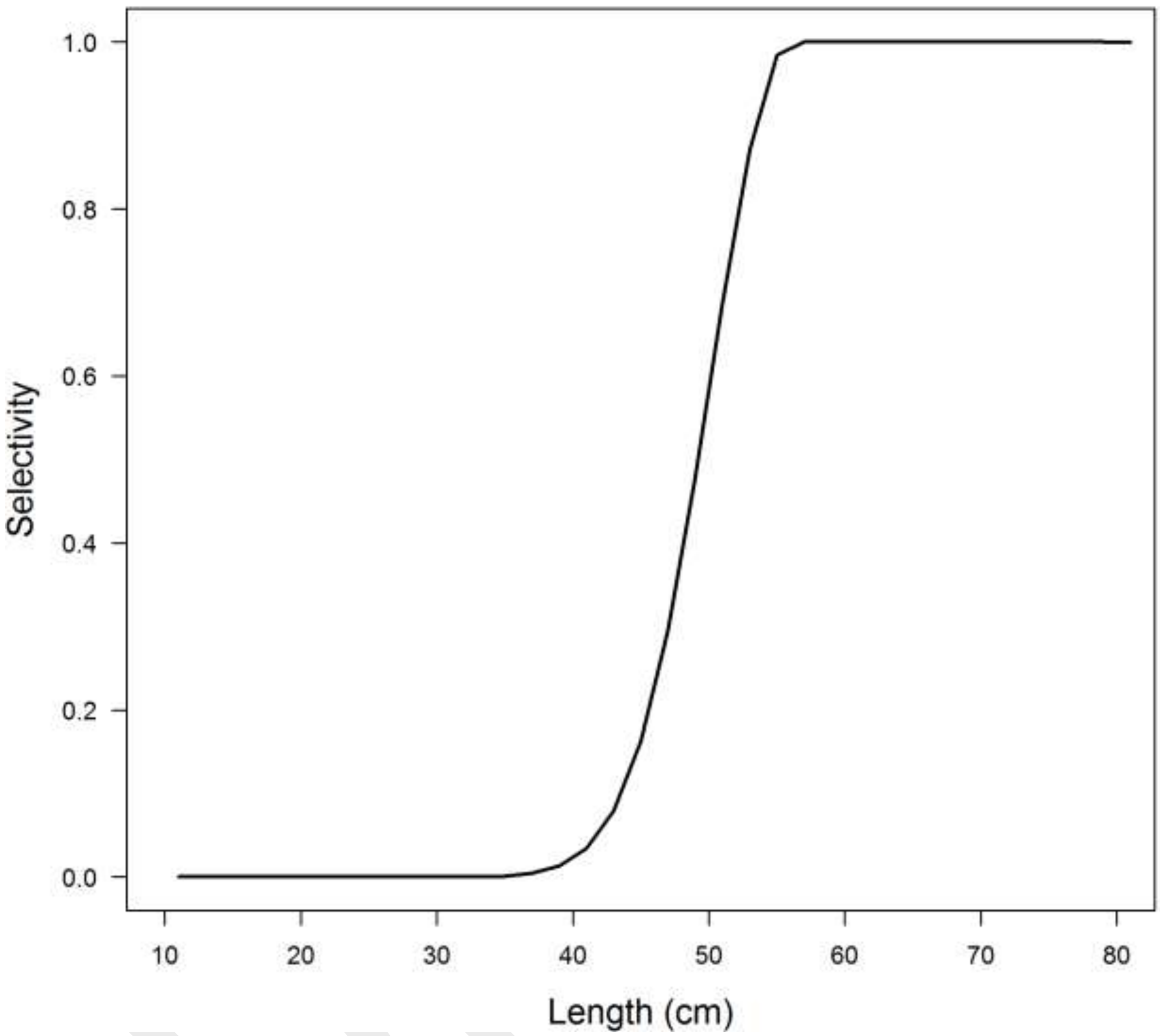



**Figure 46: Estimated length-based selectivity for the at-sea fleet.**

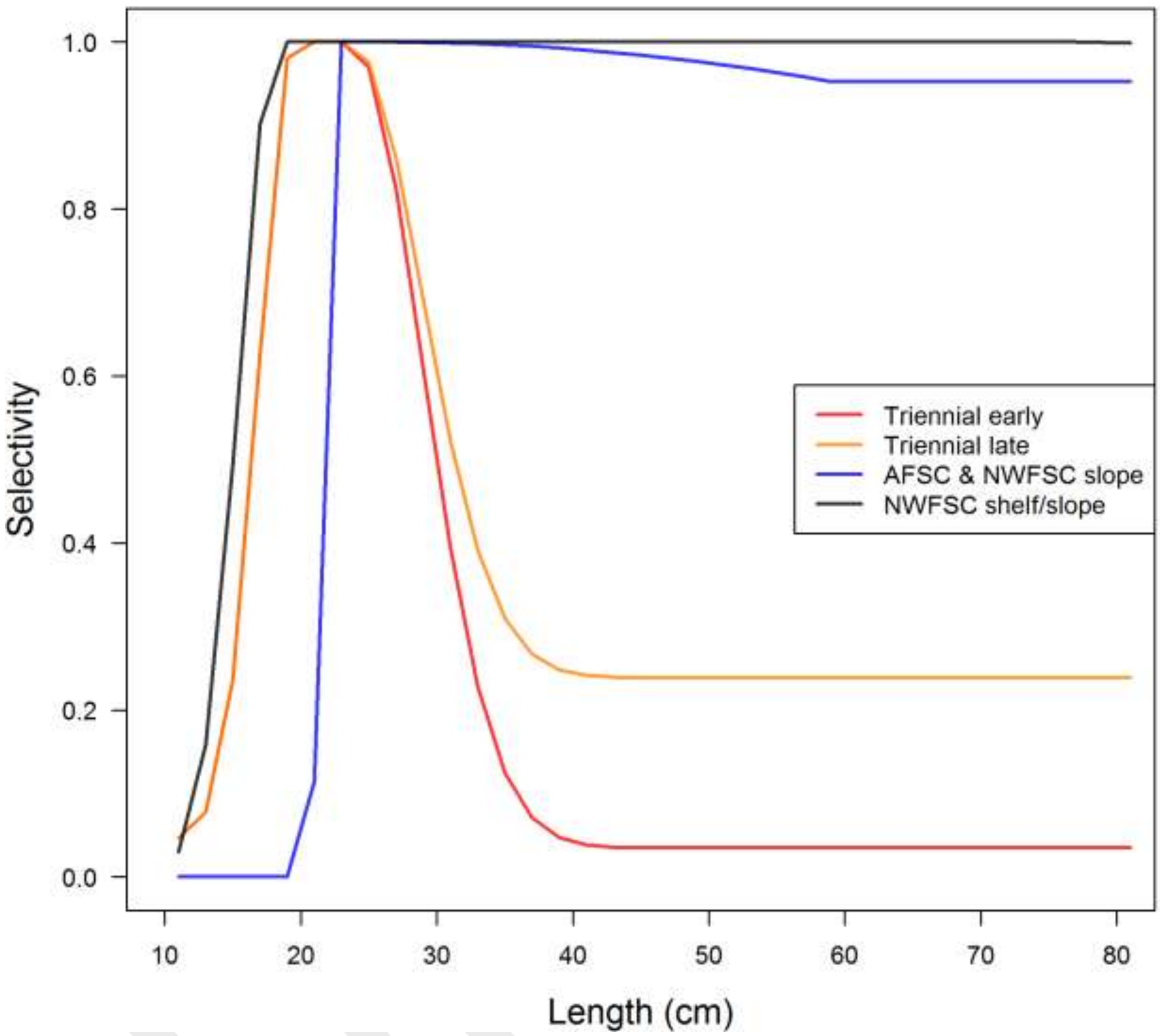



**Figure 47: Estimated selectivity curves for the surveys.**

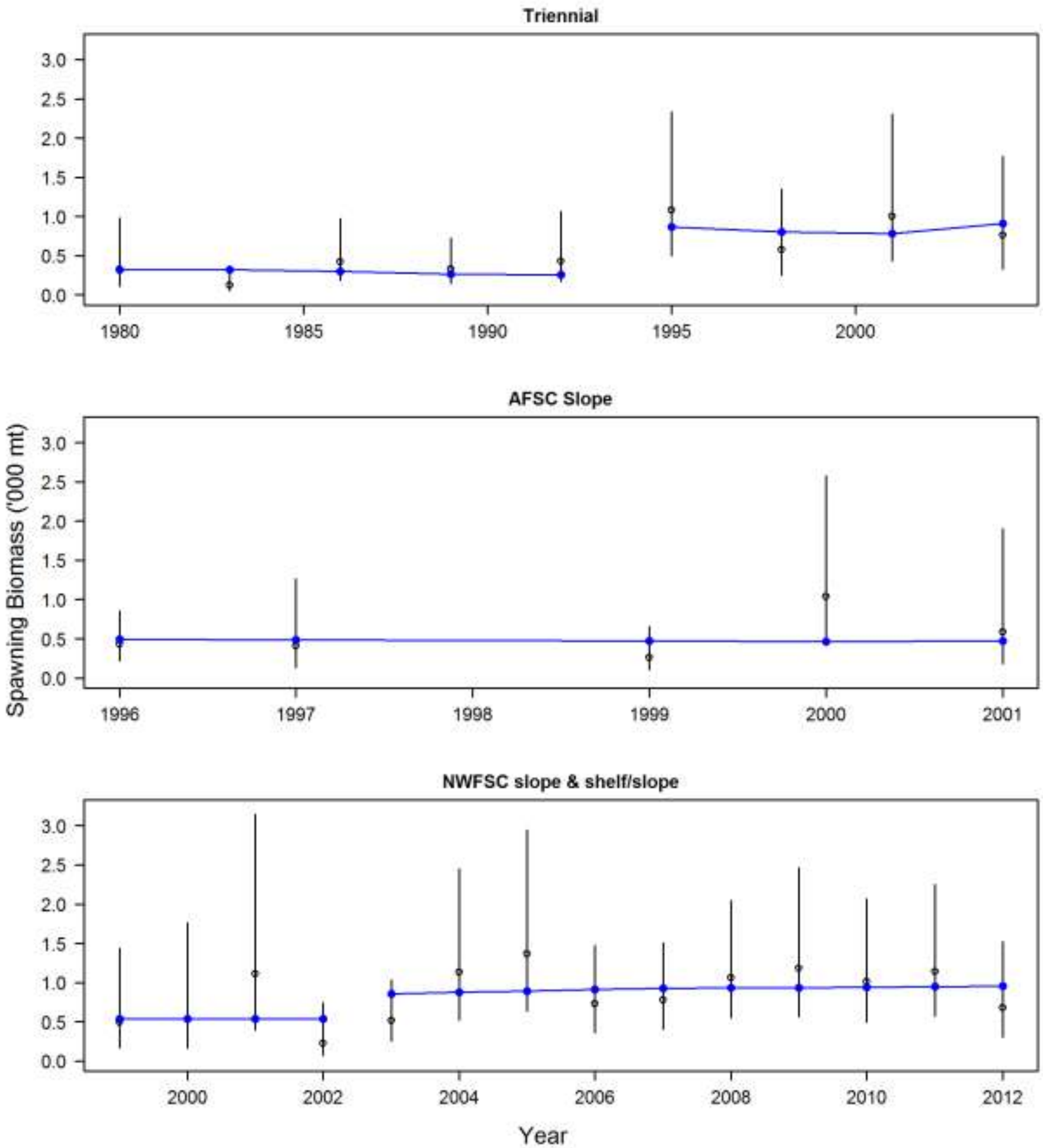



**Figure 48: Fits to the survey abundance estimates for the base model.**

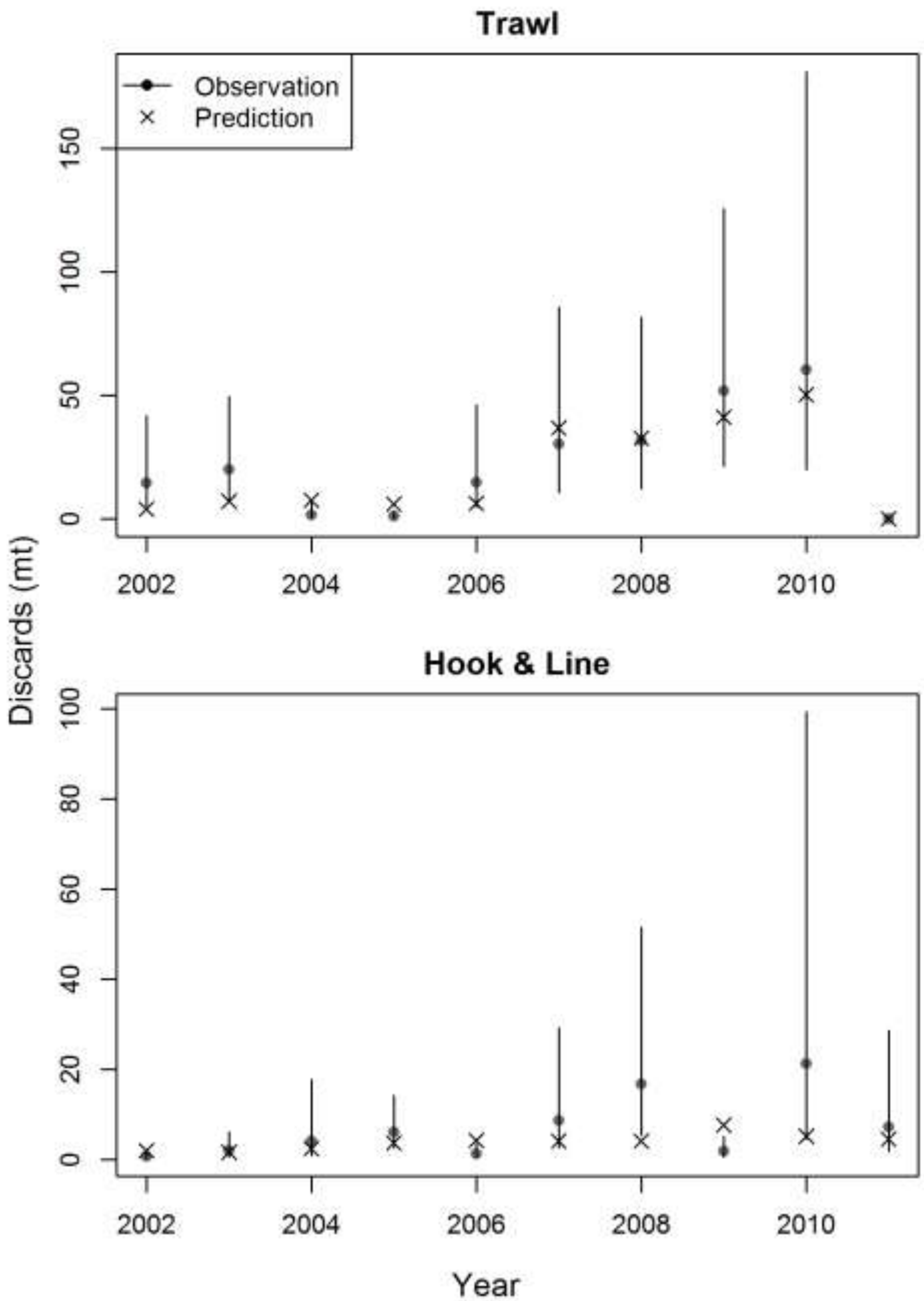



**Figure 49: Predicted and observed discards for the trawl and hook & line fleets from the base model.**

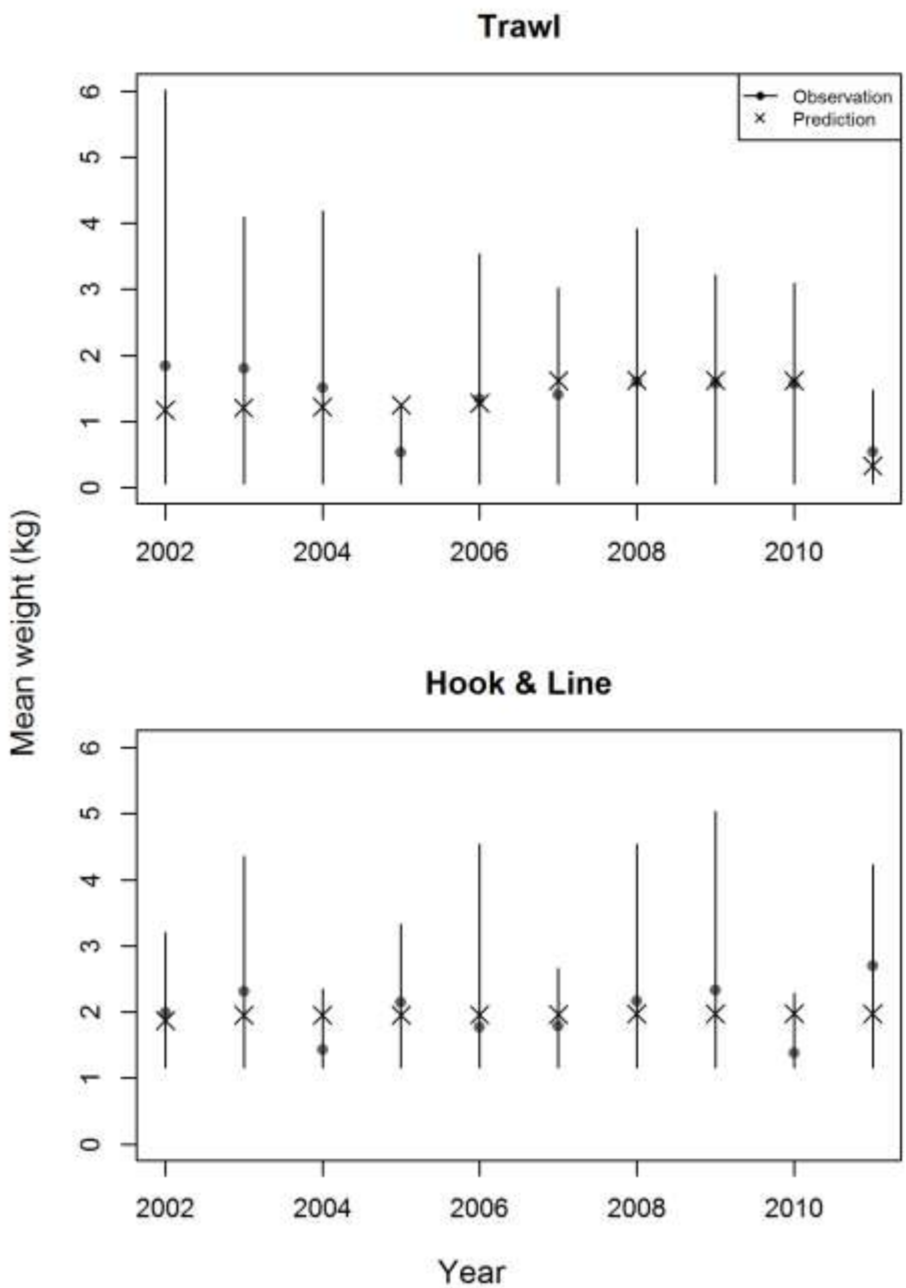



**Figure 50: Fits to the mean weight of the discards for each fleet from the base model.**

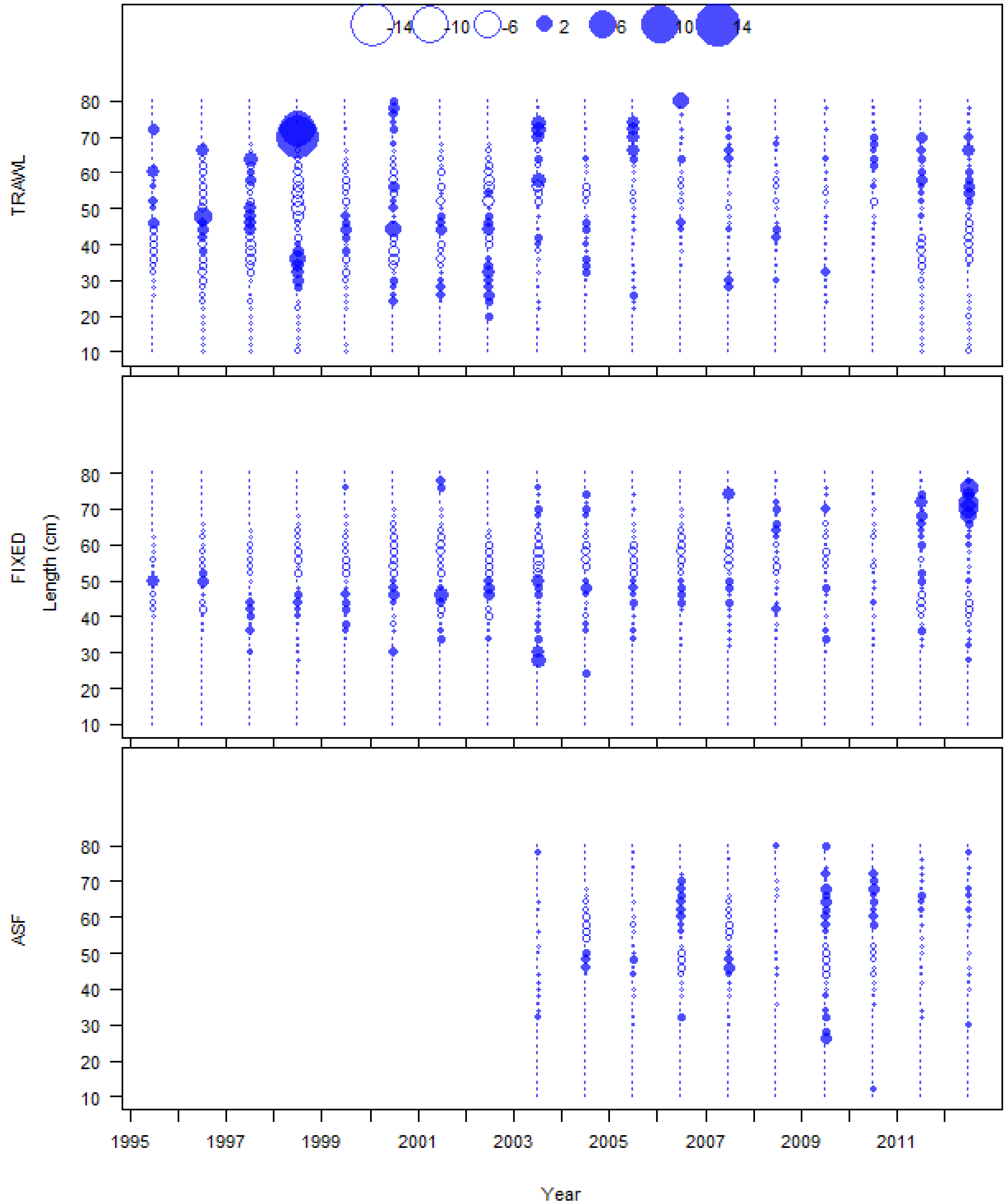



**Figure 51: Pearson residuals for fits to length frequency data from the commercial fleets. Filled circles indicate that the fitted proportion was less than the observed proportion.**

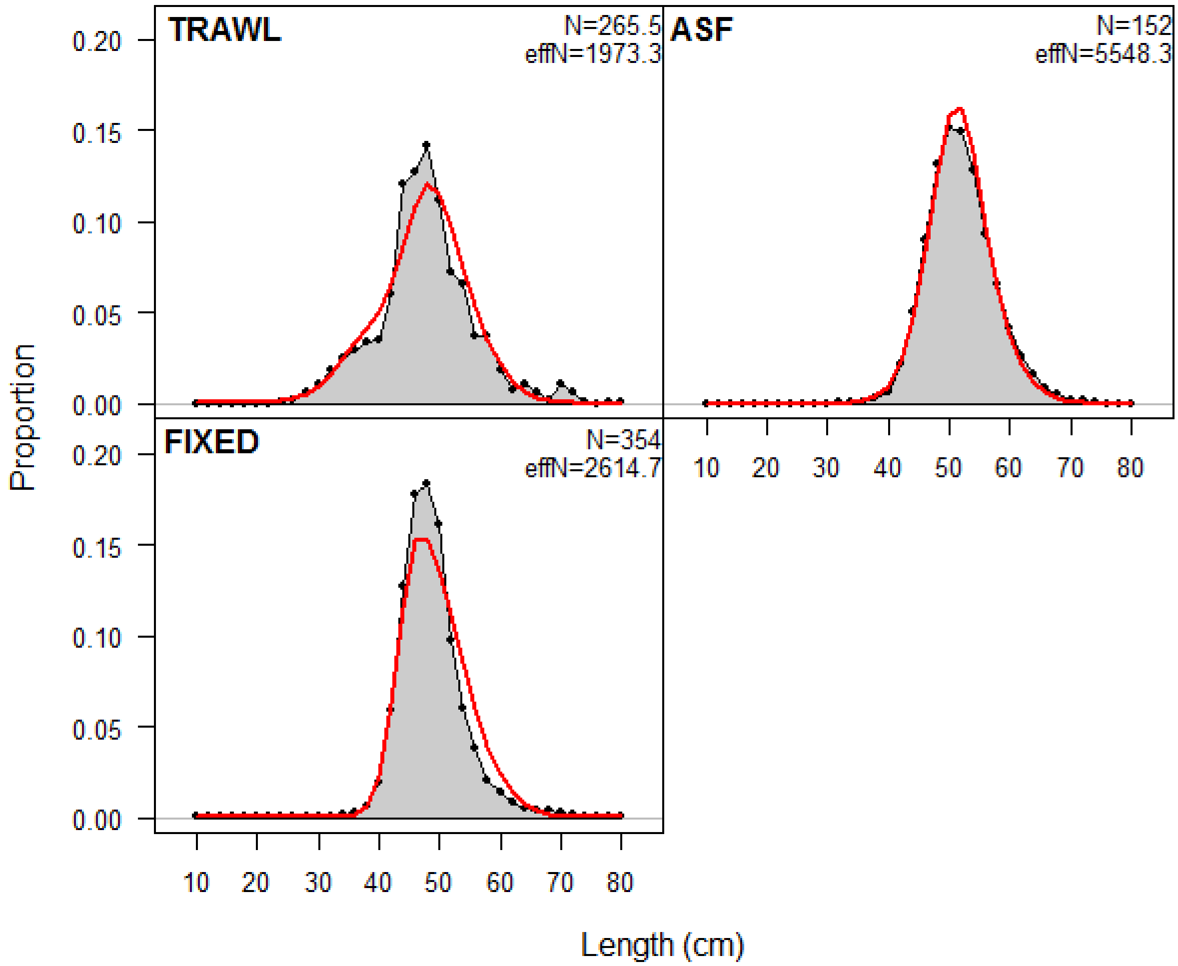



**Figure 52: Combined length frequencies for all years (points) with the overall fit (red) for each commercial fleet.**

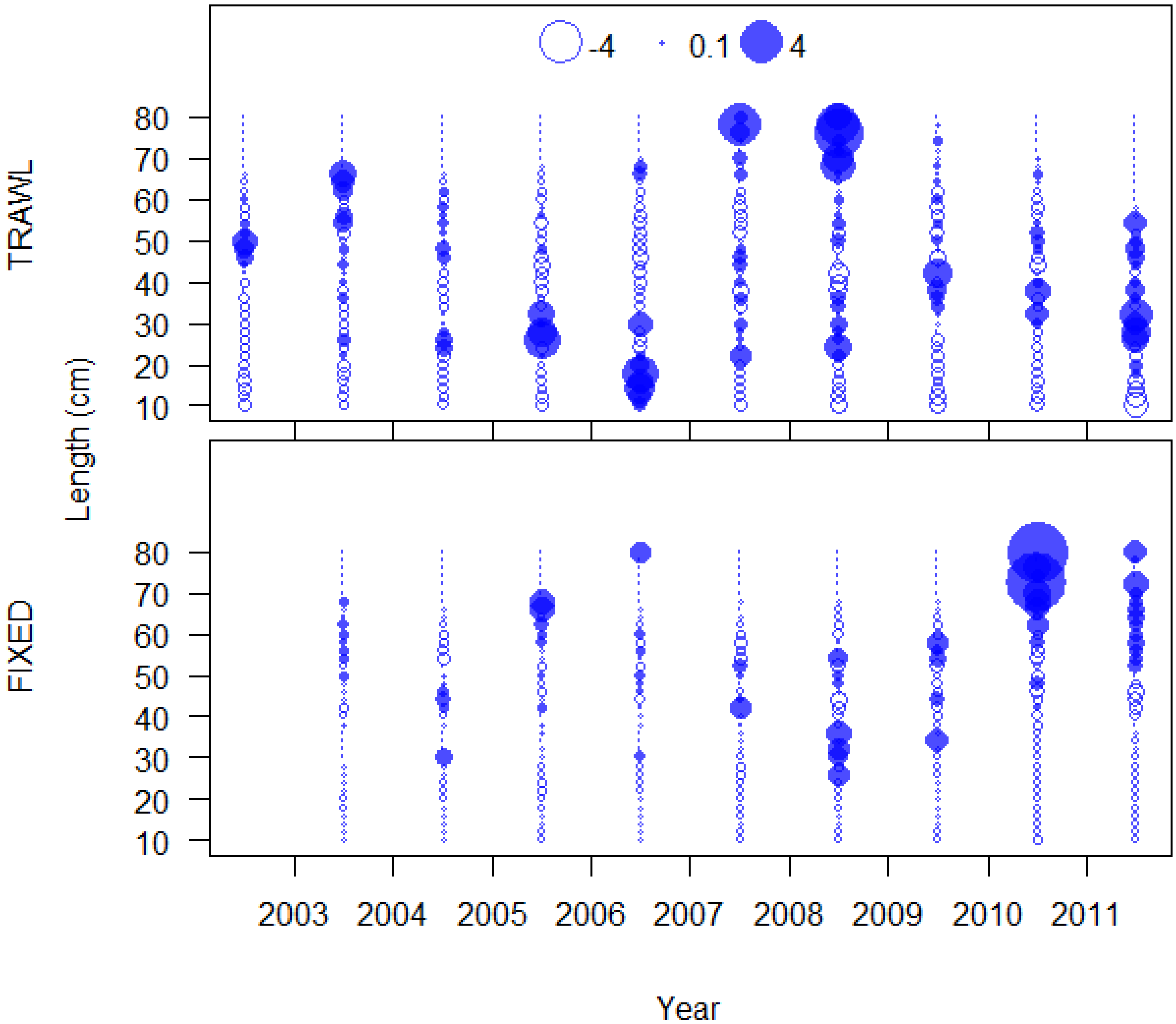


**Figure 53: Pearson residuals for fits to the discard length frequencies from the trawl and hook & line fleets. Filled circles indicate that the fitted proportion was less than the observed proportion.**

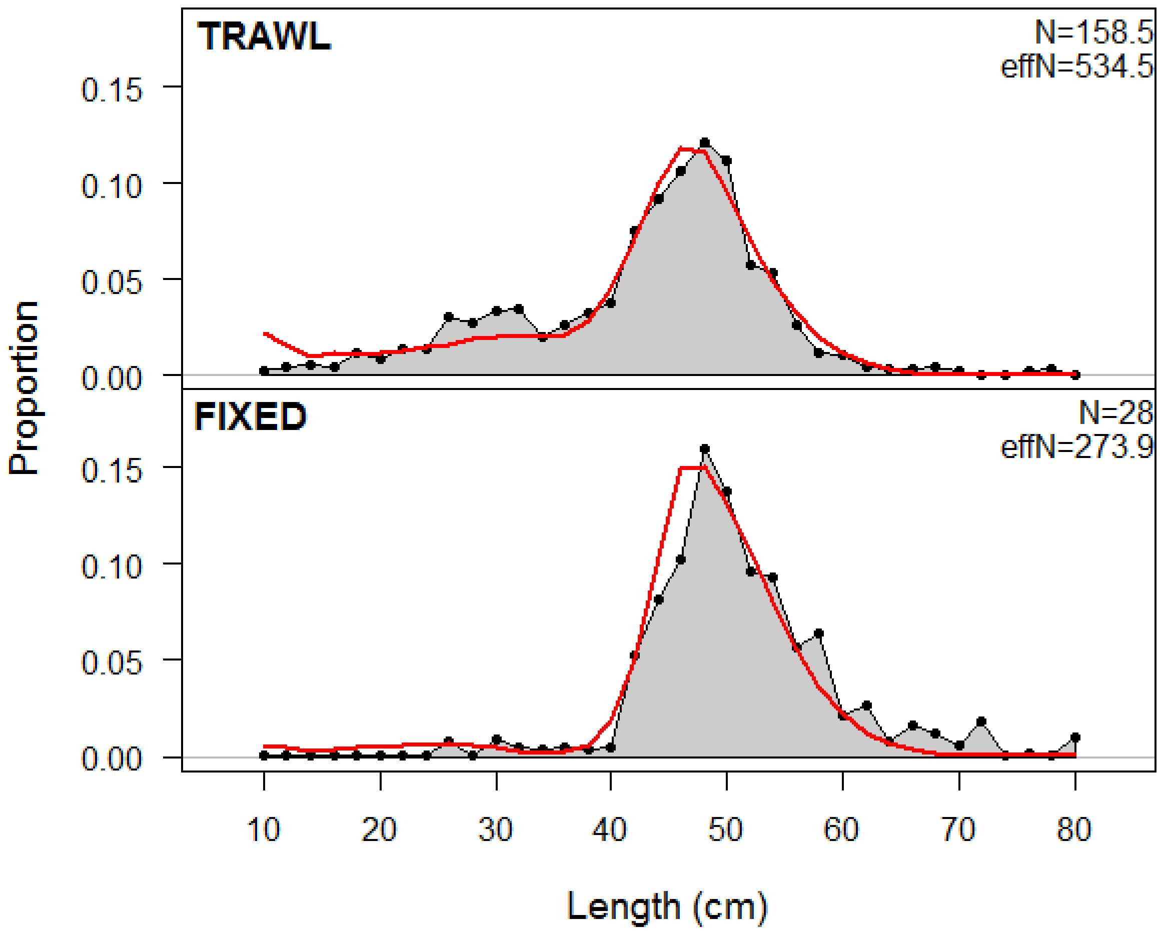



**Figure 54: Combined length frequencies for all years from trawl and hook & line discard data (points) with fits shown by the red line.**

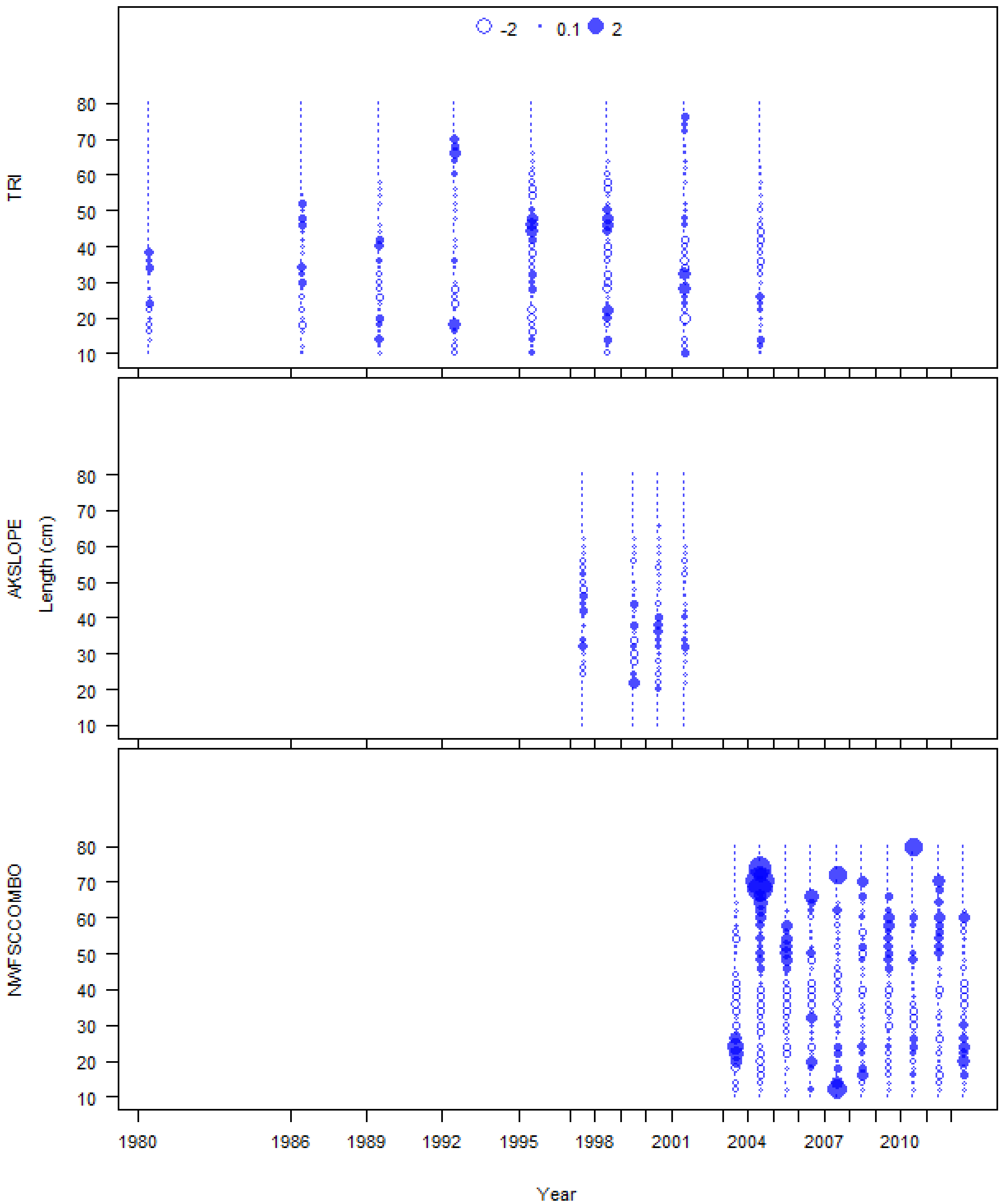



**Figure 55: Pearson residuals for fits to the survey length frequency data. Filled circles indicate that the fitted proportion was less than the observed proportion.**

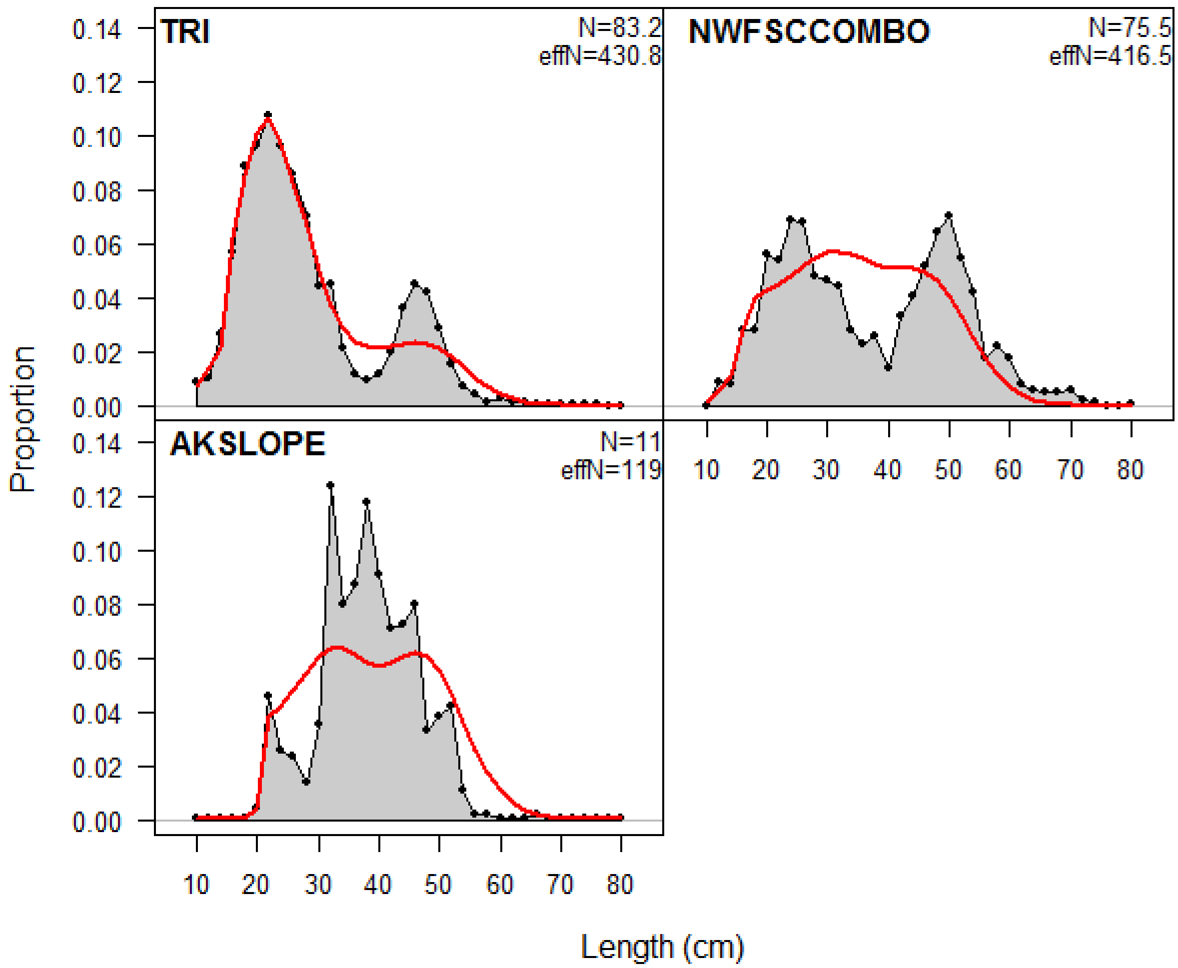



**Figure 56: Combined length frequencies for all years from survey length frequency data (points) with fits shown by the red line.**

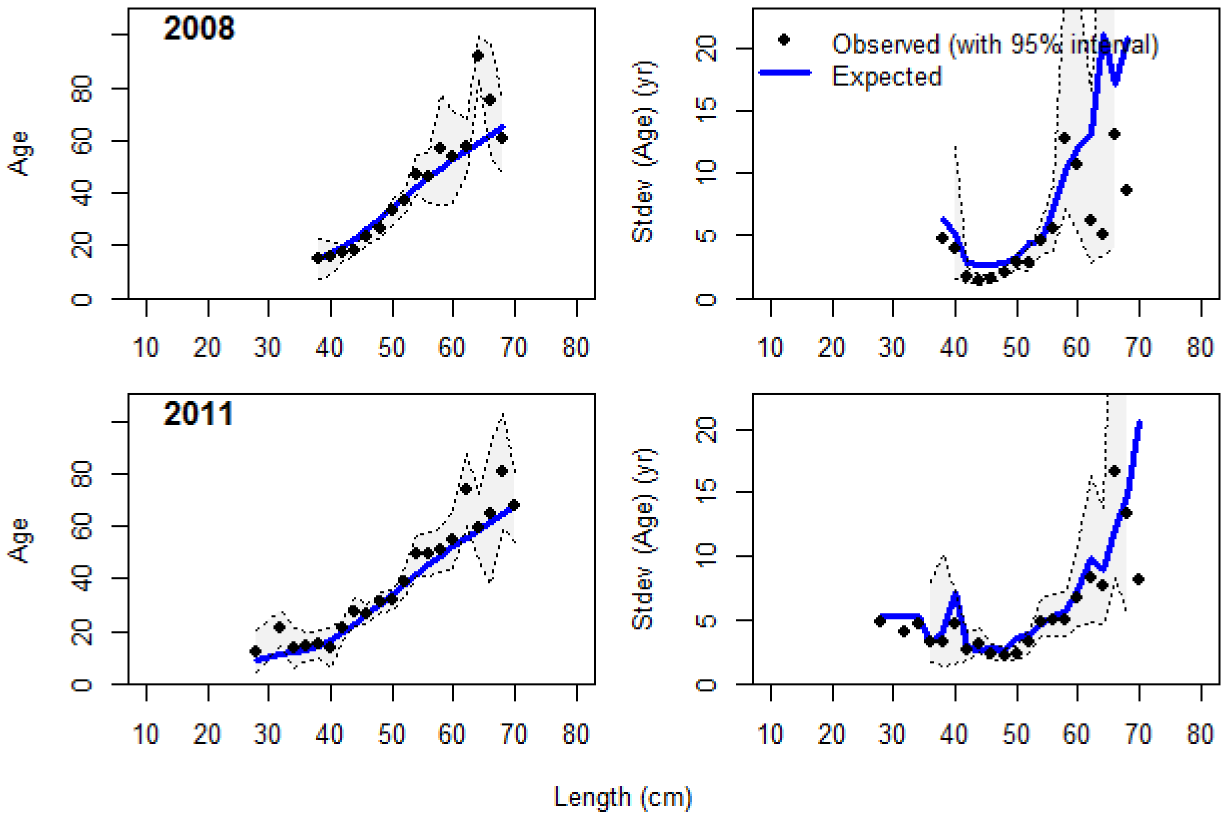



**Figure 57: Observed and expected age-at-length with 95% confidence intervals (left) and observed and expected standard deviation of age-at-length with 95% confidence intervals (right) for the trawl fishery.**

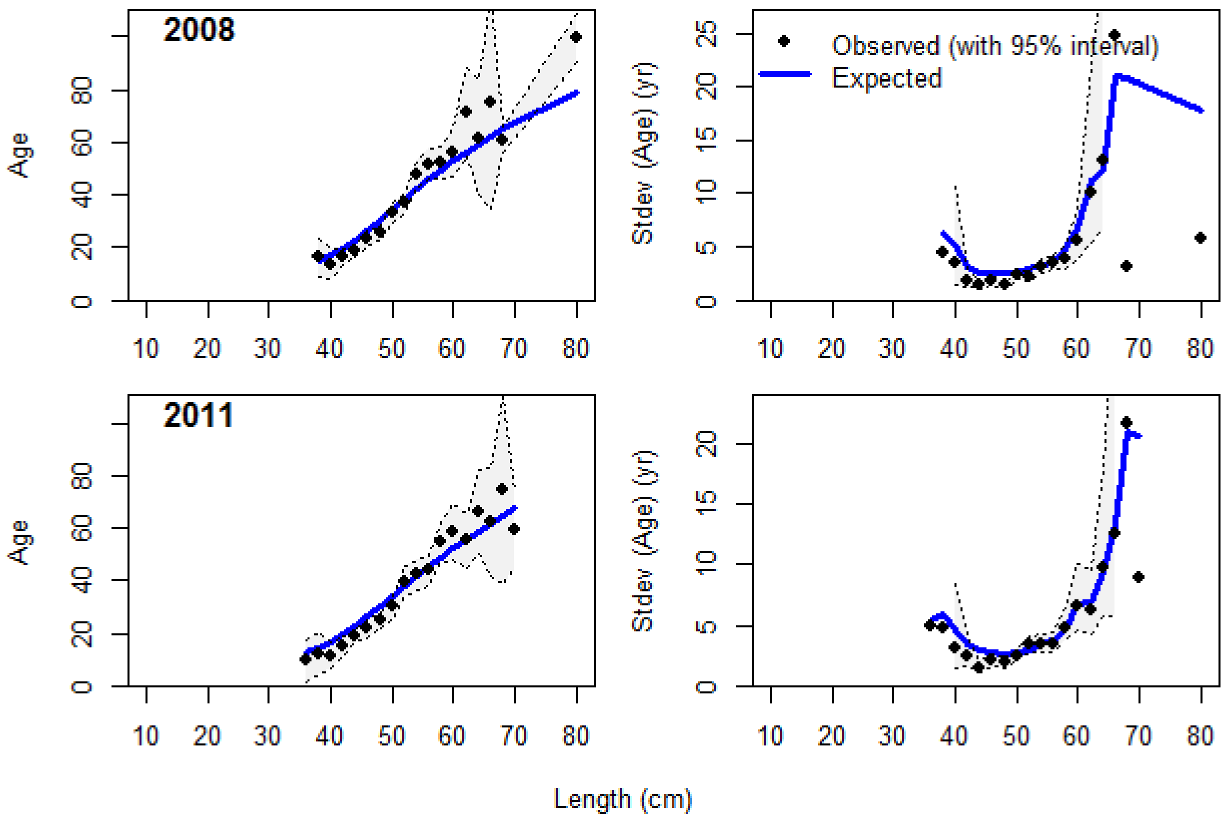



**Figure 58: Observed and expected age-at-length with 95% confidence intervals (left) and observed and expected standard deviation of age-at-length with 95% confidence intervals (right) for the at-sea fleet.**

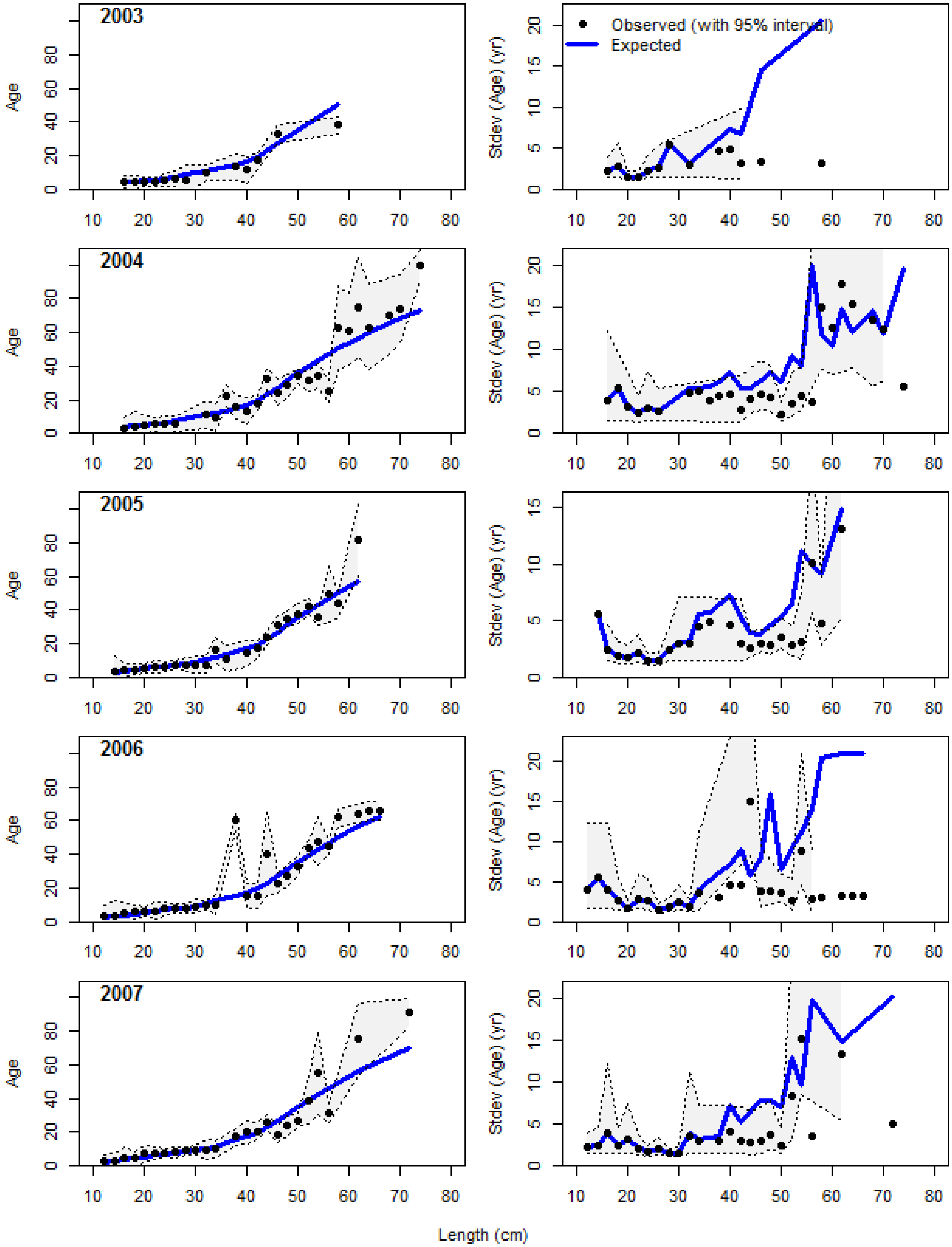



**Figure 59: Observed and expected age-at-length with 95% confidence intervals (left) and observed and expected standard deviation of age-at-length with 95% confidence intervals (right) for the NWFSC shelf/slope survey data.**

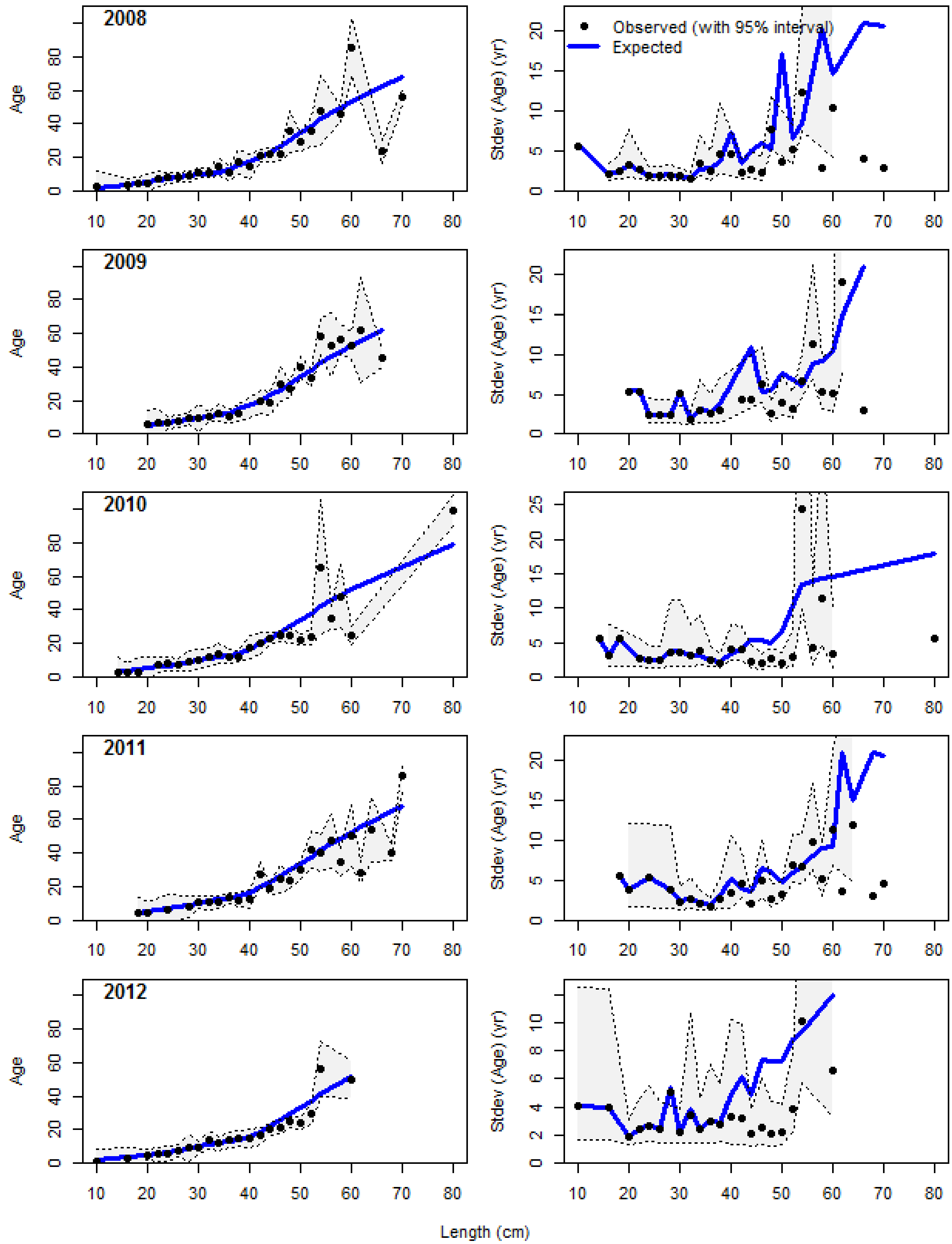


**Figure 59 (cont.): Observed and expected age-at-length with 95% confidence intervals (left) and observed and expected standard deviation of age-at-length with 95% confidence intervals (right) for the NWFSC shelf/slope survey.**

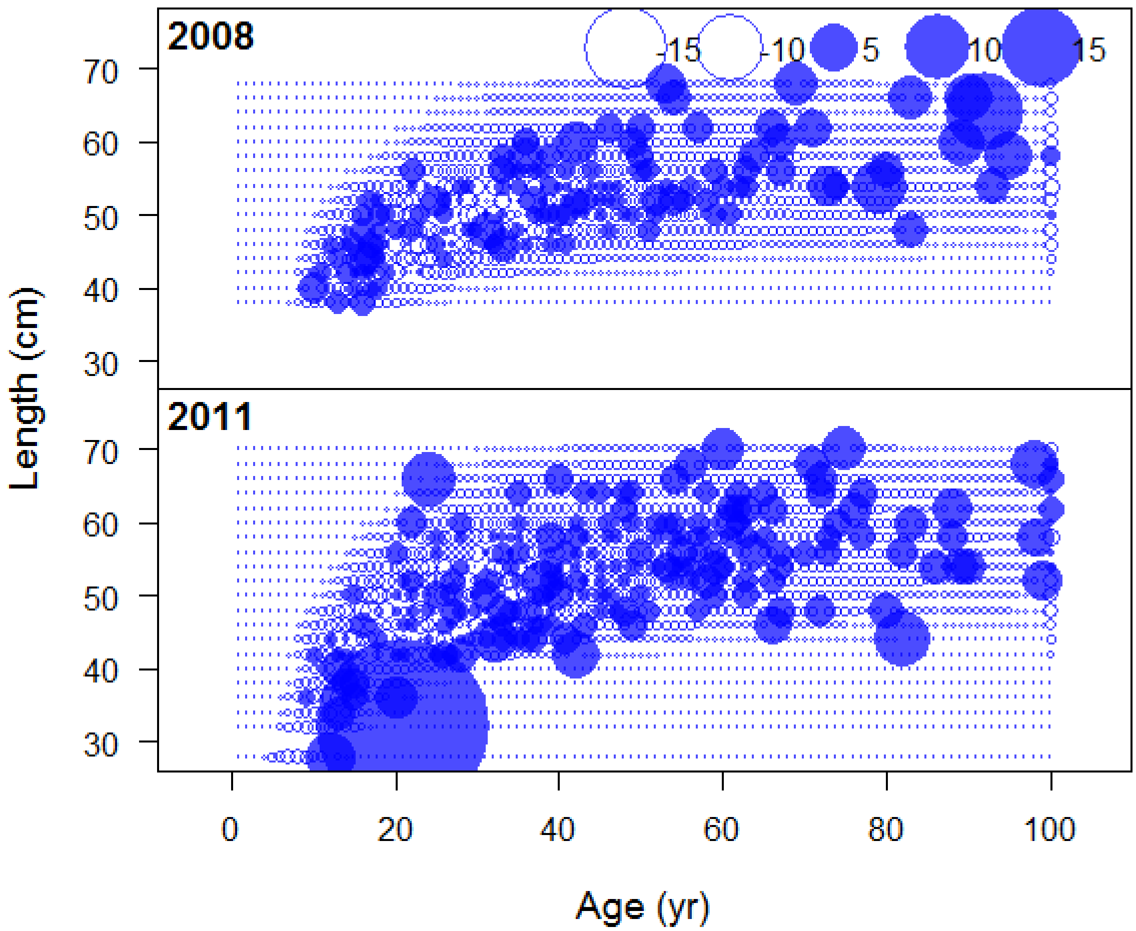



**Figure 60: Pearson residuals for fits to age-at-length data for the trawl fleet. Filled circles indicate that the fitted proportion was less than the observed proportion.**

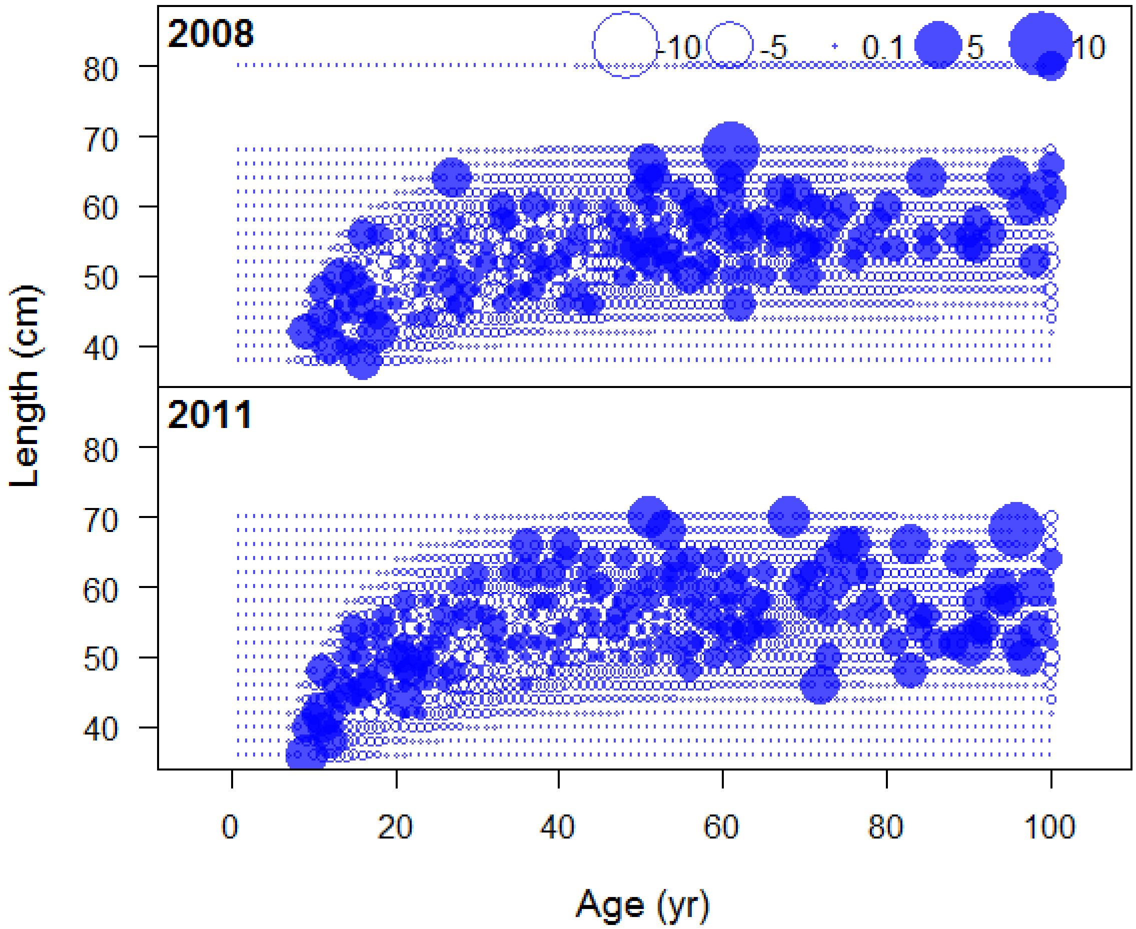



**Figure 61: Pearson residuals for fits to age-at-length data for the at-sea fleet. Filled circles indicate that the fitted proportion was less than the observed proportion.**

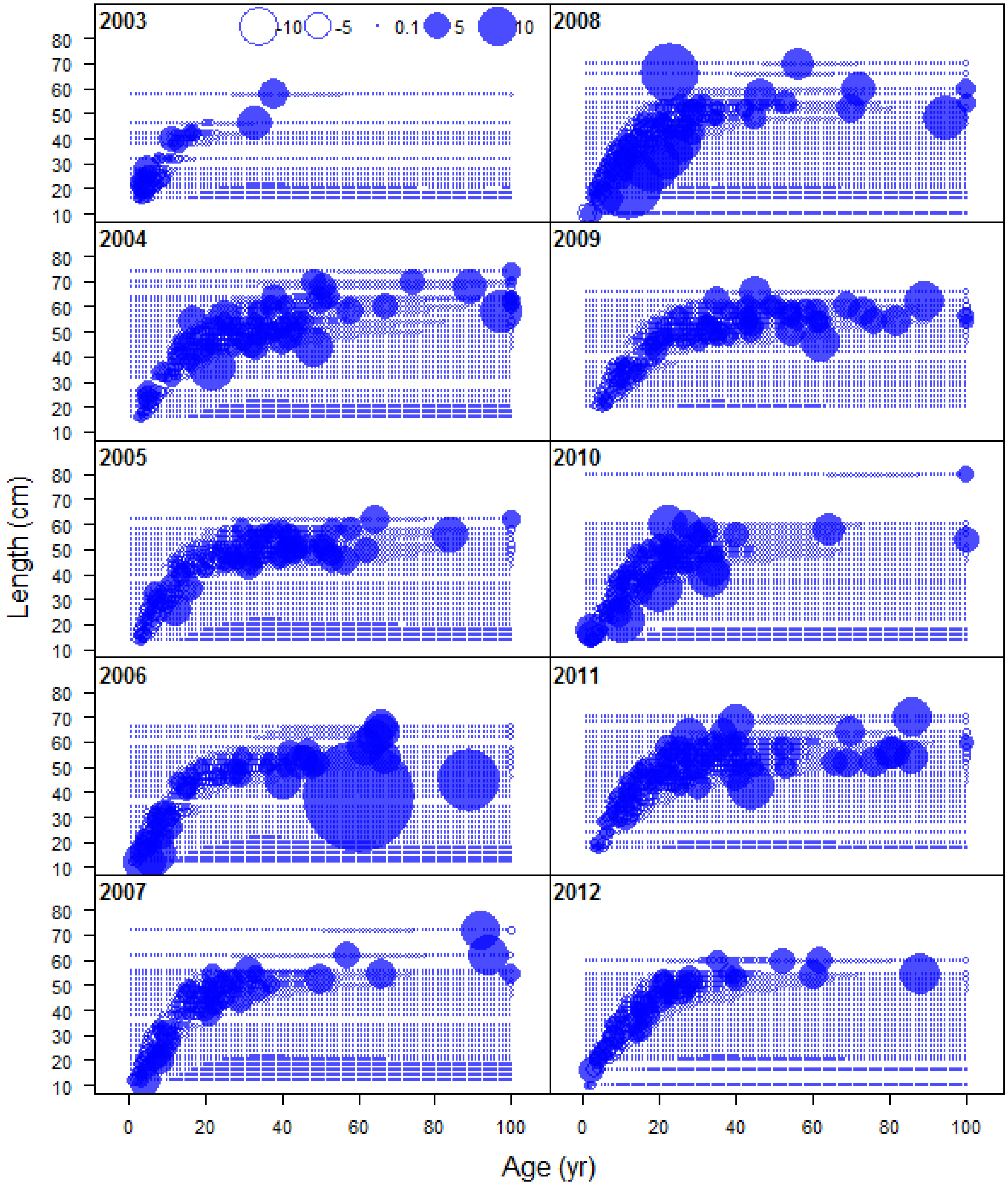



**Figure 62: Pearson residuals for fits to age-at-length data for the NWFSC shelf/slope survey. Filled circles indicate that the fitted proportion was less than the observed proportion.**

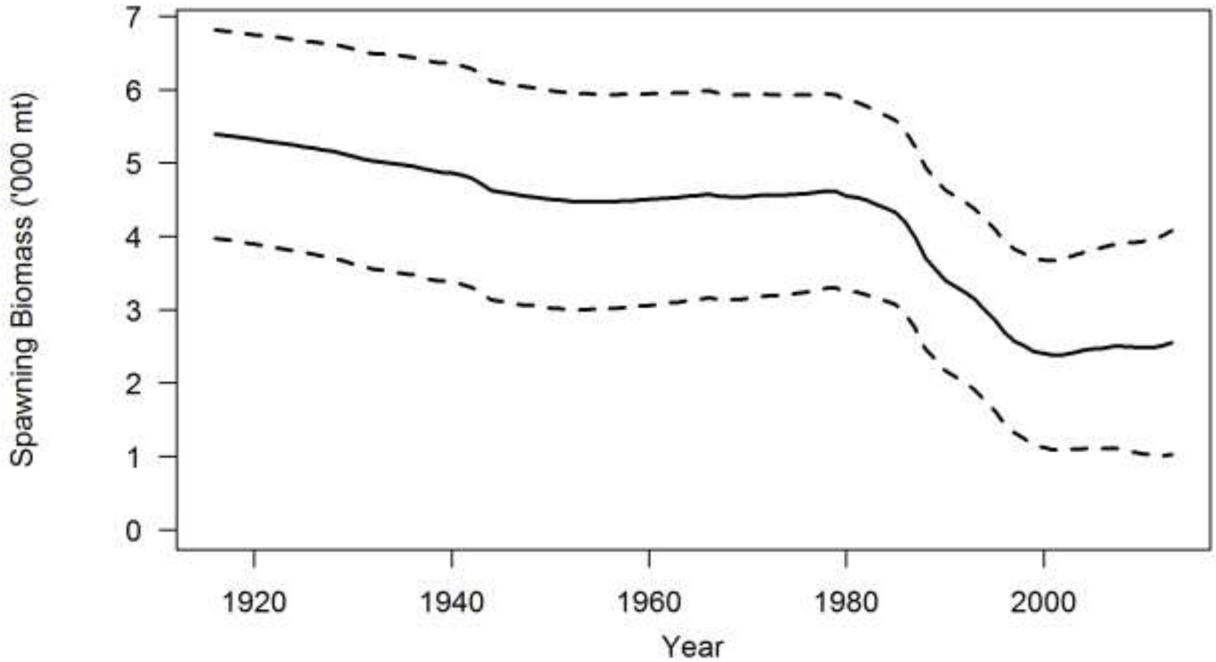



**Figure 63: Predicted spawning biomass (mt) for rougheye rockfish using the base assessment. The solid line is the MLE estimate and the dashed lines are the approximate asymptotic 95% confidence intervals.**

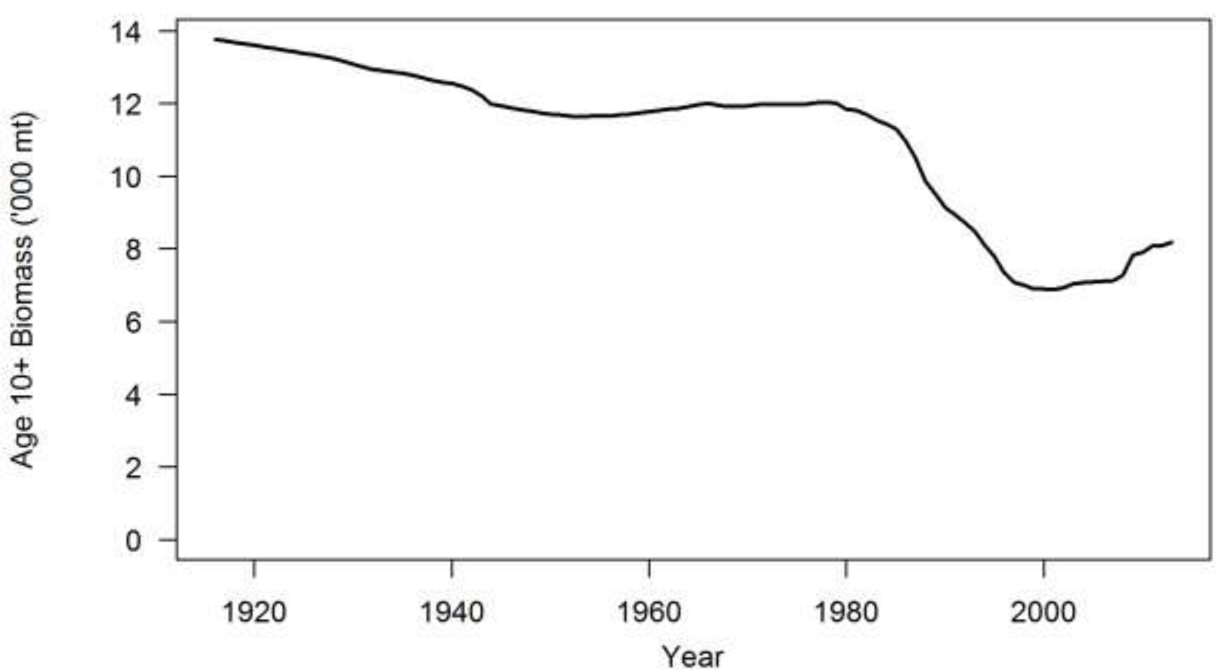



**Figure 64: Predicted summary biomass (age 10+) from the base model.**

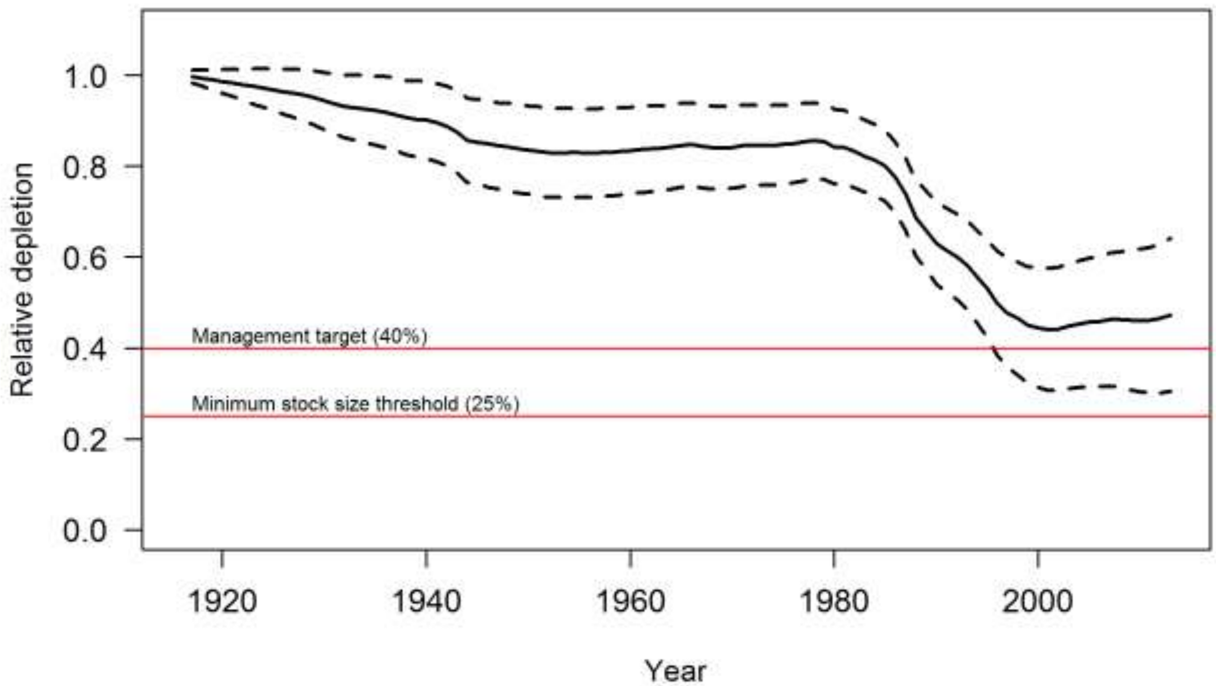



**Figure 65: Predicted depletion relative to unfished biomass from the rougheye rockfish base case assessment. The solid line is the MLE estimate and the dashed lines are the approximate asymptotic 95% confidence intervals. The red lines show the management target of 40% of unfished biomass and the minimum stock size threshold of 25% of unfished biomass.**

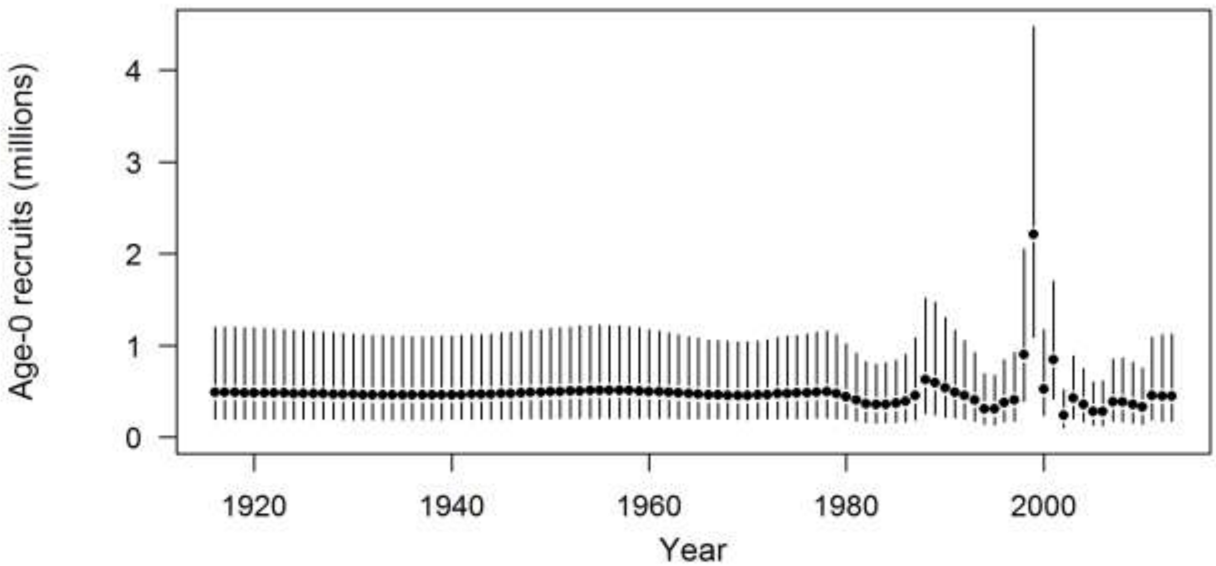



**Figure 66: Estimates of recruitment (upper) and recruitment deviates (lower) with approximate asymptotic 95% confidence intervals (vertical lines) from the MLE estimates.**

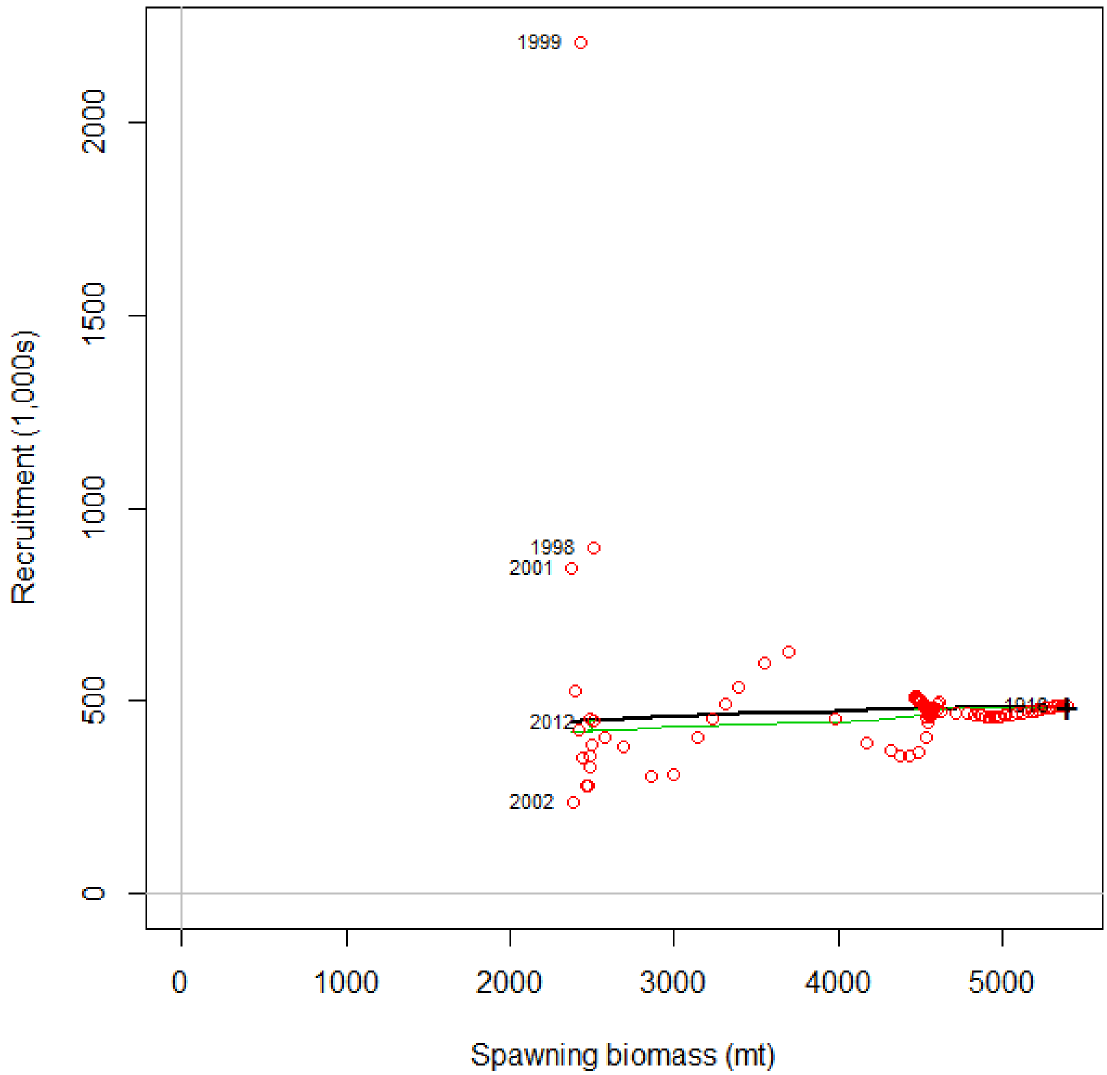



**Figure 67: Estimated recruitment (red circles) and the assumed stock-recruit relationship (black line). The green line shows the effect of the bias correction for the lognormal distribution.**

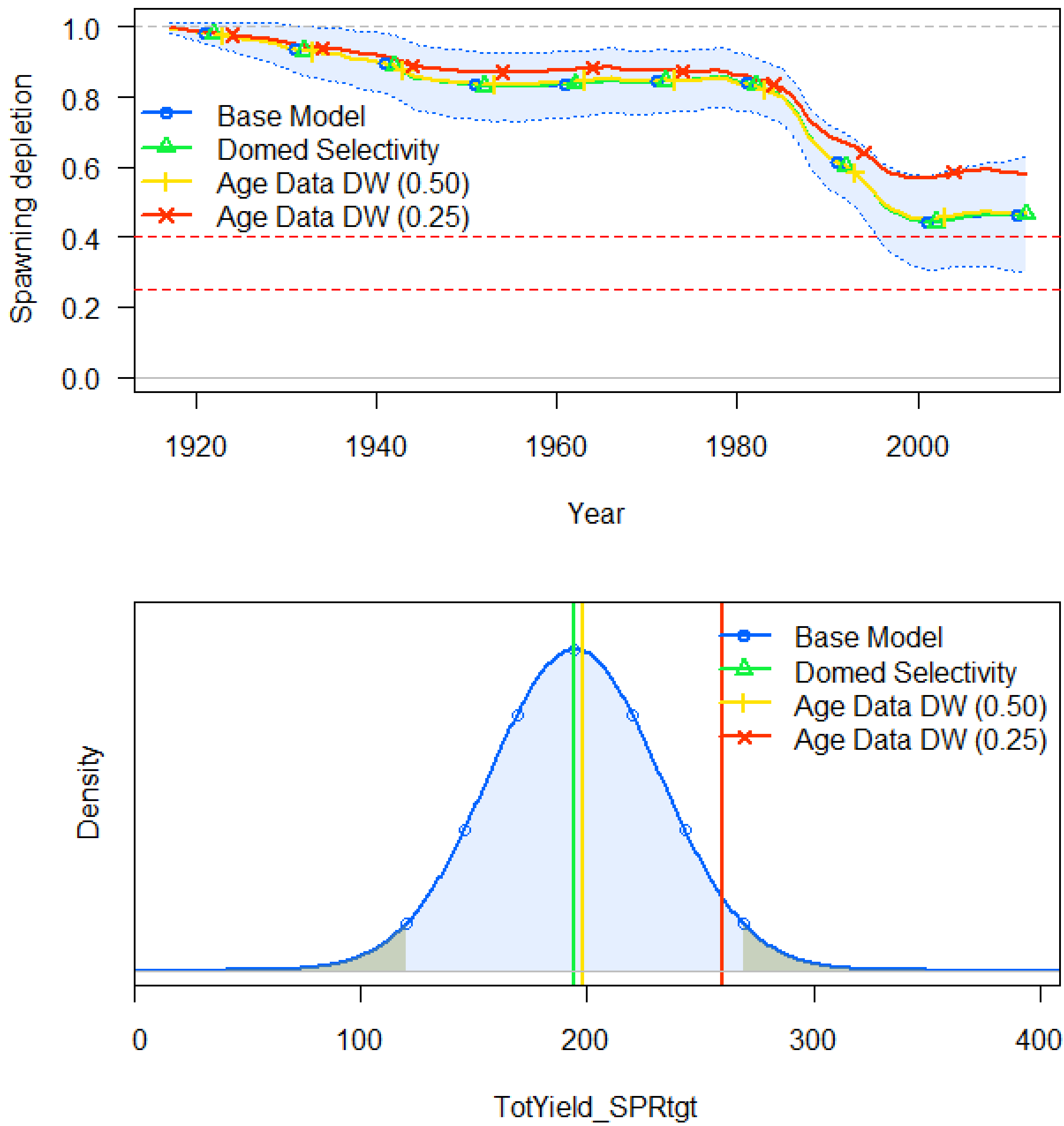



**Figure 68: Depletion and target yield estimates for the base model and sensitivities to dome-shaped selectivity and reducing the weight on age data sources in the likelihood.**

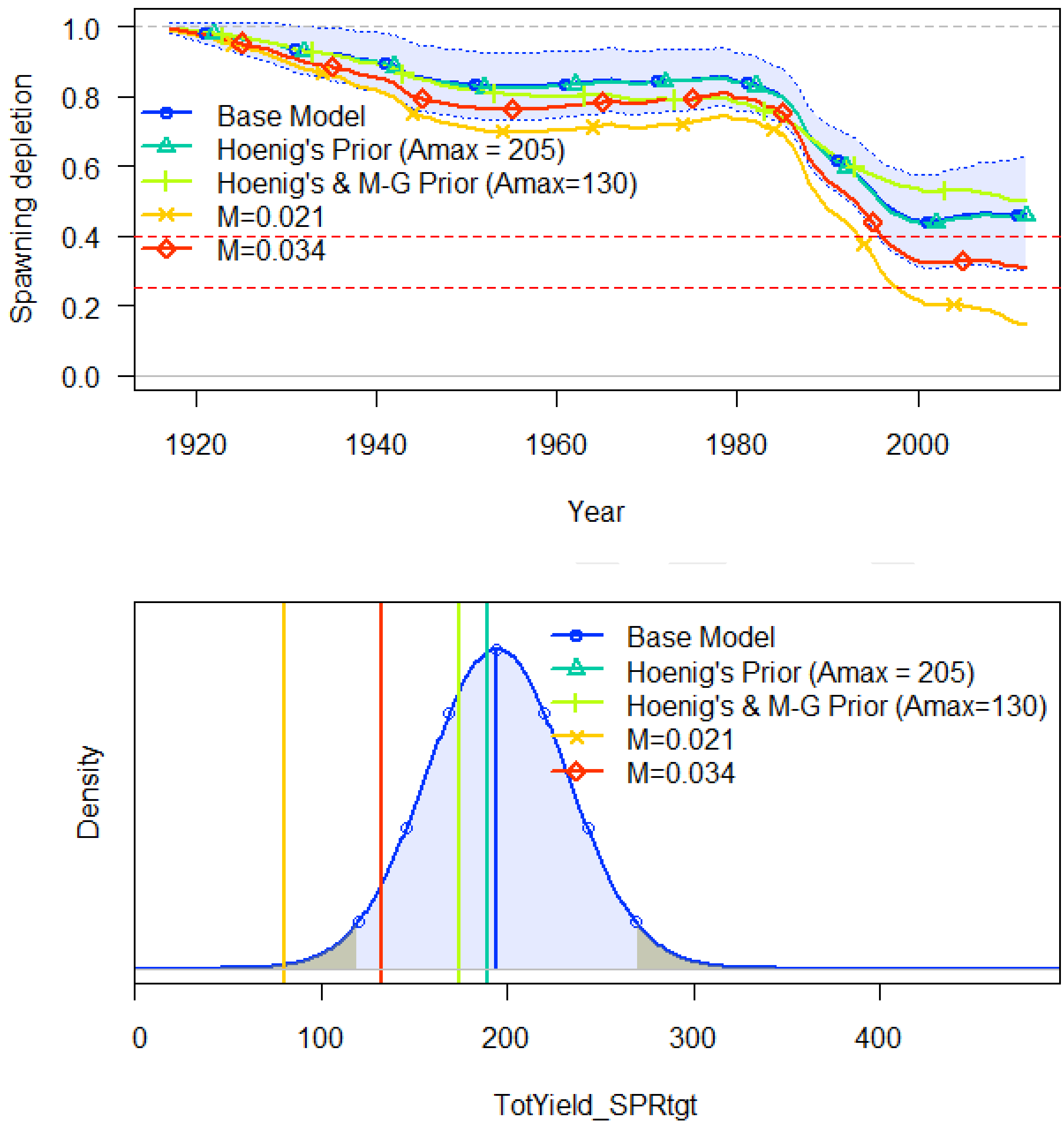



**Figure 69: Depletion and target yield estimates for the base model and sensitivities to changing the prior for *M* or fixing *M* at various values. The target yield for the high fixed *M* case is not shown because it is 11,678 mt and is beyond the scale of the x-axis.**

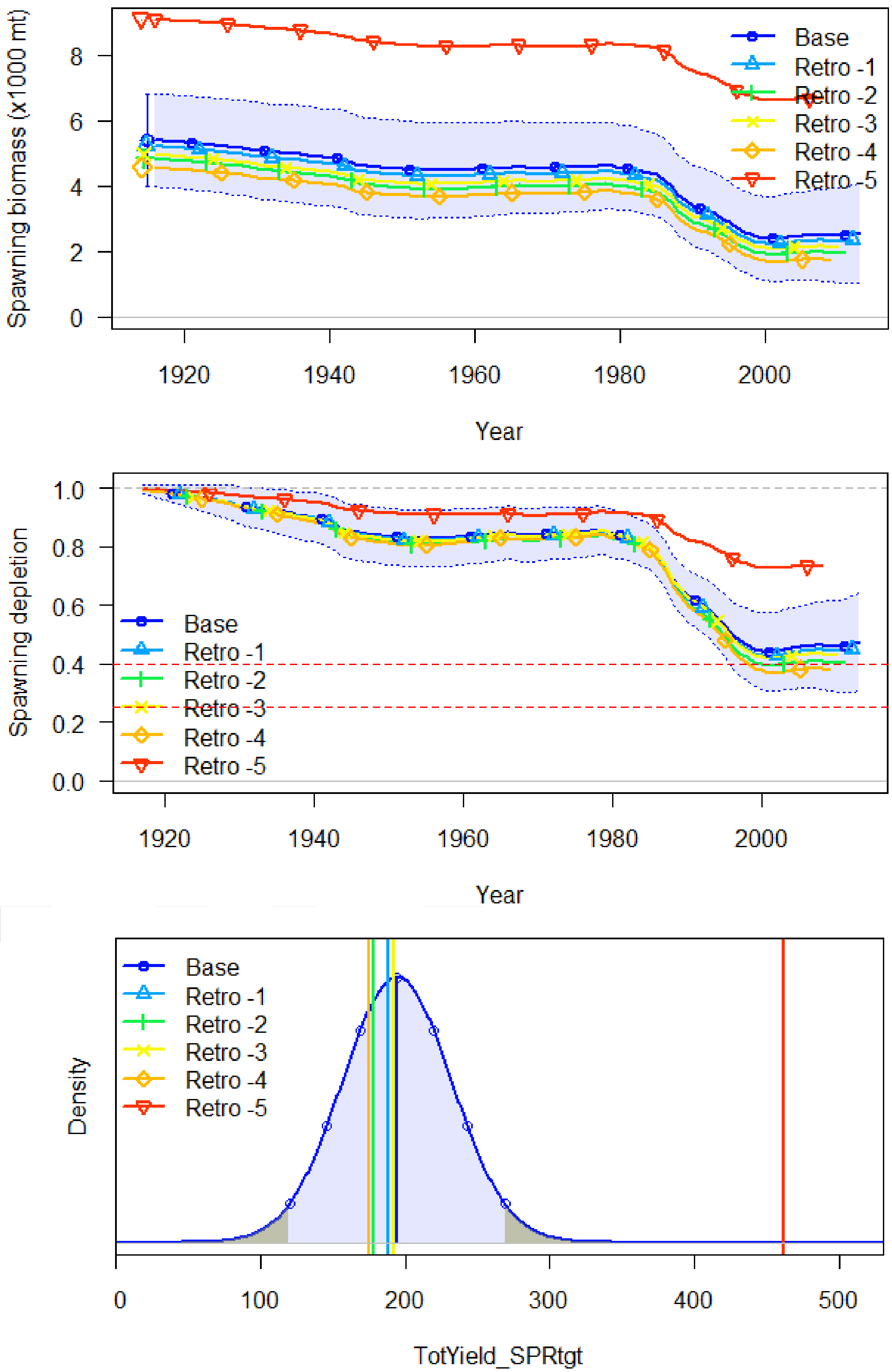



**Figure 70: Five-year retrospective estimates of spawning biomass (top left), depletion (top right), (1-SPR)/(1-SPRtarget) (bottom left), and target yield (bottom left). Uncertainty is shown for the base model only.**

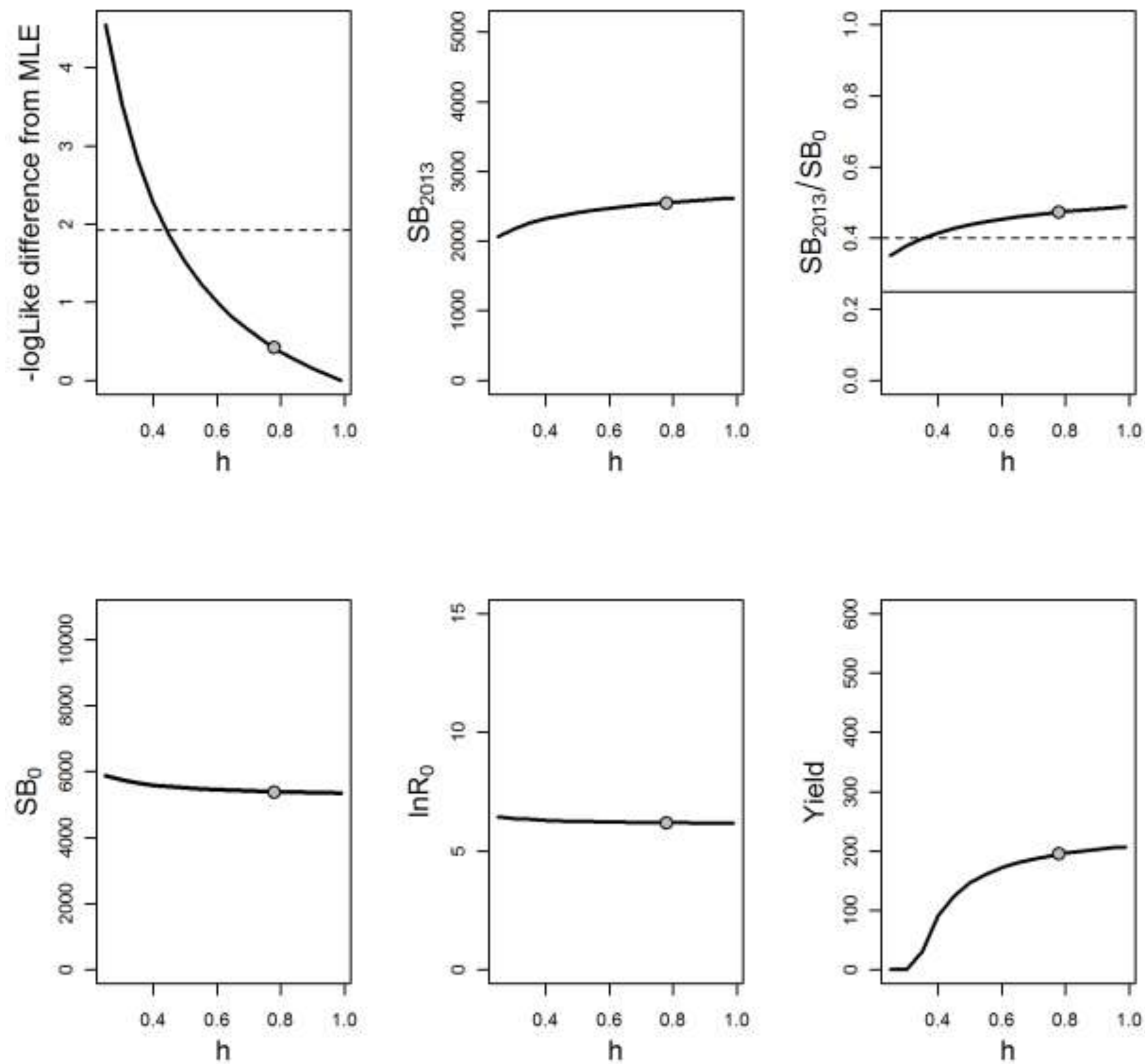



**Figure 71: Likelihood profiles and changes in estimates of key parameters when profile over steepness (*h*).**

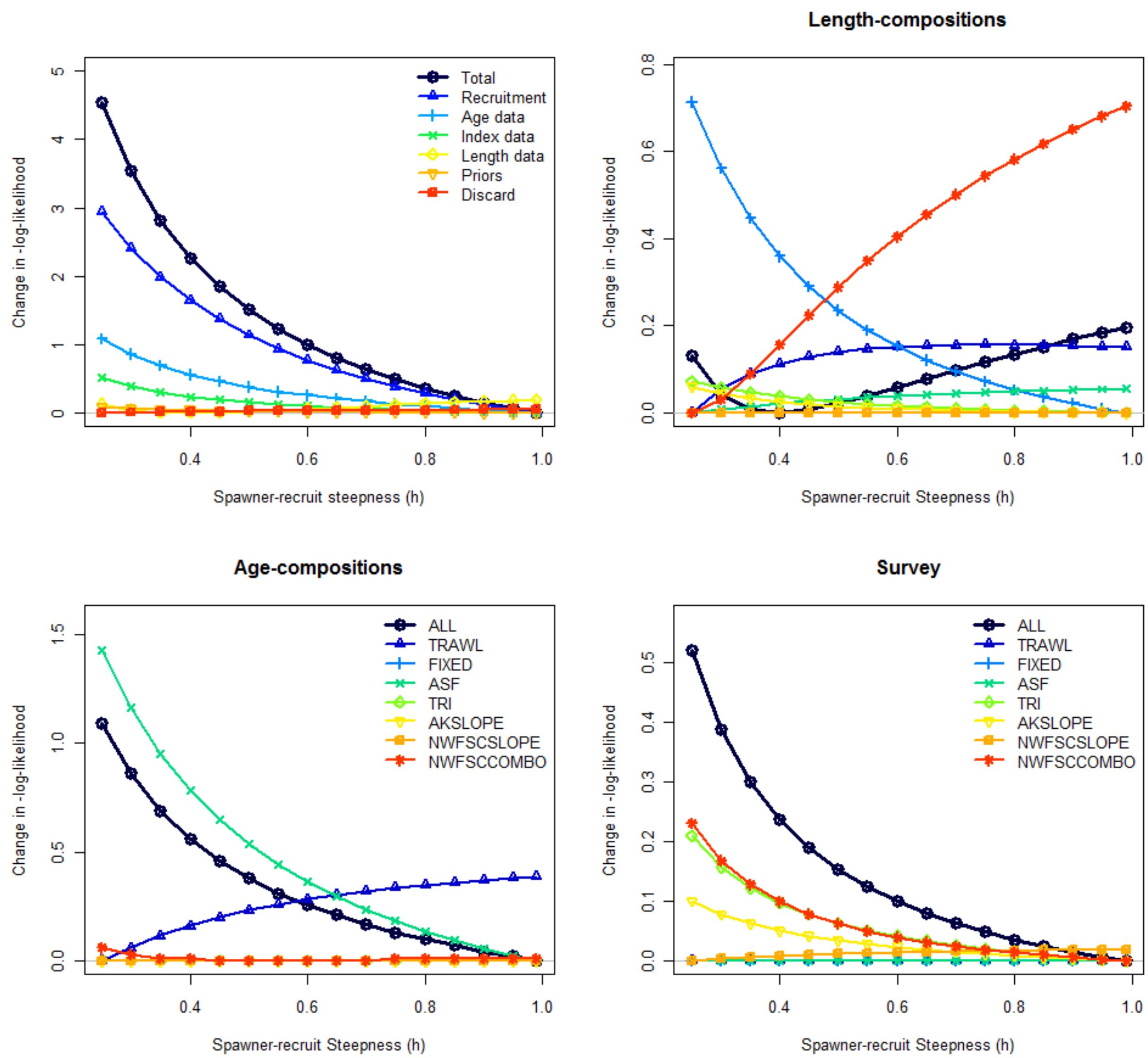



**Figure 72: Likelihood components in the likelihood profile for steepness (*h*).**

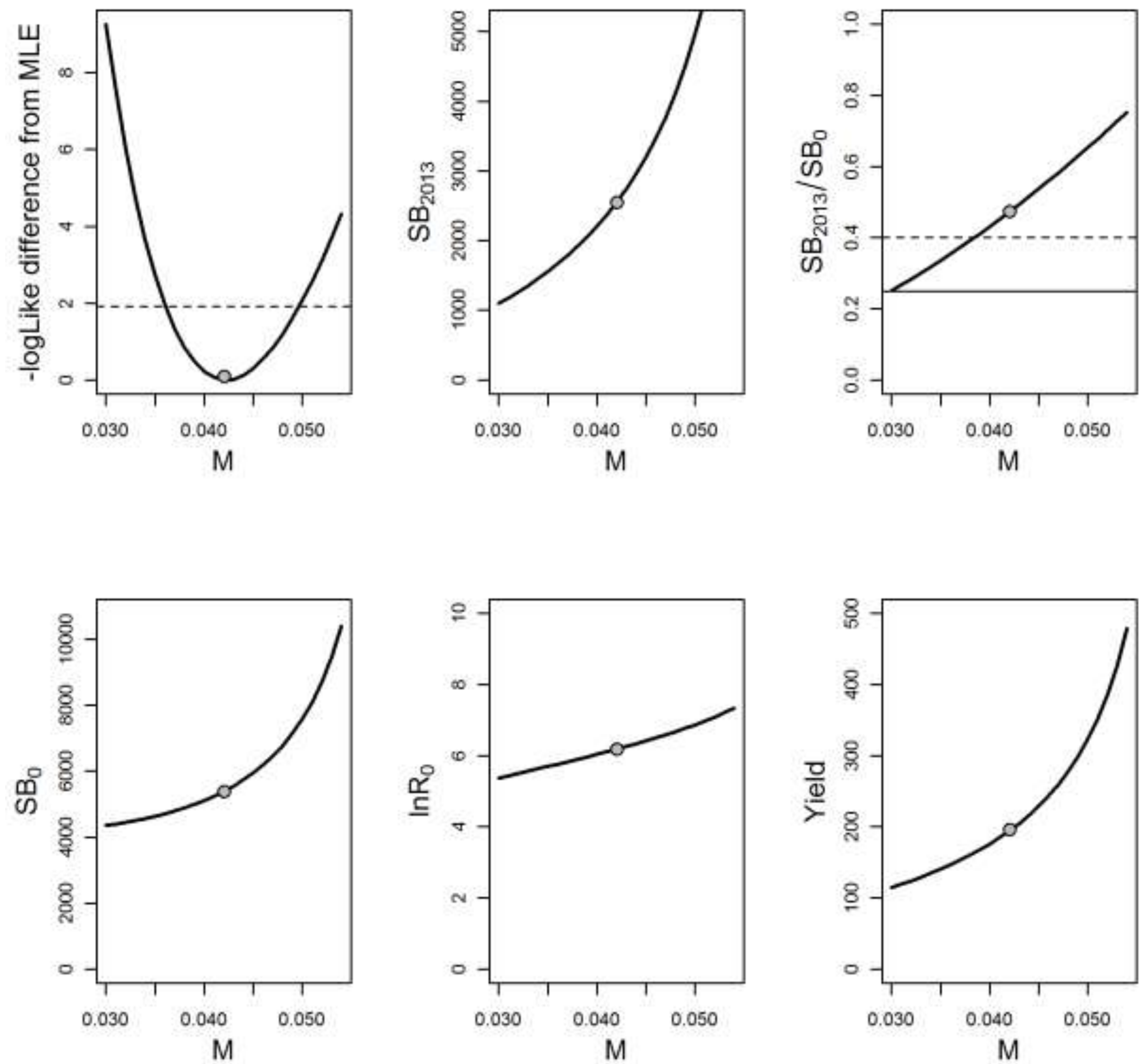



**Figure 73: Likelihood profiles and changes in estimates of key parameters when profile over natural mortality (M).**

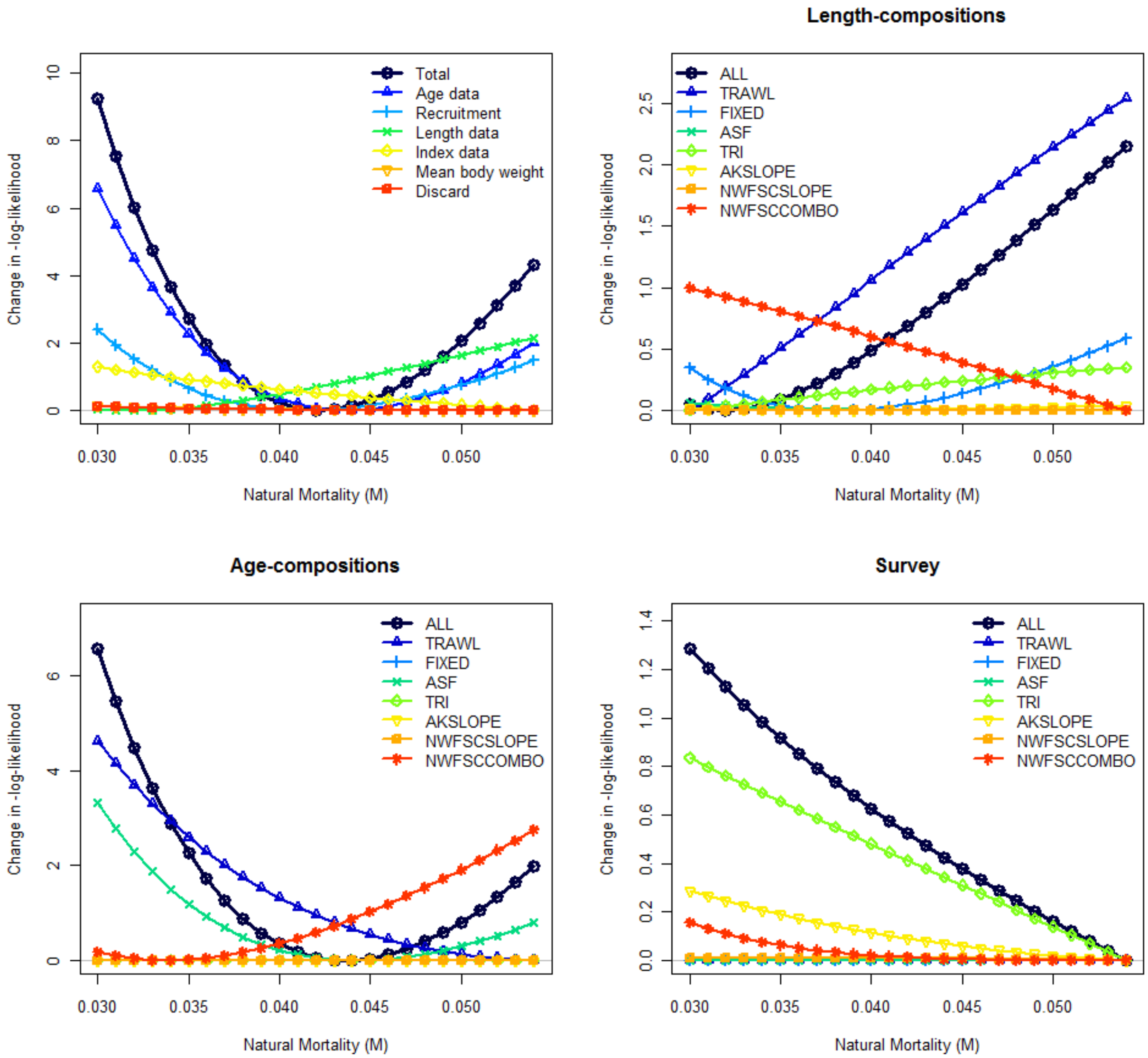



**Figure 74: Likelihood components in the likelihood profile for natural mortality (*M*).**

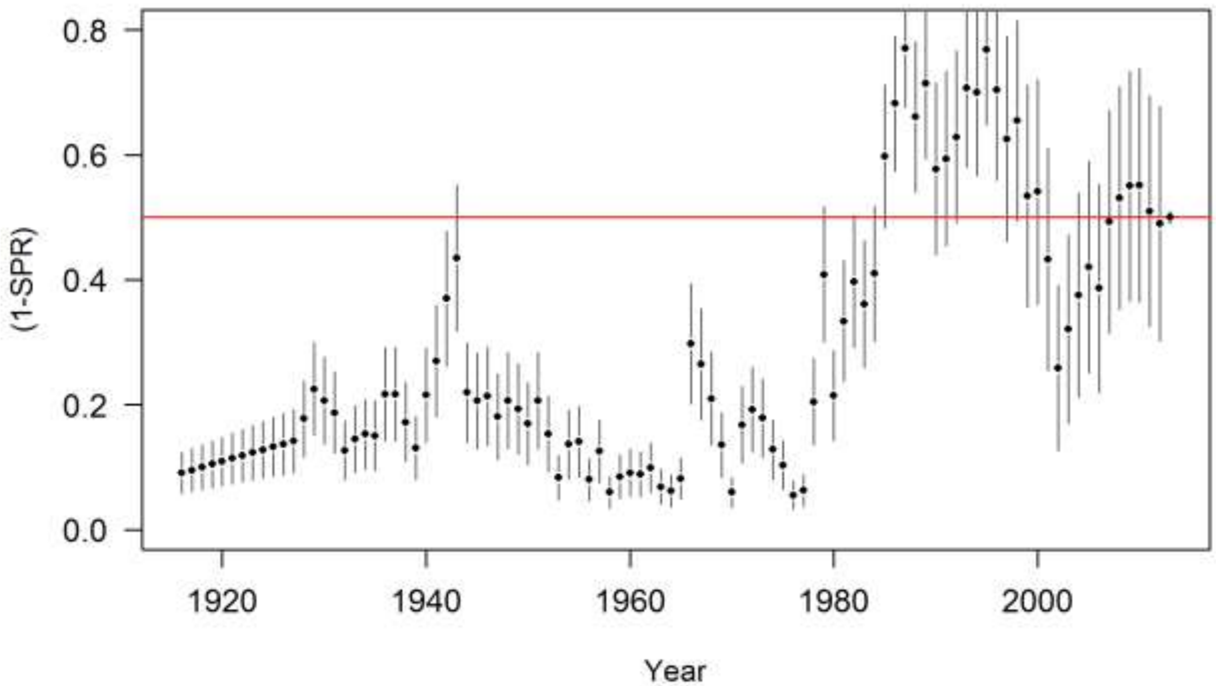



**Figure 75: Plot of the predicted (1-SPR) for each year of the model with 95% confidence intervals.**

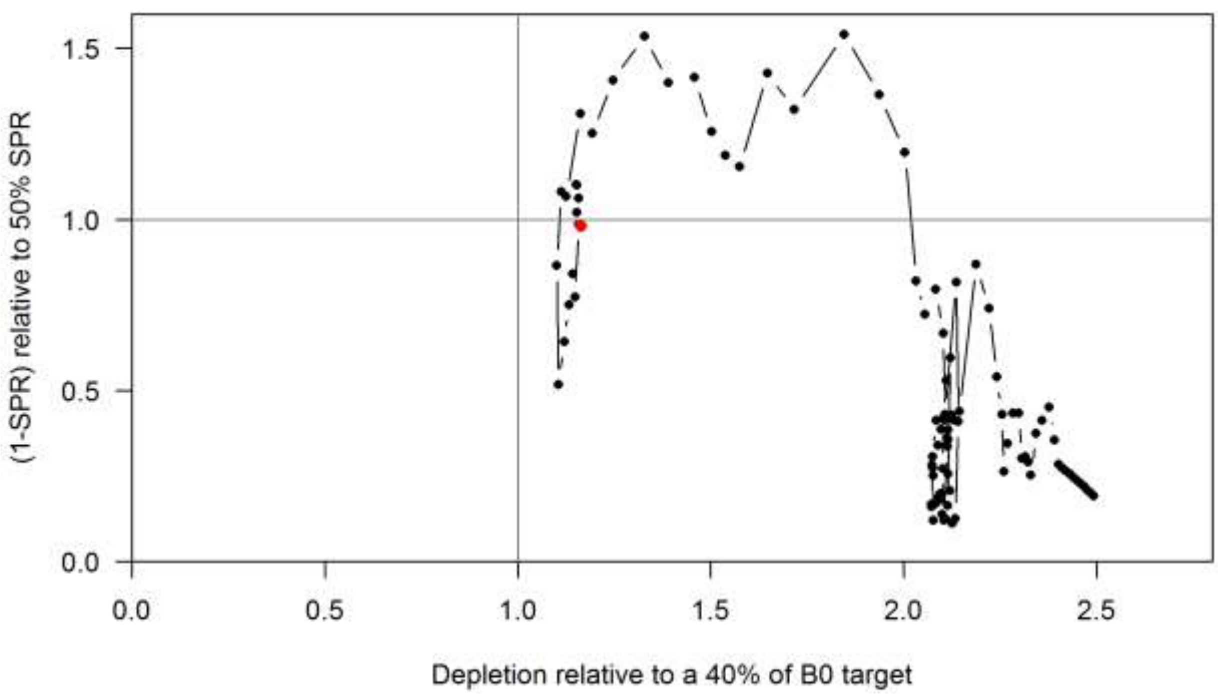



**Figure 76: Phase plot of relative (1-SPR) (y-axis) and depletion (x-axis) for rougheye rockfish. The red point represent the year 2012.**

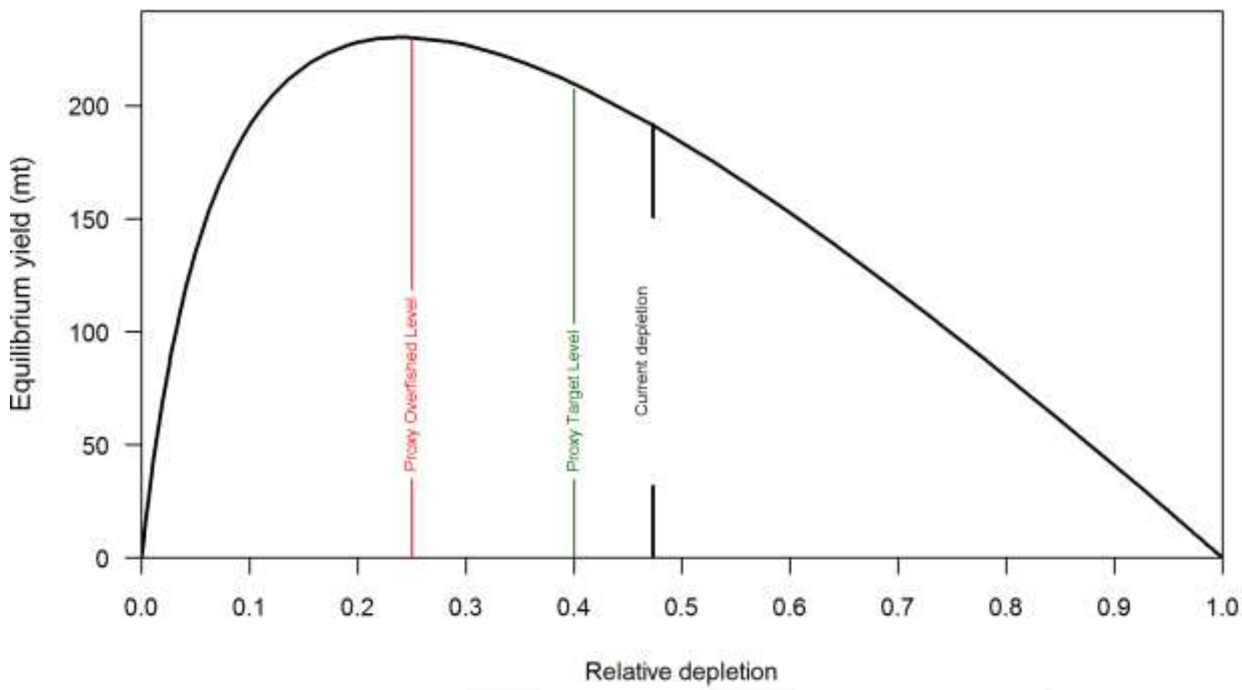



**Figure 77: Equilibrium yield curve plotted against depletion for rougheye rockfish with proxy target levels shown in red and green, and the 2013 estimated depletion shown in black.**

## Appendix A. Year-specific fits to the length compositions

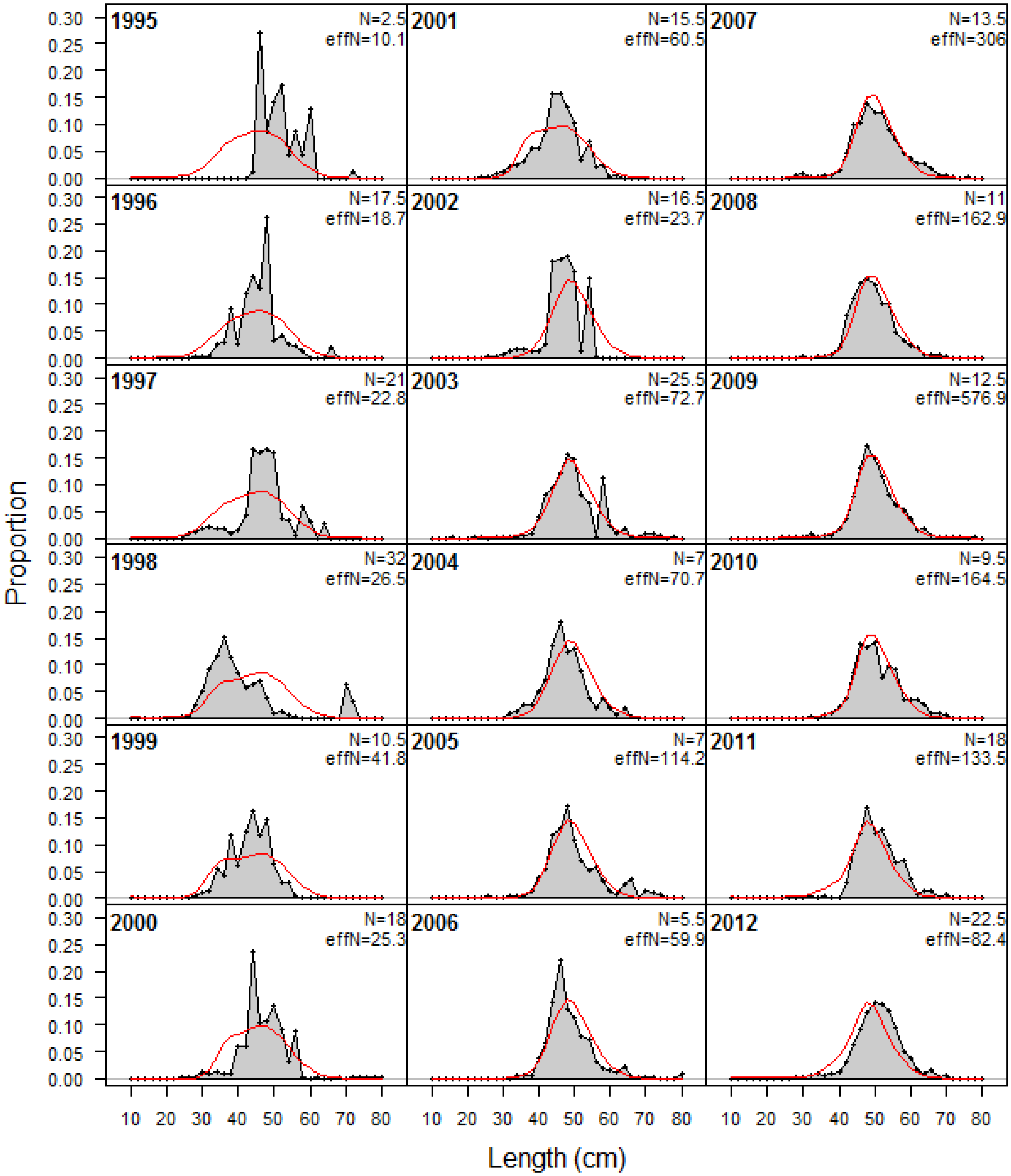



**Figure A1: Fits to the retained length compositions for the trawl fleet.**

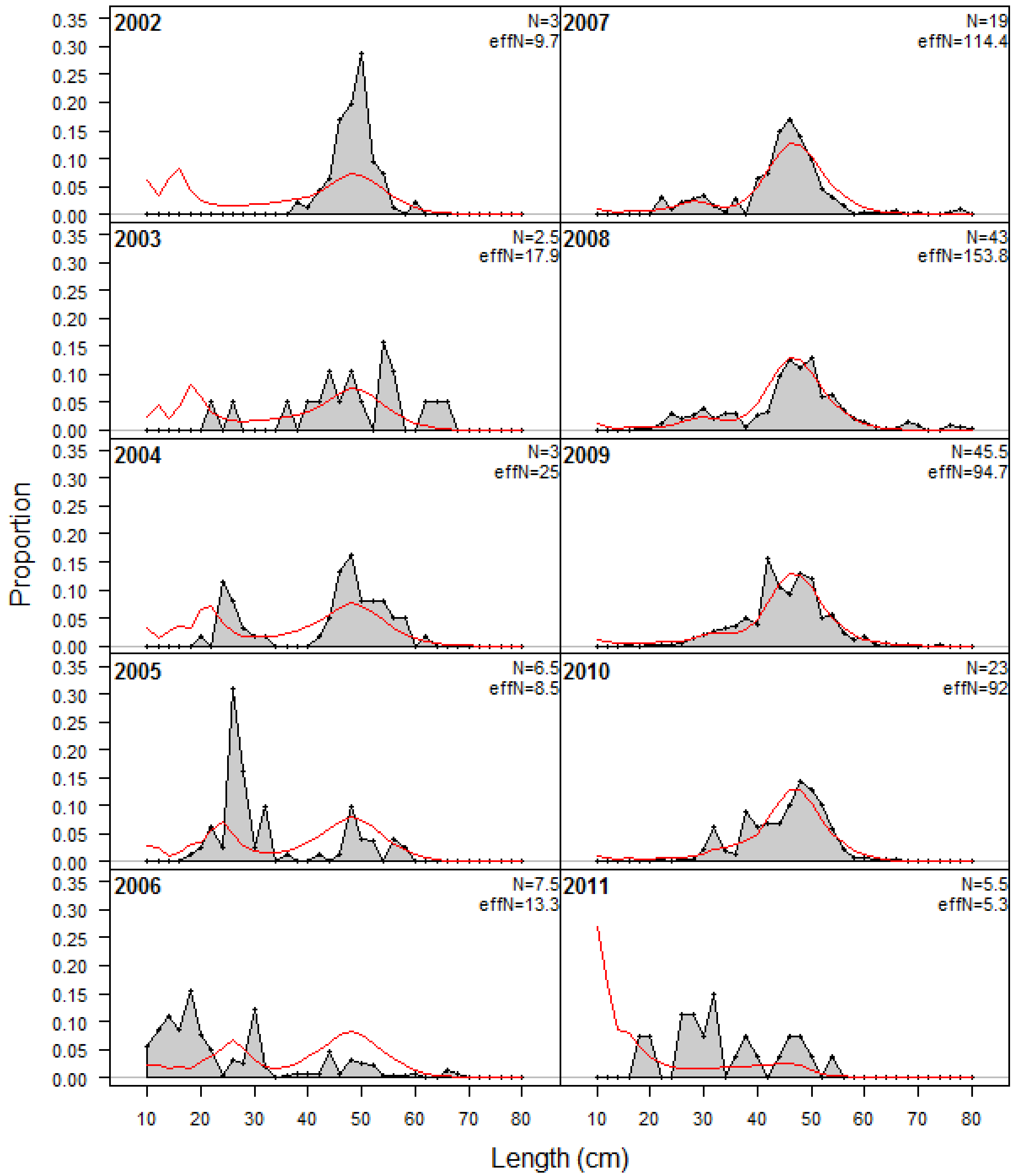



**Figure A2: Fits to the discarded length compositions for the trawl fleet.**

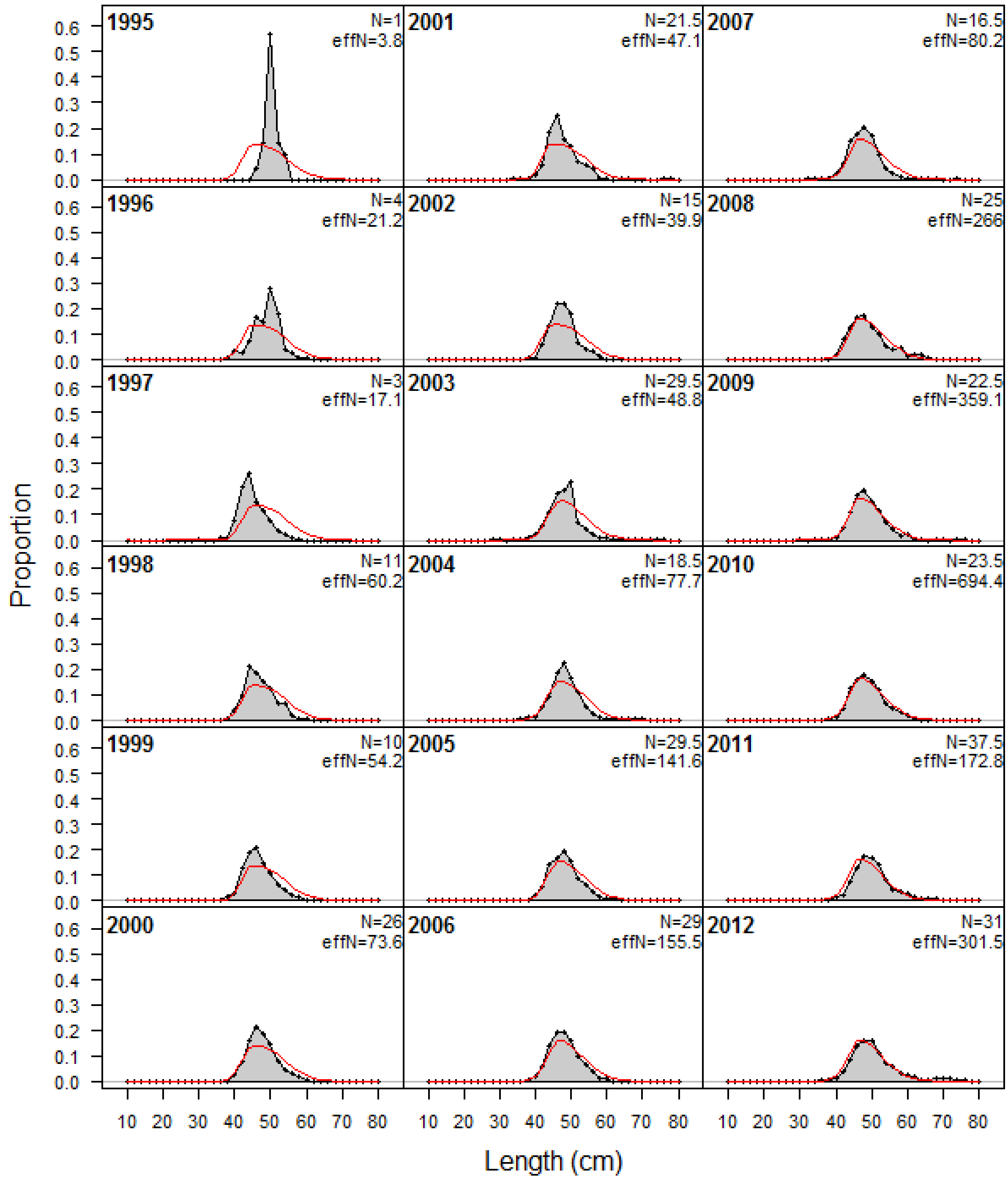



**Figure A3: Fits to the retained length compositions for the hook & line fleet.**

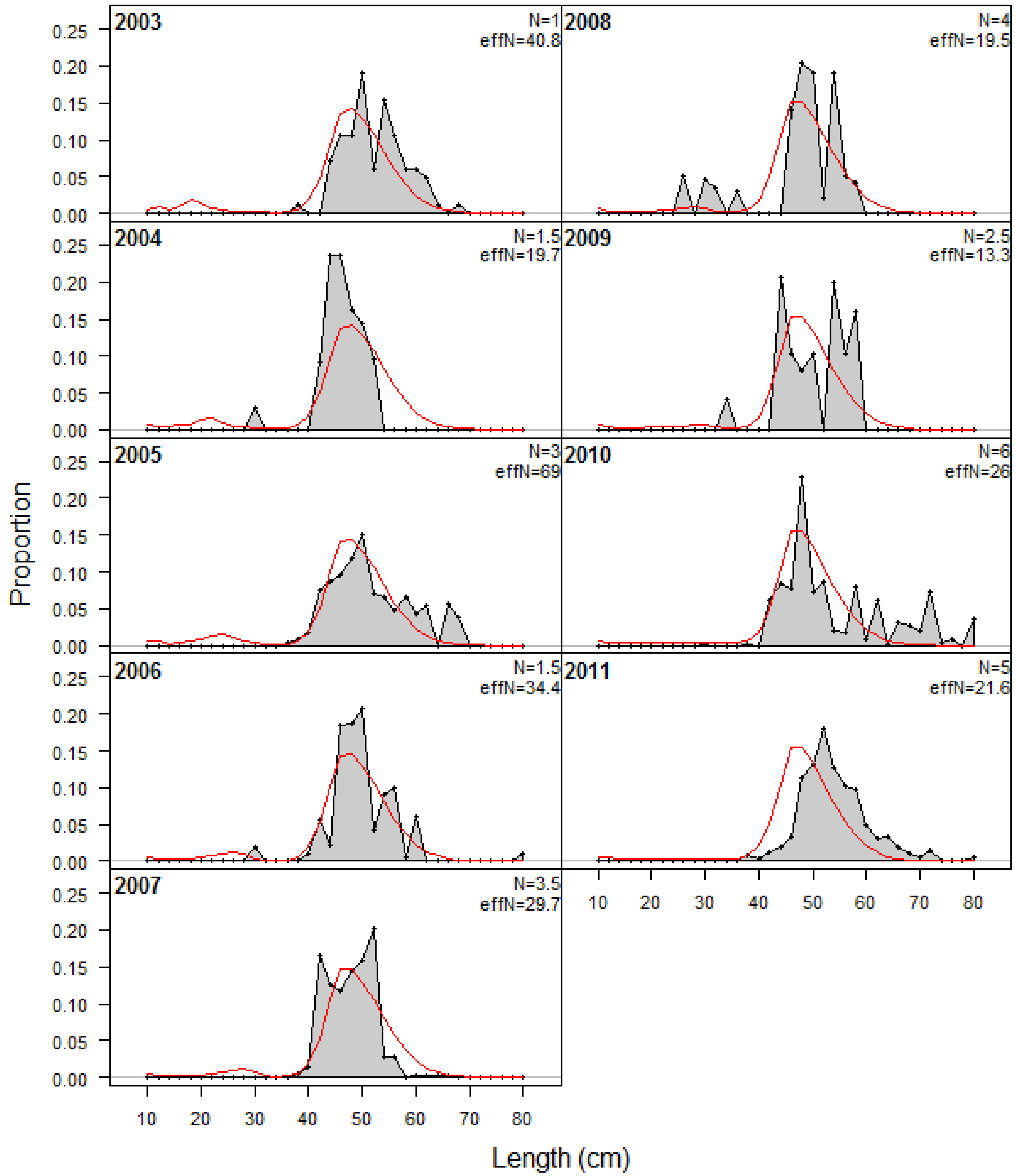



**Figure A4: Fits to the discarded length compositions for the hook & line fleet.**

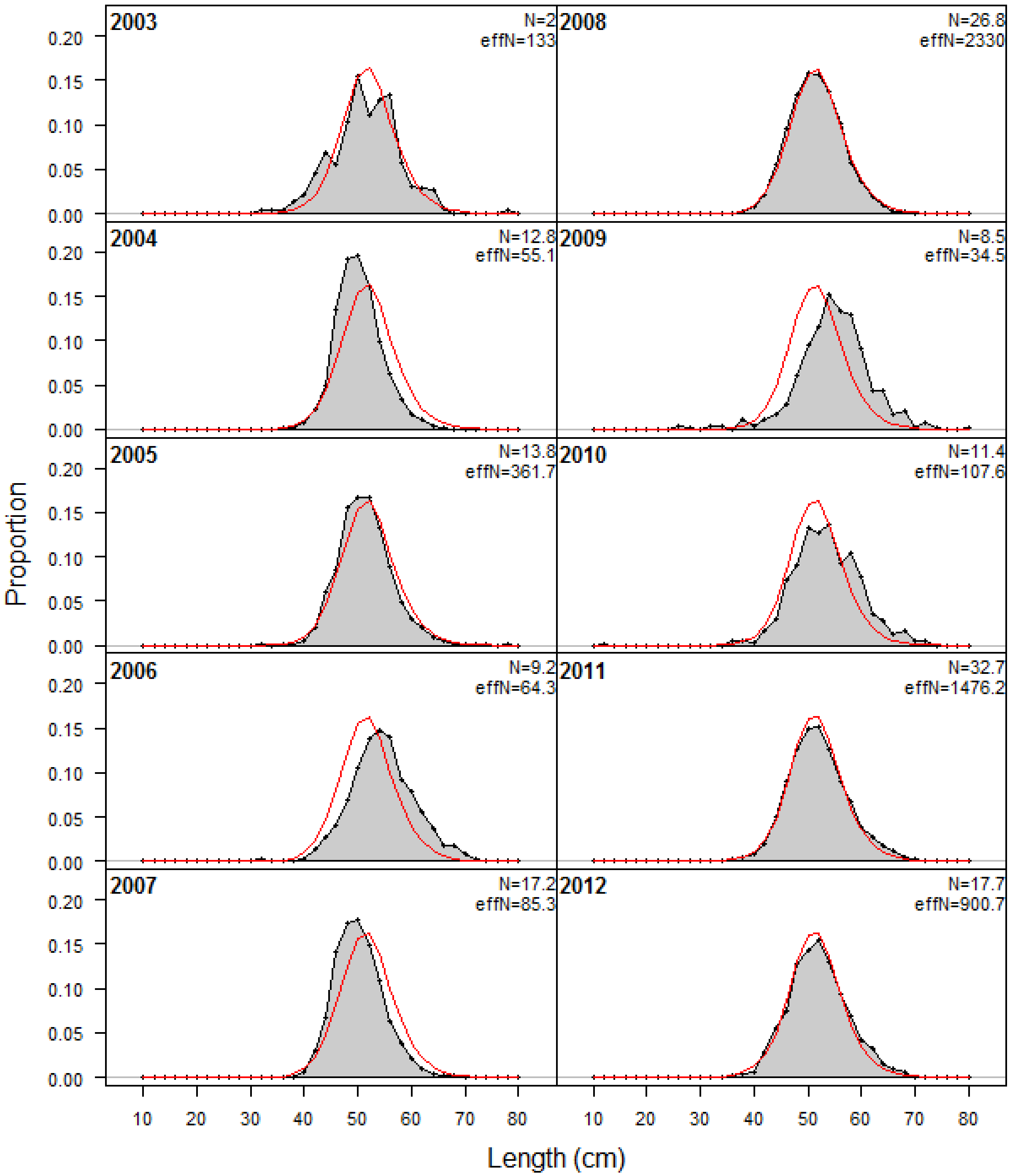



**Figure A5: Fits to the length compositions for the at-sea fleet.**

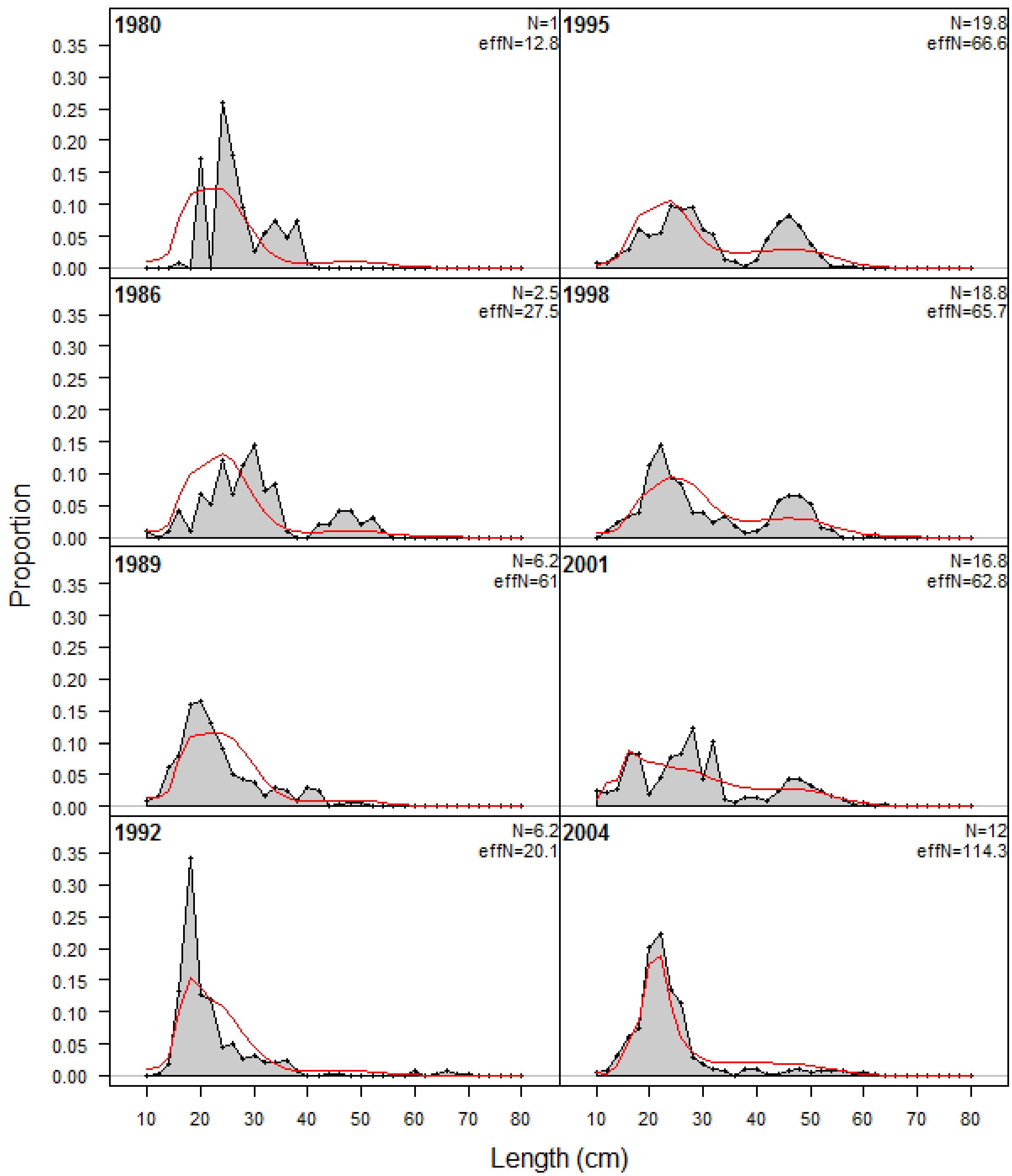



**Figure A6: Fits to the length compositions for the triennial survey.**

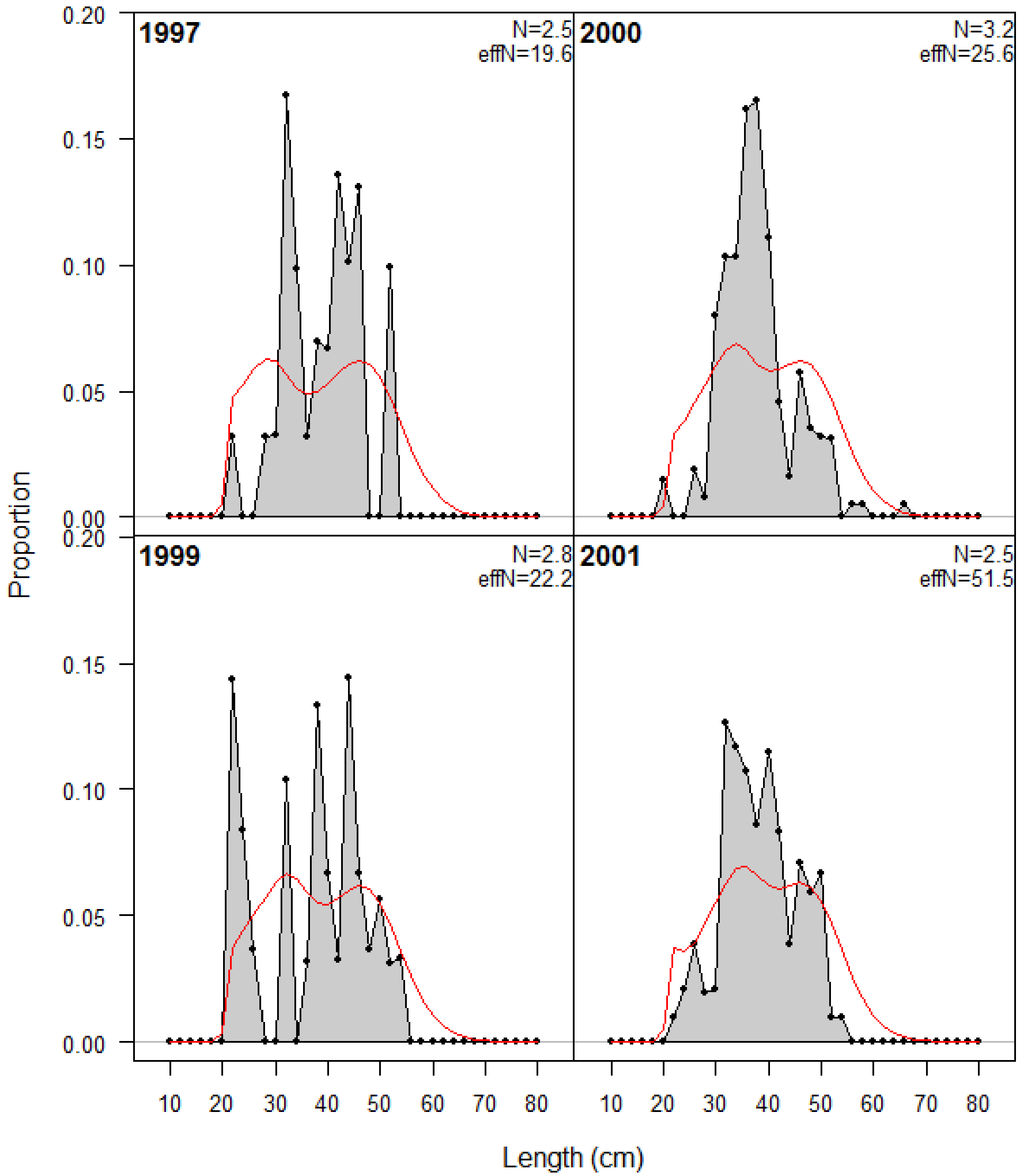



**Figure A7: Fits to the length compositions for the AFSC slope survey.**

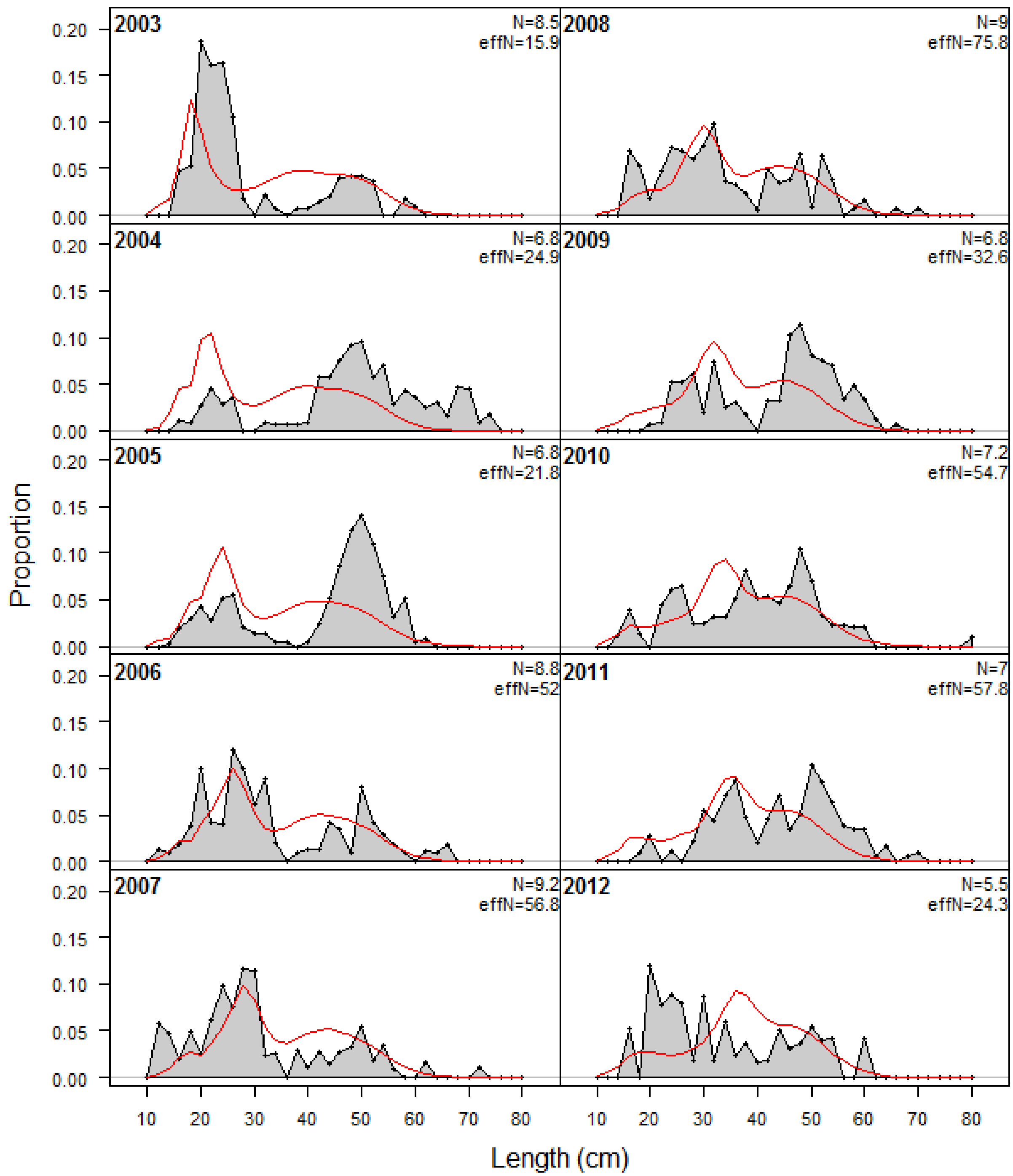



**Figure A8: Fits to the length compositions for the NWFSC shelf/slope survey.**

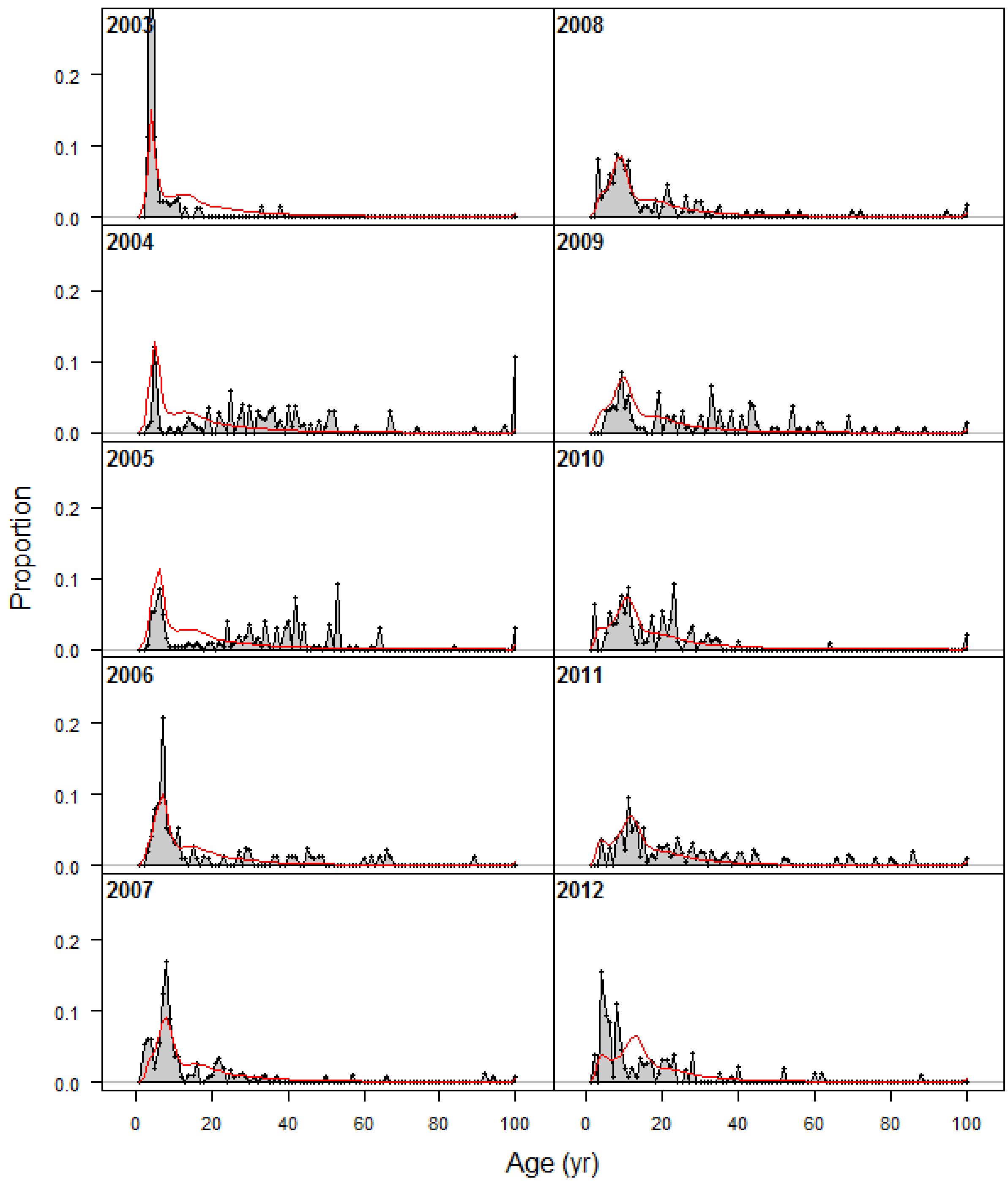


**Figure A8: Implied fits to the age compositions for the NWFSC shelf/slope survey.**

# Appendix B. Predicted numbers-at-age

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 488.90 | 469.03 | 449.87 | 431.40 | 413.62 | 396.52 | 380.09 | 364.31 | 349.17 | 334.65 | 320.73 |
| 1917 | 488.38 | 468.78 | 449.73 | 431.35 | 413.64 | 396.59 | 380.20 | 364.44 | 349.32 | 334.80 | 320.87 |
| 1918 | 487.71 | 468.29 | 449.49 | 431.22 | 413.60 | 396.62 | 380.27 | 364.55 | 349.44 | 334.94 | 321.02 |
| 1919 | 486.84 | 467.64 | 449.01 | 430.99 | 413.47 | 396.57 | 380.29 | 364.62 | 349.55 | 335.06 | 321.15 |
| 1920 | 485.75 | 466.80 | 448.40 | 430.53 | 413.25 | 396.45 | 380.25 | 364.64 | 349.61 | 335.16 | 321.27 |
| 1921 | 484.46 | 465.76 | 447.59 | 429.94 | 412.81 | 396.24 | 380.13 | 364.60 | 349.63 | 335.22 | 321.36 |
| 1922 | 482.98 | 464.53 | 446.59 | 429.17 | 412.24 | 395.82 | 379.93 | 364.48 | 349.59 | 335.24 | 321.42 |
| 1923 | 481.32 | 463.11 | 445.41 | 428.20 | 411.50 | 395.27 | 379.53 | 364.29 | 349.48 | 335.20 | 321.44 |
| 1924 | 479.48 | 461.52 | 444.05 | 427.07 | 410.58 | 394.56 | 379.00 | 363.90 | 349.29 | 335.10 | 321.40 |
| 1925 | 477.48 | 459.75 | 442.52 | 425.77 | 409.49 | 393.68 | 378.32 | 363.40 | 348.92 | 334.91 | 321.30 |
| 1926 | 475.36 | 457.83 | 440.82 | 424.30 | 408.24 | 392.64 | 377.47 | 362.75 | 348.44 | 334.56 | 321.13 |
| 1927 | 473.15 | 455.80 | 438.98 | 422.68 | 406.84 | 391.44 | 376.47 | 361.93 | 347.82 | 334.10 | 320.79 |
| 1928 | 470.86 | 453.68 | 437.04 | 420.91 | 405.28 | 390.09 | 375.32 | 360.98 | 347.03 | 333.50 | 320.35 |
| 1929 | 468.59 | 451.48 | 435.00 | 419.05 | 403.58 | 388.59 | 374.03 | 359.87 | 346.11 | 332.75 | 319.77 |
| 1930 | 466.43 | 449.31 | 432.89 | 417.09 | 401.79 | 386.96 | 372.59 | 358.63 | 345.05 | 331.86 | 319.04 |
| 1931 | 464.53 | 447.23 | 430.81 | 415.07 | 399.91 | 385.25 | 371.03 | 357.25 | 343.86 | 330.85 | 318.20 |
| 1932 | 462.94 | 445.41 | 428.82 | 413.07 | 397.98 | 383.45 | 369.39 | 355.76 | 342.54 | 329.70 | 317.22 |
| 1933 | 461.71 | 443.89 | 427.08 | 411.17 | 396.07 | 381.59 | 367.66 | 354.18 | 341.11 | 328.44 | 316.13 |
| 1934 | 460.79 | 442.72 | 425.62 | 409.50 | 394.24 | 379.76 | 365.89 | 352.53 | 339.60 | 327.07 | 314.92 |
| 1935 | 460.21 | 441.82 | 424.49 | 408.09 | 392.64 | 378.01 | 364.13 | 350.82 | 338.02 | 325.62 | 313.60 |
| 1936 | 460.05 | 441.28 | 423.64 | 407.02 | 391.29 | 376.48 | 362.45 | 349.14 | 336.38 | 324.10 | 312.21 |
| 1937 | 460.20 | 441.12 | 423.11 | 406.19 | 390.26 | 375.18 | 360.97 | 347.53 | 334.76 | 322.53 | 310.75 |
| 1938 | 460.80 | 441.27 | 422.95 | 405.68 | 389.47 | 374.19 | 359.73 | 346.11 | 333.22 | 320.97 | 309.24 |
| 1939 | 461.92 | 441.84 | 423.10 | 405.54 | 388.98 | 373.43 | 358.78 | 344.92 | 331.86 | 319.50 | 307.75 |
| 1940 | 463.55 | 442.92 | 423.65 | 405.68 | 388.85 | 372.97 | 358.06 | 344.01 | 330.72 | 318.20 | 306.34 |
| 1941 | 465.47 | 444.48 | 424.68 | 406.21 | 388.98 | 372.83 | 357.61 | 343.31 | 329.84 | 317.10 | 305.09 |
| 1942 | 467.70 | 446.32 | 426.17 | 407.19 | 389.48 | 372.96 | 357.48 | 342.88 | 329.17 | 316.25 | 304.03 |
| 1943 | 470.06 | 448.45 | 427.93 | 408.61 | 390.41 | 373.43 | 357.59 | 342.74 | 328.75 | 315.60 | 303.20 |
| 1944 | 472.58 | 450.72 | 429.96 | 410.28 | 391.76 | 374.31 | 358.02 | 342.83 | 328.59 | 315.15 | 302.52 |
| 1945 | 475.95 | 453.13 | 432.15 | 412.24 | 393.37 | 375.61 | 358.88 | 343.26 | 328.68 | 315.00 | 302.06 |
| 1946 | 479.62 | 456.36 | 434.45 | 414.33 | 395.25 | 377.15 | 360.12 | 344.07 | 329.07 | 315.03 | 301.83 |
| 1947 | 483.49 | 459.89 | 437.56 | 416.55 | 397.26 | 378.96 | 361.61 | 345.28 | 329.87 | 315.46 | 301.96 |
| 1948 | 487.57 | 463.60 | 440.94 | 419.54 | 399.39 | 380.90 | 363.35 | 346.71 | 331.04 | 316.25 | 302.41 |
| 1949 | 491.67 | 467.51 | 444.50 | 422.78 | 402.26 | 382.94 | 365.21 | 348.38 | 332.42 | 317.38 | 303.18 |
| 1950 | 495.76 | 471.44 | 448.25 | 426.19 | 405.37 | 385.69 | 367.17 | 350.16 | 334.02 | 318.70 | 304.26 |
| 1951 | 499.73 | 475.36 | 452.02 | 429.79 | 408.64 | 388.67 | 369.80 | 352.04 | 335.73 | 320.23 | 305.52 |
| 1952 | 503.31 | 479.17 | 455.78 | 433.40 | 412.09 | 391.81 | 372.66 | 354.57 | 337.53 | 321.87 | 306.99 |
| 1953 | 506.48 | 482.60 | 459.44 | 437.01 | 415.55 | 395.12 | 375.67 | 357.31 | 339.95 | 323.59 | 308.55 |
| 1954 | 509.06 | 485.64 | 462.73 | 440.52 | 419.02 | 398.45 | 378.85 | 360.20 | 342.59 | 325.93 | 310.22 |
| 1955 | 510.62 | 488.11 | 465.64 | 443.67 | 422.38 | 401.76 | 382.03 | 363.24 | 345.35 | 328.44 | 312.43 |
| 1956 | 511.04 | 489.61 | 468.01 | 446.46 | 425.40 | 404.98 | 385.21 | 366.29 | 348.26 | 331.08 | 314.84 |
| 1957 | 510.29 | 490.01 | 469.44 | 448.74 | 428.07 | 407.88 | 388.30 | 369.34 | 351.19 | 333.87 | 317.36 |
| 1958 | 508.09 | 489.29 | 469.82 | 450.10 | 430.25 | 410.44 | 391.07 | 372.30 | 354.10 | 336.66 | 320.01 |
| 1959 | 504.66 | 487.18 | 469.14 | 450.48 | 431.57 | 412.53 | 393.53 | 374.96 | 356.94 | 339.46 | 322.70 |
| 1960 | 499.98 | 483.89 | 467.12 | 449.82 | 431.93 | 413.80 | 395.54 | 377.32 | 359.50 | 342.20 | 325.41 |
| 1961 | 494.38 | 479.41 | 463.96 | 447.88 | 431.30 | 414.13 | 396.75 | 379.24 | 361.75 | 344.63 | 327.99 |
| 1962 | 488.20 | 474.04 | 459.66 | 444.85 | 429.43 | 413.53 | 397.07 | 380.40 | 363.59 | 346.78 | 330.31 |
| 1963 | 481.80 | 468.11 | 454.51 | 440.73 | 426.52 | 411.74 | 396.49 | 380.71 | 364.69 | 348.54 | 332.36 |
| 1964 | 475.64 | 461.98 | 448.83 | 435.79 | 422.58 | 408.96 | 394.78 | 380.15 | 365.00 | 349.62 | 334.08 |
| 1965 | 470.02 | 456.06 | 442.95 | 430.35 | 417.84 | 405.17 | 392.11 | 378.52 | 364.47 | 349.91 | 335.11 |
| 1966 | 465.24 | 450.68 | 437.27 | 424.70 | 412.61 | 400.62 | 388.47 | 375.94 | 362.88 | 349.35 | 335.31 |

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 461.26 | 446.10 | 431.98 | 419.13 | 407.08 | 395.49 | 383.98 | 372.27 | 360.07 | 347.18 | 333.72 |
| 1968 | 458.57 | 442.28 | 427.62 | 414.08 | 401.76 | 390.21 | 379.09 | 368.01 | 356.63 | 344.64 | 331.87 |
| 1969 | 457.30 | 439.70 | 423.98 | 409.93 | 396.95 | 385.14 | 374.06 | 363.36 | 352.62 | 341.48 | 329.67 |
| 1970 | 457.55 | 438.48 | 421.58 | 406.50 | 393.03 | 380.59 | 369.26 | 358.62 | 348.32 | 337.95 | 327.18 |
| 1971 | 459.95 | 438.72 | 420.41 | 404.21 | 389.75 | 376.83 | 364.91 | 354.03 | 343.81 | 333.89 | 323.87 |
| 1972 | 465.58 | 441.02 | 420.59 | 403.04 | 387.50 | 373.65 | 361.25 | 349.78 | 339.27 | 329.28 | 319.52 |
| 1973 | 474.45 | 446.42 | 422.78 | 403.20 | 386.37 | 371.47 | 358.18 | 346.27 | 335.16 | 324.88 | 315.01 |
| 1974 | 479.38 | 454.93 | 427.97 | 405.30 | 386.53 | 370.39 | 356.11 | 343.33 | 331.81 | 320.98 | 310.85 |
| 1975 | 480.85 | 459.65 | 436.15 | 410.30 | 388.57 | 370.57 | 355.10 | 341.38 | 329.06 | 317.89 | 307.32 |
| 1976 | 483.47 | 461.06 | 440.69 | 418.16 | 393.38 | 372.54 | 355.28 | 340.43 | 327.23 | 315.34 | 304.50 |
| 1977 | 490.96 | 463.57 | 442.07 | 422.54 | 400.93 | 377.17 | 357.19 | 340.63 | 326.37 | 313.66 | 302.19 |
| 1978 | 495.05 | 470.76 | 444.49 | 423.87 | 405.15 | 384.43 | 361.65 | 342.49 | 326.61 | 312.94 | 300.75 |
| 1979 | 475.99 | 474.68 | 451.34 | 426.16 | 406.39 | 388.43 | 368.57 | 346.71 | 328.30 | 312.99 | 299.75 |
| 1980 | 444.65 | 456.40 | 454.98 | 432.61 | 408.47 | 389.52 | 372.30 | 353.20 | 332.09 | 314.15 | 299.06 |
| 1981 | 403.71 | 426.36 | 437.55 | 436.18 | 414.73 | 391.59 | 373.42 | 356.88 | 338.49 | 318.09 | 300.68 |
| 1982 | 366.88 | 387.10 | 408.73 | 419.45 | 418.15 | 397.58 | 375.39 | 357.94 | 341.99 | 324.19 | 304.42 |
| 1983 | 355.37 | 351.78 | 371.05 | 391.78 | 402.06 | 400.81 | 381.09 | 359.77 | 342.90 | 327.34 | 309.91 |
| 1984 | 358.99 | 340.75 | 337.24 | 355.71 | 375.58 | 385.44 | 384.23 | 365.30 | 344.77 | 328.44 | 313.30 |
| 1985 | 370.97 | 344.22 | 326.64 | 323.27 | 340.98 | 360.03 | 369.47 | 368.27 | 350.00 | 330.11 | 314.15 |
| 1986 | 392.91 | 355.70 | 329.88 | 313.04 | 309.81 | 326.78 | 345.02 | 353.99 | 352.61 | 334.69 | 315.06 |
| 1987 | 456.17 | 376.74 | 340.85 | 316.11 | 299.97 | 296.88 | 313.12 | 330.51 | 338.86 | 337.04 | 319.19 |
| 1988 | 627.55 | 437.39 | 360.93 | 326.54 | 302.84 | 287.37 | 284.39 | 299.85 | 316.20 | 323.53 | 320.83 |
| 1989 | 597.76 | 601.73 | 419.12 | 345.85 | 312.90 | 290.19 | 275.35 | 272.42 | 287.00 | 302.14 | 308.40 |
| 1990 | 536.15 | 573.16 | 576.31 | 401.42 | 331.24 | 299.68 | 277.90 | 263.55 | 260.33 | 273.38 | 286.45 |
| 1991 | 493.51 | 514.08 | 549.19 | 552.20 | 384.63 | 317.38 | 287.12 | 266.17 | 252.18 | 248.62 | 260.33 |
| 1992 | 453.62 | 473.20 | 492.54 | 526.17 | 529.06 | 368.50 | 304.05 | 274.96 | 254.61 | 240.68 | 236.48 |
| 1993 | 406.48 | 434.95 | 453.41 | 471.94 | 504.17 | 506.93 | 353.06 | 291.22 | 263.11 | 243.18 | 229.23 |
| 1994 | 311.68 | 389.76 | 416.75 | 434.43 | 452.18 | 483.06 | 485.67 | 338.16 | 278.68 | 251.33 | 231.66 |
| 1995 | 306.68 | 298.85 | 373.49 | 399.35 | 416.30 | 433.30 | 462.87 | 465.26 | 323.72 | 266.39 | 239.73 |
| 1996 | 380.60 | 294.06 | 286.31 | 357.81 | 382.59 | 398.82 | 415.08 | 443.26 | 445.11 | 309.08 | 253.59 |
| 1997 | 404.22 | 364.94 | 281.77 | 274.34 | 342.86 | 366.60 | 382.13 | 397.61 | 424.27 | 425.38 | 294.68 |
| 1998 | 898.04 | 387.58 | 349.72 | 270.02 | 262.90 | 328.56 | 351.29 | 366.08 | 380.64 | 405.56 | 405.73 |
| 1999 | 2209.43 | 861.09 | 371.47 | 335.19 | 258.80 | 251.97 | 314.89 | 336.62 | 350.64 | 364.24 | 387.55 |
| 2000 | 526.41 | 2118.51 | 825.34 | 356.05 | 321.27 | 248.05 | 241.50 | 301.76 | 322.44 | 335.55 | 348.07 |
| 2001 | 846.20 | 504.75 | 2030.27 | 790.97 | 341.22 | 307.89 | 237.71 | 231.37 | 288.88 | 308.21 | 320.02 |
| 2002 | 239.26 | 811.38 | 483.74 | 1945.80 | 758.05 | 327.02 | 295.06 | 227.75 | 221.53 | 276.21 | 294.08 |
| 2003 | 426.36 | 229.42 | 777.79 | 463.72 | 1865.23 | 726.67 | 313.48 | 282.84 | 218.32 | 212.36 | 264.76 |
| 2004 | 355.09 | 408.82 | 219.87 | 745.44 | 444.43 | 1787.66 | 696.45 | 300.44 | 271.08 | 209.24 | 203.52 |
| 2005 | 282.43 | 340.48 | 391.81 | 210.72 | 714.42 | 425.94 | 1713.27 | 667.46 | 287.94 | 259.80 | 200.52 |
| 2006 | 282.40 | 270.81 | 326.34 | 375.54 | 201.97 | 684.76 | 408.25 | 1642.13 | 639.75 | 275.98 | 249.00 |
| 2007 | 385.24 | 270.78 | 259.56 | 312.78 | 359.94 | 193.59 | 656.31 | 391.29 | 1573.92 | 613.17 | 264.51 |
| 2008 | 385.01 | 369.39 | 259.46 | 248.70 | 299.70 | 344.88 | 185.49 | 628.86 | 374.92 | 1508.06 | 587.48 |
| 2009 | 357.84 | 369.16 | 353.97 | 248.62 | 238.32 | 287.19 | 330.48 | 177.74 | 602.60 | 359.26 | 1444.99 |
| 2010 | 328.25 | 343.12 | 353.68 | 339.13 | 238.20 | 228.32 | 275.15 | 316.63 | 170.29 | 577.32 | 344.17 |
| 2011 | 452.29 | 314.74 | 328.68 | 338.80 | 324.86 | 228.18 | 218.72 | 263.57 | 303.30 | 163.12 | 552.98 |
| 2012 | 448.88 | 433.68 | 301.66 | 315.02 | 324.72 | 311.36 | 218.69 | 209.63 | 252.61 | 290.69 | 156.33 |
| 2013 | 449.90 | 430.41 | 415.59 | 289.08 | 301.88 | 311.18 | 298.37 | 209.57 | 200.89 | 242.08 | 278.56 |

| Year | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 307.39 | 294.60 | 282.35 | 270.62 | 259.39 | 248.62 | 237.63 | 227.85 | 218.47 | 209.49 |
| 1917 | 307.52 | 294.72 | 282.43 | 270.63 | 259.30 | 248.44 | 238.03 | 227.42 | 217.98 | 208.95 |
| 1918 | 307.66 | 294.85 | 282.54 | 270.70 | 259.30 | 248.35 | 237.84 | 227.78 | 217.54 | 208.45 |
| 1919 | 307.80 | 294.98 | 282.67 | 270.80 | 259.36 | 248.33 | 237.73 | 227.56 | 217.86 | 208.00 |
| 1920 | 307.93 | 295.12 | 282.79 | 270.91 | 259.44 | 248.37 | 237.69 | 227.43 | 217.62 | 208.27 |
| 1921 | 308.04 | 295.24 | 282.91 | 271.03 | 259.54 | 248.43 | 237.71 | 227.38 | 217.47 | 208.02 |
| 1922 | 308.13 | 295.34 | 283.03 | 271.14 | 259.64 | 248.51 | 237.75 | 227.37 | 217.39 | 207.85 |
| 1923 | 308.19 | 295.43 | 283.13 | 271.24 | 259.74 | 248.59 | 237.80 | 227.38 | 217.35 | 207.73 |
| 1924 | 308.20 | 295.48 | 283.20 | 271.33 | 259.83 | 248.67 | 237.86 | 227.41 | 217.34 | 207.67 |
| 1925 | 308.17 | 295.50 | 283.25 | 271.40 | 259.90 | 248.74 | 237.91 | 227.43 | 217.33 | 207.62 |
| 1926 | 308.07 | 295.46 | 283.26 | 271.44 | 259.95 | 248.79 | 237.95 | 227.46 | 217.33 | 207.58 |
| 1927 | 307.90 | 295.37 | 283.23 | 271.44 | 259.98 | 248.83 | 237.98 | 227.47 | 217.32 | 207.55 |
| 1928 | 307.58 | 295.20 | 283.13 | 271.40 | 259.98 | 248.84 | 237.99 | 227.47 | 217.30 | 207.51 |
| 1929 | 307.15 | 294.88 | 282.96 | 271.26 | 259.85 | 248.70 | 237.83 | 227.27 | 217.06 | 207.23 |
| 1930 | 306.59 | 294.46 | 282.61 | 271.02 | 259.58 | 248.38 | 237.43 | 226.80 | 216.52 | 206.63 |
| 1931 | 305.90 | 293.93 | 282.22 | 270.72 | 259.40 | 248.20 | 237.23 | 226.55 | 216.21 | 206.26 |
| 1932 | 305.09 | 293.27 | 281.73 | 270.37 | 259.17 | 248.10 | 237.17 | 226.48 | 216.11 | 206.11 |
| 1933 | 304.16 | 292.51 | 281.14 | 269.99 | 258.99 | 248.11 | 237.38 | 226.78 | 216.45 | 206.46 |
| 1934 | 303.11 | 291.62 | 280.39 | 269.40 | 258.57 | 247.87 | 237.29 | 226.88 | 216.62 | 206.66 |
| 1935 | 301.95 | 290.61 | 279.53 | 268.67 | 257.99 | 247.44 | 237.03 | 226.75 | 216.66 | 206.76 |
| 1936 | 300.69 | 289.49 | 278.56 | 267.85 | 257.29 | 246.89 | 236.63 | 226.51 | 216.56 | 206.82 |
| 1937 | 299.34 | 288.26 | 277.44 | 266.82 | 256.33 | 245.97 | 235.75 | 225.71 | 215.86 | 206.21 |
| 1938 | 297.94 | 286.97 | 276.26 | 265.74 | 255.34 | 245.04 | 234.87 | 224.88 | 215.10 | 205.55 |
| 1939 | 296.50 | 285.64 | 275.06 | 264.68 | 254.44 | 244.28 | 234.23 | 224.32 | 214.62 | 205.17 |
| 1940 | 295.08 | 284.27 | 273.81 | 263.58 | 253.52 | 243.56 | 233.69 | 223.94 | 214.36 | 205.01 |
| 1941 | 293.71 | 282.87 | 272.43 | 262.26 | 252.25 | 242.36 | 232.58 | 222.92 | 213.42 | 204.13 |
| 1942 | 292.49 | 281.54 | 271.05 | 260.84 | 250.81 | 240.90 | 231.11 | 221.47 | 212.01 | 202.77 |
| 1943 | 291.45 | 280.33 | 269.66 | 259.30 | 249.09 | 238.99 | 229.01 | 219.22 | 209.67 | 200.40 |
| 1944 | 290.58 | 279.22 | 268.34 | 257.74 | 247.28 | 236.88 | 226.61 | 216.54 | 206.78 | 197.38 |
| 1945 | 289.89 | 278.38 | 267.40 | 256.83 | 246.48 | 236.25 | 226.09 | 216.08 | 206.31 | 196.87 |
| 1946 | 289.35 | 277.59 | 266.46 | 255.81 | 245.53 | 235.45 | 225.49 | 215.63 | 205.94 | 196.52 |
| 1947 | 289.25 | 277.22 | 265.86 | 255.06 | 244.67 | 234.61 | 224.76 | 215.05 | 205.48 | 196.12 |
| 1948 | 289.43 | 277.21 | 265.60 | 254.60 | 244.10 | 233.97 | 224.17 | 214.58 | 205.17 | 195.93 |
| 1949 | 289.88 | 277.39 | 265.59 | 254.33 | 243.61 | 233.33 | 223.43 | 213.86 | 204.55 | 195.45 |
| 1950 | 290.61 | 277.82 | 265.77 | 254.34 | 243.38 | 232.92 | 222.89 | 213.24 | 203.95 | 194.95 |
| 1951 | 291.65 | 278.52 | 266.19 | 254.54 | 243.44 | 232.78 | 222.60 | 212.86 | 203.51 | 194.55 |
| 1952 | 292.86 | 279.51 | 266.85 | 254.89 | 243.55 | 232.71 | 222.30 | 212.37 | 202.91 | 193.87 |
| 1953 | 294.26 | 280.67 | 267.81 | 255.58 | 244.00 | 232.99 | 222.47 | 212.38 | 202.79 | 193.66 |
| 1954 | 295.78 | 282.04 | 268.98 | 256.61 | 244.82 | 233.66 | 223.05 | 212.91 | 203.21 | 193.98 |
| 1955 | 297.33 | 283.44 | 270.21 | 257.61 | 245.65 | 234.25 | 223.44 | 213.18 | 203.40 | 194.06 |
| 1956 | 299.45 | 284.94 | 271.56 | 258.80 | 246.62 | 235.03 | 223.99 | 213.54 | 203.63 | 194.22 |
| 1957 | 301.75 | 286.96 | 273.01 | 260.14 | 247.86 | 236.13 | 224.99 | 214.36 | 204.32 | 194.81 |
| 1958 | 304.13 | 289.11 | 274.87 | 261.43 | 249.01 | 237.16 | 225.83 | 215.08 | 204.85 | 195.19 |
| 1959 | 306.69 | 291.42 | 276.99 | 263.31 | 250.40 | 238.48 | 227.09 | 216.21 | 205.90 | 196.09 |
| 1960 | 309.30 | 293.91 | 279.24 | 265.35 | 252.19 | 239.76 | 228.27 | 217.31 | 206.86 | 196.95 |
| 1961 | 311.84 | 296.34 | 281.55 | 267.44 | 254.08 | 241.41 | 229.44 | 218.40 | 207.86 | 197.83 |
| 1962 | 314.30 | 298.76 | 283.86 | 269.63 | 256.06 | 243.20 | 231.02 | 219.52 | 208.91 | 198.80 |
| 1963 | 316.50 | 301.09 | 286.15 | 271.81 | 258.12 | 245.05 | 232.69 | 220.97 | 209.92 | 199.74 |
| 1964 | 318.52 | 303.28 | 288.47 | 274.11 | 260.33 | 247.17 | 234.62 | 222.74 | 211.49 | 200.89 |
| 1965 | 320.16 | 305.20 | 290.55 | 276.33 | 262.53 | 249.30 | 236.66 | 224.61 | 213.22 | 202.43 |
| 1966 | 321.04 | 306.64 | 292.25 | 278.16 | 264.50 | 251.25 | 238.55 | 226.43 | 214.88 | 203.96 |
| 1967 | 319.72 | 305.61 | 291.54 | 277.62 | 264.10 | 251.05 | 238.42 | 226.34 | 214.81 | 203.84 |
| 1968 | 318.52 | 304.75 | 291.00 | 277.40 | 264.03 | 251.09 | 238.62 | 226.57 | 215.06 | 204.09 |
| 1969 | 317.10 | 304.03 | 290.66 | 277.40 | 264.34 | 251.53 | 239.17 | 227.26 | 215.77 | 204.78 |
| 1970 | 315.74 | 303.59 | 290.98 | 278.10 | 265.31 | 252.73 | 240.40 | 228.51 | 217.07 | 206.04 |
| 1971 | 313.46 | 302.44 | 290.74 | 278.63 | 266.26 | 254.00 | 241.94 | 230.13 | 218.73 | 207.78 |

| Year | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 309.64 | 299.44 | 288.72 | 277.44 | 265.82 | 253.98 | 242.27 | 230.75 | 219.48 | 208.61 |
| 1973 | 305.33 | 295.60 | 285.65 | 275.29 | 264.46 | 253.34 | 242.04 | 230.86 | 219.88 | 209.14 |
| 1974 | 301.10 | 291.58 | 282.09 | 272.47 | 262.52 | 252.16 | 241.54 | 230.75 | 220.09 | 209.63 |
| 1975 | 297.41 | 287.91 | 278.67 | 269.53 | 260.28 | 250.75 | 240.84 | 230.69 | 220.39 | 210.21 |
| 1976 | 294.24 | 284.63 | 275.44 | 266.54 | 257.75 | 248.89 | 239.76 | 230.27 | 220.55 | 210.69 |
| 1977 | 291.72 | 281.82 | 272.56 | 263.73 | 255.19 | 246.77 | 238.28 | 229.53 | 220.44 | 211.14 |
| 1978 | 289.74 | 279.70 | 270.18 | 261.27 | 252.75 | 244.51 | 236.38 | 228.18 | 219.76 | 211.02 |
| 1979 | 287.94 | 277.27 | 267.53 | 258.29 | 249.62 | 241.32 | 233.29 | 225.39 | 217.46 | 209.34 |
| 1980 | 285.93 | 274.22 | 263.68 | 254.08 | 244.98 | 236.43 | 228.27 | 220.42 | 212.73 | 205.08 |
| 1981 | 285.99 | 273.22 | 261.85 | 251.64 | 242.36 | 233.57 | 225.33 | 217.47 | 209.92 | 202.55 |
| 1982 | 287.48 | 273.19 | 260.74 | 249.65 | 239.65 | 230.52 | 221.88 | 213.81 | 206.14 | 198.82 |
| 1983 | 290.58 | 274.03 | 260.06 | 247.90 | 237.03 | 227.21 | 218.25 | 209.81 | 201.95 | 194.54 |
| 1984 | 296.36 | 277.62 | 261.56 | 247.95 | 236.03 | 225.34 | 215.67 | 206.87 | 198.62 | 190.99 |
| 1985 | 299.32 | 282.79 | 264.60 | 248.95 | 235.63 | 223.92 | 213.40 | 203.91 | 195.31 | 187.31 |
| 1986 | 299.15 | 284.38 | 268.05 | 250.13 | 234.60 | 221.26 | 209.52 | 199.01 | 189.62 | 181.20 |
| 1987 | 299.69 | 283.78 | 268.95 | 252.57 | 234.61 | 218.90 | 205.35 | 193.48 | 182.98 | 173.72 |
| 1988 | 302.78 | 283.20 | 267.02 | 251.70 | 234.77 | 216.38 | 200.25 | 186.43 | 174.49 | 164.12 |
| 1989 | 304.95 | 286.96 | 267.62 | 251.49 | 236.14 | 219.31 | 201.24 | 185.48 | 172.06 | 160.56 |
| 1990 | 290.78 | 286.04 | 267.96 | 248.91 | 233.03 | 218.00 | 201.75 | 184.54 | 169.63 | 157.01 |
| 1991 | 271.86 | 275.10 | 269.88 | 252.21 | 233.74 | 218.34 | 203.82 | 188.26 | 171.92 | 157.82 |
| 1992 | 246.66 | 256.66 | 258.93 | 253.37 | 236.25 | 218.50 | 203.70 | 189.83 | 175.08 | 159.69 |
| 1993 | 224.50 | 233.43 | 242.18 | 243.61 | 237.65 | 220.87 | 203.61 | 189.26 | 175.92 | 161.91 |
| 1994 | 217.69 | 212.51 | 220.20 | 227.52 | 227.75 | 220.96 | 204.19 | 187.25 | 173.25 | 160.43 |
| 1995 | 220.40 | 206.55 | 201.00 | 207.45 | 213.28 | 212.26 | 204.70 | 188.12 | 171.66 | 158.19 |
| 1996 | 227.40 | 208.29 | 194.36 | 188.14 | 192.88 | 196.78 | 194.29 | 185.97 | 169.78 | 154.10 |
| 1997 | 241.11 | 215.58 | 196.82 | 182.93 | 176.19 | 179.60 | 182.16 | 178.86 | 170.38 | 154.93 |
| 1998 | 280.36 | 228.80 | 204.04 | 185.75 | 172.06 | 165.10 | 167.66 | 169.44 | 165.85 | 157.58 |
| 1999 | 387.07 | 266.96 | 217.34 | 193.19 | 175.11 | 161.37 | 154.02 | 155.62 | 156.57 | 152.69 |
| 2000 | 369.75 | 368.66 | 253.81 | 206.21 | 182.84 | 165.26 | 151.86 | 144.55 | 145.70 | 146.31 |
| 2001 | 331.11 | 350.88 | 349.14 | 239.97 | 194.68 | 172.37 | 155.57 | 142.74 | 135.68 | 136.57 |
| 2002 | 304.62 | 314.49 | 332.68 | 330.61 | 227.01 | 184.02 | 162.81 | 146.84 | 134.66 | 127.92 |
| 2003 | 281.88 | 291.94 | 301.29 | 318.53 | 316.28 | 216.94 | 175.65 | 155.23 | 139.86 | 128.13 |
| 2004 | 253.72 | 270.06 | 279.59 | 288.36 | 304.59 | 302.09 | 206.94 | 167.32 | 147.66 | 132.87 |
| 2005 | 195.02 | 243.07 | 258.61 | 267.53 | 275.63 | 290.73 | 287.88 | 196.86 | 158.89 | 139.99 |
| 2006 | 192.17 | 186.85 | 232.78 | 247.46 | 255.69 | 263.01 | 276.90 | 273.62 | 186.72 | 150.40 |
| 2007 | 238.62 | 184.12 | 178.95 | 222.75 | 236.52 | 244.01 | 250.54 | 263.26 | 259.65 | 176.86 |
| 2008 | 253.39 | 228.51 | 176.20 | 171.04 | 212.55 | 225.20 | 231.73 | 237.28 | 248.64 | 244.57 |
| 2009 | 562.83 | 242.67 | 218.69 | 168.42 | 163.20 | 202.34 | 213.78 | 219.32 | 223.87 | 233.86 |
| 2010 | 1384.05 | 538.86 | 232.13 | 208.87 | 160.50 | 155.07 | 191.60 | 201.70 | 206.17 | 209.72 |
| 2011 | 329.59 | 1324.81 | 515.32 | 221.65 | 199.01 | 152.49 | 146.85 | 180.81 | 189.68 | 193.24 |
| 2012 | 529.91 | 315.75 | 1268.41 | 492.87 | 211.66 | 189.64 | 144.94 | 139.19 | 170.88 | 178.74 |
| 2013 | 149.79 | 507.55 | 302.24 | 1212.86 | 470.55 | 201.67 | 180.25 | 137.41 | 131.60 | 161.14 |

| Year | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 200.87 | 192.60 | 184.67 | 177.08 | 169.79 | 162.80 | 156.10 | 149.68 | 143.52 | 137.62 |
| 1917 | 200.31 | 192.03 | 184.11 | 176.52 | 169.24 | 162.27 | 155.58 | 149.18 | 143.04 | 137.15 |
| 1918 | 199.77 | 191.47 | 183.54 | 175.94 | 168.68 | 161.71 | 155.05 | 148.65 | 142.53 | 136.66 |
| 1919 | 199.26 | 190.93 | 182.97 | 175.37 | 168.10 | 161.14 | 154.49 | 148.11 | 142.00 | 136.15 |
| 1920 | 198.80 | 190.41 | 182.41 | 174.79 | 167.52 | 160.56 | 153.91 | 147.55 | 141.46 | 135.62 |
| 1921 | 199.02 | 189.93 | 181.89 | 174.23 | 166.94 | 159.98 | 153.33 | 146.97 | 140.89 | 135.07 |
| 1922 | 198.75 | 190.12 | 181.40 | 173.70 | 166.37 | 159.39 | 152.74 | 146.39 | 140.31 | 134.51 |
| 1923 | 198.55 | 189.83 | 181.55 | 173.20 | 165.83 | 158.82 | 152.15 | 145.80 | 139.73 | 133.93 |
| 1924 | 198.42 | 189.60 | 181.23 | 173.31 | 165.32 | 158.27 | 151.58 | 145.21 | 139.14 | 133.34 |
| 1925 | 198.32 | 189.44 | 180.99 | 172.98 | 165.39 | 157.76 | 151.02 | 144.63 | 138.55 | 132.75 |
| 1926 | 198.24 | 189.31 | 180.80 | 172.71 | 165.04 | 157.79 | 150.50 | 144.07 | 137.97 | 132.16 |
| 1927 | 198.18 | 189.20 | 180.64 | 172.49 | 164.76 | 157.43 | 150.51 | 143.55 | 137.41 | 131.58 |
| 1928 | 198.11 | 189.11 | 180.51 | 172.31 | 164.52 | 157.13 | 150.13 | 143.52 | 136.88 | 131.02 |
| 1929 | 197.80 | 188.77 | 180.14 | 171.92 | 164.08 | 156.64 | 149.59 | 142.92 | 136.62 | 130.29 |
| 1930 | 197.14 | 188.07 | 179.42 | 171.17 | 163.32 | 155.86 | 148.78 | 142.07 | 135.72 | 129.73 |
| 1931 | 196.72 | 187.61 | 178.92 | 170.65 | 162.77 | 155.29 | 148.17 | 141.43 | 135.04 | 129.01 |
| 1932 | 196.53 | 187.37 | 178.64 | 170.33 | 162.42 | 154.91 | 147.77 | 140.99 | 134.57 | 128.49 |
| 1933 | 196.85 | 187.65 | 178.87 | 170.51 | 162.56 | 155.00 | 147.82 | 141.00 | 134.53 | 128.40 |
| 1934 | 197.04 | 187.81 | 179.00 | 170.59 | 162.60 | 155.01 | 147.79 | 140.94 | 134.43 | 128.26 |
| 1935 | 197.18 | 187.94 | 179.10 | 170.66 | 162.63 | 154.99 | 147.74 | 140.86 | 134.32 | 128.12 |
| 1936 | 197.29 | 188.09 | 179.24 | 170.78 | 162.71 | 155.04 | 147.75 | 140.83 | 134.26 | 128.03 |
| 1937 | 196.82 | 187.67 | 178.85 | 170.39 | 162.31 | 154.62 | 147.32 | 140.38 | 133.80 | 127.55 |
| 1938 | 196.24 | 187.22 | 178.45 | 170.02 | 161.95 | 154.25 | 146.92 | 139.97 | 133.37 | 127.11 |
| 1939 | 195.97 | 187.04 | 178.39 | 170.00 | 161.94 | 154.24 | 146.89 | 139.91 | 133.28 | 126.99 |
| 1940 | 195.91 | 187.08 | 178.52 | 170.24 | 162.21 | 154.52 | 147.15 | 140.14 | 133.47 | 127.14 |
| 1941 | 195.11 | 186.37 | 177.90 | 169.72 | 161.81 | 154.17 | 146.83 | 139.83 | 133.15 | 126.81 |
| 1942 | 193.79 | 185.11 | 176.73 | 168.65 | 160.85 | 153.33 | 146.06 | 139.10 | 132.45 | 126.12 |
| 1943 | 191.43 | 182.78 | 174.46 | 166.48 | 158.80 | 151.41 | 144.30 | 137.43 | 130.87 | 124.60 |
| 1944 | 188.35 | 179.70 | 171.42 | 163.51 | 155.95 | 148.70 | 141.74 | 135.05 | 128.61 | 122.44 |
| 1945 | 187.82 | 179.16 | 170.88 | 162.97 | 155.42 | 148.22 | 141.31 | 134.68 | 128.32 | 122.20 |
| 1946 | 187.46 | 178.78 | 170.49 | 162.58 | 155.03 | 147.84 | 140.97 | 134.40 | 128.09 | 122.04 |
| 1947 | 187.06 | 178.35 | 170.05 | 162.13 | 154.58 | 147.38 | 140.53 | 133.99 | 127.74 | 121.74 |
| 1948 | 186.92 | 178.22 | 169.89 | 161.94 | 154.38 | 147.17 | 140.31 | 133.78 | 127.55 | 121.59 |
| 1949 | 186.54 | 177.90 | 169.56 | 161.59 | 154.01 | 146.80 | 139.93 | 133.40 | 127.19 | 121.26 |
| 1950 | 186.19 | 177.64 | 169.35 | 161.39 | 153.78 | 146.55 | 139.67 | 133.13 | 126.91 | 120.99 |
| 1951 | 185.89 | 177.48 | 169.29 | 161.36 | 153.75 | 146.49 | 139.59 | 133.03 | 126.80 | 120.87 |
| 1952 | 185.24 | 176.91 | 168.85 | 161.03 | 153.46 | 146.20 | 139.29 | 132.71 | 126.47 | 120.54 |
| 1953 | 184.97 | 176.69 | 168.71 | 161.00 | 153.52 | 146.30 | 139.37 | 132.77 | 126.50 | 120.55 |
| 1954 | 185.23 | 176.89 | 168.95 | 161.32 | 153.94 | 146.78 | 139.87 | 133.24 | 126.93 | 120.93 |
| 1955 | 185.20 | 176.80 | 168.81 | 161.21 | 153.91 | 146.86 | 140.02 | 133.43 | 127.10 | 121.08 |
| 1956 | 185.24 | 176.74 | 168.69 | 161.05 | 153.79 | 146.81 | 140.08 | 133.55 | 127.25 | 121.22 |
| 1957 | 185.78 | 177.17 | 169.03 | 161.32 | 154.01 | 147.06 | 140.39 | 133.94 | 127.70 | 121.68 |
| 1958 | 186.06 | 177.40 | 169.16 | 161.37 | 154.00 | 147.01 | 140.37 | 134.00 | 127.84 | 121.88 |
| 1959 | 186.83 | 178.08 | 169.79 | 161.89 | 154.43 | 147.38 | 140.69 | 134.33 | 128.23 | 122.35 |
| 1960 | 187.54 | 178.67 | 170.29 | 162.34 | 154.79 | 147.65 | 140.90 | 134.50 | 128.42 | 122.59 |
| 1961 | 188.33 | 179.31 | 170.81 | 162.79 | 155.19 | 147.96 | 141.13 | 134.68 | 128.56 | 122.75 |
| 1962 | 189.18 | 180.08 | 171.44 | 163.31 | 155.63 | 148.36 | 141.45 | 134.92 | 128.75 | 122.90 |
| 1963 | 190.05 | 180.83 | 172.11 | 163.85 | 156.07 | 148.73 | 141.78 | 135.17 | 128.93 | 123.03 |
| 1964 | 191.13 | 181.85 | 173.02 | 164.67 | 156.76 | 149.31 | 142.29 | 135.63 | 129.31 | 123.34 |
| 1965 | 192.27 | 182.92 | 174.03 | 165.57 | 157.58 | 150.01 | 142.88 | 136.15 | 129.79 | 123.74 |
| 1966 | 193.63 | 183.90 | 174.95 | 166.44 | 158.35 | 150.70 | 143.46 | 136.64 | 130.21 | 124.12 |
| 1967 | 193.47 | 183.66 | 174.43 | 165.93 | 157.86 | 150.18 | 142.93 | 136.06 | 129.59 | 123.49 |
| 1968 | 193.64 | 183.78 | 174.46 | 165.68 | 157.61 | 149.94 | 142.64 | 135.75 | 129.23 | 123.08 |
| 1969 | 194.33 | 184.37 | 174.98 | 166.10 | 157.74 | 150.05 | 142.75 | 135.80 | 129.24 | 123.03 |
| 1970 | 195.52 | 185.51 | 175.99 | 167.01 | 158.53 | 150.54 | 143.20 | 136.23 | 129.60 | 123.34 |
| 1971 | 197.22 | 187.15 | 177.56 | 168.45 | 159.85 | 151.73 | 144.09 | 137.06 | 130.38 | 124.04 |

| Year | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 198.16 | 188.09 | 178.48 | 169.34 | 160.65 | 152.45 | 144.71 | 137.42 | 130.71 | 124.35 |
| 1973 | 198.78 | 188.81 | 179.22 | 170.06 | 161.35 | 153.07 | 145.26 | 137.88 | 130.93 | 124.55 |
| 1974 | 199.38 | 189.50 | 180.01 | 170.86 | 162.13 | 153.82 | 145.93 | 138.48 | 131.44 | 124.82 |
| 1975 | 200.21 | 190.42 | 180.99 | 171.92 | 163.18 | 154.84 | 146.91 | 139.37 | 132.26 | 125.54 |
| 1976 | 200.95 | 191.38 | 182.02 | 173.00 | 164.32 | 155.97 | 148.00 | 140.42 | 133.21 | 126.40 |
| 1977 | 201.70 | 192.37 | 183.21 | 174.25 | 165.61 | 157.31 | 149.31 | 141.68 | 134.42 | 127.52 |
| 1978 | 202.08 | 193.02 | 184.08 | 175.30 | 166.72 | 158.45 | 150.50 | 142.84 | 135.54 | 128.59 |
| 1979 | 200.94 | 192.38 | 183.72 | 175.18 | 166.81 | 158.63 | 150.75 | 143.18 | 135.89 | 128.94 |
| 1980 | 197.29 | 189.29 | 181.15 | 172.95 | 164.88 | 156.97 | 149.26 | 141.83 | 134.70 | 127.84 |
| 1981 | 195.22 | 187.78 | 180.14 | 172.38 | 164.57 | 156.88 | 149.35 | 142.01 | 134.94 | 128.15 |
| 1982 | 191.72 | 184.69 | 177.59 | 170.31 | 162.95 | 155.53 | 148.25 | 141.12 | 134.17 | 127.48 |
| 1983 | 187.50 | 180.70 | 174.01 | 167.26 | 160.37 | 153.41 | 146.41 | 139.54 | 132.83 | 126.28 |
| 1984 | 183.83 | 177.07 | 170.57 | 164.20 | 157.79 | 151.26 | 144.67 | 138.06 | 131.57 | 125.23 |
| 1985 | 179.94 | 173.08 | 166.62 | 160.44 | 154.40 | 148.34 | 142.18 | 135.97 | 129.74 | 123.63 |
| 1986 | 173.45 | 166.39 | 159.87 | 153.78 | 147.99 | 142.35 | 136.72 | 131.01 | 125.26 | 119.50 |
| 1987 | 165.53 | 158.11 | 151.43 | 145.31 | 139.65 | 134.30 | 129.12 | 123.96 | 118.74 | 113.51 |
| 1988 | 155.13 | 147.33 | 140.37 | 134.18 | 128.58 | 123.44 | 118.61 | 113.96 | 109.36 | 104.72 |
| 1989 | 150.65 | 142.14 | 134.80 | 128.29 | 122.53 | 117.34 | 112.59 | 108.14 | 103.87 | 99.65 |
| 1990 | 146.27 | 137.07 | 129.20 | 122.43 | 116.45 | 111.18 | 106.44 | 102.11 | 98.05 | 94.17 |
| 1991 | 145.92 | 135.83 | 127.21 | 119.85 | 113.54 | 107.96 | 103.05 | 98.64 | 94.62 | 90.86 |
| 1992 | 146.46 | 135.33 | 125.89 | 117.85 | 111.00 | 105.13 | 99.95 | 95.39 | 91.30 | 87.56 |
| 1993 | 147.43 | 135.03 | 124.64 | 115.86 | 108.40 | 102.05 | 96.61 | 91.83 | 87.62 | 83.85 |
| 1994 | 147.21 | 133.74 | 122.28 | 112.72 | 104.68 | 97.87 | 92.08 | 87.14 | 82.80 | 78.99 |
| 1995 | 146.02 | 133.66 | 121.20 | 110.66 | 101.90 | 94.55 | 88.34 | 83.08 | 78.60 | 74.66 |
| 1996 | 141.40 | 130.09 | 118.78 | 107.51 | 98.02 | 90.17 | 83.60 | 78.06 | 73.38 | 69.40 |
| 1997 | 140.17 | 128.31 | 117.83 | 107.43 | 97.13 | 88.49 | 81.35 | 75.39 | 70.37 | 66.13 |
| 1998 | 143.00 | 129.17 | 118.09 | 108.34 | 98.71 | 89.20 | 81.22 | 74.64 | 69.16 | 64.54 |
| 1999 | 144.64 | 130.95 | 118.07 | 107.79 | 98.78 | 89.92 | 81.20 | 73.90 | 67.89 | 62.87 |
| 2000 | 142.46 | 134.78 | 121.90 | 109.83 | 100.21 | 91.79 | 83.53 | 75.41 | 68.62 | 63.02 |
| 2001 | 136.95 | 133.18 | 125.86 | 113.71 | 102.35 | 93.30 | 85.40 | 77.66 | 70.06 | 63.71 |
| 2002 | 128.70 | 129.00 | 125.40 | 118.46 | 106.99 | 96.28 | 87.74 | 80.29 | 73.00 | 65.84 |
| 2003 | 121.62 | 122.28 | 122.50 | 119.02 | 112.40 | 101.49 | 91.30 | 83.19 | 76.11 | 69.19 |
| 2004 | 121.58 | 115.29 | 115.80 | 115.92 | 112.56 | 106.24 | 95.88 | 86.22 | 78.54 | 71.84 |
| 2005 | 125.78 | 114.94 | 108.86 | 109.23 | 109.25 | 106.00 | 99.98 | 90.19 | 81.06 | 73.81 |
| 2006 | 132.26 | 118.62 | 108.24 | 102.37 | 102.60 | 102.52 | 99.38 | 93.66 | 84.44 | 75.85 |
| 2007 | 142.23 | 124.89 | 111.88 | 101.97 | 96.36 | 96.51 | 96.37 | 93.37 | 87.96 | 79.27 |
| 2008 | 166.19 | 133.35 | 116.87 | 104.51 | 95.12 | 89.77 | 89.81 | 89.60 | 86.75 | 81.67 |
| 2009 | 229.36 | 155.43 | 124.41 | 108.79 | 97.10 | 88.22 | 83.14 | 83.07 | 82.78 | 80.07 |
| 2010 | 218.40 | 213.61 | 144.41 | 115.36 | 100.71 | 89.76 | 81.46 | 76.69 | 76.57 | 76.25 |
| 2011 | 195.96 | 203.52 | 198.58 | 133.97 | 106.83 | 93.13 | 82.90 | 75.15 | 70.69 | 70.52 |
| 2012 | 181.59 | 183.69 | 190.32 | 185.31 | 124.79 | 99.35 | 86.48 | 76.88 | 69.62 | 65.42 |
| 2013 | 168.14 | 170.43 | 172.04 | 177.94 | 172.98 | 116.32 | 92.49 | 80.43 | 71.44 | 64.64 |

| **Year** | **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 131.95 | 126.52 | 121.32 | 116.33 | 111.54 | 106.95 | 102.55 | 98.33 | 94.28 | 90.40 |
| 1917 | 131.50 | 126.09 | 120.90 | 115.93 | 111.15 | 106.58 | 102.19 | 97.99 | 93.96 | 90.09 |
| 1918 | 131.03 | 125.64 | 120.46 | 115.51 | 110.75 | 106.19 | 101.82 | 97.63 | 93.61 | 89.76 |
| 1919 | 130.54 | 125.16 | 120.01 | 115.07 | 110.33 | 105.79 | 101.43 | 97.26 | 93.26 | 89.42 |
| 1920 | 130.03 | 124.67 | 119.53 | 114.61 | 109.89 | 105.36 | 101.03 | 96.87 | 92.88 | 89.06 |
| 1921 | 129.49 | 124.15 | 119.04 | 114.13 | 109.43 | 104.92 | 100.60 | 96.46 | 92.49 | 88.68 |
| 1922 | 128.95 | 123.62 | 118.52 | 113.63 | 108.95 | 104.46 | 100.16 | 96.03 | 92.08 | 88.29 |
| 1923 | 128.38 | 123.07 | 117.99 | 113.12 | 108.46 | 103.98 | 99.70 | 95.59 | 91.66 | 87.88 |
| 1924 | 127.80 | 122.51 | 117.44 | 112.59 | 107.94 | 103.49 | 99.22 | 95.14 | 91.22 | 87.46 |
| 1925 | 127.22 | 121.93 | 116.88 | 112.05 | 107.42 | 102.98 | 98.73 | 94.66 | 90.76 | 87.02 |
| 1926 | 126.63 | 121.35 | 116.31 | 111.49 | 106.87 | 102.46 | 98.23 | 94.17 | 90.29 | 86.57 |
| 1927 | 126.04 | 120.76 | 115.73 | 110.92 | 106.32 | 101.92 | 97.71 | 93.67 | 89.81 | 86.10 |
| 1928 | 125.46 | 120.18 | 115.14 | 110.34 | 105.75 | 101.37 | 97.17 | 93.15 | 89.31 | 85.62 |
| 1929 | 124.71 | 119.42 | 114.39 | 109.60 | 105.02 | 100.66 | 96.48 | 92.49 | 88.66 | 85.00 |
| 1930 | 123.72 | 118.42 | 113.39 | 108.61 | 104.06 | 99.71 | 95.57 | 91.60 | 87.81 | 84.18 |
| 1931 | 123.31 | 117.59 | 112.55 | 107.77 | 103.22 | 98.89 | 94.77 | 90.82 | 87.06 | 83.45 |
| 1932 | 122.74 | 117.32 | 111.87 | 107.07 | 102.52 | 98.20 | 94.08 | 90.15 | 86.40 | 82.82 |
| 1933 | 122.59 | 117.11 | 111.93 | 106.74 | 102.16 | 97.82 | 93.69 | 89.76 | 86.01 | 82.43 |
| 1934 | 122.41 | 116.87 | 111.64 | 106.71 | 101.75 | 97.39 | 93.25 | 89.31 | 85.57 | 81.99 |
| 1935 | 122.23 | 116.65 | 111.37 | 106.39 | 101.68 | 96.96 | 92.80 | 88.86 | 85.11 | 81.54 |
| 1936 | 122.11 | 116.50 | 111.18 | 106.15 | 101.40 | 96.91 | 92.41 | 88.44 | 84.68 | 81.11 |
| 1937 | 121.62 | 116.00 | 110.66 | 105.61 | 100.83 | 96.31 | 92.05 | 87.78 | 84.01 | 80.44 |
| 1938 | 121.17 | 115.54 | 110.19 | 105.12 | 100.32 | 95.78 | 91.49 | 87.44 | 83.38 | 79.80 |
| 1939 | 121.03 | 115.37 | 110.00 | 104.91 | 100.09 | 95.51 | 91.19 | 87.10 | 83.25 | 79.38 |
| 1940 | 121.14 | 115.45 | 110.05 | 104.93 | 100.08 | 95.47 | 91.11 | 86.98 | 83.09 | 79.41 |
| 1941 | 120.80 | 115.09 | 109.68 | 104.55 | 99.69 | 95.07 | 90.69 | 86.55 | 82.63 | 78.93 |
| 1942 | 120.11 | 114.41 | 109.00 | 103.87 | 99.01 | 94.40 | 90.03 | 85.89 | 81.96 | 78.25 |
| 1943 | 118.63 | 112.97 | 107.60 | 102.51 | 97.69 | 93.12 | 88.78 | 84.67 | 80.77 | 77.08 |
| 1944 | 116.57 | 110.98 | 105.68 | 100.65 | 95.89 | 91.37 | 87.09 | 83.03 | 79.19 | 75.54 |
| 1945 | 116.34 | 110.75 | 105.44 | 100.40 | 95.62 | 91.10 | 86.81 | 82.74 | 78.89 | 75.23 |
| 1946 | 116.21 | 110.63 | 105.32 | 100.27 | 95.47 | 90.93 | 86.62 | 82.54 | 78.68 | 75.01 |
| 1947 | 115.98 | 110.44 | 105.14 | 100.09 | 95.28 | 90.73 | 86.41 | 82.32 | 78.44 | 74.77 |
| 1948 | 115.88 | 110.40 | 105.12 | 100.07 | 95.26 | 90.69 | 86.36 | 82.24 | 78.35 | 74.66 |
| 1949 | 115.59 | 110.15 | 104.94 | 99.92 | 95.12 | 90.55 | 86.21 | 82.08 | 78.17 | 74.47 |
| 1950 | 115.35 | 109.95 | 104.78 | 99.82 | 95.04 | 90.48 | 86.13 | 82.00 | 78.07 | 74.36 |
| 1951 | 115.23 | 109.85 | 104.71 | 99.78 | 95.06 | 90.51 | 86.16 | 82.02 | 78.08 | 74.35 |
| 1952 | 114.90 | 109.54 | 104.43 | 99.54 | 94.85 | 90.36 | 86.04 | 81.90 | 77.96 | 74.22 |
| 1953 | 114.89 | 109.51 | 104.40 | 99.53 | 94.87 | 90.40 | 86.12 | 82.00 | 78.06 | 74.30 |
| 1954 | 115.24 | 109.83 | 104.69 | 99.80 | 95.14 | 90.69 | 86.42 | 82.33 | 78.38 | 74.62 |
| 1955 | 115.36 | 109.93 | 104.77 | 99.86 | 95.20 | 90.75 | 86.50 | 82.43 | 78.52 | 74.77 |
| 1956 | 115.47 | 110.01 | 104.83 | 99.91 | 95.23 | 90.78 | 86.54 | 82.49 | 78.61 | 74.88 |
| 1957 | 115.91 | 110.41 | 105.19 | 100.24 | 95.53 | 91.06 | 86.80 | 82.75 | 78.87 | 75.16 |
| 1958 | 116.13 | 110.62 | 105.37 | 100.39 | 95.67 | 91.17 | 86.90 | 82.84 | 78.97 | 75.28 |
| 1959 | 116.64 | 111.14 | 105.86 | 100.84 | 96.07 | 91.55 | 87.25 | 83.16 | 79.28 | 75.58 |
| 1960 | 116.96 | 111.51 | 106.25 | 101.20 | 96.40 | 91.84 | 87.52 | 83.41 | 79.50 | 75.79 |
| 1961 | 117.17 | 111.79 | 106.58 | 101.55 | 96.73 | 92.14 | 87.78 | 83.65 | 79.72 | 75.99 |
| 1962 | 117.34 | 112.01 | 106.87 | 101.88 | 97.07 | 92.46 | 88.08 | 83.91 | 79.96 | 76.21 |
| 1963 | 117.44 | 112.13 | 107.03 | 102.11 | 97.35 | 92.76 | 88.35 | 84.16 | 80.18 | 76.41 |
| 1964 | 117.70 | 112.35 | 107.27 | 102.39 | 97.69 | 93.13 | 88.73 | 84.52 | 80.51 | 76.71 |
| 1965 | 118.02 | 112.62 | 107.50 | 102.64 | 97.98 | 93.47 | 89.11 | 84.91 | 80.88 | 77.04 |
| 1966 | 118.33 | 112.87 | 107.70 | 102.81 | 98.16 | 93.69 | 89.39 | 85.22 | 81.20 | 77.34 |
| 1967 | 117.72 | 112.23 | 107.04 | 102.15 | 97.50 | 93.09 | 88.86 | 84.78 | 80.82 | 77.01 |
| 1968 | 117.29 | 111.80 | 106.59 | 101.67 | 97.01 | 92.60 | 88.41 | 84.40 | 80.52 | 76.76 |
| 1969 | 117.18 | 111.66 | 106.44 | 101.48 | 96.79 | 92.36 | 88.16 | 84.17 | 80.35 | 76.66 |
| 1970 | 117.40 | 111.82 | 106.56 | 101.57 | 96.83 | 92.36 | 88.13 | 84.13 | 80.32 | 76.67 |
| 1971 | 118.05 | 112.37 | 107.02 | 101.98 | 97.21 | 92.68 | 88.40 | 84.35 | 80.52 | 76.88 |

| Year | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 118.30 | 112.58 | 107.16 | 102.07 | 97.26 | 92.71 | 88.39 | 84.30 | 80.45 | 76.79 |
| 1973 | 118.48 | 112.71 | 107.27 | 102.11 | 97.25 | 92.67 | 88.34 | 84.22 | 80.33 | 76.65 |
| 1974 | 118.74 | 112.95 | 107.46 | 102.26 | 97.34 | 92.71 | 88.35 | 84.22 | 80.29 | 76.58 |
| 1975 | 119.21 | 113.40 | 107.87 | 102.63 | 97.67 | 92.97 | 88.55 | 84.38 | 80.43 | 76.68 |
| 1976 | 119.98 | 113.94 | 108.38 | 103.10 | 98.08 | 93.34 | 88.85 | 84.62 | 80.64 | 76.87 |
| 1977 | 121.01 | 114.86 | 109.07 | 103.75 | 98.69 | 93.89 | 89.35 | 85.05 | 81.01 | 77.19 |
| 1978 | 121.99 | 115.76 | 109.87 | 104.34 | 99.25 | 94.41 | 89.82 | 85.47 | 81.36 | 77.49 |
| 1979 | 122.33 | 116.05 | 110.12 | 104.52 | 99.25 | 94.41 | 89.81 | 85.44 | 81.31 | 77.39 |
| 1980 | 121.29 | 115.07 | 109.15 | 103.58 | 98.31 | 93.35 | 88.80 | 84.47 | 80.36 | 76.47 |
| 1981 | 121.62 | 115.39 | 109.47 | 103.84 | 98.54 | 93.52 | 88.81 | 84.47 | 80.36 | 76.44 |
| 1982 | 121.07 | 114.89 | 109.01 | 103.41 | 98.09 | 93.08 | 88.34 | 83.89 | 79.79 | 75.90 |
| 1983 | 119.98 | 113.93 | 108.12 | 102.58 | 97.31 | 92.31 | 87.59 | 83.13 | 78.94 | 75.08 |
| 1984 | 119.05 | 113.10 | 107.40 | 101.92 | 96.69 | 91.72 | 87.01 | 82.56 | 78.35 | 74.40 |
| 1985 | 117.66 | 111.85 | 106.26 | 100.90 | 95.75 | 90.84 | 86.17 | 81.73 | 77.55 | 73.61 |
| 1986 | 113.86 | 108.36 | 103.00 | 97.84 | 92.91 | 88.16 | 83.63 | 79.33 | 75.25 | 71.40 |
| 1987 | 108.27 | 103.15 | 98.15 | 93.29 | 88.61 | 84.14 | 79.83 | 75.73 | 71.83 | 68.13 |
| 1988 | 100.07 | 95.43 | 90.90 | 86.48 | 82.19 | 78.07 | 74.11 | 70.32 | 66.70 | 63.27 |
| 1989 | 95.40 | 91.15 | 86.92 | 82.78 | 78.75 | 74.83 | 71.07 | 67.47 | 64.01 | 60.72 |
| 1990 | 90.33 | 86.47 | 82.62 | 78.77 | 75.02 | 71.37 | 67.81 | 64.40 | 61.14 | 58.00 |
| 1991 | 87.25 | 83.69 | 80.11 | 76.54 | 72.98 | 69.50 | 66.11 | 62.82 | 59.66 | 56.64 |
| 1992 | 84.08 | 80.73 | 77.44 | 74.12 | 70.81 | 67.52 | 64.29 | 61.16 | 58.11 | 55.19 |
| 1993 | 80.41 | 77.20 | 74.12 | 71.09 | 68.04 | 65.00 | 61.97 | 59.01 | 56.13 | 53.33 |
| 1994 | 75.57 | 72.46 | 69.56 | 66.78 | 64.04 | 61.29 | 58.55 | 55.82 | 53.15 | 50.56 |
| 1995 | 71.21 | 68.11 | 65.30 | 62.68 | 60.17 | 57.70 | 55.22 | 52.74 | 50.28 | 47.88 |
| 1996 | 65.90 | 62.84 | 60.10 | 57.61 | 55.29 | 53.07 | 50.89 | 48.70 | 46.51 | 44.34 |
| 1997 | 62.52 | 59.36 | 56.60 | 54.12 | 51.87 | 49.78 | 47.78 | 45.81 | 43.84 | 41.87 |
| 1998 | 60.64 | 57.32 | 54.42 | 51.88 | 49.60 | 47.54 | 45.62 | 43.78 | 41.98 | 40.17 |
| 1999 | 58.66 | 55.10 | 52.08 | 49.43 | 47.11 | 45.04 | 43.17 | 41.42 | 39.75 | 38.11 |
| 2000 | 58.36 | 54.44 | 51.13 | 48.32 | 45.86 | 43.71 | 41.79 | 40.04 | 38.42 | 36.87 |
| 2001 | 58.48 | 54.13 | 50.47 | 47.39 | 44.77 | 42.48 | 40.48 | 38.69 | 37.07 | 35.56 |
| 2002 | 59.87 | 54.95 | 50.85 | 47.41 | 44.51 | 42.05 | 39.89 | 38.01 | 36.33 | 34.80 |
| 2003 | 62.40 | 56.73 | 52.06 | 48.18 | 44.92 | 42.17 | 39.83 | 37.79 | 36.00 | 34.41 |
| 2004 | 65.29 | 58.87 | 53.51 | 49.11 | 45.44 | 42.36 | 39.76 | 37.56 | 35.63 | 33.94 |
| 2005 | 67.49 | 61.32 | 55.28 | 50.24 | 46.09 | 42.64 | 39.75 | 37.31 | 35.24 | 33.42 |
| 2006 | 69.03 | 63.10 | 57.31 | 51.65 | 46.92 | 43.04 | 39.81 | 37.10 | 34.82 | 32.88 |
| 2007 | 71.19 | 64.77 | 59.19 | 53.75 | 48.43 | 44.00 | 40.35 | 37.32 | 34.78 | 32.64 |
| 2008 | 73.56 | 66.03 | 60.05 | 54.86 | 49.80 | 44.86 | 40.75 | 37.36 | 34.55 | 32.19 |
| 2009 | 75.31 | 67.78 | 60.80 | 55.27 | 50.46 | 45.79 | 41.23 | 37.44 | 34.32 | 31.73 |
| 2010 | 73.71 | 69.30 | 62.35 | 55.91 | 50.81 | 46.38 | 42.07 | 37.88 | 34.39 | 31.52 |
| 2011 | 70.18 | 67.81 | 63.73 | 57.31 | 51.37 | 46.67 | 42.59 | 38.63 | 34.78 | 31.56 |
| 2012 | 65.21 | 64.85 | 62.62 | 58.81 | 52.86 | 47.37 | 43.02 | 39.24 | 35.58 | 32.02 |
| 2013 | 60.70 | 60.47 | 60.10 | 58.00 | 54.46 | 48.93 | 43.83 | 39.80 | 36.30 | 32.91 |

| Year | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 86.68 | 83.12 | 79.70 | 76.42 | 73.27 | 70.26 | 67.37 | 64.59 | 61.94 | 59.39 |
| 1917 | 86.38 | 82.83 | 79.42 | 76.15 | 73.02 | 70.01 | 67.13 | 64.37 | 61.72 | 59.18 |
| 1918 | 86.07 | 82.53 | 79.13 | 75.87 | 72.75 | 69.76 | 66.89 | 64.14 | 61.50 | 58.97 |
| 1919 | 85.74 | 82.21 | 78.83 | 75.58 | 72.47 | 69.49 | 66.63 | 63.89 | 61.26 | 58.74 |
| 1920 | 85.39 | 81.88 | 78.51 | 75.28 | 72.18 | 69.21 | 66.36 | 63.63 | 61.01 | 58.50 |
| 1921 | 85.03 | 81.53 | 78.17 | 74.96 | 71.87 | 68.92 | 66.08 | 63.36 | 60.75 | 58.25 |
| 1922 | 84.65 | 81.17 | 77.83 | 74.63 | 71.55 | 68.61 | 65.79 | 63.08 | 60.48 | 57.99 |
| 1923 | 84.26 | 80.79 | 77.47 | 74.28 | 71.22 | 68.29 | 65.48 | 62.79 | 60.20 | 57.72 |
| 1924 | 83.86 | 80.40 | 77.09 | 73.92 | 70.88 | 67.96 | 65.16 | 62.48 | 59.91 | 57.44 |
| 1925 | 83.44 | 80.00 | 76.71 | 73.55 | 70.52 | 67.62 | 64.84 | 62.17 | 59.61 | 57.15 |
| 1926 | 83.00 | 79.58 | 76.31 | 73.16 | 70.15 | 67.26 | 64.50 | 61.84 | 59.30 | 56.85 |
| 1927 | 82.55 | 79.15 | 75.89 | 72.77 | 69.77 | 66.90 | 64.14 | 61.50 | 58.97 | 56.54 |
| 1928 | 82.09 | 78.71 | 75.47 | 72.36 | 69.38 | 66.52 | 63.78 | 61.15 | 58.64 | 56.22 |
| 1929 | 81.49 | 78.13 | 74.91 | 71.83 | 68.87 | 66.03 | 63.31 | 60.70 | 58.21 | 55.81 |
| 1930 | 80.70 | 77.37 | 74.18 | 71.12 | 68.19 | 65.38 | 62.69 | 60.11 | 57.63 | 55.26 |
| 1931 | 80.00 | 76.70 | 73.53 | 70.50 | 67.59 | 64.81 | 62.14 | 59.58 | 57.12 | 54.77 |
| 1932 | 79.39 | 76.10 | 72.96 | 69.95 | 67.06 | 64.30 | 61.65 | 59.11 | 56.67 | 54.34 |
| 1933 | 79.01 | 75.74 | 72.61 | 69.61 | 66.74 | 63.98 | 61.35 | 58.82 | 56.39 | 54.07 |
| 1934 | 78.58 | 75.32 | 72.20 | 69.22 | 66.36 | 63.62 | 60.99 | 58.48 | 56.07 | 53.76 |
| 1935 | 78.13 | 74.88 | 71.77 | 68.80 | 65.96 | 63.23 | 60.62 | 58.12 | 55.72 | 53.43 |
| 1936 | 77.71 | 74.46 | 71.36 | 68.40 | 65.57 | 62.86 | 60.26 | 57.77 | 55.39 | 53.11 |
| 1937 | 77.04 | 73.81 | 70.73 | 67.79 | 64.97 | 62.28 | 59.70 | 57.24 | 54.88 | 52.61 |
| 1938 | 76.40 | 73.18 | 70.11 | 67.18 | 64.39 | 61.71 | 59.16 | 56.71 | 54.37 | 52.12 |
| 1939 | 75.97 | 72.74 | 69.67 | 66.75 | 63.96 | 61.30 | 58.75 | 56.32 | 53.99 | 51.76 |
| 1940 | 75.72 | 72.47 | 69.39 | 66.46 | 63.67 | 61.01 | 58.47 | 56.04 | 53.72 | 51.50 |
| 1941 | 75.43 | 71.93 | 68.84 | 65.91 | 63.13 | 60.48 | 57.96 | 55.54 | 53.24 | 51.03 |
| 1942 | 74.74 | 71.43 | 68.11 | 65.19 | 62.42 | 59.78 | 57.27 | 54.88 | 52.60 | 50.41 |
| 1943 | 73.58 | 70.29 | 67.17 | 64.05 | 61.30 | 58.69 | 56.22 | 53.86 | 51.61 | 49.46 |
| 1944 | 72.08 | 68.82 | 65.73 | 62.82 | 59.90 | 57.33 | 54.89 | 52.57 | 50.37 | 48.26 |
| 1945 | 71.76 | 68.48 | 65.38 | 62.45 | 59.68 | 56.91 | 54.46 | 52.15 | 49.95 | 47.85 |
| 1946 | 71.53 | 68.24 | 65.12 | 62.17 | 59.38 | 56.75 | 54.11 | 51.79 | 49.58 | 47.49 |
| 1947 | 71.28 | 67.98 | 64.85 | 61.88 | 59.07 | 56.43 | 53.93 | 51.42 | 49.21 | 47.12 |
| 1948 | 71.16 | 67.84 | 64.70 | 61.72 | 58.89 | 56.23 | 53.70 | 51.33 | 48.94 | 46.84 |
| 1949 | 70.96 | 67.64 | 64.49 | 61.50 | 58.66 | 55.98 | 53.44 | 51.05 | 48.79 | 46.52 |
| 1950 | 70.83 | 67.50 | 64.33 | 61.34 | 58.49 | 55.80 | 53.24 | 50.83 | 48.55 | 46.40 |
| 1951 | 70.81 | 67.45 | 64.28 | 61.26 | 58.41 | 55.70 | 53.13 | 50.70 | 48.41 | 46.24 |
| 1952 | 70.67 | 67.31 | 64.12 | 61.10 | 58.23 | 55.52 | 52.95 | 50.51 | 48.19 | 46.01 |
| 1953 | 70.74 | 67.35 | 64.15 | 61.11 | 58.23 | 55.50 | 52.91 | 50.46 | 48.13 | 45.93 |
| 1954 | 71.03 | 67.62 | 64.39 | 61.32 | 58.41 | 55.66 | 53.05 | 50.58 | 48.24 | 46.01 |
| 1955 | 71.17 | 67.75 | 64.50 | 61.41 | 58.49 | 55.72 | 53.09 | 50.60 | 48.25 | 46.01 |
| 1956 | 71.30 | 67.87 | 64.61 | 61.51 | 58.56 | 55.77 | 53.13 | 50.63 | 48.26 | 46.01 |
| 1957 | 71.60 | 68.17 | 64.90 | 61.78 | 58.81 | 56.00 | 53.33 | 50.80 | 48.41 | 46.14 |
| 1958 | 71.73 | 68.33 | 65.06 | 61.94 | 58.96 | 56.13 | 53.44 | 50.90 | 48.49 | 46.20 |
| 1959 | 72.04 | 68.65 | 65.39 | 62.26 | 59.27 | 56.42 | 53.71 | 51.14 | 48.71 | 46.40 |
| 1960 | 72.25 | 68.86 | 65.62 | 62.51 | 59.52 | 56.66 | 53.94 | 51.35 | 48.89 | 46.56 |
| 1961 | 72.44 | 69.05 | 65.82 | 62.72 | 59.75 | 56.89 | 54.16 | 51.55 | 49.08 | 46.73 |
| 1962 | 72.64 | 69.24 | 66.01 | 62.92 | 59.95 | 57.11 | 54.38 | 51.77 | 49.28 | 46.91 |
| 1963 | 72.82 | 69.41 | 66.16 | 63.07 | 60.12 | 57.29 | 54.57 | 51.96 | 49.46 | 47.09 |
| 1964 | 73.09 | 69.66 | 66.40 | 63.29 | 60.34 | 57.51 | 54.80 | 52.21 | 49.71 | 47.32 |
| 1965 | 73.40 | 69.94 | 66.66 | 63.53 | 60.56 | 57.74 | 55.03 | 52.44 | 49.96 | 47.56 |
| 1966 | 73.67 | 70.19 | 66.88 | 63.74 | 60.76 | 57.92 | 55.21 | 52.63 | 50.15 | 47.77 |
| 1967 | 73.35 | 69.87 | 66.57 | 63.43 | 60.45 | 57.62 | 54.93 | 52.36 | 49.91 | 47.56 |
| 1968 | 73.14 | 69.67 | 66.36 | 63.22 | 60.25 | 57.42 | 54.73 | 52.17 | 49.73 | 47.40 |
| 1969 | 73.08 | 69.63 | 66.32 | 63.18 | 60.19 | 57.35 | 54.66 | 52.10 | 49.67 | 47.35 |
| 1970 | 73.15 | 69.74 | 66.44 | 63.29 | 60.29 | 57.44 | 54.73 | 52.16 | 49.72 | 47.39 |
| 1971 | 73.38 | 70.01 | 66.74 | 63.59 | 60.57 | 57.70 | 54.97 | 52.38 | 49.92 | 47.58 |

| Year | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 73.32 | 69.98 | 66.77 | 63.65 | 60.65 | 57.77 | 55.03 | 52.43 | 49.96 | 47.61 |
| 1973 | 73.17 | 69.86 | 66.68 | 63.62 | 60.65 | 57.79 | 55.04 | 52.43 | 49.95 | 47.60 |
| 1974 | 73.08 | 69.75 | 66.60 | 63.57 | 60.65 | 57.82 | 55.09 | 52.48 | 49.99 | 47.62 |
| 1975 | 73.14 | 69.79 | 66.62 | 63.60 | 60.71 | 57.92 | 55.22 | 52.61 | 50.12 | 47.74 |
| 1976 | 73.28 | 69.90 | 66.70 | 63.66 | 60.78 | 58.02 | 55.36 | 52.77 | 50.28 | 47.90 |
| 1977 | 73.58 | 70.15 | 66.91 | 63.85 | 60.94 | 58.19 | 55.54 | 52.99 | 50.52 | 48.13 |
| 1978 | 73.84 | 70.39 | 67.10 | 64.00 | 61.08 | 58.30 | 55.66 | 53.13 | 50.69 | 48.32 |
| 1979 | 73.71 | 70.24 | 66.95 | 63.83 | 60.88 | 58.10 | 55.45 | 52.95 | 50.54 | 48.22 |
| 1980 | 72.79 | 69.33 | 66.06 | 62.97 | 60.03 | 57.26 | 54.64 | 52.16 | 49.80 | 47.53 |
| 1981 | 72.75 | 69.25 | 65.95 | 62.85 | 59.91 | 57.11 | 54.47 | 51.98 | 49.62 | 47.37 |
| 1982 | 72.21 | 68.71 | 65.41 | 62.29 | 59.36 | 56.58 | 53.94 | 51.45 | 49.10 | 46.86 |
| 1983 | 71.42 | 67.94 | 64.66 | 61.55 | 58.62 | 55.86 | 53.24 | 50.76 | 48.41 | 46.20 |
| 1984 | 70.77 | 67.32 | 64.04 | 60.94 | 58.01 | 55.25 | 52.65 | 50.18 | 47.84 | 45.63 |
| 1985 | 69.89 | 66.48 | 63.24 | 60.16 | 57.25 | 54.49 | 51.90 | 49.45 | 47.14 | 44.94 |
| 1986 | 67.76 | 64.34 | 61.20 | 58.21 | 55.38 | 52.70 | 50.16 | 47.78 | 45.53 | 43.39 |
| 1987 | 64.65 | 61.35 | 58.26 | 55.41 | 52.71 | 50.14 | 47.71 | 45.42 | 43.26 | 41.22 |
| 1988 | 60.01 | 56.93 | 54.03 | 51.30 | 48.80 | 46.41 | 44.15 | 42.02 | 39.99 | 38.09 |
| 1989 | 57.59 | 54.62 | 51.82 | 49.18 | 46.69 | 44.41 | 42.24 | 40.18 | 38.24 | 36.40 |
| 1990 | 55.02 | 52.18 | 49.49 | 46.96 | 44.56 | 42.31 | 40.24 | 38.28 | 36.41 | 34.65 |
| 1991 | 53.73 | 50.96 | 48.34 | 45.84 | 43.49 | 41.28 | 39.19 | 37.28 | 35.46 | 33.73 |
| 1992 | 52.39 | 49.71 | 47.15 | 44.72 | 42.41 | 40.23 | 38.18 | 36.25 | 34.48 | 32.80 |
| 1993 | 50.65 | 48.08 | 45.61 | 43.26 | 41.03 | 38.92 | 36.92 | 35.04 | 33.27 | 31.64 |
| 1994 | 48.04 | 45.62 | 43.30 | 41.08 | 38.96 | 36.96 | 35.05 | 33.25 | 31.56 | 29.96 |
| 1995 | 45.54 | 43.27 | 41.09 | 39.00 | 37.00 | 35.09 | 33.28 | 31.57 | 29.95 | 28.42 |
| 1996 | 42.22 | 40.15 | 38.15 | 36.23 | 34.39 | 32.62 | 30.94 | 29.35 | 27.83 | 26.40 |
| 1997 | 39.91 | 38.00 | 36.14 | 34.34 | 32.61 | 30.95 | 29.36 | 27.85 | 26.41 | 25.05 |
| 1998 | 38.36 | 36.57 | 34.81 | 33.11 | 31.46 | 29.87 | 28.36 | 26.90 | 25.51 | 24.20 |
| 1999 | 36.46 | 34.82 | 33.19 | 31.60 | 30.05 | 28.55 | 27.11 | 25.73 | 24.41 | 23.15 |
| 2000 | 35.35 | 33.82 | 32.30 | 30.78 | 29.31 | 27.87 | 26.48 | 25.14 | 23.87 | 22.64 |
| 2001 | 34.12 | 32.70 | 31.29 | 29.87 | 28.47 | 27.10 | 25.77 | 24.48 | 23.25 | 22.07 |
| 2002 | 33.38 | 32.03 | 30.70 | 29.37 | 28.04 | 26.73 | 25.44 | 24.19 | 22.98 | 21.82 |
| 2003 | 32.96 | 31.62 | 30.34 | 29.08 | 27.82 | 26.56 | 25.31 | 24.10 | 22.92 | 21.77 |
| 2004 | 32.44 | 31.08 | 29.81 | 28.60 | 27.41 | 26.22 | 25.04 | 23.86 | 22.71 | 21.60 |
| 2005 | 31.84 | 30.43 | 29.15 | 27.96 | 26.82 | 25.71 | 24.59 | 23.48 | 22.37 | 21.30 |
| 2006 | 31.19 | 29.71 | 28.39 | 27.19 | 26.08 | 25.01 | 23.97 | 22.93 | 21.89 | 20.86 |
| 2007 | 30.82 | 29.23 | 27.84 | 26.60 | 25.48 | 24.44 | 23.44 | 22.46 | 21.49 | 20.52 |
| 2008 | 30.20 | 28.52 | 27.04 | 25.76 | 24.61 | 23.57 | 22.60 | 21.68 | 20.78 | 19.87 |
| 2009 | 29.56 | 27.72 | 26.17 | 24.82 | 23.63 | 22.58 | 21.62 | 20.73 | 19.89 | 19.06 |
| 2010 | 29.14 | 27.14 | 25.46 | 24.03 | 22.78 | 21.69 | 20.72 | 19.85 | 19.03 | 18.25 |
| 2011 | 28.93 | 26.74 | 24.90 | 23.35 | 22.04 | 20.90 | 19.90 | 19.01 | 18.20 | 17.45 |
| 2012 | 29.06 | 26.63 | 24.61 | 22.91 | 21.49 | 20.28 | 19.22 | 18.30 | 17.48 | 16.74 |
| 2013 | 29.61 | 26.86 | 24.61 | 22.74 | 21.17 | 19.85 | 18.74 | 17.76 | 16.91 | 16.15 |

| Year | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 56.94 | 54.60 | 52.35 | 50.20 | 48.13 | 46.15 | 44.25 | 42.43 | 40.69 | 39.01 |
| 1917 | 56.75 | 54.41 | 52.17 | 50.03 | 47.97 | 45.99 | 44.10 | 42.29 | 40.55 | 38.88 |
| 1918 | 56.54 | 54.21 | 51.98 | 49.84 | 47.79 | 45.83 | 43.94 | 42.13 | 40.40 | 38.74 |
| 1919 | 56.32 | 54.00 | 51.78 | 49.65 | 47.61 | 45.65 | 43.77 | 41.97 | 40.24 | 38.59 |
| 1920 | 56.09 | 53.79 | 51.57 | 49.45 | 47.42 | 45.46 | 43.59 | 41.80 | 40.08 | 38.43 |
| 1921 | 55.86 | 53.56 | 51.35 | 49.24 | 47.21 | 45.27 | 43.41 | 41.62 | 39.91 | 38.27 |
| 1922 | 55.61 | 53.32 | 51.13 | 49.02 | 47.00 | 45.07 | 43.22 | 41.44 | 39.73 | 38.10 |
| 1923 | 55.35 | 53.07 | 50.89 | 48.79 | 46.79 | 44.86 | 43.01 | 41.24 | 39.55 | 37.92 |
| 1924 | 55.08 | 52.81 | 50.64 | 48.56 | 46.56 | 44.64 | 42.81 | 41.05 | 39.36 | 37.74 |
| 1925 | 54.80 | 52.55 | 50.39 | 48.31 | 46.32 | 44.42 | 42.59 | 40.84 | 39.16 | 37.55 |
| 1926 | 54.51 | 52.27 | 50.12 | 48.06 | 46.08 | 44.18 | 42.37 | 40.62 | 38.95 | 37.35 |
| 1927 | 54.22 | 51.99 | 49.85 | 47.80 | 45.83 | 43.94 | 42.13 | 40.40 | 38.74 | 37.14 |
| 1928 | 53.91 | 51.69 | 49.56 | 47.52 | 45.57 | 43.69 | 41.90 | 40.17 | 38.52 | 36.93 |
| 1929 | 53.51 | 51.31 | 49.20 | 47.17 | 45.23 | 43.37 | 41.59 | 39.87 | 38.23 | 36.66 |
| 1930 | 52.98 | 50.80 | 48.71 | 46.71 | 44.79 | 42.94 | 41.18 | 39.48 | 37.86 | 36.30 |
| 1931 | 52.52 | 50.35 | 48.28 | 46.29 | 44.39 | 42.56 | 40.81 | 39.13 | 37.52 | 35.98 |
| 1932 | 52.10 | 49.96 | 47.90 | 45.93 | 44.04 | 42.23 | 40.49 | 38.82 | 37.23 | 35.69 |
| 1933 | 51.84 | 49.71 | 47.66 | 45.70 | 43.82 | 42.02 | 40.29 | 38.63 | 37.04 | 35.52 |
| 1934 | 51.54 | 49.42 | 47.39 | 45.44 | 43.57 | 41.77 | 40.05 | 38.40 | 36.82 | 35.31 |
| 1935 | 51.23 | 49.12 | 47.09 | 45.15 | 43.30 | 41.51 | 39.81 | 38.17 | 36.60 | 35.09 |
| 1936 | 50.92 | 48.82 | 46.81 | 44.88 | 43.03 | 41.26 | 39.56 | 37.93 | 36.37 | 34.88 |
| 1937 | 50.44 | 48.36 | 46.37 | 44.46 | 42.63 | 40.88 | 39.19 | 37.58 | 36.03 | 34.55 |
| 1938 | 49.97 | 47.91 | 45.94 | 44.05 | 42.23 | 40.49 | 38.83 | 37.23 | 35.69 | 34.23 |
| 1939 | 49.62 | 47.58 | 45.62 | 43.74 | 41.93 | 40.21 | 38.55 | 36.96 | 35.44 | 33.98 |
| 1940 | 49.37 | 47.33 | 45.38 | 43.51 | 41.72 | 40.00 | 38.35 | 36.77 | 35.26 | 33.81 |
| 1941 | 48.92 | 46.90 | 44.96 | 43.11 | 41.33 | 39.63 | 38.00 | 36.43 | 34.93 | 33.49 |
| 1942 | 48.33 | 46.33 | 44.41 | 42.58 | 40.82 | 39.14 | 37.53 | 35.98 | 34.50 | 33.08 |
| 1943 | 47.41 | 45.44 | 43.56 | 41.76 | 40.04 | 38.39 | 36.81 | 35.29 | 33.84 | 32.44 |
| 1944 | 46.26 | 44.34 | 42.50 | 40.74 | 39.06 | 37.45 | 35.90 | 34.42 | 33.00 | 31.64 |
| 1945 | 45.85 | 43.94 | 42.12 | 40.37 | 38.70 | 37.11 | 35.57 | 34.11 | 32.70 | 31.35 |
| 1946 | 45.50 | 43.60 | 41.78 | 40.05 | 38.39 | 36.80 | 35.28 | 33.83 | 32.43 | 31.09 |
| 1947 | 45.13 | 43.24 | 41.43 | 39.71 | 38.06 | 36.48 | 34.97 | 33.53 | 32.14 | 30.82 |
| 1948 | 44.85 | 42.95 | 41.15 | 39.43 | 37.79 | 36.22 | 34.72 | 33.29 | 31.91 | 30.59 |
| 1949 | 44.52 | 42.63 | 40.83 | 39.11 | 37.48 | 35.92 | 34.43 | 33.00 | 31.64 | 30.33 |
| 1950 | 44.25 | 42.35 | 40.54 | 38.83 | 37.20 | 35.65 | 34.17 | 32.75 | 31.39 | 30.09 |
| 1951 | 44.19 | 42.13 | 40.32 | 38.61 | 36.98 | 35.43 | 33.95 | 32.53 | 31.18 | 29.89 |
| 1952 | 43.95 | 42.00 | 40.05 | 38.33 | 36.70 | 35.15 | 33.67 | 32.27 | 30.93 | 29.64 |
| 1953 | 43.85 | 41.88 | 40.03 | 38.17 | 36.53 | 34.98 | 33.50 | 32.09 | 30.75 | 29.47 |
| 1954 | 43.91 | 41.92 | 40.04 | 38.27 | 36.49 | 34.92 | 33.43 | 32.02 | 30.68 | 29.40 |
| 1955 | 43.89 | 41.88 | 39.98 | 38.19 | 36.50 | 34.80 | 33.31 | 31.89 | 30.54 | 29.26 |
| 1956 | 43.87 | 41.85 | 39.94 | 38.13 | 36.42 | 34.81 | 33.19 | 31.76 | 30.41 | 29.13 |
| 1957 | 43.99 | 41.95 | 40.02 | 38.19 | 36.46 | 34.82 | 33.28 | 31.73 | 30.37 | 29.08 |
| 1958 | 44.04 | 41.98 | 40.04 | 38.19 | 36.44 | 34.79 | 33.23 | 31.76 | 30.28 | 28.98 |
| 1959 | 44.21 | 42.14 | 40.18 | 38.31 | 36.55 | 34.88 | 33.30 | 31.80 | 30.39 | 28.98 |
| 1960 | 44.36 | 42.27 | 40.28 | 38.41 | 36.63 | 34.94 | 33.34 | 31.83 | 30.40 | 29.06 |
| 1961 | 44.50 | 42.39 | 40.40 | 38.50 | 36.71 | 35.01 | 33.39 | 31.87 | 30.42 | 29.06 |
| 1962 | 44.67 | 42.54 | 40.52 | 38.62 | 36.81 | 35.09 | 33.46 | 31.92 | 30.46 | 29.08 |
| 1963 | 44.83 | 42.68 | 40.65 | 38.72 | 36.90 | 35.17 | 33.53 | 31.97 | 30.50 | 29.11 |
| 1964 | 45.04 | 42.88 | 40.83 | 38.89 | 37.04 | 35.30 | 33.64 | 32.08 | 30.59 | 29.18 |
| 1965 | 45.28 | 43.10 | 41.03 | 39.07 | 37.21 | 35.45 | 33.78 | 32.19 | 30.69 | 29.27 |
| 1966 | 45.49 | 43.30 | 41.22 | 39.24 | 37.36 | 35.58 | 33.90 | 32.30 | 30.79 | 29.35 |
| 1967 | 45.31 | 43.14 | 41.07 | 39.09 | 37.21 | 35.43 | 33.75 | 32.15 | 30.63 | 29.20 |
| 1968 | 45.17 | 43.03 | 40.97 | 39.00 | 37.13 | 35.34 | 33.65 | 32.05 | 30.53 | 29.09 |
| 1969 | 45.13 | 43.00 | 40.97 | 39.01 | 37.13 | 35.35 | 33.65 | 32.04 | 30.51 | 29.07 |
| 1970 | 45.18 | 43.06 | 41.04 | 39.09 | 37.22 | 35.43 | 33.73 | 32.11 | 30.57 | 29.12 |
| 1971 | 45.36 | 43.24 | 41.22 | 39.28 | 37.42 | 35.62 | 33.91 | 32.28 | 30.73 | 29.26 |

| Year | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 45.38 | 43.26 | 41.24 | 39.31 | 37.46 | 35.68 | 33.97 | 32.34 | 30.79 | 29.31 |
| 1973 | 45.36 | 43.24 | 41.22 | 39.29 | 37.45 | 35.69 | 34.00 | 32.37 | 30.82 | 29.33 |
| 1974 | 45.38 | 43.25 | 41.22 | 39.30 | 37.46 | 35.71 | 34.02 | 32.41 | 30.86 | 29.38 |
| 1975 | 45.48 | 43.34 | 41.30 | 39.37 | 37.53 | 35.78 | 34.10 | 32.50 | 30.96 | 29.47 |
| 1976 | 45.62 | 43.47 | 41.42 | 39.47 | 37.62 | 35.87 | 34.19 | 32.59 | 31.05 | 29.58 |
| 1977 | 45.85 | 43.67 | 41.61 | 39.65 | 37.79 | 36.02 | 34.33 | 32.73 | 31.20 | 29.73 |
| 1978 | 46.04 | 43.86 | 41.78 | 39.80 | 37.93 | 36.15 | 34.45 | 32.84 | 31.31 | 29.84 |
| 1979 | 45.97 | 43.80 | 41.72 | 39.74 | 37.86 | 36.08 | 34.38 | 32.77 | 31.24 | 29.78 |
| 1980 | 45.35 | 43.23 | 41.19 | 39.24 | 37.37 | 35.61 | 33.93 | 32.34 | 30.82 | 29.38 |
| 1981 | 45.22 | 43.14 | 41.13 | 39.19 | 37.33 | 35.55 | 33.87 | 32.28 | 30.76 | 29.32 |
| 1982 | 44.74 | 42.71 | 40.75 | 38.85 | 37.01 | 35.26 | 33.58 | 31.99 | 30.49 | 29.06 |
| 1983 | 44.10 | 42.10 | 40.19 | 38.34 | 36.55 | 34.83 | 33.17 | 31.60 | 30.11 | 28.69 |
| 1984 | 43.54 | 41.56 | 39.68 | 37.88 | 36.14 | 34.45 | 32.83 | 31.27 | 29.78 | 28.38 |
| 1985 | 42.86 | 40.90 | 39.04 | 37.28 | 35.58 | 33.95 | 32.36 | 30.84 | 29.37 | 27.98 |
| 1986 | 41.37 | 39.46 | 37.65 | 35.94 | 34.31 | 32.75 | 31.25 | 29.79 | 28.39 | 27.04 |
| 1987 | 39.29 | 37.46 | 35.72 | 34.09 | 32.54 | 31.07 | 29.66 | 28.29 | 26.97 | 25.70 |
| 1988 | 36.30 | 34.60 | 32.98 | 31.46 | 30.02 | 28.65 | 27.36 | 26.11 | 24.92 | 23.75 |
| 1989 | 34.66 | 33.03 | 31.49 | 30.02 | 28.63 | 27.32 | 26.08 | 24.90 | 23.77 | 22.67 |
| 1990 | 32.98 | 31.41 | 29.93 | 28.53 | 27.20 | 25.94 | 24.75 | 23.63 | 22.56 | 21.54 |
| 1991 | 32.09 | 30.55 | 29.09 | 27.72 | 26.43 | 25.19 | 24.03 | 22.93 | 21.89 | 20.90 |
| 1992 | 31.20 | 29.69 | 28.26 | 26.91 | 25.65 | 24.45 | 23.30 | 22.23 | 21.21 | 20.25 |
| 1993 | 30.09 | 28.63 | 27.24 | 25.93 | 24.70 | 23.53 | 22.43 | 21.38 | 20.40 | 19.46 |
| 1994 | 28.50 | 27.10 | 25.78 | 24.53 | 23.35 | 22.24 | 21.19 | 20.20 | 19.26 | 18.37 |
| 1995 | 26.98 | 25.66 | 24.41 | 23.22 | 22.10 | 21.03 | 20.03 | 19.09 | 18.19 | 17.35 |
| 1996 | 25.06 | 23.79 | 22.63 | 21.52 | 20.47 | 19.48 | 18.54 | 17.66 | 16.83 | 16.04 |
| 1997 | 23.76 | 22.55 | 21.41 | 20.36 | 19.37 | 18.42 | 17.53 | 16.69 | 15.89 | 15.15 |
| 1998 | 22.95 | 21.77 | 20.66 | 19.61 | 18.65 | 17.74 | 16.88 | 16.06 | 15.29 | 14.56 |
| 1999 | 21.96 | 20.82 | 19.75 | 18.75 | 17.80 | 16.93 | 16.10 | 15.32 | 14.58 | 13.87 |
| 2000 | 21.47 | 20.36 | 19.31 | 18.32 | 17.39 | 16.51 | 15.70 | 14.93 | 14.21 | 13.52 |
| 2001 | 20.93 | 19.85 | 18.82 | 17.85 | 16.94 | 16.07 | 15.26 | 14.51 | 13.80 | 13.13 |
| 2002 | 20.71 | 19.65 | 18.63 | 17.67 | 16.76 | 15.90 | 15.08 | 14.32 | 13.62 | 12.96 |
| 2003 | 20.67 | 19.62 | 18.61 | 17.65 | 16.74 | 15.87 | 15.06 | 14.29 | 13.56 | 12.90 |
| 2004 | 20.52 | 19.48 | 18.49 | 17.54 | 16.63 | 15.77 | 14.96 | 14.19 | 13.47 | 12.78 |
| 2005 | 20.25 | 19.24 | 18.27 | 17.34 | 16.44 | 15.60 | 14.79 | 14.03 | 13.31 | 12.63 |
| 2006 | 19.86 | 18.88 | 17.94 | 17.03 | 16.16 | 15.33 | 14.54 | 13.79 | 13.08 | 12.41 |
| 2007 | 19.55 | 18.61 | 17.70 | 16.81 | 15.96 | 15.15 | 14.37 | 13.62 | 12.92 | 12.25 |
| 2008 | 18.97 | 18.08 | 17.21 | 16.36 | 15.54 | 14.76 | 14.01 | 13.29 | 12.60 | 11.95 |
| 2009 | 18.23 | 17.40 | 16.58 | 15.78 | 15.00 | 14.25 | 13.53 | 12.84 | 12.18 | 11.55 |
| 2010 | 17.49 | 16.73 | 15.97 | 15.22 | 14.48 | 13.77 | 13.08 | 12.42 | 11.79 | 11.18 |
| 2011 | 16.74 | 16.04 | 15.34 | 14.65 | 13.95 | 13.28 | 12.63 | 12.00 | 11.39 | 10.81 |
| 2012 | 16.05 | 15.39 | 14.75 | 14.10 | 13.46 | 12.83 | 12.21 | 11.61 | 11.03 | 10.47 |
| 2013 | 15.46 | 14.82 | 14.22 | 13.62 | 13.03 | 12.44 | 11.85 | 11.28 | 10.72 | 10.18 |

| **Year** | **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 37.41 | 35.87 | 34.39 | 32.98 | 31.62 | 30.32 | 29.07 | 27.88 | 26.73 | 25.63 |
| 1917 | 37.28 | 35.74 | 34.27 | 32.86 | 31.51 | 30.21 | 28.97 | 27.78 | 26.64 | 25.54 |
| 1918 | 37.14 | 35.61 | 34.15 | 32.74 | 31.40 | 30.10 | 28.87 | 27.68 | 26.54 | 25.45 |
| 1919 | 37.00 | 35.48 | 34.02 | 32.62 | 31.28 | 29.99 | 28.75 | 27.57 | 26.44 | 25.35 |
| 1920 | 36.85 | 35.33 | 33.88 | 32.49 | 31.15 | 29.87 | 28.64 | 27.46 | 26.33 | 25.25 |
| 1921 | 36.69 | 35.18 | 33.74 | 32.35 | 31.02 | 29.74 | 28.52 | 27.34 | 26.22 | 25.14 |
| 1922 | 36.53 | 35.03 | 33.59 | 32.20 | 30.88 | 29.61 | 28.39 | 27.22 | 26.10 | 25.03 |
| 1923 | 36.36 | 34.86 | 33.43 | 32.05 | 30.74 | 29.47 | 28.26 | 27.10 | 25.98 | 24.91 |
| 1924 | 36.18 | 34.70 | 33.27 | 31.90 | 30.59 | 29.33 | 28.12 | 26.96 | 25.86 | 24.79 |
| 1925 | 36.00 | 34.52 | 33.10 | 31.74 | 30.43 | 29.18 | 27.98 | 26.83 | 25.72 | 24.67 |
| 1926 | 35.81 | 34.34 | 32.93 | 31.57 | 30.27 | 29.03 | 27.83 | 26.69 | 25.59 | 24.54 |
| 1927 | 35.62 | 34.15 | 32.75 | 31.40 | 30.11 | 28.87 | 27.68 | 26.54 | 25.45 | 24.40 |
| 1928 | 35.41 | 33.96 | 32.56 | 31.22 | 29.94 | 28.70 | 27.52 | 26.39 | 25.31 | 24.26 |
| 1929 | 35.15 | 33.71 | 32.32 | 30.99 | 29.71 | 28.49 | 27.32 | 26.20 | 25.12 | 24.09 |
| 1930 | 34.81 | 33.37 | 32.00 | 30.68 | 29.42 | 28.21 | 27.05 | 25.94 | 24.87 | 23.85 |
| 1931 | 34.50 | 33.08 | 31.72 | 30.41 | 29.16 | 27.96 | 26.81 | 25.71 | 24.65 | 23.64 |
| 1932 | 34.23 | 32.82 | 31.47 | 30.17 | 28.93 | 27.74 | 26.60 | 25.51 | 24.46 | 23.45 |
| 1933 | 34.05 | 32.65 | 31.31 | 30.02 | 28.79 | 27.60 | 26.47 | 25.38 | 24.33 | 23.33 |
| 1934 | 33.86 | 32.46 | 31.13 | 29.85 | 28.62 | 27.44 | 26.31 | 25.23 | 24.19 | 23.20 |
| 1935 | 33.65 | 32.26 | 30.93 | 29.66 | 28.44 | 27.27 | 26.15 | 25.07 | 24.04 | 23.05 |
| 1936 | 33.44 | 32.07 | 30.75 | 29.48 | 28.27 | 27.11 | 25.99 | 24.92 | 23.90 | 22.91 |
| 1937 | 33.13 | 31.76 | 30.46 | 29.20 | 28.00 | 26.85 | 25.75 | 24.69 | 23.67 | 22.70 |
| 1938 | 32.82 | 31.47 | 30.17 | 28.93 | 27.74 | 26.60 | 25.50 | 24.46 | 23.45 | 22.48 |
| 1939 | 32.58 | 31.24 | 29.96 | 28.72 | 27.54 | 26.41 | 25.32 | 24.28 | 23.28 | 22.33 |
| 1940 | 32.42 | 31.08 | 29.80 | 28.58 | 27.40 | 26.27 | 25.19 | 24.16 | 23.16 | 22.21 |
| 1941 | 32.11 | 30.79 | 29.53 | 28.31 | 27.15 | 26.03 | 24.96 | 23.93 | 22.95 | 22.00 |
| 1942 | 31.72 | 30.41 | 29.16 | 27.96 | 26.81 | 25.71 | 24.65 | 23.63 | 22.66 | 21.73 |
| 1943 | 31.11 | 29.83 | 28.60 | 27.42 | 26.29 | 25.21 | 24.17 | 23.18 | 22.23 | 21.31 |
| 1944 | 30.34 | 29.09 | 27.89 | 26.75 | 25.65 | 24.59 | 23.58 | 22.61 | 21.68 | 20.79 |
| 1945 | 30.06 | 28.82 | 27.64 | 26.50 | 25.41 | 24.36 | 23.36 | 22.40 | 21.48 | 20.60 |
| 1946 | 29.81 | 28.59 | 27.41 | 26.28 | 25.20 | 24.16 | 23.17 | 22.21 | 21.30 | 20.42 |
| 1947 | 29.55 | 28.33 | 27.16 | 26.04 | 24.97 | 23.94 | 22.96 | 22.01 | 21.11 | 20.24 |
| 1948 | 29.33 | 28.12 | 26.96 | 25.85 | 24.79 | 23.77 | 22.79 | 21.85 | 20.95 | 20.09 |
| 1949 | 29.08 | 27.88 | 26.73 | 25.63 | 24.57 | 23.56 | 22.59 | 21.66 | 20.77 | 19.92 |
| 1950 | 28.85 | 27.66 | 26.52 | 25.43 | 24.38 | 23.37 | 22.41 | 21.49 | 20.60 | 19.76 |
| 1951 | 28.66 | 27.47 | 26.34 | 25.25 | 24.21 | 23.21 | 22.26 | 21.34 | 20.46 | 19.62 |
| 1952 | 28.41 | 27.24 | 26.11 | 25.04 | 24.00 | 23.01 | 22.07 | 21.16 | 20.29 | 19.45 |
| 1953 | 28.25 | 27.08 | 25.96 | 24.89 | 23.86 | 22.88 | 21.93 | 21.03 | 20.16 | 19.33 |
| 1954 | 28.17 | 27.01 | 25.89 | 24.82 | 23.79 | 22.81 | 21.87 | 20.97 | 20.10 | 19.28 |
| 1955 | 28.04 | 26.87 | 25.76 | 24.69 | 23.67 | 22.69 | 21.76 | 20.86 | 20.00 | 19.18 |
| 1956 | 27.91 | 26.74 | 25.63 | 24.56 | 23.55 | 22.57 | 21.64 | 20.75 | 19.89 | 19.07 |
| 1957 | 27.85 | 26.68 | 25.57 | 24.50 | 23.49 | 22.51 | 21.58 | 20.69 | 19.84 | 19.02 |
| 1958 | 27.75 | 26.58 | 25.46 | 24.40 | 23.39 | 22.42 | 21.49 | 20.60 | 19.75 | 18.93 |
| 1959 | 27.74 | 26.56 | 25.44 | 24.37 | 23.35 | 22.38 | 21.45 | 20.56 | 19.71 | 18.90 |
| 1960 | 27.71 | 26.52 | 25.39 | 24.32 | 23.30 | 22.32 | 21.39 | 20.51 | 19.66 | 18.84 |
| 1961 | 27.77 | 26.48 | 25.34 | 24.26 | 23.24 | 22.27 | 21.34 | 20.45 | 19.60 | 18.79 |
| 1962 | 27.78 | 26.55 | 25.31 | 24.23 | 23.20 | 22.22 | 21.28 | 20.39 | 19.55 | 18.74 |
| 1963 | 27.79 | 26.54 | 25.37 | 24.19 | 23.15 | 22.16 | 21.23 | 20.34 | 19.49 | 18.68 |
| 1964 | 27.84 | 26.58 | 25.39 | 24.27 | 23.14 | 22.14 | 21.20 | 20.31 | 19.46 | 18.64 |
| 1965 | 27.92 | 26.64 | 25.44 | 24.30 | 23.22 | 22.14 | 21.19 | 20.29 | 19.43 | 18.62 |
| 1966 | 27.99 | 26.70 | 25.48 | 24.32 | 23.23 | 22.20 | 21.17 | 20.26 | 19.40 | 18.58 |
| 1967 | 27.84 | 26.55 | 25.32 | 24.16 | 23.07 | 22.03 | 21.06 | 20.08 | 19.22 | 18.40 |
| 1968 | 27.73 | 26.44 | 25.21 | 24.05 | 22.95 | 21.91 | 20.93 | 20.00 | 19.07 | 18.25 |
| 1969 | 27.70 | 26.40 | 25.17 | 24.00 | 22.90 | 21.85 | 20.86 | 19.92 | 19.04 | 18.16 |
| 1970 | 27.74 | 26.43 | 25.19 | 24.02 | 22.90 | 21.85 | 20.85 | 19.90 | 19.01 | 18.17 |
| 1971 | 27.87 | 26.55 | 25.30 | 24.11 | 22.99 | 21.92 | 20.91 | 19.95 | 19.05 | 18.20 |

| Year | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 27.91 | 26.58 | 25.32 | 24.13 | 22.99 | 21.92 | 20.91 | 19.94 | 19.03 | 18.17 |
| 1973 | 27.93 | 26.59 | 25.32 | 24.12 | 22.99 | 21.91 | 20.89 | 19.92 | 19.00 | 18.13 |
| 1974 | 27.97 | 26.62 | 25.35 | 24.14 | 23.00 | 21.91 | 20.89 | 19.91 | 18.99 | 18.12 |
| 1975 | 28.06 | 26.71 | 25.43 | 24.21 | 23.06 | 21.96 | 20.93 | 19.95 | 19.02 | 18.14 |
| 1976 | 28.17 | 26.81 | 25.52 | 24.30 | 23.14 | 22.03 | 20.99 | 20.00 | 19.06 | 18.18 |
| 1977 | 28.32 | 26.96 | 25.67 | 24.43 | 23.26 | 22.15 | 21.09 | 20.09 | 19.15 | 18.25 |
| 1978 | 28.44 | 27.09 | 25.79 | 24.55 | 23.37 | 22.25 | 21.19 | 20.18 | 19.22 | 18.32 |
| 1979 | 28.39 | 27.05 | 25.77 | 24.53 | 23.36 | 22.23 | 21.17 | 20.15 | 19.19 | 18.28 |
| 1980 | 28.01 | 26.70 | 25.44 | 24.24 | 23.07 | 21.97 | 20.91 | 19.91 | 18.95 | 18.05 |
| 1981 | 27.95 | 26.65 | 25.40 | 24.20 | 23.06 | 21.95 | 20.90 | 19.89 | 18.94 | 18.03 |
| 1982 | 27.69 | 26.40 | 25.17 | 23.99 | 22.86 | 21.78 | 20.73 | 19.74 | 18.79 | 17.89 |
| 1983 | 27.34 | 26.06 | 24.84 | 23.68 | 22.57 | 21.51 | 20.49 | 19.51 | 18.57 | 17.68 |
| 1984 | 27.04 | 25.77 | 24.56 | 23.41 | 22.32 | 21.28 | 20.27 | 19.31 | 18.39 | 17.51 |
| 1985 | 26.65 | 25.40 | 24.21 | 23.07 | 21.99 | 20.97 | 19.99 | 19.05 | 18.14 | 17.27 |
| 1986 | 25.76 | 24.54 | 23.38 | 22.28 | 21.24 | 20.25 | 19.30 | 18.40 | 17.53 | 16.70 |
| 1987 | 24.48 | 23.32 | 22.22 | 21.17 | 20.18 | 19.23 | 18.33 | 17.48 | 16.66 | 15.88 |
| 1988 | 22.63 | 21.56 | 20.54 | 19.57 | 18.64 | 17.77 | 16.94 | 16.15 | 15.39 | 14.67 |
| 1989 | 21.62 | 20.60 | 19.62 | 18.69 | 17.81 | 16.97 | 16.17 | 15.41 | 14.70 | 14.01 |
| 1990 | 20.55 | 19.59 | 18.66 | 17.78 | 16.94 | 16.14 | 15.38 | 14.65 | 13.97 | 13.32 |
| 1991 | 19.95 | 19.03 | 18.14 | 17.29 | 16.47 | 15.69 | 14.95 | 14.24 | 13.57 | 12.94 |
| 1992 | 19.33 | 18.45 | 17.61 | 16.78 | 15.99 | 15.23 | 14.51 | 13.83 | 13.18 | 12.56 |
| 1993 | 18.58 | 17.74 | 16.93 | 16.15 | 15.40 | 14.67 | 13.98 | 13.32 | 12.69 | 12.09 |
| 1994 | 17.53 | 16.73 | 15.98 | 15.25 | 14.55 | 13.87 | 13.22 | 12.59 | 11.99 | 11.43 |
| 1995 | 16.54 | 15.79 | 15.07 | 14.39 | 13.73 | 13.10 | 12.49 | 11.90 | 11.34 | 10.80 |
| 1996 | 15.29 | 14.59 | 13.92 | 13.29 | 12.69 | 12.11 | 11.55 | 11.02 | 10.50 | 10.00 |
| 1997 | 14.44 | 13.76 | 13.13 | 12.53 | 11.96 | 11.42 | 10.90 | 10.40 | 9.92 | 9.45 |
| 1998 | 13.88 | 13.23 | 12.61 | 12.03 | 11.48 | 10.96 | 10.46 | 9.99 | 9.53 | 9.08 |
| 1999 | 13.21 | 12.59 | 12.00 | 11.44 | 10.91 | 10.42 | 9.94 | 9.49 | 9.06 | 8.65 |
| 2000 | 12.87 | 12.25 | 11.68 | 11.13 | 10.61 | 10.12 | 9.66 | 9.22 | 8.80 | 8.41 |
| 2001 | 12.49 | 11.89 | 11.33 | 10.79 | 10.29 | 9.81 | 9.36 | 8.93 | 8.52 | 8.14 |
| 2002 | 12.32 | 11.73 | 11.16 | 10.63 | 10.13 | 9.66 | 9.21 | 8.78 | 8.38 | 8.00 |
| 2003 | 12.27 | 11.67 | 11.11 | 10.57 | 10.07 | 9.60 | 9.15 | 8.72 | 8.32 | 7.94 |
| 2004 | 12.16 | 11.57 | 11.00 | 10.47 | 9.96 | 9.49 | 9.04 | 8.62 | 8.22 | 7.84 |
| 2005 | 11.99 | 11.40 | 10.84 | 10.32 | 9.82 | 9.34 | 8.90 | 8.48 | 8.08 | 7.71 |
| 2006 | 11.77 | 11.18 | 10.63 | 10.11 | 9.62 | 9.15 | 8.71 | 8.30 | 7.91 | 7.54 |
| 2007 | 11.62 | 11.03 | 10.47 | 9.96 | 9.47 | 9.01 | 8.58 | 8.16 | 7.78 | 7.41 |
| 2008 | 11.33 | 10.75 | 10.20 | 9.68 | 9.21 | 8.76 | 8.33 | 7.93 | 7.55 | 7.19 |
| 2009 | 10.95 | 10.39 | 9.86 | 9.35 | 8.88 | 8.45 | 8.03 | 7.64 | 7.27 | 6.92 |
| 2010 | 10.60 | 10.05 | 9.53 | 9.05 | 8.58 | 8.15 | 7.75 | 7.37 | 7.01 | 6.68 |
| 2011 | 10.25 | 9.72 | 9.22 | 8.74 | 8.30 | 7.87 | 7.47 | 7.11 | 6.76 | 6.43 |
| 2012 | 9.94 | 9.42 | 8.94 | 8.48 | 8.04 | 7.63 | 7.24 | 6.87 | 6.54 | 6.22 |
| 2013 | 9.67 | 9.18 | 8.70 | 8.26 | 7.83 | 7.42 | 7.04 | 6.68 | 6.35 | 6.04 |

| Year | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 24.57 | 23.56 | 22.59 | 21.66 | 20.77 | 19.92 | 19.10 | 18.31 | 17.56 | 16.84 |
| 1917 | 24.49 | 23.48 | 22.52 | 21.59 | 20.70 | 19.85 | 19.03 | 18.25 | 17.50 | 16.78 |
| 1918 | 24.40 | 23.40 | 22.43 | 21.51 | 20.63 | 19.78 | 18.96 | 18.18 | 17.43 | 16.72 |
| 1919 | 24.31 | 23.31 | 22.35 | 21.43 | 20.55 | 19.70 | 18.89 | 18.11 | 17.37 | 16.65 |
| 1920 | 24.21 | 23.21 | 22.26 | 21.34 | 20.46 | 19.62 | 18.81 | 18.04 | 17.30 | 16.59 |
| 1921 | 24.11 | 23.11 | 22.16 | 21.25 | 20.38 | 19.54 | 18.73 | 17.96 | 17.22 | 16.52 |
| 1922 | 24.00 | 23.01 | 22.06 | 21.16 | 20.29 | 19.45 | 18.65 | 17.88 | 17.15 | 16.44 |
| 1923 | 23.89 | 22.90 | 21.96 | 21.06 | 20.19 | 19.36 | 18.56 | 17.80 | 17.07 | 16.37 |
| 1924 | 23.77 | 22.79 | 21.86 | 20.96 | 20.09 | 19.27 | 18.47 | 17.71 | 16.99 | 16.29 |
| 1925 | 23.65 | 22.68 | 21.75 | 20.85 | 19.99 | 19.17 | 18.38 | 17.63 | 16.90 | 16.21 |
| 1926 | 23.53 | 22.56 | 21.63 | 20.74 | 19.89 | 19.07 | 18.29 | 17.53 | 16.81 | 16.12 |
| 1927 | 23.40 | 22.44 | 21.51 | 20.63 | 19.78 | 18.97 | 18.19 | 17.44 | 16.72 | 16.03 |
| 1928 | 23.27 | 22.31 | 21.39 | 20.51 | 19.67 | 18.86 | 18.08 | 17.34 | 16.63 | 15.94 |
| 1929 | 23.09 | 22.14 | 21.23 | 20.36 | 19.52 | 18.72 | 17.95 | 17.21 | 16.50 | 15.82 |
| 1930 | 22.87 | 21.93 | 21.02 | 20.16 | 19.33 | 18.53 | 17.77 | 17.04 | 16.34 | 15.67 |
| 1931 | 22.66 | 21.73 | 20.84 | 19.98 | 19.16 | 18.37 | 17.62 | 16.89 | 16.20 | 15.53 |
| 1932 | 22.49 | 21.56 | 20.67 | 19.82 | 19.01 | 18.23 | 17.48 | 16.76 | 16.07 | 15.41 |
| 1933 | 22.37 | 21.45 | 20.57 | 19.72 | 18.91 | 18.14 | 17.39 | 16.67 | 15.99 | 15.33 |
| 1934 | 22.24 | 21.33 | 20.45 | 19.61 | 18.80 | 18.03 | 17.29 | 16.58 | 15.90 | 15.24 |
| 1935 | 22.11 | 21.20 | 20.32 | 19.49 | 18.69 | 17.92 | 17.18 | 16.47 | 15.80 | 15.15 |
| 1936 | 21.97 | 21.07 | 20.20 | 19.37 | 18.57 | 17.81 | 17.08 | 16.37 | 15.70 | 15.06 |
| 1937 | 21.76 | 20.87 | 20.01 | 19.19 | 18.40 | 17.64 | 16.92 | 16.22 | 15.55 | 14.91 |
| 1938 | 21.56 | 20.67 | 19.82 | 19.01 | 18.23 | 17.48 | 16.76 | 16.07 | 15.41 | 14.77 |
| 1939 | 21.41 | 20.53 | 19.68 | 18.87 | 18.10 | 17.35 | 16.64 | 15.95 | 15.30 | 14.67 |
| 1940 | 21.30 | 20.42 | 19.58 | 18.77 | 18.00 | 17.26 | 16.55 | 15.87 | 15.22 | 14.59 |
| 1941 | 21.10 | 20.23 | 19.40 | 18.60 | 17.84 | 17.10 | 16.40 | 15.72 | 15.08 | 14.46 |
| 1942 | 20.84 | 19.98 | 19.16 | 18.37 | 17.61 | 16.89 | 16.20 | 15.53 | 14.89 | 14.28 |
| 1943 | 20.44 | 19.59 | 18.79 | 18.02 | 17.28 | 16.56 | 15.88 | 15.23 | 14.60 | 14.00 |
| 1944 | 19.93 | 19.11 | 18.33 | 17.57 | 16.85 | 16.16 | 15.49 | 14.86 | 14.25 | 13.66 |
| 1945 | 19.75 | 18.94 | 18.16 | 17.41 | 16.69 | 16.01 | 15.35 | 14.72 | 14.11 | 13.53 |
| 1946 | 19.58 | 18.78 | 18.01 | 17.27 | 16.56 | 15.87 | 15.22 | 14.60 | 14.00 | 13.42 |
| 1947 | 19.41 | 18.61 | 17.84 | 17.11 | 16.41 | 15.73 | 15.09 | 14.47 | 13.87 | 13.30 |
| 1948 | 19.26 | 18.47 | 17.71 | 16.98 | 16.29 | 15.62 | 14.97 | 14.36 | 13.77 | 13.20 |
| 1949 | 19.10 | 18.31 | 17.56 | 16.84 | 16.14 | 15.48 | 14.84 | 14.23 | 13.65 | 13.09 |
| 1950 | 18.94 | 18.16 | 17.42 | 16.70 | 16.01 | 15.36 | 14.72 | 14.12 | 13.54 | 12.98 |
| 1951 | 18.81 | 18.04 | 17.30 | 16.59 | 15.90 | 15.25 | 14.62 | 14.02 | 13.45 | 12.89 |
| 1952 | 18.65 | 17.88 | 17.15 | 16.44 | 15.77 | 15.12 | 14.50 | 13.90 | 13.33 | 12.78 |
| 1953 | 18.54 | 17.78 | 17.04 | 16.34 | 15.67 | 15.03 | 14.41 | 13.82 | 13.25 | 12.70 |
| 1954 | 18.48 | 17.72 | 16.99 | 16.29 | 15.62 | 14.98 | 14.36 | 13.77 | 13.21 | 12.66 |
| 1955 | 18.39 | 17.63 | 16.90 | 16.21 | 15.54 | 14.90 | 14.29 | 13.70 | 13.14 | 12.60 |
| 1956 | 18.29 | 17.53 | 16.81 | 16.12 | 15.46 | 14.82 | 14.21 | 13.63 | 13.07 | 12.53 |
| 1957 | 18.24 | 17.48 | 16.76 | 16.07 | 15.41 | 14.78 | 14.17 | 13.59 | 13.03 | 12.49 |
| 1958 | 18.15 | 17.40 | 16.69 | 16.00 | 15.34 | 14.71 | 14.10 | 13.52 | 12.97 | 12.43 |
| 1959 | 18.12 | 17.37 | 16.66 | 15.97 | 15.31 | 14.68 | 14.08 | 13.50 | 12.94 | 12.41 |
| 1960 | 18.07 | 17.32 | 16.61 | 15.92 | 15.27 | 14.64 | 14.03 | 13.46 | 12.90 | 12.37 |
| 1961 | 18.01 | 17.27 | 16.55 | 15.87 | 15.22 | 14.59 | 13.99 | 13.41 | 12.86 | 12.33 |
| 1962 | 17.96 | 17.22 | 16.51 | 15.82 | 15.17 | 14.55 | 13.95 | 13.37 | 12.82 | 12.30 |
| 1963 | 17.90 | 17.16 | 16.45 | 15.77 | 15.12 | 14.50 | 13.90 | 13.33 | 12.78 | 12.25 |
| 1964 | 17.87 | 17.13 | 16.42 | 15.74 | 15.09 | 14.47 | 13.87 | 13.30 | 12.75 | 12.22 |
| 1965 | 17.84 | 17.10 | 16.39 | 15.71 | 15.06 | 14.44 | 13.84 | 13.27 | 12.72 | 12.20 |
| 1966 | 17.80 | 17.06 | 16.35 | 15.67 | 15.02 | 14.40 | 13.81 | 13.24 | 12.69 | 12.17 |
| 1967 | 17.62 | 16.88 | 16.18 | 15.51 | 14.86 | 14.25 | 13.66 | 13.09 | 12.55 | 12.04 |
| 1968 | 17.48 | 16.74 | 16.04 | 15.37 | 14.73 | 14.12 | 13.53 | 12.97 | 12.44 | 11.92 |
| 1969 | 17.38 | 16.64 | 15.94 | 15.27 | 14.63 | 14.02 | 13.44 | 12.88 | 12.35 | 11.84 |
| 1970 | 17.33 | 16.58 | 15.88 | 15.21 | 14.57 | 13.96 | 13.38 | 12.82 | 12.29 | 11.78 |
| 1971 | 17.39 | 16.58 | 15.87 | 15.20 | 14.55 | 13.94 | 13.36 | 12.81 | 12.27 | 11.77 |

| Year | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 17.35 | 16.59 | 15.81 | 15.14 | 14.49 | 13.88 | 13.30 | 12.74 | 12.21 | 11.71 |
| 1973 | 17.31 | 16.54 | 15.80 | 15.07 | 14.42 | 13.81 | 13.23 | 12.67 | 12.14 | 11.64 |
| 1974 | 17.29 | 16.50 | 15.76 | 15.07 | 14.37 | 13.75 | 13.16 | 12.61 | 12.08 | 11.57 |
| 1975 | 17.30 | 16.51 | 15.76 | 15.05 | 14.39 | 13.72 | 13.13 | 12.57 | 12.04 | 11.54 |
| 1976 | 17.33 | 16.53 | 15.78 | 15.06 | 14.39 | 13.75 | 13.11 | 12.55 | 12.01 | 11.51 |
| 1977 | 17.40 | 16.59 | 15.83 | 15.10 | 14.42 | 13.77 | 13.16 | 12.55 | 12.01 | 11.50 |
| 1978 | 17.46 | 16.64 | 15.87 | 15.14 | 14.45 | 13.79 | 13.17 | 12.59 | 12.01 | 11.49 |
| 1979 | 17.42 | 16.61 | 15.83 | 15.10 | 14.40 | 13.74 | 13.12 | 12.53 | 11.98 | 11.42 |
| 1980 | 17.20 | 16.39 | 15.62 | 14.89 | 14.20 | 13.55 | 12.93 | 12.34 | 11.79 | 11.27 |
| 1981 | 17.17 | 16.36 | 15.59 | 14.86 | 14.17 | 13.51 | 12.89 | 12.30 | 11.74 | 11.21 |
| 1982 | 17.03 | 16.22 | 15.45 | 14.72 | 14.03 | 13.38 | 12.76 | 12.17 | 11.62 | 11.09 |
| 1983 | 16.83 | 16.03 | 15.26 | 14.54 | 13.86 | 13.21 | 12.59 | 12.01 | 11.45 | 10.93 |
| 1984 | 16.66 | 15.86 | 15.11 | 14.39 | 13.71 | 13.06 | 12.45 | 11.87 | 11.32 | 10.80 |
| 1985 | 16.45 | 15.65 | 14.90 | 14.19 | 13.51 | 12.87 | 12.27 | 11.69 | 11.15 | 10.63 |
| 1986 | 15.90 | 15.14 | 14.41 | 13.72 | 13.06 | 12.44 | 11.85 | 11.29 | 10.77 | 10.26 |
| 1987 | 15.12 | 14.40 | 13.71 | 13.05 | 12.42 | 11.83 | 11.27 | 10.73 | 10.23 | 9.75 |
| 1988 | 13.98 | 13.32 | 12.68 | 12.07 | 11.49 | 10.94 | 10.42 | 9.92 | 9.45 | 9.01 |
| 1989 | 13.35 | 12.73 | 12.12 | 11.54 | 10.99 | 10.46 | 9.96 | 9.48 | 9.03 | 8.61 |
| 1990 | 12.70 | 12.10 | 11.53 | 10.99 | 10.46 | 9.96 | 9.48 | 9.03 | 8.59 | 8.19 |
| 1991 | 12.34 | 11.76 | 11.21 | 10.68 | 10.18 | 9.69 | 9.23 | 8.78 | 8.36 | 7.96 |
| 1992 | 11.97 | 11.41 | 10.88 | 10.37 | 9.88 | 9.41 | 8.96 | 8.53 | 8.12 | 7.73 |
| 1993 | 11.52 | 10.98 | 10.47 | 9.98 | 9.52 | 9.07 | 8.64 | 8.23 | 7.83 | 7.46 |
| 1994 | 10.89 | 10.38 | 9.89 | 9.43 | 8.99 | 8.57 | 8.17 | 7.78 | 7.41 | 7.05 |
| 1995 | 10.29 | 9.81 | 9.35 | 8.91 | 8.50 | 8.10 | 7.72 | 7.36 | 7.01 | 6.68 |
| 1996 | 9.53 | 9.08 | 8.65 | 8.24 | 7.86 | 7.49 | 7.14 | 6.81 | 6.49 | 6.18 |
| 1997 | 9.00 | 8.57 | 8.17 | 7.79 | 7.42 | 7.07 | 6.74 | 6.43 | 6.13 | 5.84 |
| 1998 | 8.66 | 8.25 | 7.86 | 7.48 | 7.13 | 6.80 | 6.48 | 6.18 | 5.89 | 5.62 |
| 1999 | 8.24 | 7.86 | 7.48 | 7.13 | 6.79 | 6.47 | 6.17 | 5.88 | 5.61 | 5.35 |
| 2000 | 8.02 | 7.65 | 7.29 | 6.94 | 6.61 | 6.30 | 6.00 | 5.72 | 5.46 | 5.20 |
| 2001 | 7.77 | 7.41 | 7.07 | 6.74 | 6.42 | 6.11 | 5.82 | 5.55 | 5.29 | 5.04 |
| 2002 | 7.64 | 7.29 | 6.96 | 6.63 | 6.32 | 6.02 | 5.74 | 5.47 | 5.21 | 4.97 |
| 2003 | 7.58 | 7.24 | 6.91 | 6.59 | 6.28 | 5.99 | 5.70 | 5.43 | 5.18 | 4.93 |
| 2004 | 7.48 | 7.14 | 6.82 | 6.51 | 6.21 | 5.92 | 5.64 | 5.38 | 5.12 | 4.88 |
| 2005 | 7.35 | 7.02 | 6.70 | 6.40 | 6.11 | 5.83 | 5.55 | 5.29 | 5.04 | 4.80 |
| 2006 | 7.19 | 6.86 | 6.54 | 6.25 | 5.96 | 5.69 | 5.43 | 5.18 | 4.94 | 4.70 |
| 2007 | 7.06 | 6.73 | 6.42 | 6.13 | 5.85 | 5.59 | 5.34 | 5.09 | 4.85 | 4.63 |
| 2008 | 6.85 | 6.53 | 6.23 | 5.94 | 5.67 | 5.41 | 5.17 | 4.93 | 4.71 | 4.49 |
| 2009 | 6.59 | 6.28 | 5.99 | 5.71 | 5.45 | 5.20 | 4.96 | 4.74 | 4.53 | 4.32 |
| 2010 | 6.35 | 6.05 | 5.77 | 5.50 | 5.24 | 5.00 | 4.77 | 4.56 | 4.35 | 4.16 |
| 2011 | 6.12 | 5.83 | 5.55 | 5.29 | 5.04 | 4.81 | 4.59 | 4.38 | 4.18 | 3.99 |
| 2012 | 5.91 | 5.63 | 5.36 | 5.10 | 4.86 | 4.64 | 4.42 | 4.22 | 4.03 | 3.84 |
| 2013 | 5.74 | 5.46 | 5.20 | 4.95 | 4.72 | 4.49 | 4.28 | 4.09 | 3.90 | 3.72 |

| Year | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 16.14 | 15.48 | 14.84 | 14.23 | 13.65 | 13.08 | 12.55 | 12.03 | 11.53 | 11.06 |
| 1917 | 16.09 | 15.43 | 14.79 | 14.18 | 13.60 | 13.04 | 12.50 | 11.99 | 11.49 | 11.02 |
| 1918 | 16.03 | 15.37 | 14.74 | 14.13 | 13.55 | 12.99 | 12.46 | 11.94 | 11.45 | 10.98 |
| 1919 | 15.97 | 15.31 | 14.68 | 14.08 | 13.50 | 12.94 | 12.41 | 11.90 | 11.41 | 10.94 |
| 1920 | 15.90 | 15.25 | 14.62 | 14.02 | 13.44 | 12.89 | 12.36 | 11.85 | 11.36 | 10.90 |
| 1921 | 15.84 | 15.18 | 14.56 | 13.96 | 13.39 | 12.84 | 12.31 | 11.80 | 11.32 | 10.85 |
| 1922 | 15.77 | 15.12 | 14.50 | 13.90 | 13.33 | 12.78 | 12.25 | 11.75 | 11.27 | 10.80 |
| 1923 | 15.69 | 15.05 | 14.43 | 13.83 | 13.27 | 12.72 | 12.20 | 11.69 | 11.21 | 10.75 |
| 1924 | 15.62 | 14.97 | 14.36 | 13.77 | 13.20 | 12.66 | 12.14 | 11.64 | 11.16 | 10.70 |
| 1925 | 15.54 | 14.90 | 14.29 | 13.70 | 13.13 | 12.59 | 12.08 | 11.58 | 11.10 | 10.65 |
| 1926 | 15.46 | 14.82 | 14.21 | 13.63 | 13.07 | 12.53 | 12.01 | 11.52 | 11.04 | 10.59 |
| 1927 | 15.37 | 14.74 | 14.13 | 13.55 | 12.99 | 12.46 | 11.95 | 11.46 | 10.98 | 10.53 |
| 1928 | 15.29 | 14.66 | 14.05 | 13.48 | 12.92 | 12.39 | 11.88 | 11.39 | 10.92 | 10.47 |
| 1929 | 15.17 | 14.55 | 13.95 | 13.38 | 12.83 | 12.30 | 11.79 | 11.31 | 10.84 | 10.40 |
| 1930 | 15.02 | 14.41 | 13.81 | 13.25 | 12.70 | 12.18 | 11.68 | 11.20 | 10.74 | 10.29 |
| 1931 | 14.89 | 14.28 | 13.69 | 13.13 | 12.59 | 12.07 | 11.57 | 11.10 | 10.64 | 10.20 |
| 1932 | 14.77 | 14.17 | 13.58 | 13.02 | 12.49 | 11.98 | 11.48 | 11.01 | 10.56 | 10.12 |
| 1933 | 14.70 | 14.10 | 13.52 | 12.96 | 12.43 | 11.92 | 11.43 | 10.96 | 10.50 | 10.07 |
| 1934 | 14.61 | 14.01 | 13.44 | 12.88 | 12.35 | 11.85 | 11.36 | 10.89 | 10.44 | 10.01 |
| 1935 | 14.52 | 13.93 | 13.35 | 12.80 | 12.28 | 11.77 | 11.29 | 10.82 | 10.38 | 9.95 |
| 1936 | 14.44 | 13.84 | 13.27 | 12.73 | 12.20 | 11.70 | 11.22 | 10.76 | 10.32 | 9.89 |
| 1937 | 14.30 | 13.71 | 13.15 | 12.61 | 12.09 | 11.59 | 11.12 | 10.66 | 10.22 | 9.80 |
| 1938 | 14.17 | 13.58 | 13.03 | 12.49 | 11.98 | 11.48 | 11.01 | 10.56 | 10.12 | 9.71 |
| 1939 | 14.07 | 13.49 | 12.93 | 12.40 | 11.89 | 11.40 | 10.93 | 10.48 | 10.05 | 9.64 |
| 1940 | 13.99 | 13.42 | 12.87 | 12.34 | 11.83 | 11.34 | 10.88 | 10.43 | 10.00 | 9.59 |
| 1941 | 13.86 | 13.29 | 12.75 | 12.22 | 11.72 | 11.24 | 10.78 | 10.33 | 9.91 | 9.50 |
| 1942 | 13.69 | 13.13 | 12.59 | 12.07 | 11.57 | 11.10 | 10.64 | 10.20 | 9.78 | 9.38 |
| 1943 | 13.43 | 12.88 | 12.35 | 11.84 | 11.35 | 10.89 | 10.44 | 10.01 | 9.60 | 9.20 |
| 1944 | 13.10 | 12.56 | 12.04 | 11.55 | 11.07 | 10.62 | 10.18 | 9.76 | 9.36 | 8.98 |
| 1945 | 12.98 | 12.44 | 11.93 | 11.44 | 10.97 | 10.52 | 10.09 | 9.67 | 9.27 | 8.89 |
| 1946 | 12.87 | 12.34 | 11.83 | 11.35 | 10.88 | 10.43 | 10.00 | 9.59 | 9.20 | 8.82 |
| 1947 | 12.75 | 12.23 | 11.73 | 11.24 | 10.78 | 10.34 | 9.91 | 9.51 | 9.12 | 8.74 |
| 1948 | 12.66 | 12.14 | 11.64 | 11.16 | 10.70 | 10.26 | 9.84 | 9.44 | 9.05 | 8.68 |
| 1949 | 12.55 | 12.03 | 11.54 | 11.06 | 10.61 | 10.17 | 9.76 | 9.35 | 8.97 | 8.60 |
| 1950 | 12.45 | 11.94 | 11.45 | 10.98 | 10.52 | 10.09 | 9.68 | 9.28 | 8.90 | 8.53 |
| 1951 | 12.36 | 11.85 | 11.37 | 10.90 | 10.45 | 10.02 | 9.61 | 9.22 | 8.84 | 8.47 |
| 1952 | 12.26 | 11.75 | 11.27 | 10.81 | 10.36 | 9.94 | 9.53 | 9.14 | 8.76 | 8.40 |
| 1953 | 12.18 | 11.68 | 11.20 | 10.74 | 10.30 | 9.87 | 9.47 | 9.08 | 8.71 | 8.35 |
| 1954 | 12.14 | 11.64 | 11.17 | 10.71 | 10.27 | 9.84 | 9.44 | 9.05 | 8.68 | 8.32 |
| 1955 | 12.08 | 11.58 | 11.11 | 10.65 | 10.21 | 9.79 | 9.39 | 9.00 | 8.63 | 8.28 |
| 1956 | 12.01 | 11.52 | 11.05 | 10.59 | 10.16 | 9.74 | 9.34 | 8.95 | 8.59 | 8.23 |
| 1957 | 11.98 | 11.49 | 11.01 | 10.56 | 10.13 | 9.71 | 9.31 | 8.93 | 8.56 | 8.21 |
| 1958 | 11.92 | 11.43 | 10.96 | 10.51 | 10.08 | 9.67 | 9.27 | 8.89 | 8.52 | 8.17 |
| 1959 | 11.90 | 11.41 | 10.94 | 10.49 | 10.06 | 9.65 | 9.25 | 8.87 | 8.50 | 8.16 |
| 1960 | 11.86 | 11.38 | 10.91 | 10.46 | 10.03 | 9.62 | 9.22 | 8.84 | 8.48 | 8.13 |
| 1961 | 11.83 | 11.34 | 10.87 | 10.43 | 10.00 | 9.59 | 9.19 | 8.81 | 8.45 | 8.10 |
| 1962 | 11.79 | 11.30 | 10.84 | 10.39 | 9.97 | 9.56 | 9.16 | 8.79 | 8.43 | 8.08 |
| 1963 | 11.75 | 11.27 | 10.80 | 10.36 | 9.93 | 9.52 | 9.13 | 8.76 | 8.40 | 8.05 |
| 1964 | 11.72 | 11.24 | 10.78 | 10.33 | 9.91 | 9.50 | 9.11 | 8.74 | 8.38 | 8.03 |
| 1965 | 11.70 | 11.22 | 10.75 | 10.31 | 9.89 | 9.48 | 9.09 | 8.72 | 8.36 | 8.02 |
| 1966 | 11.67 | 11.19 | 10.73 | 10.28 | 9.86 | 9.46 | 9.07 | 8.69 | 8.34 | 7.99 |
| 1967 | 11.54 | 11.06 | 10.61 | 10.17 | 9.75 | 9.35 | 8.97 | 8.60 | 8.25 | 7.91 |
| 1968 | 11.43 | 10.96 | 10.51 | 10.08 | 9.66 | 9.26 | 8.88 | 8.52 | 8.17 | 7.83 |
| 1969 | 11.35 | 10.88 | 10.43 | 10.00 | 9.59 | 9.20 | 8.82 | 8.46 | 8.11 | 7.78 |
| 1970 | 11.30 | 10.83 | 10.39 | 9.96 | 9.55 | 9.15 | 8.78 | 8.42 | 8.07 | 7.74 |
| 1971 | 11.28 | 10.81 | 10.37 | 9.94 | 9.53 | 9.14 | 8.76 | 8.40 | 8.05 | 7.72 |

| Year | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 11.22 | 10.76 | 10.31 | 9.89 | 9.48 | 9.09 | 8.71 | 8.36 | 8.01 | 7.68 |
| 1973 | 11.15 | 10.69 | 10.25 | 9.83 | 9.42 | 9.03 | 8.66 | 8.30 | 7.96 | 7.63 |
| 1974 | 11.09 | 10.63 | 10.19 | 9.77 | 9.37 | 8.98 | 8.61 | 8.26 | 7.92 | 7.59 |
| 1975 | 11.05 | 10.59 | 10.15 | 9.73 | 9.33 | 8.95 | 8.58 | 8.22 | 7.88 | 7.56 |
| 1976 | 11.02 | 10.56 | 10.12 | 9.70 | 9.30 | 8.92 | 8.55 | 8.20 | 7.86 | 7.54 |
| 1977 | 11.02 | 10.55 | 10.11 | 9.69 | 9.29 | 8.91 | 8.54 | 8.18 | 7.85 | 7.52 |
| 1978 | 11.00 | 10.54 | 10.10 | 9.67 | 9.27 | 8.89 | 8.52 | 8.17 | 7.83 | 7.51 |
| 1979 | 10.93 | 10.47 | 10.02 | 9.60 | 9.20 | 8.82 | 8.45 | 8.10 | 7.77 | 7.45 |
| 1980 | 10.74 | 10.28 | 9.84 | 9.43 | 9.03 | 8.66 | 8.29 | 7.95 | 7.62 | 7.31 |
| 1981 | 10.72 | 10.22 | 9.78 | 9.36 | 8.97 | 8.59 | 8.23 | 7.89 | 7.56 | 7.25 |
| 1982 | 10.59 | 10.12 | 9.65 | 9.24 | 8.85 | 8.47 | 8.12 | 7.78 | 7.45 | 7.14 |
| 1983 | 10.43 | 9.97 | 9.53 | 9.08 | 8.69 | 8.32 | 7.97 | 7.64 | 7.32 | 7.01 |
| 1984 | 10.30 | 9.84 | 9.39 | 8.98 | 8.56 | 8.19 | 7.85 | 7.51 | 7.20 | 6.90 |
| 1985 | 10.14 | 9.68 | 9.24 | 8.83 | 8.43 | 8.04 | 7.70 | 7.37 | 7.06 | 6.76 |
| 1986 | 9.79 | 9.34 | 8.91 | 8.51 | 8.13 | 7.77 | 7.40 | 7.09 | 6.79 | 6.50 |
| 1987 | 9.30 | 8.86 | 8.46 | 8.07 | 7.70 | 7.36 | 7.03 | 6.71 | 6.42 | 6.14 |
| 1988 | 8.59 | 8.19 | 7.81 | 7.45 | 7.11 | 6.79 | 6.48 | 6.19 | 5.91 | 5.65 |
| 1989 | 8.20 | 7.82 | 7.45 | 7.11 | 6.78 | 6.47 | 6.18 | 5.90 | 5.64 | 5.38 |
| 1990 | 7.80 | 7.43 | 7.08 | 6.75 | 6.44 | 6.14 | 5.86 | 5.60 | 5.35 | 5.11 |
| 1991 | 7.58 | 7.22 | 6.88 | 6.56 | 6.26 | 5.97 | 5.69 | 5.43 | 5.19 | 4.95 |
| 1992 | 7.37 | 7.02 | 6.68 | 6.37 | 6.07 | 5.79 | 5.52 | 5.27 | 5.02 | 4.80 |
| 1993 | 7.10 | 6.76 | 6.44 | 6.13 | 5.84 | 5.57 | 5.31 | 5.07 | 4.83 | 4.61 |
| 1994 | 6.72 | 6.39 | 6.09 | 5.80 | 5.52 | 5.26 | 5.02 | 4.78 | 4.56 | 4.35 |
| 1995 | 6.36 | 6.05 | 5.76 | 5.48 | 5.22 | 4.98 | 4.74 | 4.52 | 4.31 | 4.11 |
| 1996 | 5.89 | 5.60 | 5.34 | 5.08 | 4.84 | 4.61 | 4.39 | 4.18 | 3.99 | 3.80 |
| 1997 | 5.57 | 5.30 | 5.05 | 4.80 | 4.57 | 4.35 | 4.15 | 3.95 | 3.77 | 3.59 |
| 1998 | 5.35 | 5.10 | 4.86 | 4.62 | 4.40 | 4.19 | 3.99 | 3.80 | 3.62 | 3.45 |
| 1999 | 5.10 | 4.86 | 4.63 | 4.41 | 4.20 | 3.99 | 3.80 | 3.62 | 3.45 | 3.29 |
| 2000 | 4.96 | 4.73 | 4.51 | 4.29 | 4.09 | 3.89 | 3.70 | 3.53 | 3.36 | 3.20 |
| 2001 | 4.81 | 4.58 | 4.37 | 4.17 | 3.97 | 3.78 | 3.60 | 3.42 | 3.26 | 3.10 |
| 2002 | 4.73 | 4.51 | 4.30 | 4.10 | 3.91 | 3.72 | 3.55 | 3.38 | 3.21 | 3.06 |
| 2003 | 4.70 | 4.48 | 4.28 | 4.08 | 3.89 | 3.70 | 3.53 | 3.36 | 3.20 | 3.04 |
| 2004 | 4.65 | 4.43 | 4.23 | 4.03 | 3.84 | 3.66 | 3.49 | 3.33 | 3.17 | 3.02 |
| 2005 | 4.58 | 4.36 | 4.16 | 3.96 | 3.78 | 3.60 | 3.44 | 3.27 | 3.12 | 2.97 |
| 2006 | 4.48 | 4.27 | 4.07 | 3.88 | 3.70 | 3.52 | 3.36 | 3.20 | 3.05 | 2.91 |
| 2007 | 4.41 | 4.20 | 4.00 | 3.81 | 3.63 | 3.46 | 3.30 | 3.15 | 3.00 | 2.86 |
| 2008 | 4.28 | 4.08 | 3.88 | 3.70 | 3.53 | 3.36 | 3.20 | 3.06 | 2.91 | 2.78 |
| 2009 | 4.12 | 3.92 | 3.74 | 3.56 | 3.39 | 3.23 | 3.08 | 2.94 | 2.80 | 2.67 |
| 2010 | 3.97 | 3.78 | 3.60 | 3.43 | 3.27 | 3.12 | 2.97 | 2.83 | 2.70 | 2.57 |
| 2011 | 3.81 | 3.64 | 3.47 | 3.31 | 3.15 | 3.00 | 2.86 | 2.72 | 2.60 | 2.48 |
| 2012 | 3.67 | 3.51 | 3.34 | 3.19 | 3.04 | 2.90 | 2.76 | 2.63 | 2.51 | 2.39 |
| 2013 | 3.55 | 3.39 | 3.24 | 3.09 | 2.95 | 2.81 | 2.68 | 2.55 | 2.43 | 2.31 |

| Year | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 10.60 | 10.17 | 9.75 | 9.35 | 8.96 | 8.60 | 8.24 | 7.90 | 7.58 | 7.27 |
| 1917 | 10.57 | 10.13 | 9.72 | 9.32 | 8.93 | 8.57 | 8.21 | 7.88 | 7.55 | 7.24 |
| 1918 | 10.53 | 10.10 | 9.68 | 9.28 | 8.90 | 8.53 | 8.18 | 7.85 | 7.52 | 7.21 |
| 1919 | 10.49 | 10.06 | 9.64 | 9.25 | 8.87 | 8.50 | 8.15 | 7.82 | 7.49 | 7.19 |
| 1920 | 10.45 | 10.02 | 9.61 | 9.21 | 8.83 | 8.47 | 8.12 | 7.79 | 7.46 | 7.16 |
| 1921 | 10.40 | 9.97 | 9.56 | 9.17 | 8.79 | 8.43 | 8.08 | 7.75 | 7.43 | 7.13 |
| 1922 | 10.36 | 9.93 | 9.52 | 9.13 | 8.75 | 8.39 | 8.05 | 7.72 | 7.40 | 7.10 |
| 1923 | 10.31 | 9.88 | 9.48 | 9.09 | 8.71 | 8.36 | 8.01 | 7.68 | 7.37 | 7.06 |
| 1924 | 10.26 | 9.84 | 9.43 | 9.04 | 8.67 | 8.32 | 7.97 | 7.65 | 7.33 | 7.03 |
| 1925 | 10.21 | 9.79 | 9.39 | 9.00 | 8.63 | 8.27 | 7.93 | 7.61 | 7.29 | 6.99 |
| 1926 | 10.15 | 9.74 | 9.34 | 8.95 | 8.58 | 8.23 | 7.89 | 7.57 | 7.26 | 6.96 |
| 1927 | 10.10 | 9.68 | 9.29 | 8.90 | 8.54 | 8.19 | 7.85 | 7.53 | 7.22 | 6.92 |
| 1928 | 10.04 | 9.63 | 9.23 | 8.85 | 8.49 | 8.14 | 7.80 | 7.48 | 7.18 | 6.88 |
| 1929 | 9.97 | 9.56 | 9.16 | 8.79 | 8.43 | 8.08 | 7.75 | 7.43 | 7.12 | 6.83 |
| 1930 | 9.87 | 9.46 | 9.07 | 8.70 | 8.34 | 8.00 | 7.67 | 7.36 | 7.05 | 6.76 |
| 1931 | 9.78 | 9.38 | 8.99 | 8.62 | 8.27 | 7.93 | 7.60 | 7.29 | 6.99 | 6.70 |
| 1932 | 9.71 | 9.31 | 8.92 | 8.56 | 8.20 | 7.87 | 7.54 | 7.23 | 6.94 | 6.65 |
| 1933 | 9.66 | 9.26 | 8.88 | 8.51 | 8.16 | 7.83 | 7.51 | 7.20 | 6.90 | 6.62 |
| 1934 | 9.60 | 9.21 | 8.83 | 8.46 | 8.12 | 7.78 | 7.46 | 7.16 | 6.86 | 6.58 |
| 1935 | 9.54 | 9.15 | 8.77 | 8.41 | 8.07 | 7.73 | 7.42 | 7.11 | 6.82 | 6.54 |
| 1936 | 9.48 | 9.09 | 8.72 | 8.36 | 8.02 | 7.69 | 7.37 | 7.07 | 6.78 | 6.50 |
| 1937 | 9.40 | 9.01 | 8.64 | 8.28 | 7.94 | 7.62 | 7.30 | 7.00 | 6.71 | 6.44 |
| 1938 | 9.31 | 8.93 | 8.56 | 8.21 | 7.87 | 7.54 | 7.23 | 6.94 | 6.65 | 6.38 |
| 1939 | 9.24 | 8.86 | 8.50 | 8.15 | 7.81 | 7.49 | 7.18 | 6.89 | 6.60 | 6.33 |
| 1940 | 9.19 | 8.82 | 8.45 | 8.11 | 7.77 | 7.45 | 7.15 | 6.85 | 6.57 | 6.30 |
| 1941 | 9.11 | 8.73 | 8.38 | 8.03 | 7.70 | 7.38 | 7.08 | 6.79 | 6.51 | 6.24 |
| 1942 | 9.00 | 8.63 | 8.27 | 7.93 | 7.61 | 7.29 | 6.99 | 6.70 | 6.43 | 6.16 |
| 1943 | 8.82 | 8.46 | 8.11 | 7.78 | 7.46 | 7.15 | 6.86 | 6.58 | 6.31 | 6.05 |
| 1944 | 8.61 | 8.25 | 7.91 | 7.59 | 7.28 | 6.98 | 6.69 | 6.41 | 6.15 | 5.90 |
| 1945 | 8.53 | 8.18 | 7.84 | 7.52 | 7.21 | 6.91 | 6.63 | 6.36 | 6.09 | 5.84 |
| 1946 | 8.46 | 8.11 | 7.78 | 7.46 | 7.15 | 6.85 | 6.57 | 6.30 | 6.04 | 5.79 |
| 1947 | 8.38 | 8.04 | 7.71 | 7.39 | 7.08 | 6.79 | 6.51 | 6.25 | 5.99 | 5.74 |
| 1948 | 8.32 | 7.98 | 7.65 | 7.33 | 7.03 | 6.74 | 6.47 | 6.20 | 5.95 | 5.70 |
| 1949 | 8.25 | 7.91 | 7.58 | 7.27 | 6.97 | 6.68 | 6.41 | 6.15 | 5.89 | 5.65 |
| 1950 | 8.18 | 7.84 | 7.52 | 7.21 | 6.92 | 6.63 | 6.36 | 6.10 | 5.85 | 5.61 |
| 1951 | 8.12 | 7.79 | 7.47 | 7.16 | 6.87 | 6.59 | 6.31 | 6.06 | 5.81 | 5.57 |
| 1952 | 8.05 | 7.72 | 7.41 | 7.10 | 6.81 | 6.53 | 6.26 | 6.00 | 5.76 | 5.52 |
| 1953 | 8.01 | 7.68 | 7.36 | 7.06 | 6.77 | 6.49 | 6.22 | 5.97 | 5.72 | 5.49 |
| 1954 | 7.98 | 7.65 | 7.34 | 7.04 | 6.75 | 6.47 | 6.20 | 5.95 | 5.70 | 5.47 |
| 1955 | 7.94 | 7.61 | 7.30 | 7.00 | 6.71 | 6.44 | 6.17 | 5.92 | 5.67 | 5.44 |
| 1956 | 7.90 | 7.57 | 7.26 | 6.96 | 6.67 | 6.40 | 6.14 | 5.88 | 5.64 | 5.41 |
| 1957 | 7.87 | 7.55 | 7.24 | 6.94 | 6.66 | 6.38 | 6.12 | 5.87 | 5.63 | 5.40 |
| 1958 | 7.84 | 7.51 | 7.20 | 6.91 | 6.62 | 6.35 | 6.09 | 5.84 | 5.60 | 5.37 |
| 1959 | 7.82 | 7.50 | 7.19 | 6.89 | 6.61 | 6.34 | 6.08 | 5.83 | 5.59 | 5.36 |
| 1960 | 7.80 | 7.48 | 7.17 | 6.87 | 6.59 | 6.32 | 6.06 | 5.81 | 5.57 | 5.34 |
| 1961 | 7.77 | 7.45 | 7.15 | 6.85 | 6.57 | 6.30 | 6.04 | 5.79 | 5.55 | 5.33 |
| 1962 | 7.75 | 7.43 | 7.12 | 6.83 | 6.55 | 6.28 | 6.02 | 5.77 | 5.54 | 5.31 |
| 1963 | 7.72 | 7.40 | 7.10 | 6.81 | 6.53 | 6.26 | 6.00 | 5.75 | 5.52 | 5.29 |
| 1964 | 7.70 | 7.39 | 7.08 | 6.79 | 6.51 | 6.24 | 5.99 | 5.74 | 5.50 | 5.28 |
| 1965 | 7.69 | 7.37 | 7.07 | 6.78 | 6.50 | 6.23 | 5.97 | 5.73 | 5.49 | 5.27 |
| 1966 | 7.66 | 7.35 | 7.05 | 6.76 | 6.48 | 6.21 | 5.96 | 5.71 | 5.48 | 5.25 |
| 1967 | 7.58 | 7.27 | 6.97 | 6.68 | 6.41 | 6.15 | 5.89 | 5.65 | 5.42 | 5.20 |
| 1968 | 7.51 | 7.20 | 6.90 | 6.62 | 6.35 | 6.09 | 5.84 | 5.60 | 5.37 | 5.15 |
| 1969 | 7.46 | 7.15 | 6.85 | 6.57 | 6.30 | 6.04 | 5.80 | 5.56 | 5.33 | 5.11 |
| 1970 | 7.42 | 7.11 | 6.82 | 6.54 | 6.27 | 6.01 | 5.77 | 5.53 | 5.30 | 5.08 |
| 1971 | 7.41 | 7.10 | 6.81 | 6.53 | 6.26 | 6.00 | 5.76 | 5.52 | 5.29 | 5.08 |

| Year | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 7.37 | 7.06 | 6.77 | 6.49 | 6.23 | 5.97 | 5.73 | 5.49 | 5.26 | 5.05 |
| 1973 | 7.32 | 7.02 | 6.73 | 6.45 | 6.19 | 5.93 | 5.69 | 5.46 | 5.23 | 5.02 |
| 1974 | 7.28 | 6.98 | 6.69 | 6.42 | 6.15 | 5.90 | 5.66 | 5.42 | 5.20 | 4.99 |
| 1975 | 7.25 | 6.95 | 6.66 | 6.39 | 6.13 | 5.88 | 5.63 | 5.40 | 5.18 | 4.97 |
| 1976 | 7.22 | 6.93 | 6.64 | 6.37 | 6.11 | 5.86 | 5.61 | 5.38 | 5.16 | 4.95 |
| 1977 | 7.21 | 6.92 | 6.63 | 6.36 | 6.10 | 5.85 | 5.61 | 5.37 | 5.15 | 4.94 |
| 1978 | 7.20 | 6.90 | 6.62 | 6.34 | 6.08 | 5.83 | 5.59 | 5.36 | 5.14 | 4.93 |
| 1979 | 7.14 | 6.85 | 6.56 | 6.29 | 6.03 | 5.79 | 5.55 | 5.32 | 5.10 | 4.89 |
| 1980 | 7.00 | 6.72 | 6.44 | 6.17 | 5.92 | 5.68 | 5.44 | 5.22 | 5.00 | 4.80 |
| 1981 | 6.95 | 6.66 | 6.39 | 6.13 | 5.87 | 5.63 | 5.40 | 5.18 | 4.96 | 4.76 |
| 1982 | 6.85 | 6.57 | 6.29 | 6.03 | 5.79 | 5.55 | 5.32 | 5.10 | 4.89 | 4.69 |
| 1983 | 6.72 | 6.44 | 6.18 | 5.92 | 5.68 | 5.44 | 5.22 | 5.01 | 4.80 | 4.60 |
| 1984 | 6.61 | 6.34 | 6.07 | 5.82 | 5.58 | 5.35 | 5.13 | 4.92 | 4.72 | 4.52 |
| 1985 | 6.48 | 6.21 | 5.95 | 5.71 | 5.47 | 5.24 | 5.03 | 4.82 | 4.62 | 4.43 |
| 1986 | 6.23 | 5.97 | 5.72 | 5.48 | 5.25 | 5.04 | 4.83 | 4.63 | 4.44 | 4.26 |
| 1987 | 5.89 | 5.64 | 5.40 | 5.18 | 4.96 | 4.76 | 4.56 | 4.37 | 4.19 | 4.02 |
| 1988 | 5.41 | 5.18 | 4.97 | 4.76 | 4.56 | 4.37 | 4.19 | 4.02 | 3.85 | 3.69 |
| 1989 | 5.15 | 4.93 | 4.72 | 4.52 | 4.33 | 4.15 | 3.98 | 3.81 | 3.66 | 3.51 |
| 1990 | 4.87 | 4.66 | 4.46 | 4.28 | 4.10 | 3.93 | 3.76 | 3.61 | 3.46 | 3.31 |
| 1991 | 4.73 | 4.51 | 4.32 | 4.14 | 3.96 | 3.80 | 3.64 | 3.49 | 3.34 | 3.20 |
| 1992 | 4.58 | 4.38 | 4.18 | 4.00 | 3.83 | 3.66 | 3.51 | 3.36 | 3.22 | 3.09 |
| 1993 | 4.40 | 4.20 | 4.02 | 3.83 | 3.67 | 3.51 | 3.36 | 3.22 | 3.09 | 2.96 |
| 1994 | 4.15 | 3.97 | 3.79 | 3.62 | 3.45 | 3.30 | 3.16 | 3.03 | 2.90 | 2.78 |
| 1995 | 3.92 | 3.74 | 3.57 | 3.41 | 3.26 | 3.11 | 2.98 | 2.85 | 2.73 | 2.61 |
| 1996 | 3.62 | 3.46 | 3.30 | 3.15 | 3.01 | 2.88 | 2.74 | 2.62 | 2.51 | 2.41 |
| 1997 | 3.42 | 3.26 | 3.11 | 2.97 | 2.84 | 2.71 | 2.59 | 2.47 | 2.36 | 2.26 |
| 1998 | 3.29 | 3.14 | 2.99 | 2.85 | 2.72 | 2.60 | 2.48 | 2.37 | 2.26 | 2.16 |
| 1999 | 3.13 | 2.98 | 2.85 | 2.71 | 2.59 | 2.47 | 2.36 | 2.25 | 2.15 | 2.05 |
| 2000 | 3.05 | 2.90 | 2.77 | 2.64 | 2.52 | 2.40 | 2.29 | 2.19 | 2.09 | 2.00 |
| 2001 | 2.96 | 2.82 | 2.68 | 2.56 | 2.44 | 2.33 | 2.22 | 2.12 | 2.02 | 1.93 |
| 2002 | 2.91 | 2.78 | 2.64 | 2.52 | 2.40 | 2.29 | 2.18 | 2.08 | 1.99 | 1.90 |
| 2003 | 2.90 | 2.76 | 2.63 | 2.50 | 2.39 | 2.28 | 2.17 | 2.07 | 1.97 | 1.88 |
| 2004 | 2.87 | 2.73 | 2.60 | 2.48 | 2.36 | 2.25 | 2.14 | 2.04 | 1.95 | 1.86 |
| 2005 | 2.83 | 2.69 | 2.56 | 2.44 | 2.32 | 2.21 | 2.11 | 2.01 | 1.92 | 1.83 |
| 2006 | 2.77 | 2.64 | 2.51 | 2.39 | 2.28 | 2.17 | 2.06 | 1.97 | 1.88 | 1.79 |
| 2007 | 2.73 | 2.60 | 2.47 | 2.35 | 2.24 | 2.13 | 2.03 | 1.94 | 1.84 | 1.76 |
| 2008 | 2.65 | 2.52 | 2.40 | 2.29 | 2.18 | 2.07 | 1.97 | 1.88 | 1.79 | 1.71 |
| 2009 | 2.55 | 2.43 | 2.31 | 2.20 | 2.10 | 2.00 | 1.90 | 1.81 | 1.72 | 1.64 |
| 2010 | 2.45 | 2.34 | 2.23 | 2.12 | 2.02 | 1.92 | 1.83 | 1.74 | 1.66 | 1.58 |
| 2011 | 2.36 | 2.25 | 2.14 | 2.04 | 1.95 | 1.85 | 1.77 | 1.68 | 1.60 | 1.52 |
| 2012 | 2.28 | 2.17 | 2.07 | 1.97 | 1.88 | 1.79 | 1.71 | 1.62 | 1.55 | 1.47 |
| 2013 | 2.21 | 2.10 | 2.00 | 1.91 | 1.82 | 1.74 | 1.65 | 1.58 | 1.50 | 1.43 |

| Year | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 6.97 | 6.68 | 6.41 | 6.14 | 5.89 | 5.65 | 5.41 | 5.19 | 4.98 | 4.77 |
| 1917 | 6.94 | 6.66 | 6.38 | 6.12 | 5.87 | 5.63 | 5.40 | 5.17 | 4.96 | 4.76 |
| 1918 | 6.92 | 6.63 | 6.36 | 6.10 | 5.85 | 5.61 | 5.38 | 5.15 | 4.94 | 4.74 |
| 1919 | 6.89 | 6.61 | 6.34 | 6.07 | 5.82 | 5.58 | 5.36 | 5.13 | 4.92 | 4.72 |
| 1920 | 6.86 | 6.58 | 6.31 | 6.05 | 5.80 | 5.56 | 5.33 | 5.11 | 4.90 | 4.70 |
| 1921 | 6.83 | 6.55 | 6.28 | 6.02 | 5.78 | 5.54 | 5.31 | 5.09 | 4.88 | 4.68 |
| 1922 | 6.80 | 6.52 | 6.26 | 6.00 | 5.75 | 5.51 | 5.29 | 5.07 | 4.86 | 4.66 |
| 1923 | 6.77 | 6.49 | 6.23 | 5.97 | 5.72 | 5.49 | 5.26 | 5.05 | 4.84 | 4.64 |
| 1924 | 6.74 | 6.46 | 6.20 | 5.94 | 5.70 | 5.46 | 5.24 | 5.02 | 4.82 | 4.62 |
| 1925 | 6.71 | 6.43 | 6.17 | 5.91 | 5.67 | 5.44 | 5.21 | 5.00 | 4.79 | 4.59 |
| 1926 | 6.67 | 6.40 | 6.13 | 5.88 | 5.64 | 5.41 | 5.18 | 4.97 | 4.77 | 4.57 |
| 1927 | 6.63 | 6.36 | 6.10 | 5.85 | 5.61 | 5.38 | 5.16 | 4.94 | 4.74 | 4.55 |
| 1928 | 6.60 | 6.33 | 6.07 | 5.82 | 5.58 | 5.35 | 5.13 | 4.92 | 4.71 | 4.52 |
| 1929 | 6.55 | 6.28 | 6.02 | 5.77 | 5.54 | 5.31 | 5.09 | 4.88 | 4.68 | 4.49 |
| 1930 | 6.48 | 6.22 | 5.96 | 5.72 | 5.48 | 5.26 | 5.04 | 4.83 | 4.63 | 4.44 |
| 1931 | 6.43 | 6.16 | 5.91 | 5.67 | 5.43 | 5.21 | 4.99 | 4.79 | 4.59 | 4.40 |
| 1932 | 6.38 | 6.11 | 5.86 | 5.62 | 5.39 | 5.17 | 4.96 | 4.75 | 4.56 | 4.37 |
| 1933 | 6.34 | 6.08 | 5.83 | 5.59 | 5.36 | 5.14 | 4.93 | 4.73 | 4.53 | 4.35 |
| 1934 | 6.31 | 6.05 | 5.80 | 5.56 | 5.33 | 5.11 | 4.90 | 4.70 | 4.51 | 4.32 |
| 1935 | 6.27 | 6.01 | 5.76 | 5.53 | 5.30 | 5.08 | 4.87 | 4.67 | 4.48 | 4.29 |
| 1936 | 6.23 | 5.97 | 5.73 | 5.49 | 5.27 | 5.05 | 4.84 | 4.64 | 4.45 | 4.27 |
| 1937 | 6.17 | 5.92 | 5.68 | 5.44 | 5.22 | 5.00 | 4.80 | 4.60 | 4.41 | 4.23 |
| 1938 | 6.12 | 5.86 | 5.62 | 5.39 | 5.17 | 4.96 | 4.75 | 4.56 | 4.37 | 4.19 |
| 1939 | 6.07 | 5.82 | 5.58 | 5.35 | 5.13 | 4.92 | 4.72 | 4.52 | 4.34 | 4.16 |
| 1940 | 6.04 | 5.79 | 5.55 | 5.33 | 5.11 | 4.90 | 4.69 | 4.50 | 4.32 | 4.14 |
| 1941 | 5.98 | 5.74 | 5.50 | 5.28 | 5.06 | 4.85 | 4.65 | 4.46 | 4.28 | 4.10 |
| 1942 | 5.91 | 5.67 | 5.43 | 5.21 | 5.00 | 4.79 | 4.59 | 4.40 | 4.22 | 4.05 |
| 1943 | 5.80 | 5.56 | 5.33 | 5.11 | 4.90 | 4.70 | 4.51 | 4.32 | 4.14 | 3.97 |
| 1944 | 5.65 | 5.42 | 5.20 | 4.98 | 4.78 | 4.58 | 4.39 | 4.21 | 4.04 | 3.87 |
| 1945 | 5.60 | 5.37 | 5.15 | 4.94 | 4.74 | 4.54 | 4.35 | 4.18 | 4.00 | 3.84 |
| 1946 | 5.56 | 5.33 | 5.11 | 4.90 | 4.70 | 4.50 | 4.32 | 4.14 | 3.97 | 3.81 |
| 1947 | 5.51 | 5.28 | 5.06 | 4.85 | 4.65 | 4.46 | 4.28 | 4.10 | 3.93 | 3.77 |
| 1948 | 5.47 | 5.24 | 5.03 | 4.82 | 4.62 | 4.43 | 4.25 | 4.07 | 3.91 | 3.75 |
| 1949 | 5.42 | 5.20 | 4.98 | 4.78 | 4.58 | 4.39 | 4.21 | 4.04 | 3.87 | 3.71 |
| 1950 | 5.38 | 5.15 | 4.94 | 4.74 | 4.54 | 4.36 | 4.18 | 4.01 | 3.84 | 3.68 |
| 1951 | 5.34 | 5.12 | 4.91 | 4.71 | 4.51 | 4.33 | 4.15 | 3.98 | 3.81 | 3.66 |
| 1952 | 5.29 | 5.07 | 4.87 | 4.67 | 4.47 | 4.29 | 4.11 | 3.94 | 3.78 | 3.63 |
| 1953 | 5.26 | 5.04 | 4.84 | 4.64 | 4.45 | 4.26 | 4.09 | 3.92 | 3.76 | 3.60 |
| 1954 | 5.24 | 5.03 | 4.82 | 4.62 | 4.43 | 4.25 | 4.08 | 3.91 | 3.75 | 3.59 |
| 1955 | 5.22 | 5.00 | 4.80 | 4.60 | 4.41 | 4.23 | 4.05 | 3.89 | 3.73 | 3.57 |
| 1956 | 5.19 | 4.97 | 4.77 | 4.57 | 4.39 | 4.21 | 4.03 | 3.87 | 3.71 | 3.55 |
| 1957 | 5.17 | 4.96 | 4.76 | 4.56 | 4.37 | 4.19 | 4.02 | 3.86 | 3.70 | 3.54 |
| 1958 | 5.15 | 4.94 | 4.73 | 4.54 | 4.35 | 4.17 | 4.00 | 3.84 | 3.68 | 3.53 |
| 1959 | 5.14 | 4.93 | 4.72 | 4.53 | 4.34 | 4.17 | 3.99 | 3.83 | 3.67 | 3.52 |
| 1960 | 5.12 | 4.91 | 4.71 | 4.52 | 4.33 | 4.15 | 3.98 | 3.82 | 3.66 | 3.51 |
| 1961 | 5.11 | 4.90 | 4.70 | 4.50 | 4.32 | 4.14 | 3.97 | 3.81 | 3.65 | 3.50 |
| 1962 | 5.09 | 4.88 | 4.68 | 4.49 | 4.30 | 4.13 | 3.96 | 3.79 | 3.64 | 3.49 |
| 1963 | 5.07 | 4.86 | 4.66 | 4.47 | 4.29 | 4.11 | 3.94 | 3.78 | 3.63 | 3.48 |
| 1964 | 5.06 | 4.85 | 4.65 | 4.46 | 4.28 | 4.10 | 3.93 | 3.77 | 3.62 | 3.47 |
| 1965 | 5.05 | 4.84 | 4.64 | 4.45 | 4.27 | 4.09 | 3.93 | 3.76 | 3.61 | 3.46 |
| 1966 | 5.04 | 4.83 | 4.63 | 4.44 | 4.26 | 4.08 | 3.92 | 3.75 | 3.60 | 3.45 |
| 1967 | 4.98 | 4.78 | 4.58 | 4.39 | 4.21 | 4.04 | 3.87 | 3.71 | 3.56 | 3.41 |
| 1968 | 4.93 | 4.73 | 4.54 | 4.35 | 4.17 | 4.00 | 3.84 | 3.68 | 3.53 | 3.38 |
| 1969 | 4.90 | 4.70 | 4.50 | 4.32 | 4.14 | 3.97 | 3.81 | 3.65 | 3.50 | 3.36 |
| 1970 | 4.88 | 4.68 | 4.48 | 4.30 | 4.12 | 3.95 | 3.79 | 3.63 | 3.48 | 3.34 |
| 1971 | 4.87 | 4.67 | 4.47 | 4.29 | 4.11 | 3.95 | 3.78 | 3.63 | 3.48 | 3.34 |

| Year | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 4.84 | 4.64 | 4.45 | 4.27 | 4.09 | 3.92 | 3.76 | 3.61 | 3.46 | 3.32 |
| 1973 | 4.81 | 4.61 | 4.42 | 4.24 | 4.07 | 3.90 | 3.74 | 3.59 | 3.44 | 3.30 |
| 1974 | 4.78 | 4.59 | 4.40 | 4.22 | 4.04 | 3.88 | 3.72 | 3.56 | 3.42 | 3.28 |
| 1975 | 4.76 | 4.57 | 4.38 | 4.20 | 4.03 | 3.86 | 3.70 | 3.55 | 3.40 | 3.26 |
| 1976 | 4.75 | 4.55 | 4.36 | 4.18 | 4.01 | 3.85 | 3.69 | 3.54 | 3.39 | 3.25 |
| 1977 | 4.74 | 4.54 | 4.36 | 4.18 | 4.01 | 3.84 | 3.68 | 3.53 | 3.39 | 3.25 |
| 1978 | 4.73 | 4.53 | 4.35 | 4.17 | 4.00 | 3.83 | 3.67 | 3.52 | 3.38 | 3.24 |
| 1979 | 4.69 | 4.50 | 4.31 | 4.13 | 3.96 | 3.80 | 3.65 | 3.50 | 3.35 | 3.21 |
| 1980 | 4.60 | 4.41 | 4.23 | 4.06 | 3.89 | 3.73 | 3.58 | 3.43 | 3.29 | 3.15 |
| 1981 | 4.56 | 4.38 | 4.20 | 4.02 | 3.86 | 3.70 | 3.55 | 3.40 | 3.26 | 3.13 |
| 1982 | 4.50 | 4.31 | 4.13 | 3.96 | 3.80 | 3.64 | 3.49 | 3.35 | 3.21 | 3.08 |
| 1983 | 4.41 | 4.23 | 4.06 | 3.89 | 3.73 | 3.58 | 3.43 | 3.29 | 3.15 | 3.02 |
| 1984 | 4.34 | 4.16 | 3.99 | 3.82 | 3.67 | 3.52 | 3.37 | 3.23 | 3.10 | 2.97 |
| 1985 | 4.25 | 4.07 | 3.91 | 3.75 | 3.59 | 3.44 | 3.30 | 3.17 | 3.04 | 2.91 |
| 1986 | 4.08 | 3.91 | 3.75 | 3.60 | 3.45 | 3.31 | 3.17 | 3.04 | 2.92 | 2.80 |
| 1987 | 3.85 | 3.69 | 3.54 | 3.40 | 3.26 | 3.12 | 2.99 | 2.87 | 2.75 | 2.64 |
| 1988 | 3.54 | 3.39 | 3.25 | 3.12 | 2.99 | 2.87 | 2.75 | 2.64 | 2.53 | 2.43 |
| 1989 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 |
| 1990 | 3.18 | 3.05 | 2.92 | 2.80 | 2.68 | 2.57 | 2.47 | 2.37 | 2.27 | 2.18 |
| 1991 | 3.07 | 2.94 | 2.82 | 2.71 | 2.59 | 2.49 | 2.38 | 2.29 | 2.19 | 2.10 |
| 1992 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.21 | 2.12 | 2.03 |
| 1993 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.20 | 2.11 | 2.02 | 1.94 |
| 1994 | 2.67 | 2.55 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 | 1.98 | 1.90 | 1.82 |
| 1995 | 2.51 | 2.40 | 2.30 | 2.21 | 2.11 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 |
| 1996 | 2.31 | 2.21 | 2.12 | 2.03 | 1.95 | 1.87 | 1.79 | 1.71 | 1.64 | 1.58 |
| 1997 | 2.17 | 2.08 | 1.99 | 1.91 | 1.83 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 |
| 1998 | 2.07 | 1.98 | 1.90 | 1.82 | 1.75 | 1.67 | 1.60 | 1.54 | 1.47 | 1.41 |
| 1999 | 1.96 | 1.88 | 1.80 | 1.73 | 1.65 | 1.59 | 1.52 | 1.46 | 1.40 | 1.34 |
| 2000 | 1.90 | 1.82 | 1.74 | 1.67 | 1.60 | 1.53 | 1.47 | 1.41 | 1.35 | 1.29 |
| 2001 | 1.85 | 1.76 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.30 | 1.25 |
| 2002 | 1.81 | 1.73 | 1.65 | 1.58 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 |
| 2003 | 1.80 | 1.72 | 1.64 | 1.56 | 1.50 | 1.43 | 1.37 | 1.32 | 1.26 | 1.21 |
| 2004 | 1.77 | 1.69 | 1.62 | 1.55 | 1.47 | 1.41 | 1.35 | 1.29 | 1.24 | 1.19 |
| 2005 | 1.74 | 1.66 | 1.59 | 1.52 | 1.45 | 1.38 | 1.32 | 1.27 | 1.21 | 1.16 |
| 2006 | 1.71 | 1.63 | 1.55 | 1.48 | 1.42 | 1.35 | 1.29 | 1.23 | 1.18 | 1.13 |
| 2007 | 1.68 | 1.60 | 1.52 | 1.45 | 1.39 | 1.33 | 1.27 | 1.21 | 1.16 | 1.11 |
| 2008 | 1.63 | 1.55 | 1.48 | 1.41 | 1.35 | 1.28 | 1.23 | 1.17 | 1.12 | 1.07 |
| 2009 | 1.56 | 1.49 | 1.42 | 1.36 | 1.29 | 1.23 | 1.18 | 1.13 | 1.08 | 1.03 |
| 2010 | 1.51 | 1.44 | 1.37 | 1.31 | 1.24 | 1.19 | 1.13 | 1.08 | 1.03 | 0.99 |
| 2011 | 1.45 | 1.38 | 1.32 | 1.26 | 1.20 | 1.14 | 1.09 | 1.04 | 0.99 | 0.95 |
| 2012 | 1.40 | 1.33 | 1.27 | 1.21 | 1.15 | 1.10 | 1.05 | 1.00 | 0.96 | 0.91 |
| 2013 | 1.36 | 1.29 | 1.23 | 1.17 | 1.12 | 1.07 | 1.02 | 0.97 | 0.93 | 0.88 |

| Year | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 4.58 | 4.39 | 4.21 | 4.03 | 3.87 | 3.71 | 3.56 | 3.41 | 3.27 | 3.14 |
| 1917 | 4.56 | 4.37 | 4.19 | 4.02 | 3.86 | 3.70 | 3.54 | 3.40 | 3.26 | 3.12 |
| 1918 | 4.54 | 4.36 | 4.18 | 4.01 | 3.84 | 3.68 | 3.53 | 3.39 | 3.25 | 3.11 |
| 1919 | 4.53 | 4.34 | 4.16 | 3.99 | 3.83 | 3.67 | 3.52 | 3.37 | 3.23 | 3.10 |
| 1920 | 4.51 | 4.32 | 4.15 | 3.97 | 3.81 | 3.65 | 3.50 | 3.36 | 3.22 | 3.09 |
| 1921 | 4.49 | 4.30 | 4.13 | 3.96 | 3.79 | 3.64 | 3.49 | 3.35 | 3.21 | 3.08 |
| 1922 | 4.47 | 4.29 | 4.11 | 3.94 | 3.78 | 3.62 | 3.47 | 3.33 | 3.19 | 3.06 |
| 1923 | 4.45 | 4.27 | 4.09 | 3.92 | 3.76 | 3.61 | 3.46 | 3.32 | 3.18 | 3.05 |
| 1924 | 4.43 | 4.25 | 4.07 | 3.90 | 3.74 | 3.59 | 3.44 | 3.30 | 3.16 | 3.03 |
| 1925 | 4.41 | 4.22 | 4.05 | 3.88 | 3.72 | 3.57 | 3.42 | 3.28 | 3.15 | 3.02 |
| 1926 | 4.38 | 4.20 | 4.03 | 3.86 | 3.70 | 3.55 | 3.41 | 3.27 | 3.13 | 3.00 |
| 1927 | 4.36 | 4.18 | 4.01 | 3.84 | 3.68 | 3.53 | 3.39 | 3.25 | 3.11 | 2.99 |
| 1928 | 4.33 | 4.16 | 3.98 | 3.82 | 3.66 | 3.51 | 3.37 | 3.23 | 3.10 | 2.97 |
| 1929 | 4.30 | 4.12 | 3.96 | 3.79 | 3.64 | 3.49 | 3.34 | 3.21 | 3.07 | 2.95 |
| 1930 | 4.26 | 4.08 | 3.92 | 3.75 | 3.60 | 3.45 | 3.31 | 3.17 | 3.04 | 2.92 |
| 1931 | 4.22 | 4.05 | 3.88 | 3.72 | 3.57 | 3.42 | 3.28 | 3.15 | 3.02 | 2.89 |
| 1932 | 4.19 | 4.02 | 3.85 | 3.69 | 3.54 | 3.40 | 3.26 | 3.12 | 2.99 | 2.87 |
| 1933 | 4.17 | 4.00 | 3.83 | 3.67 | 3.52 | 3.38 | 3.24 | 3.11 | 2.98 | 2.86 |
| 1934 | 4.14 | 3.97 | 3.81 | 3.65 | 3.50 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 |
| 1935 | 4.12 | 3.95 | 3.79 | 3.63 | 3.48 | 3.34 | 3.20 | 3.07 | 2.94 | 2.82 |
| 1936 | 4.09 | 3.92 | 3.76 | 3.61 | 3.46 | 3.32 | 3.18 | 3.05 | 2.92 | 2.80 |
| 1937 | 4.05 | 3.89 | 3.73 | 3.57 | 3.43 | 3.29 | 3.15 | 3.02 | 2.90 | 2.78 |
| 1938 | 4.02 | 3.85 | 3.69 | 3.54 | 3.40 | 3.26 | 3.12 | 2.99 | 2.87 | 2.75 |
| 1939 | 3.99 | 3.82 | 3.67 | 3.52 | 3.37 | 3.23 | 3.10 | 2.97 | 2.85 | 2.73 |
| 1940 | 3.97 | 3.80 | 3.65 | 3.50 | 3.35 | 3.22 | 3.08 | 2.96 | 2.84 | 2.72 |
| 1941 | 3.93 | 3.77 | 3.61 | 3.47 | 3.32 | 3.19 | 3.06 | 2.93 | 2.81 | 2.69 |
| 1942 | 3.88 | 3.72 | 3.57 | 3.42 | 3.28 | 3.15 | 3.02 | 2.89 | 2.77 | 2.66 |
| 1943 | 3.81 | 3.65 | 3.50 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 | 2.72 | 2.61 |
| 1944 | 3.71 | 3.56 | 3.42 | 3.27 | 3.14 | 3.01 | 2.89 | 2.77 | 2.65 | 2.54 |
| 1945 | 3.68 | 3.53 | 3.38 | 3.24 | 3.11 | 2.98 | 2.86 | 2.74 | 2.63 | 2.52 |
| 1946 | 3.65 | 3.50 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 |
| 1947 | 3.62 | 3.47 | 3.33 | 3.19 | 3.06 | 2.93 | 2.81 | 2.70 | 2.58 | 2.48 |
| 1948 | 3.59 | 3.44 | 3.30 | 3.17 | 3.04 | 2.91 | 2.79 | 2.68 | 2.57 | 2.46 |
| 1949 | 3.56 | 3.41 | 3.27 | 3.14 | 3.01 | 2.89 | 2.77 | 2.65 | 2.54 | 2.44 |
| 1950 | 3.53 | 3.39 | 3.25 | 3.11 | 2.98 | 2.86 | 2.74 | 2.63 | 2.52 | 2.42 |
| 1951 | 3.51 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 | 2.73 | 2.61 | 2.51 | 2.40 |
| 1952 | 3.48 | 3.33 | 3.20 | 3.07 | 2.94 | 2.82 | 2.70 | 2.59 | 2.48 | 2.38 |
| 1953 | 3.46 | 3.31 | 3.18 | 3.05 | 2.92 | 2.80 | 2.69 | 2.58 | 2.47 | 2.37 |
| 1954 | 3.45 | 3.30 | 3.17 | 3.04 | 2.91 | 2.79 | 2.68 | 2.57 | 2.46 | 2.36 |
| 1955 | 3.43 | 3.29 | 3.15 | 3.02 | 2.90 | 2.78 | 2.66 | 2.55 | 2.45 | 2.35 |
| 1956 | 3.41 | 3.27 | 3.13 | 3.00 | 2.88 | 2.76 | 2.65 | 2.54 | 2.44 | 2.34 |
| 1957 | 3.40 | 3.26 | 3.13 | 3.00 | 2.87 | 2.76 | 2.64 | 2.53 | 2.43 | 2.33 |
| 1958 | 3.38 | 3.24 | 3.11 | 2.98 | 2.86 | 2.74 | 2.63 | 2.52 | 2.42 | 2.32 |
| 1959 | 3.38 | 3.24 | 3.10 | 2.98 | 2.85 | 2.74 | 2.62 | 2.52 | 2.41 | 2.31 |
| 1960 | 3.37 | 3.23 | 3.10 | 2.97 | 2.85 | 2.73 | 2.62 | 2.51 | 2.41 | 2.31 |
| 1961 | 3.36 | 3.22 | 3.09 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 |
| 1962 | 3.35 | 3.21 | 3.08 | 2.95 | 2.83 | 2.71 | 2.60 | 2.49 | 2.39 | 2.29 |
| 1963 | 3.33 | 3.20 | 3.06 | 2.94 | 2.82 | 2.70 | 2.59 | 2.48 | 2.38 | 2.28 |
| 1964 | 3.33 | 3.19 | 3.06 | 2.93 | 2.81 | 2.70 | 2.58 | 2.48 | 2.38 | 2.28 |
| 1965 | 3.32 | 3.18 | 3.05 | 2.93 | 2.81 | 2.69 | 2.58 | 2.47 | 2.37 | 2.27 |
| 1966 | 3.31 | 3.17 | 3.04 | 2.92 | 2.80 | 2.68 | 2.57 | 2.47 | 2.37 | 2.27 |
| 1967 | 3.27 | 3.14 | 3.01 | 2.89 | 2.77 | 2.65 | 2.54 | 2.44 | 2.34 | 2.24 |
| 1968 | 3.24 | 3.11 | 2.98 | 2.86 | 2.74 | 2.63 | 2.52 | 2.42 | 2.32 | 2.22 |
| 1969 | 3.22 | 3.09 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.21 |
| 1970 | 3.20 | 3.07 | 2.95 | 2.82 | 2.71 | 2.60 | 2.49 | 2.39 | 2.29 | 2.20 |
| 1971 | 3.20 | 3.07 | 2.94 | 2.82 | 2.70 | 2.59 | 2.49 | 2.38 | 2.29 | 2.19 |

| Year | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 3.18 | 3.05 | 2.92 | 2.80 | 2.69 | 2.58 | 2.47 | 2.37 | 2.27 | 2.18 |
| 1973 | 3.16 | 3.03 | 2.91 | 2.79 | 2.67 | 2.56 | 2.46 | 2.36 | 2.26 | 2.17 |
| 1974 | 3.14 | 3.01 | 2.89 | 2.77 | 2.66 | 2.55 | 2.44 | 2.34 | 2.25 | 2.15 |
| 1975 | 3.13 | 3.00 | 2.88 | 2.76 | 2.65 | 2.54 | 2.43 | 2.33 | 2.24 | 2.14 |
| 1976 | 3.12 | 2.99 | 2.87 | 2.75 | 2.64 | 2.53 | 2.42 | 2.33 | 2.23 | 2.14 |
| 1977 | 3.11 | 2.99 | 2.86 | 2.75 | 2.63 | 2.52 | 2.42 | 2.32 | 2.23 | 2.13 |
| 1978 | 3.11 | 2.98 | 2.86 | 2.74 | 2.63 | 2.52 | 2.41 | 2.32 | 2.22 | 2.13 |
| 1979 | 3.08 | 2.96 | 2.83 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.20 | 2.11 |
| 1980 | 3.02 | 2.90 | 2.78 | 2.67 | 2.56 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 |
| 1981 | 3.00 | 2.88 | 2.76 | 2.64 | 2.54 | 2.43 | 2.33 | 2.24 | 2.14 | 2.06 |
| 1982 | 2.95 | 2.83 | 2.72 | 2.60 | 2.50 | 2.39 | 2.30 | 2.20 | 2.11 | 2.02 |
| 1983 | 2.90 | 2.78 | 2.67 | 2.56 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 | 1.99 |
| 1984 | 2.85 | 2.73 | 2.62 | 2.51 | 2.41 | 2.31 | 2.22 | 2.12 | 2.04 | 1.95 |
| 1985 | 2.79 | 2.68 | 2.57 | 2.46 | 2.36 | 2.26 | 2.17 | 2.08 | 2.00 | 1.91 |
| 1986 | 2.68 | 2.57 | 2.46 | 2.36 | 2.27 | 2.17 | 2.08 | 2.00 | 1.92 | 1.84 |
| 1987 | 2.53 | 2.43 | 2.33 | 2.23 | 2.14 | 2.05 | 1.97 | 1.89 | 1.81 | 1.74 |
| 1988 | 2.33 | 2.23 | 2.14 | 2.05 | 1.97 | 1.89 | 1.81 | 1.73 | 1.66 | 1.59 |
| 1989 | 2.21 | 2.12 | 2.03 | 1.95 | 1.87 | 1.79 | 1.72 | 1.65 | 1.58 | 1.51 |
| 1990 | 2.09 | 2.00 | 1.92 | 1.84 | 1.76 | 1.69 | 1.62 | 1.56 | 1.49 | 1.43 |
| 1991 | 2.02 | 1.93 | 1.85 | 1.78 | 1.70 | 1.63 | 1.57 | 1.50 | 1.44 | 1.38 |
| 1992 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 | 1.58 | 1.51 | 1.45 | 1.39 | 1.33 |
| 1993 | 1.86 | 1.78 | 1.71 | 1.64 | 1.57 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 |
| 1994 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.30 | 1.25 | 1.20 |
| 1995 | 1.64 | 1.57 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 1.17 | 1.13 |
| 1996 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 1.17 | 1.13 | 1.08 | 1.04 |
| 1997 | 1.42 | 1.36 | 1.30 | 1.25 | 1.20 | 1.15 | 1.10 | 1.06 | 1.01 | 0.97 |
| 1998 | 1.36 | 1.30 | 1.25 | 1.19 | 1.15 | 1.10 | 1.05 | 1.01 | 0.97 | 0.93 |
| 1999 | 1.28 | 1.23 | 1.18 | 1.13 | 1.08 | 1.04 | 1.00 | 0.96 | 0.92 | 0.88 |
| 2000 | 1.24 | 1.19 | 1.14 | 1.09 | 1.05 | 1.01 | 0.96 | 0.92 | 0.89 | 0.85 |
| 2001 | 1.20 | 1.15 | 1.10 | 1.05 | 1.01 | 0.97 | 0.93 | 0.89 | 0.85 | 0.82 |
| 2002 | 1.17 | 1.12 | 1.08 | 1.03 | 0.99 | 0.95 | 0.91 | 0.87 | 0.84 | 0.80 |
| 2003 | 1.16 | 1.11 | 1.06 | 1.02 | 0.98 | 0.94 | 0.90 | 0.86 | 0.83 | 0.79 |
| 2004 | 1.14 | 1.09 | 1.05 | 1.00 | 0.96 | 0.92 | 0.88 | 0.85 | 0.81 | 0.78 |
| 2005 | 1.11 | 1.07 | 1.02 | 0.98 | 0.94 | 0.90 | 0.86 | 0.83 | 0.79 | 0.76 |
| 2006 | 1.08 | 1.04 | 1.00 | 0.95 | 0.92 | 0.88 | 0.84 | 0.81 | 0.77 | 0.74 |
| 2007 | 1.06 | 1.02 | 0.97 | 0.93 | 0.89 | 0.86 | 0.82 | 0.79 | 0.76 | 0.72 |
| 2008 | 1.02 | 0.98 | 0.94 | 0.90 | 0.86 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 |
| 2009 | 0.98 | 0.94 | 0.90 | 0.86 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 | 0.67 |
| 2010 | 0.94 | 0.90 | 0.86 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 | 0.67 | 0.64 |
| 2011 | 0.91 | 0.86 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 | 0.67 | 0.64 | 0.61 |
| 2012 | 0.87 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 | 0.67 | 0.64 | 0.61 | 0.59 |
| 2013 | 0.84 | 0.80 | 0.77 | 0.73 | 0.70 | 0.67 | 0.64 | 0.62 | 0.59 | 0.57 |

| Year | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 3.01 | 2.88 | 2.76 | 2.65 | 2.54 | 2.44 | 2.34 | 2.24 | 2.15 | 2.06 |
| 1917 | 3.00 | 2.87 | 2.75 | 2.64 | 2.53 | 2.43 | 2.33 | 2.23 | 2.14 | 2.05 |
| 1918 | 2.99 | 2.86 | 2.74 | 2.63 | 2.52 | 2.42 | 2.32 | 2.22 | 2.13 | 2.05 |
| 1919 | 2.97 | 2.85 | 2.73 | 2.62 | 2.51 | 2.41 | 2.31 | 2.22 | 2.12 | 2.04 |
| 1920 | 2.96 | 2.84 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.21 | 2.12 | 2.03 |
| 1921 | 2.95 | 2.83 | 2.71 | 2.60 | 2.49 | 2.39 | 2.29 | 2.20 | 2.11 | 2.02 |
| 1922 | 2.94 | 2.82 | 2.70 | 2.59 | 2.48 | 2.38 | 2.28 | 2.19 | 2.10 | 2.01 |
| 1923 | 2.92 | 2.80 | 2.69 | 2.58 | 2.47 | 2.37 | 2.27 | 2.18 | 2.09 | 2.00 |
| 1924 | 2.91 | 2.79 | 2.67 | 2.56 | 2.46 | 2.36 | 2.26 | 2.17 | 2.08 | 1.99 |
| 1925 | 2.89 | 2.77 | 2.66 | 2.55 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 | 1.98 |
| 1926 | 2.88 | 2.76 | 2.65 | 2.54 | 2.43 | 2.33 | 2.24 | 2.15 | 2.06 | 1.97 |
| 1927 | 2.86 | 2.75 | 2.63 | 2.52 | 2.42 | 2.32 | 2.23 | 2.13 | 2.05 | 1.96 |
| 1928 | 2.85 | 2.73 | 2.62 | 2.51 | 2.41 | 2.31 | 2.21 | 2.12 | 2.03 | 1.95 |
| 1929 | 2.83 | 2.71 | 2.60 | 2.49 | 2.39 | 2.29 | 2.20 | 2.11 | 2.02 | 1.94 |
| 1930 | 2.80 | 2.68 | 2.57 | 2.47 | 2.37 | 2.27 | 2.17 | 2.09 | 2.00 | 1.92 |
| 1931 | 2.77 | 2.66 | 2.55 | 2.44 | 2.34 | 2.25 | 2.16 | 2.07 | 1.98 | 1.90 |
| 1932 | 2.75 | 2.64 | 2.53 | 2.43 | 2.33 | 2.23 | 2.14 | 2.05 | 1.97 | 1.89 |
| 1933 | 2.74 | 2.63 | 2.52 | 2.41 | 2.31 | 2.22 | 2.13 | 2.04 | 1.96 | 1.88 |
| 1934 | 2.72 | 2.61 | 2.50 | 2.40 | 2.30 | 2.21 | 2.12 | 2.03 | 1.95 | 1.86 |
| 1935 | 2.71 | 2.59 | 2.49 | 2.38 | 2.29 | 2.19 | 2.10 | 2.02 | 1.93 | 1.85 |
| 1936 | 2.69 | 2.58 | 2.47 | 2.37 | 2.27 | 2.18 | 2.09 | 2.00 | 1.92 | 1.84 |
| 1937 | 2.66 | 2.55 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 | 1.98 | 1.90 | 1.82 |
| 1938 | 2.64 | 2.53 | 2.43 | 2.33 | 2.23 | 2.14 | 2.05 | 1.97 | 1.89 | 1.81 |
| 1939 | 2.62 | 2.51 | 2.41 | 2.31 | 2.21 | 2.12 | 2.04 | 1.95 | 1.87 | 1.80 |
| 1940 | 2.61 | 2.50 | 2.40 | 2.30 | 2.20 | 2.11 | 2.03 | 1.94 | 1.86 | 1.79 |
| 1941 | 2.58 | 2.48 | 2.37 | 2.28 | 2.18 | 2.09 | 2.01 | 1.92 | 1.85 | 1.77 |
| 1942 | 2.55 | 2.45 | 2.35 | 2.25 | 2.16 | 2.07 | 1.98 | 1.90 | 1.82 | 1.75 |
| 1943 | 2.50 | 2.40 | 2.30 | 2.21 | 2.11 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 |
| 1944 | 2.44 | 2.34 | 2.24 | 2.15 | 2.06 | 1.98 | 1.90 | 1.82 | 1.74 | 1.67 |
| 1945 | 2.42 | 2.32 | 2.22 | 2.13 | 2.04 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 |
| 1946 | 2.40 | 2.30 | 2.20 | 2.11 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 |
| 1947 | 2.38 | 2.28 | 2.18 | 2.09 | 2.01 | 1.93 | 1.85 | 1.77 | 1.70 | 1.63 |
| 1948 | 2.36 | 2.26 | 2.17 | 2.08 | 1.99 | 1.91 | 1.83 | 1.76 | 1.69 | 1.62 |
| 1949 | 2.34 | 2.24 | 2.15 | 2.06 | 1.98 | 1.90 | 1.82 | 1.74 | 1.67 | 1.60 |
| 1950 | 2.32 | 2.22 | 2.13 | 2.04 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 |
| 1951 | 2.30 | 2.21 | 2.12 | 2.03 | 1.95 | 1.87 | 1.79 | 1.72 | 1.65 | 1.58 |
| 1952 | 2.28 | 2.19 | 2.10 | 2.01 | 1.93 | 1.85 | 1.77 | 1.70 | 1.63 | 1.56 |
| 1953 | 2.27 | 2.18 | 2.09 | 2.00 | 1.92 | 1.84 | 1.76 | 1.69 | 1.62 | 1.56 |
| 1954 | 2.26 | 2.17 | 2.08 | 2.00 | 1.91 | 1.83 | 1.76 | 1.69 | 1.62 | 1.55 |
| 1955 | 2.25 | 2.16 | 2.07 | 1.98 | 1.90 | 1.82 | 1.75 | 1.68 | 1.61 | 1.54 |
| 1956 | 2.24 | 2.15 | 2.06 | 1.97 | 1.89 | 1.81 | 1.74 | 1.67 | 1.60 | 1.53 |
| 1957 | 2.23 | 2.14 | 2.05 | 1.97 | 1.89 | 1.81 | 1.74 | 1.66 | 1.60 | 1.53 |
| 1958 | 2.22 | 2.13 | 2.04 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 | 1.52 |
| 1959 | 2.22 | 2.13 | 2.04 | 1.96 | 1.88 | 1.80 | 1.72 | 1.65 | 1.58 | 1.52 |
| 1960 | 2.21 | 2.12 | 2.03 | 1.95 | 1.87 | 1.79 | 1.72 | 1.65 | 1.58 | 1.52 |
| 1961 | 2.20 | 2.11 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 | 1.58 | 1.51 |
| 1962 | 2.20 | 2.11 | 2.02 | 1.94 | 1.86 | 1.78 | 1.71 | 1.64 | 1.57 | 1.51 |
| 1963 | 2.19 | 2.10 | 2.01 | 1.93 | 1.85 | 1.78 | 1.70 | 1.63 | 1.56 | 1.50 |
| 1964 | 2.19 | 2.10 | 2.01 | 1.93 | 1.85 | 1.77 | 1.70 | 1.63 | 1.56 | 1.50 |
| 1965 | 2.18 | 2.09 | 2.00 | 1.92 | 1.84 | 1.77 | 1.69 | 1.62 | 1.56 | 1.49 |
| 1966 | 2.17 | 2.09 | 2.00 | 1.92 | 1.84 | 1.76 | 1.69 | 1.62 | 1.55 | 1.49 |
| 1967 | 2.15 | 2.06 | 1.98 | 1.90 | 1.82 | 1.74 | 1.67 | 1.60 | 1.54 | 1.47 |
| 1968 | 2.13 | 2.04 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 | 1.52 | 1.46 |
| 1969 | 2.12 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 | 1.58 | 1.51 | 1.45 |
| 1970 | 2.11 | 2.02 | 1.94 | 1.86 | 1.78 | 1.71 | 1.64 | 1.57 | 1.50 | 1.44 |
| 1971 | 2.10 | 2.01 | 1.93 | 1.85 | 1.78 | 1.70 | 1.63 | 1.57 | 1.50 | 1.44 |

| Year | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 2.09 | 2.00 | 1.92 | 1.84 | 1.77 | 1.69 | 1.62 | 1.56 | 1.49 | 1.43 |
| 1973 | 2.08 | 1.99 | 1.91 | 1.83 | 1.76 | 1.68 | 1.61 | 1.55 | 1.48 | 1.42 |
| 1974 | 2.06 | 1.98 | 1.90 | 1.82 | 1.75 | 1.67 | 1.60 | 1.54 | 1.48 | 1.41 |
| 1975 | 2.06 | 1.97 | 1.89 | 1.81 | 1.74 | 1.67 | 1.60 | 1.53 | 1.47 | 1.41 |
| 1976 | 2.05 | 1.97 | 1.88 | 1.81 | 1.73 | 1.66 | 1.59 | 1.53 | 1.46 | 1.40 |
| 1977 | 2.05 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 | 1.53 | 1.46 | 1.40 |
| 1978 | 2.04 | 1.96 | 1.88 | 1.80 | 1.73 | 1.65 | 1.59 | 1.52 | 1.46 | 1.40 |
| 1979 | 2.03 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 | 1.57 | 1.51 | 1.45 | 1.39 |
| 1980 | 1.99 | 1.90 | 1.83 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 |
| 1981 | 1.97 | 1.89 | 1.81 | 1.74 | 1.67 | 1.60 | 1.53 | 1.47 | 1.41 | 1.35 |
| 1982 | 1.94 | 1.86 | 1.79 | 1.71 | 1.64 | 1.57 | 1.51 | 1.45 | 1.39 | 1.33 |
| 1983 | 1.91 | 1.83 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.31 |
| 1984 | 1.87 | 1.80 | 1.72 | 1.65 | 1.58 | 1.52 | 1.46 | 1.40 | 1.34 | 1.28 |
| 1985 | 1.83 | 1.76 | 1.69 | 1.62 | 1.55 | 1.49 | 1.43 | 1.37 | 1.31 | 1.26 |
| 1986 | 1.76 | 1.69 | 1.62 | 1.55 | 1.49 | 1.43 | 1.37 | 1.31 | 1.26 | 1.21 |
| 1987 | 1.66 | 1.60 | 1.53 | 1.47 | 1.41 | 1.35 | 1.29 | 1.24 | 1.19 | 1.14 |
| 1988 | 1.53 | 1.47 | 1.41 | 1.35 | 1.29 | 1.24 | 1.19 | 1.14 | 1.09 | 1.05 |
| 1989 | 1.45 | 1.39 | 1.33 | 1.28 | 1.23 | 1.18 | 1.13 | 1.08 | 1.04 | 0.99 |
| 1990 | 1.37 | 1.31 | 1.26 | 1.21 | 1.16 | 1.11 | 1.07 | 1.02 | 0.98 | 0.94 |
| 1991 | 1.32 | 1.27 | 1.22 | 1.17 | 1.12 | 1.07 | 1.03 | 0.99 | 0.95 | 0.91 |
| 1992 | 1.28 | 1.23 | 1.17 | 1.13 | 1.08 | 1.04 | 0.99 | 0.95 | 0.91 | 0.88 |
| 1993 | 1.22 | 1.17 | 1.12 | 1.08 | 1.03 | 0.99 | 0.95 | 0.91 | 0.87 | 0.84 |
| 1994 | 1.15 | 1.10 | 1.06 | 1.01 | 0.97 | 0.93 | 0.89 | 0.86 | 0.82 | 0.79 |
| 1995 | 1.08 | 1.03 | 0.99 | 0.95 | 0.91 | 0.87 | 0.84 | 0.80 | 0.77 | 0.74 |
| 1996 | 0.99 | 0.95 | 0.91 | 0.88 | 0.84 | 0.80 | 0.77 | 0.74 | 0.71 | 0.68 |
| 1997 | 0.93 | 0.89 | 0.86 | 0.82 | 0.79 | 0.76 | 0.72 | 0.69 | 0.67 | 0.64 |
| 1998 | 0.89 | 0.85 | 0.82 | 0.78 | 0.75 | 0.72 | 0.69 | 0.66 | 0.64 | 0.61 |
| 1999 | 0.84 | 0.81 | 0.77 | 0.74 | 0.71 | 0.68 | 0.66 | 0.63 | 0.60 | 0.58 |
| 2000 | 0.82 | 0.78 | 0.75 | 0.72 | 0.69 | 0.66 | 0.63 | 0.61 | 0.58 | 0.56 |
| 2001 | 0.79 | 0.75 | 0.72 | 0.69 | 0.66 | 0.64 | 0.61 | 0.59 | 0.56 | 0.54 |
| 2002 | 0.77 | 0.74 | 0.71 | 0.68 | 0.65 | 0.62 | 0.60 | 0.57 | 0.55 | 0.53 |
| 2003 | 0.76 | 0.73 | 0.70 | 0.67 | 0.64 | 0.62 | 0.59 | 0.57 | 0.54 | 0.52 |
| 2004 | 0.75 | 0.72 | 0.69 | 0.66 | 0.63 | 0.61 | 0.58 | 0.56 | 0.53 | 0.51 |
| 2005 | 0.73 | 0.70 | 0.67 | 0.64 | 0.62 | 0.59 | 0.57 | 0.54 | 0.52 | 0.50 |
| 2006 | 0.71 | 0.68 | 0.65 | 0.63 | 0.60 | 0.58 | 0.55 | 0.53 | 0.51 | 0.49 |
| 2007 | 0.69 | 0.67 | 0.64 | 0.61 | 0.59 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 |
| 2008 | 0.67 | 0.64 | 0.62 | 0.59 | 0.57 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 |
| 2009 | 0.64 | 0.61 | 0.59 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 |
| 2010 | 0.61 | 0.59 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 | 0.42 |
| 2011 | 0.59 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 | 0.42 | 0.40 |
| 2012 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 | 0.42 | 0.40 | 0.39 |
| 2013 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 | 0.42 | 0.40 | 0.39 | 0.37 |

| Year | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1916 | 1.97 | 1.89 | 1.82 | 1.74 | 1.67 | 1.60 | 1.53 | 1.47 | 1.41 | 32.88 |
| 1917 | 1.97 | 1.89 | 1.81 | 1.74 | 1.66 | 1.60 | 1.53 | 1.47 | 1.41 | 32.77 |
| 1918 | 1.96 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 | 1.52 | 1.46 | 1.40 | 32.65 |
| 1919 | 1.95 | 1.87 | 1.80 | 1.72 | 1.65 | 1.58 | 1.52 | 1.46 | 1.40 | 32.53 |
| 1920 | 1.95 | 1.87 | 1.79 | 1.72 | 1.64 | 1.58 | 1.51 | 1.45 | 1.39 | 32.39 |
| 1921 | 1.94 | 1.86 | 1.78 | 1.71 | 1.64 | 1.57 | 1.51 | 1.44 | 1.38 | 32.26 |
| 1922 | 1.93 | 1.85 | 1.77 | 1.70 | 1.63 | 1.56 | 1.50 | 1.44 | 1.38 | 32.11 |
| 1923 | 1.92 | 1.84 | 1.77 | 1.69 | 1.62 | 1.56 | 1.49 | 1.43 | 1.37 | 31.97 |
| 1924 | 1.91 | 1.83 | 1.76 | 1.68 | 1.62 | 1.55 | 1.48 | 1.42 | 1.37 | 31.81 |
| 1925 | 1.90 | 1.82 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 31.65 |
| 1926 | 1.89 | 1.81 | 1.74 | 1.67 | 1.60 | 1.53 | 1.47 | 1.41 | 1.35 | 31.49 |
| 1927 | 1.88 | 1.80 | 1.73 | 1.66 | 1.59 | 1.52 | 1.46 | 1.40 | 1.34 | 31.31 |
| 1928 | 1.87 | 1.79 | 1.72 | 1.65 | 1.58 | 1.52 | 1.45 | 1.39 | 1.34 | 31.14 |
| 1929 | 1.86 | 1.78 | 1.71 | 1.64 | 1.57 | 1.50 | 1.44 | 1.38 | 1.33 | 30.91 |
| 1930 | 1.84 | 1.76 | 1.69 | 1.62 | 1.55 | 1.49 | 1.43 | 1.37 | 1.31 | 30.61 |
| 1931 | 1.82 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.30 | 30.33 |
| 1932 | 1.81 | 1.73 | 1.66 | 1.59 | 1.53 | 1.47 | 1.40 | 1.35 | 1.29 | 30.10 |
| 1933 | 1.80 | 1.72 | 1.65 | 1.59 | 1.52 | 1.46 | 1.40 | 1.34 | 1.29 | 29.95 |
| 1934 | 1.79 | 1.71 | 1.64 | 1.58 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 29.77 |
| 1935 | 1.78 | 1.70 | 1.63 | 1.57 | 1.50 | 1.44 | 1.38 | 1.32 | 1.27 | 29.59 |
| 1936 | 1.77 | 1.69 | 1.62 | 1.56 | 1.49 | 1.43 | 1.37 | 1.32 | 1.26 | 29.41 |
| 1937 | 1.75 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.30 | 1.25 | 29.14 |
| 1938 | 1.73 | 1.66 | 1.59 | 1.53 | 1.47 | 1.41 | 1.35 | 1.29 | 1.24 | 28.86 |
| 1939 | 1.72 | 1.65 | 1.58 | 1.52 | 1.45 | 1.40 | 1.34 | 1.28 | 1.23 | 28.66 |
| 1940 | 1.71 | 1.64 | 1.57 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 28.51 |
| 1941 | 1.70 | 1.63 | 1.56 | 1.50 | 1.43 | 1.38 | 1.32 | 1.26 | 1.21 | 28.25 |
| 1942 | 1.68 | 1.61 | 1.54 | 1.48 | 1.42 | 1.36 | 1.30 | 1.25 | 1.20 | 27.90 |
| 1943 | 1.64 | 1.58 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 1.17 | 27.36 |
| 1944 | 1.60 | 1.54 | 1.47 | 1.41 | 1.36 | 1.30 | 1.25 | 1.19 | 1.15 | 26.69 |
| 1945 | 1.59 | 1.52 | 1.46 | 1.40 | 1.34 | 1.29 | 1.23 | 1.18 | 1.13 | 26.45 |
| 1946 | 1.58 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 1.17 | 1.13 | 26.23 |
| 1947 | 1.56 | 1.50 | 1.44 | 1.38 | 1.32 | 1.27 | 1.21 | 1.16 | 1.12 | 25.99 |
| 1948 | 1.55 | 1.49 | 1.42 | 1.37 | 1.31 | 1.26 | 1.20 | 1.15 | 1.11 | 25.80 |
| 1949 | 1.54 | 1.47 | 1.41 | 1.35 | 1.30 | 1.25 | 1.19 | 1.14 | 1.10 | 25.58 |
| 1950 | 1.52 | 1.46 | 1.40 | 1.34 | 1.29 | 1.24 | 1.18 | 1.14 | 1.09 | 25.37 |
| 1951 | 1.51 | 1.45 | 1.39 | 1.33 | 1.28 | 1.23 | 1.18 | 1.13 | 1.08 | 25.20 |
| 1952 | 1.50 | 1.44 | 1.38 | 1.32 | 1.27 | 1.22 | 1.17 | 1.12 | 1.07 | 24.98 |
| 1953 | 1.49 | 1.43 | 1.37 | 1.31 | 1.26 | 1.21 | 1.16 | 1.11 | 1.07 | 24.83 |
| 1954 | 1.49 | 1.43 | 1.37 | 1.31 | 1.26 | 1.21 | 1.16 | 1.11 | 1.06 | 24.76 |
| 1955 | 1.48 | 1.42 | 1.36 | 1.30 | 1.25 | 1.20 | 1.15 | 1.10 | 1.06 | 24.63 |
| 1956 | 1.47 | 1.41 | 1.35 | 1.30 | 1.24 | 1.19 | 1.14 | 1.10 | 1.05 | 24.49 |
| 1957 | 1.47 | 1.41 | 1.35 | 1.29 | 1.24 | 1.19 | 1.14 | 1.09 | 1.05 | 24.42 |
| 1958 | 1.46 | 1.40 | 1.34 | 1.29 | 1.23 | 1.18 | 1.13 | 1.09 | 1.04 | 24.31 |
| 1959 | 1.46 | 1.40 | 1.34 | 1.28 | 1.23 | 1.18 | 1.13 | 1.09 | 1.04 | 24.26 |
| 1960 | 1.45 | 1.39 | 1.34 | 1.28 | 1.23 | 1.18 | 1.13 | 1.08 | 1.04 | 24.19 |
| 1961 | 1.45 | 1.39 | 1.33 | 1.28 | 1.22 | 1.17 | 1.13 | 1.08 | 1.03 | 24.11 |
| 1962 | 1.44 | 1.38 | 1.33 | 1.27 | 1.22 | 1.17 | 1.12 | 1.08 | 1.03 | 24.04 |
| 1963 | 1.44 | 1.38 | 1.32 | 1.27 | 1.22 | 1.17 | 1.12 | 1.07 | 1.03 | 23.95 |
| 1964 | 1.44 | 1.38 | 1.32 | 1.27 | 1.21 | 1.16 | 1.12 | 1.07 | 1.03 | 23.90 |
| 1965 | 1.43 | 1.37 | 1.32 | 1.26 | 1.21 | 1.16 | 1.11 | 1.07 | 1.02 | 23.85 |
| 1966 | 1.43 | 1.37 | 1.31 | 1.26 | 1.21 | 1.16 | 1.11 | 1.06 | 1.02 | 23.79 |
| 1967 | 1.41 | 1.35 | 1.30 | 1.25 | 1.19 | 1.15 | 1.10 | 1.05 | 1.01 | 23.53 |
| 1968 | 1.40 | 1.34 | 1.29 | 1.23 | 1.18 | 1.13 | 1.09 | 1.04 | 1.00 | 23.30 |
| 1969 | 1.39 | 1.33 | 1.28 | 1.23 | 1.17 | 1.13 | 1.08 | 1.04 | 0.99 | 23.14 |
| 1970 | 1.38 | 1.33 | 1.27 | 1.22 | 1.17 | 1.12 | 1.07 | 1.03 | 0.99 | 23.03 |
| 1971 | 1.38 | 1.32 | 1.27 | 1.22 | 1.17 | 1.12 | 1.07 | 1.03 | 0.99 | 22.99 |

| Year | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | 1.37 | 1.32 | 1.26 | 1.21 | 1.16 | 1.11 | 1.07 | 1.02 | 0.98 | 22.86 |
| 1973 | 1.36 | 1.31 | 1.25 | 1.20 | 1.15 | 1.11 | 1.06 | 1.02 | 0.97 | 22.72 |
| 1974 | 1.36 | 1.30 | 1.25 | 1.20 | 1.15 | 1.10 | 1.05 | 1.01 | 0.97 | 22.59 |
| 1975 | 1.35 | 1.30 | 1.24 | 1.19 | 1.14 | 1.10 | 1.05 | 1.01 | 0.97 | 22.50 |
| 1976 | 1.35 | 1.29 | 1.24 | 1.19 | 1.14 | 1.09 | 1.05 | 1.00 | 0.96 | 22.42 |
| 1977 | 1.34 | 1.29 | 1.24 | 1.19 | 1.14 | 1.09 | 1.04 | 1.00 | 0.96 | 22.39 |
| 1978 | 1.34 | 1.29 | 1.23 | 1.18 | 1.13 | 1.09 | 1.04 | 1.00 | 0.96 | 22.33 |
| 1979 | 1.33 | 1.28 | 1.22 | 1.17 | 1.12 | 1.08 | 1.03 | 0.99 | 0.95 | 22.16 |
| 1980 | 1.31 | 1.25 | 1.20 | 1.15 | 1.10 | 1.06 | 1.01 | 0.97 | 0.93 | 21.73 |
| 1981 | 1.30 | 1.24 | 1.19 | 1.14 | 1.09 | 1.05 | 1.01 | 0.97 | 0.93 | 21.56 |
| 1982 | 1.28 | 1.22 | 1.17 | 1.12 | 1.08 | 1.03 | 0.99 | 0.95 | 0.91 | 21.24 |
| 1983 | 1.25 | 1.20 | 1.15 | 1.10 | 1.06 | 1.01 | 0.97 | 0.93 | 0.89 | 20.85 |
| 1984 | 1.23 | 1.18 | 1.13 | 1.08 | 1.04 | 1.00 | 0.96 | 0.92 | 0.88 | 20.49 |
| 1985 | 1.21 | 1.16 | 1.11 | 1.06 | 1.02 | 0.98 | 0.94 | 0.90 | 0.86 | 20.08 |
| 1986 | 1.16 | 1.11 | 1.06 | 1.02 | 0.98 | 0.94 | 0.90 | 0.86 | 0.83 | 19.28 |
| 1987 | 1.09 | 1.05 | 1.01 | 0.96 | 0.92 | 0.89 | 0.85 | 0.81 | 0.78 | 18.21 |
| 1988 | 1.00 | 0.96 | 0.92 | 0.89 | 0.85 | 0.81 | 0.78 | 0.75 | 0.72 | 16.73 |
| 1989 | 0.95 | 0.91 | 0.88 | 0.84 | 0.81 | 0.77 | 0.74 | 0.71 | 0.68 | 15.88 |
| 1990 | 0.90 | 0.86 | 0.83 | 0.79 | 0.76 | 0.73 | 0.70 | 0.67 | 0.64 | 15.00 |
| 1991 | 0.87 | 0.83 | 0.80 | 0.77 | 0.74 | 0.71 | 0.68 | 0.65 | 0.62 | 14.50 |
| 1992 | 0.84 | 0.81 | 0.77 | 0.74 | 0.71 | 0.68 | 0.65 | 0.63 | 0.60 | 13.99 |
| 1993 | 0.80 | 0.77 | 0.74 | 0.71 | 0.68 | 0.65 | 0.62 | 0.60 | 0.57 | 13.39 |
| 1994 | 0.75 | 0.72 | 0.69 | 0.67 | 0.64 | 0.61 | 0.59 | 0.56 | 0.54 | 12.57 |
| 1995 | 0.71 | 0.68 | 0.65 | 0.63 | 0.60 | 0.57 | 0.55 | 0.53 | 0.51 | 11.81 |
| 1996 | 0.65 | 0.63 | 0.60 | 0.58 | 0.55 | 0.53 | 0.51 | 0.49 | 0.47 | 10.87 |
| 1997 | 0.61 | 0.59 | 0.56 | 0.54 | 0.52 | 0.50 | 0.48 | 0.46 | 0.44 | 10.20 |
| 1998 | 0.59 | 0.56 | 0.54 | 0.52 | 0.49 | 0.47 | 0.45 | 0.44 | 0.42 | 9.75 |
| 1999 | 0.55 | 0.53 | 0.51 | 0.49 | 0.47 | 0.45 | 0.43 | 0.41 | 0.40 | 9.23 |
| 2000 | 0.54 | 0.51 | 0.49 | 0.47 | 0.45 | 0.43 | 0.42 | 0.40 | 0.38 | 8.92 |
| 2001 | 0.52 | 0.50 | 0.47 | 0.46 | 0.44 | 0.42 | 0.40 | 0.38 | 0.37 | 8.60 |
| 2002 | 0.51 | 0.48 | 0.46 | 0.45 | 0.43 | 0.41 | 0.39 | 0.38 | 0.36 | 8.42 |
| 2003 | 0.50 | 0.48 | 0.46 | 0.44 | 0.42 | 0.40 | 0.39 | 0.37 | 0.36 | 8.32 |
| 2004 | 0.49 | 0.47 | 0.45 | 0.43 | 0.42 | 0.40 | 0.38 | 0.37 | 0.35 | 8.18 |
| 2005 | 0.48 | 0.46 | 0.44 | 0.42 | 0.41 | 0.39 | 0.37 | 0.36 | 0.34 | 8.00 |
| 2006 | 0.47 | 0.45 | 0.43 | 0.41 | 0.39 | 0.38 | 0.36 | 0.35 | 0.33 | 7.78 |
| 2007 | 0.46 | 0.44 | 0.42 | 0.40 | 0.39 | 0.37 | 0.35 | 0.34 | 0.33 | 7.60 |
| 2008 | 0.44 | 0.42 | 0.40 | 0.39 | 0.37 | 0.36 | 0.34 | 0.33 | 0.31 | 7.33 |
| 2009 | 0.42 | 0.40 | 0.39 | 0.37 | 0.36 | 0.34 | 0.33 | 0.31 | 0.30 | 7.01 |
| 2010 | 0.40 | 0.39 | 0.37 | 0.36 | 0.34 | 0.33 | 0.31 | 0.30 | 0.29 | 6.72 |
| 2011 | 0.39 | 0.37 | 0.35 | 0.34 | 0.33 | 0.31 | 0.30 | 0.29 | 0.28 | 6.43 |
| 2012 | 0.37 | 0.35 | 0.34 | 0.33 | 0.31 | 0.30 | 0.29 | 0.28 | 0.26 | 6.16 |
| 2013 | 0.36 | 0.34 | 0.33 | 0.31 | 0.30 | 0.29 | 0.28 | 0.27 | 0.25 | 5.94 |

## SS data file

```
#C 2013 Rougheye assessment (Hicks, Wetzel, Harms)
############################################
#           Rougheye Rockfish 2013          #
#  Allan Hicks, Chantel Wetzel, John Harms #
############################################
###     Global model specifications      ###
1916   # Start year
2012   # End year
1      # Number of seasons/year
12     # Number of months/season
1      # Spawning occurs at beginning of season
3      # Number of fishing fleets
4      # Number of surveys
1      # Number of areas
TRAWL%FIXED%ASF%TRI%AKSLOPE%NWFSCSLOPE%NWFSCCOMBO
0.5   0.5   0.5 0.55 0.825   0.65        0.65 # fleet timing_in_season
1 1 1 1 1 1 1 # Area of each fleet
1 1 1  # Units for catch by fishing fleet: 1=Biomass(mt),2=Numbers(1000s)
0.01 0.01 0.01  # SE of log(catch) by fleet for equilibrium and continuous options
1      # Number of genders
140    # Number of ages in population dynamics
### Catch section ###
0 0 0  # Initial equilibrium catch (landings + discard) by fishing fleet
97  # Number of lines of catch
# Catch Year Season
#Trawl Fixed  AS     Year   Season
0.01   41.85  0.01   1916   1
0.01   44.04  0.01   1917   1
0.01   46.24  0.01   1918   1
0.01   48.43  0.01   1919   1
0.01   50.62  0.01   1920   1
0.01   52.81  0.01   1921   1
0.01   55.00  0.01   1922   1
0.01   57.19  0.01   1923   1
0.01   59.39  0.01   1924   1
0.01   61.58  0.01   1925   1
0.01   63.77  0.01   1926   1
0.01   66.00  0.01   1927   1
0.01   85.42  0.01   1928   1
0.01   113.63 0.01   1929   1
0.01   101.26 0.01   1930   1
0.01   89.44  0.01   1931   1
0.01   56.29  0.01   1932   1
0.01   65.63  0.01   1933   1
```

| | | | | |
|---|---|---|---|---|
| 0.01 | 69.64 | 0.01 | 1934 | 1 |
| 0.29 | 67.80 | 0.01 | 1935 | 1 |
| 0.49 | 104.29 | 0.01 | 1936 | 1 |
| 0.41 | 103.70 | 0.01 | 1937 | 1 |
| 0.46 | 77.79 | 0.01 | 1938 | 1 |
| 0.45 | 56.49 | 0.01 | 1939 | 1 |
| 0.92 | 101.00 | 0.01 | 1940 | 1 |
| 1.39 | 133.79 | 0.01 | 1941 | 1 |
| 2.31 | 205.97 | 0.01 | 1942 | 1 |
| 7.39 | 255.53 | 0.01 | 1943 | 1 |
| 12.16 | 85.42 | 0.01 | 1944 | 1 |
| 20.29 | 68.37 | 0.01 | 1945 | 1 |
| 10.83 | 82.94 | 0.01 | 1946 | 1 |
| 6.48 | 70.11 | 0.01 | 1947 | 1 |
| 5.50 | 84.41 | 0.01 | 1948 | 1 |
| 5.62 | 76.95 | 0.01 | 1949 | 1 |
| 6.08 | 64.30 | 0.01 | 1950 | 1 |
| 5.40 | 83.38 | 0.01 | 1951 | 1 |
| 6.90 | 55.08 | 0.01 | 1952 | 1 |
| 5.35 | 25.93 | 0.01 | 1953 | 1 |
| 8.44 | 45.53 | 0.01 | 1954 | 1 |
| 7.62 | 48.47 | 0.01 | 1955 | 1 |
| 9.22 | 20.28 | 0.01 | 1956 | 1 |
| 11.62 | 37.02 | 0.01 | 1957 | 1 |
| 10.60 | 10.60 | 0.01 | 1958 | 1 |
| 8.11 | 23.57 | 0.01 | 1959 | 1 |
| 11.81 | 22.18 | 0.01 | 1960 | 1 |
| 13.20 | 19.79 | 0.01 | 1961 | 1 |
| 14.23 | 23.01 | 0.01 | 1962 | 1 |
| 10.53 | 14.46 | 0.01 | 1963 | 1 |
| 11.32 | 11.28 | 0.01 | 1964 | 1 |
| 18.78 | 11.11 | 0.01 | 1965 | 1 |
| 120.56 | 7.81 | 0.01 | 1966 | 1 |
| 98.39 | 12.11 | 0.01 | 1967 | 1 |
| 74.88 | 8.03 | 0.01 | 1968 | 1 |
| 24.45 | 27.96 | 0.01 | 1969 | 1 |
| 17.22 | 3.81 | 0.01 | 1970 | 1 |
| 62.75 | 0.85 | 0.01 | 1971 | 1 |
| 73.03 | 1.44 | 0.01 | 1972 | 1 |
| 67.82 | 0.24 | 0.01 | 1973 | 1 |
| 46.31 | 0.60 | 0.01 | 1974 | 1 |
| 32.11 | 2.56 | 3.24 | 1975 | 1 |
| 18.60 | 0.01 | 0.71 | 1976 | 1 |
| 0.30 | 22.98 | 1.22 | 1977 | 1 |
| 31.95 | 54.87 | 0.38 | 1978 | 1 |

```
110.73 101.51 0.78   1979   1
56.44  31.06  0.19   1980   1
59.55  98.56  2.13   1981   1
93.33  107.61 0.01   1982   1
54.53  121.55 1.23   1983   1
73.15  134.76 2.28   1984   1
136.46 269.68 0.91   1985   1
152.56 392.33 1.21   1986   1
196.14 559.75 4.23   1987   1
151.01 277.74 15.85  1988   1
282.93 200.28 0.27   1989   1
166.33 118.85 0.73   1990   1
189.34 99.70  3.99   1991   1
153.68 175.14 9.12   1992   1
142.74 311.15 1.50   1993   1
109.79 316.15 5.01   1994   1
145.52 400.44 2.65   1995   1
108.15 278.39 6.71   1996   1
98.00  169.09 9.73   1997   1
60.87  236.23 17.21  1998   1
60.46  122.00 8.96   1999   1
81.98  28.81  71.37  2000   1
75.59  16.28  20.69  2001   1
30.90  26.99  0.73   2002   1
55.89  21.90  2.16   2003   1
59.07  31.44  13.69  2004   1
45.63  49.02  35.95  2005   1
47.72  56.10  6.64   2006   1
62.33  54.44  29.08  2007   1
54.98  54.32  75.58  2008   1
68.90  101.70 9.30   2009   1
83.76  68.56  21.57  2010   1
57.30  59.58  80.95  2011   1
79.81  47.98  54.00  2012   1

28 # Number of index observations
# Units: 0=numbers,1=biomass,2=F; Errortype: -1=normal,0=lognormal,>0=T
# Fleet Units Errortype
1      1      0 #TRAWL
2      1      0 #FIXED
3      1      0 #AT SEA/FOREIGN FLEET
4      1      0 #TRIENNIAL
5      1      0 #AKFSC SLOPE
6      1      0 #NWFSC SLOPE
7      1      0 #NWFSC COMBO
```

```
#year seas   index  obs       se(log)
1980  1      4      325.769   0.4594
1983  1      4      125.377   0.3077
1986  1      4      423.897   0.3195
1989  1      4      326.618   0.3014
1992  1      4      429.246   0.3598
1995  1      4      1078.993  0.2889
1998  1      4      579.967   0.3260
2001  1      4      999.435   0.3218
2004  1      4      761.362   0.3250
1996  1      5      427.783   0.3017
1997  1      5      406.204   0.5276
1999  1      5      258.749   0.4256
2000  1      5      1036.921  0.4133
2001  1      5      584.978   0.5512
1999  1      6      496.269   0.4896
2000  1      6      536.454   0.5527
2001  1      6      1113.272  0.4757
2002  1      6      228.419   0.5498
2003  1      7      512.498   0.3587
2004  1      7      1130.905  0.3947
2005  1      7      1366.460  0.3916
2006  1      7      727.516   0.3601
2007  1      7      780.511   0.3351
2008  1      7      1063.013  0.3342
2009  1      7      1181.969  0.3743
2010  1      7      1008.902  0.3664
2011  1      7      1136.463  0.3496
2012  1      7      681.453   0.4099

2 #_N_fleets_with_discard
#Fleet       Units  Error
1       1       -2
2       1       -2
20 #_N_discard_obs
#Lognormal discards values are median
#Year  Season Fleet  Discard             SElog(bootstrapped)
2002    1       1       14.4620     0.3815  #TRAWL
2003    1       1       19.8433     0.2937
2004    1       1       1.6134      0.6049
2005    1       1       0.9774      0.4243
2006    1       1       14.7902     0.4337
2007    1       1       30.2520     0.3714
2008    1       1       31.6008     0.3128
2009    1       1       51.7018     0.2774
```

```
2010    1       1       60.2267     0.4091
2011    1       1       0.0383      0.030
2002    1       2       0.7106      0.4634  #FIXED
2003    1       2       2.0126      0.5212
2004    1       2       4.1077      0.7641
2005    1       2       6.0832      0.3532
2006    1       2       1.2622      0.4824
2007    1       2       8.6847      0.5849
2008    1       2       16.8214     0.5212
2009    1       2       1.8543      0.4514
2010    1       2       21.3752     0.8215
2011    1       2       7.2975      0.6950

20 #_N_meanbodywt_obs
30 #_DF_meanwt
#Year   Season  Fleet   Part    Value         CV
2002    1       1       1       1.837824573   1.16 #TRAWL
2003    1       1       1       1.803001641   0.65
2004    1       1       1       1.514902413   0.9
2005    1       1       1       0.530873839   0.71
2006    1       1       1       1.33703054    0.84
2007    1       1       1       1.402125321   0.59
2008    1       1       1       1.59780249    0.74
2009    1       1       1       1.579676541   0.53
2010    1       1       1       1.574469455   0.49
2011    1       1       1       0.548034363   0.86
2002    1       2       1       1.993521585   0.31 #FIXED
2003    1       2       1       2.311551264   0.45
2004    1       2       1       1.428361987   0.33
2005    1       2       1       2.147353366   0.28
2006    1       2       1       1.768075717   0.8
2007    1       2       1       1.785023915   0.25
2008    1       2       1       2.164774098   0.56
2009    1       2       1       2.332403249   0.59
2010    1       2       1       1.384264872   0.33
2011    1       2       1       2.695545068   0.29

## Population size structure
1 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
# binwidth for population size comp
# minimum size in the population (lower edge of first bin and size at age 0.00)
# maximum size in the population (lower edge of last bin)
-1 #_comp_tail_compression
0.0001 #_add_to_comp
0 #_combine males into females at or below this bin number
```

```
36 #_N_LengthBins
10      12      14      16      18      20      22      24      26      28      30      32      34      36      38      40      42      44
        46      48      50      52      54      56      58      60      62      64      66      68      70      72      74      76      78
        80
87 #_N_Length_obs
#year   season fleet  gender partition     nSamps F10    F12    F14    F16    F18    F20    F22    F24    F26    F28    F30
        F32    F34    F36    F38    F40    F42    F44    F46    F48    F50    F52    F54    F56    F58    F60    F62    F64
        F66    F68    F70    F72    F74    F76    F78    F80    F82    F84    F86    F88    F90    F92    M10    M12    M14
        M16    M18    M20    M22    M24    M26    M28    M30    M32    M34    M36    M38    M40    M42    M44    M46    M48
        M50    M52    M54    M56    M58    M60    M62    M64    M66    M68    M70    M72    M74    M76    M78    M80    M82
        M84    M86    M88    M90    M92
#COMMERCIAL DISCARDED LENGTHS
#TRAWL
2002    1       1       0       1       8       0.000000        0.000000        0.000000        0.000000        0.000000
        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
        0.000000        0.022510        0.011255        0.042841        0.065069        0.171364        0.198594        0.288996
        0.093358        0.074427        0.011255        0.000000        0.020331        0.000000        0.000000        0.000000
        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
2003    1       1       0       1       6       0.000000        0.000000        0.000000        0.000000        0.000000
        0.000000        0.052632        0.000000        0.052632        0.000000        0.000000        0.000000        0.000000
        0.052632        0.000000        0.052632        0.052632        0.105263        0.052632        0.105263        0.052632
        0.000000        0.157895        0.105263        0.000000        0.000000        0.052632        0.052632        0.052632
        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
2004    1       1       0       1       8       0.000000        0.000000        0.000000        0.000000        0.000000
        0.016413        0.000000        0.114894        0.082067        0.032827        0.016413        0.016413        0.000000
        0.000000        0.000000        0.000000        0.016413        0.049184        0.130920        0.163747        0.082067
        0.081902        0.082067        0.049184        0.049075        0.000000        0.016413        0.000000        0.000000
        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
2005    1       1       0       1       16      0.000000        0.000000        0.000000        0.000000        0.012356
        0.024711        0.061778        0.024711        0.311835        0.161281        0.024711        0.099503        0.000000
        0.012356        0.000000        0.000000        0.012356        0.000000        0.012356        0.096866        0.041703
        0.037067        0.000000        0.041703        0.024711        0.000000        0.000000        0.000000        0.000000
        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
2006    1       1       0       1       19      0.053946        0.086313        0.109689        0.084515        0.154644
        0.076123        0.050349        0.002997        0.030569        0.024575        0.120479        0.017982        0.000000
        0.002997        0.007792        0.007792        0.005994        0.044756        0.005994        0.029772        0.024575
        0.021979        0.004597        0.002997        0.004597        0.005994        0.000000        0.000000        0.011988
        0.005994        0.000000        0.000000        0.000000        0.000000        0.000000        0.000000
2007    1       1       0       1       48      0.000000        0.000000        0.000000        0.000000        0.000389
        0.000389        0.030341        0.010229        0.022995        0.028630        0.033910        0.015288        0.002530
        0.028633        0.001557        0.063750        0.073239        0.150222        0.171460        0.138708        0.097832
        0.045573        0.030904        0.016939        0.001401        0.004541        0.003366        0.003710        0.006552
        0.000000        0.003081        0.000000        0.000389        0.002335        0.009936        0.001168
```

```
2008   1      1      0      1       108   0.000000     0.000000     0.000000     0.000000     0.003605
       0.002804     0.012623     0.031222     0.019407     0.026946     0.040056     0.021999     0.028513
       0.029024     0.006961     0.026861     0.034324     0.097626     0.127055     0.111695     0.128475
       0.059933     0.064511     0.037437     0.019607     0.015426     0.006087     0.002243     0.002981
       0.013914     0.007698     0.000841     0.001001     0.009701     0.006657     0.002764
2009   1      1      0      1       114   0.000000     0.000000     0.000000     0.002542     0.000148
       0.000709     0.001212     0.002808     0.003551     0.013829     0.018805     0.025143     0.033009
       0.035951     0.050524     0.038379     0.155207     0.106205     0.093045     0.130506     0.119292
       0.051758     0.057348     0.022784     0.009568     0.017592     0.001271     0.004588     0.001803
       0.001596     0.000148     0.000000     0.000532     0.000000     0.000148     0.000000
2010   1      1      0      1       57    0.000000     0.000000     0.000000     0.000000     0.000000
       0.000373     0.002631     0.001738     0.005029     0.004423     0.023730     0.061049     0.020022
       0.013751     0.090228     0.061500     0.068987     0.066857     0.100297     0.142683     0.128581
       0.101849     0.058286     0.021950     0.006825     0.005812     0.004241     0.004583     0.003527
       0.000396     0.000652     0.000000     0.000000     0.000000     0.000000     0.000000
2011   1      1      0      1       14    0.000000     0.000000     0.000000     0.000000     0.074074
       0.074074     0.000000     0.000000     0.111111     0.111111     0.074074     0.148148     0.000000
       0.037037     0.074074     0.037037     0.000000     0.037037     0.074074     0.074074     0.037037
       0.000000     0.037037     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
#FIXED
2003   1      2      0      1       2     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.011905     0.000000     0.000000     0.071429     0.107143     0.107143     0.190476
       0.059524     0.154762     0.107143     0.059524     0.059524     0.047619     0.011905     0.000000
       0.011905     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2004   1      2      0      1       4     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.028991     0.000000     0.000000
       0.000000     0.000000     0.000000     0.091799     0.236714     0.236714     0.164264     0.144916
       0.096603     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2005   1      2      0      1       7     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
       0.003844     0.007963     0.018305     0.075127     0.086914     0.095830     0.118539     0.152008
       0.070549     0.066974     0.046947     0.066783     0.043566     0.053218     0.000000     0.056059
       0.037372     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2006   1      2      0      1       4     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.018907     0.000000     0.000000
       0.000000     0.000000     0.010805     0.056721     0.020922     0.186045     0.187900     0.208733
       0.042568     0.090215     0.100928     0.005041     0.061762     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.009454
2007   1      2      0      1       9     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
       0.000000     0.005464     0.013466     0.166565     0.126070     0.117753     0.145584     0.158466
```

```
        0.201744      0.027419      0.027006      0.000000      0.003144      0.002439      0.002927      0.001952
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
2008    1       2       0       1           10      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.051134      0.000000      0.045496      0.034089      0.000000
        0.030680      0.000000      0.000000      0.000000      0.000000      0.139767      0.204537      0.190901
        0.020454      0.190901      0.051134      0.040907      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
2009    1       2       0       1           6       0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.040000
        0.000000      0.000000      0.000000      0.000000      0.208000      0.104000      0.080000      0.104000
        0.000000      0.200000      0.104000      0.160000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
2010    1       2       0       1           15      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000698      0.000000      0.000000
        0.000000      0.000441      0.000000      0.061824      0.083140      0.076478      0.228619      0.073474
        0.086705      0.020232      0.018468      0.078535      0.008306      0.062057      0.002368      0.031942
        0.025736      0.019616      0.073763      0.002676      0.009168      0.000000      0.035753
2011    1       2       0       1           13      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000729      0.000000
        0.000729      0.007068      0.003862      0.013262      0.020185      0.032062      0.114695      0.131041
        0.179584      0.126860      0.102235      0.097214      0.049478      0.030532      0.033580      0.019687
        0.009983      0.005538      0.014463      0.000000      0.000000      0.000729      0.006485
#RETAINED COMMERCIAL LENGTHS
#TRAWL
1995    1       1       0       2           5       0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000700      0.136291      0.045197      0.068605
        0.090176      0.022489      0.045230      0.022708      0.067905      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000700      0.000000      0.000000      0.000000      0.000000
1996    1       1       0       2           35      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.000000      0.006848      0.002323      0.006848      0.010216
        0.010547      0.027899      0.016029      0.062995      0.092684      0.082911      0.085602      0.050217
        0.019093      0.012479      0.005598      0.004365      0.000000      0.000000      0.000000      0.003348
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
1997    1       1       0       2           42      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000000      0.009369      0.015614      0.024983      0.027325      0.024202
        0.023421      0.010149      0.021079      0.056211      0.082292      0.074136      0.048350      0.038981
        0.014872      0.010188      0.007026      0.007042      0.003161      0.000000      0.001600      0.000000
        0.000000      0.000000      0.000000      0.000000      0.000000      0.000000      0.000000
1998    1       1       0       2           64      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.000000      0.000842      0.002525      0.013467      0.027775      0.050500      0.064809
        0.083326      0.063125      0.046292      0.031984      0.035350      0.038717      0.020200      0.005050
        0.007575      0.003367      0.000842      0.000000      0.000000      0.000000      0.000000      0.000000
        0.000000      0.002556      0.001699      0.000000      0.000000      0.000000      0.000000
```

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1999   1   1   0   2   21   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.000000   0.001152   0.009215   0.018431   0.023039   0.025231
   0.033937   0.030280   0.033316   0.068915   0.083290   0.060841   0.036539   0.032143
   0.017799   0.013202   0.009215   0.001152   0.001152   0.000000   0.000000   0.000000
   0.000000   0.000000   0.001152   0.000000   0.000000   0.000000   0.000000
2000   1   1   0   2   36   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.003089   0.002317   0.006177   0.017760   0.016216   0.016988
   0.009376   0.015443   0.027262   0.053196   0.079740   0.077997   0.062581   0.035289
   0.027447   0.012976   0.010774   0.002426   0.000000   0.003964   0.001044   0.000772
   0.002391   0.000772   0.001648   0.002317   0.003861   0.003861   0.002317
2001   1   1   0   2   31   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.001034   0.008275   0.017583   0.025858   0.055853   0.067231
   0.071676   0.026183   0.019028   0.019952   0.034335   0.035362   0.037661   0.062211
   0.009166   0.004131   0.002622   0.000657   0.001081   0.000102   0.000000   0.000000
   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
2002   1   1   0   2   33   0.000000   0.000000   0.000000   0.000000   0.000000
   0.002213   0.000000   0.002213   0.006640   0.006640   0.008853   0.021026   0.024346
   0.023239   0.019919   0.020277   0.039092   0.072935   0.079575   0.079503   0.043056
   0.021026   0.022410   0.004427   0.001503   0.000000   0.000000   0.000000   0.000000
   0.000000   0.001107   0.000000   0.000000   0.000000   0.000000   0.000000
2003   1   1   0   2   51   0.000000   0.000000   0.000000   0.000479   0.000000
   0.000000   0.000957   0.001436   0.000000   0.001436   0.000479   0.000957   0.005742
   0.010049   0.019620   0.026061   0.053797   0.084905   0.092802   0.088214   0.044801
   0.016977   0.011445   0.004785   0.008171   0.002853   0.004646   0.001952   0.000479
   0.003492   0.006328   0.006328   0.000332   0.000000   0.000479   0.000000
2004   1   1   0   2   14   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.000000   0.000000   0.000000   0.001587   0.001587   0.003175
   0.004762   0.004762   0.019048   0.033333   0.088889   0.095238   0.069841   0.069841
   0.050794   0.030159   0.007937   0.007937   0.003175   0.001587   0.003175   0.001587
   0.000000   0.000000   0.001587   0.000000   0.000000   0.000000   0.000000
2005   1   1   0   2   14   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000069   0.000067   0.000270   0.000110   0.000043   0.000218   0.002406
   0.004728   0.009642   0.024219   0.055662   0.096377   0.090841   0.073851   0.040550
   0.028595   0.016532   0.006536   0.008397   0.003018   0.000422   0.001448   0.033775
   0.000067   0.000854   0.000650   0.000650   0.000000   0.000000   0.000000
2006   1   1   0   2   11   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.000000   0.000000   0.000000   0.001566   0.000000   0.007828
   0.000161   0.010960   0.042622   0.060387   0.076595   0.119629   0.068484   0.041888
   0.036155   0.011350   0.010124   0.002036   0.000397   0.000359   0.000637   0.000053
   0.003430   0.000104   0.003386   0.000000   0.001566   0.000000   0.000283
2007   1   1   0   2   27   0.000000   0.000000   0.000000   0.000000   0.000000
   0.000000   0.000000   0.000000   0.000004   0.000182   0.000248   0.000093   0.000012
   0.006855   0.009639   0.021290   0.050901   0.087754   0.090722   0.083363   0.060252
   0.038805   0.014961   0.009398   0.003953   0.004657   0.007495   0.002566   0.001696
   0.002360   0.002686   0.000091   0.000000   0.000016   0.000000   0.000000
```

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2008   1      1      0      2      22     0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000022    0.002790    0.001254    0.001364
       0.004236    0.009329    0.025125    0.074262    0.089501    0.099117    0.075700    0.042358
       0.032252    0.021809    0.006671    0.004990    0.003993    0.002295    0.000878    0.000732
       0.000978    0.000345    0.000000    0.000000    0.000000    0.000000    0.000000
2009   1      1      0      2      25     0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000085    0.000057    0.000057    0.000103    0.000964    0.000232
       0.002811    0.002907    0.020520    0.034828    0.068618    0.097506    0.095910    0.066671
       0.032228    0.027949    0.016214    0.008274    0.006525    0.001859    0.005335    0.003507
       0.001606    0.000087    0.000252    0.000699    0.000000    0.004197    0.000000
2010   1      1      0      2      19     0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000029    0.000029    0.001219    0.000205
       0.004246    0.004733    0.018383    0.039727    0.070786    0.097143    0.074866    0.061854
       0.034451    0.032171    0.024961    0.007488    0.009039    0.007106    0.005186    0.002098
       0.001891    0.001900    0.000285    0.000093    0.000029    0.000083    0.000000
2011   1      1      0      2      36     0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.001278    0.000000    0.002167    0.001278
       0.004046    0.003836    0.002556    0.018547    0.054758    0.082986    0.075019    0.086824
       0.058932    0.038345    0.022076    0.018770    0.015290    0.002223    0.003226    0.005791
       0.000163    0.001112    0.000778    0.000000    0.000000    0.000000    0.000000
2012   1      1      0      2      45     0.000000    0.000000    0.000000    0.000514    0.000000
       0.000000    0.000000    0.000000    0.001541    0.003109    0.004110    0.007212    0.007835
       0.005285    0.006351    0.012496    0.025912    0.047622    0.064180    0.065462    0.072452
       0.058151    0.045660    0.029545    0.015769    0.013671    0.004272    0.002568    0.004218
       0.000377    0.001237    0.000281    0.000030    0.000022    0.000121    0.000000
#FIXED
1995   1      2      0      2      2      0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.023675    0.072441    0.285512
       0.071024    0.047349    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1996   1      2      0      2      8      0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
       0.000641    0.004029    0.016117    0.012088    0.036904    0.084615    0.072527    0.141665
       0.088644    0.020787    0.013924    0.004029    0.004029    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1997   1      2      0      2      6      0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.002105    0.000000    0.000000
       0.006315    0.004210    0.039992    0.106396    0.130500    0.075774    0.058935    0.039992
       0.018944    0.010524    0.004210    0.002105    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1998   1      2      0      2      22     0.000000    0.000000    0.000000    0.000000    0.000000
       0.000000    0.000000    0.000218    0.000000    0.000874    0.000218    0.000437    0.000498
       0.000000    0.003489    0.021089    0.051341    0.105790    0.093673    0.077994    0.062505
```

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.031674 | 0.032635 | 0.009280 | 0.003643 | 0.004640 | 0.000000 | 0.000000 | 0.000000 | | |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | | |
| 1999 | 1 | 2 | 0 | 2 | 20 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000697 | | |
| | 0.001851 | 0.007672 | 0.015100 | 0.063336 | 0.095258 | 0.105986 | 0.075704 | 0.054354 | | |
| | 0.030988 | 0.022728 | 0.012537 | 0.008199 | 0.002454 | 0.001042 | 0.000697 | 0.000697 | | |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000697 | 0.000000 | 0.000000 | | | |
| 2000 | 1 | 2 | 0 | 2 | 52 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.001106 | 0.000000 | 0.000000 | | |
| | 0.001106 | 0.001106 | 0.011614 | 0.041236 | 0.079346 | 0.105722 | 0.093287 | 0.072828 | | |
| | 0.039229 | 0.023769 | 0.016664 | 0.008287 | 0.003595 | 0.000553 | 0.000553 | 0.000000 | | |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | | |
| 2001 | 1 | 2 | 0 | 2 | 43 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.001274 | | |
| | 0.001685 | 0.003369 | 0.010155 | 0.030323 | 0.091137 | 0.124534 | 0.078086 | 0.065868 | | |
| | 0.034123 | 0.029939 | 0.021926 | 0.003369 | 0.000842 | 0.000000 | 0.000842 | 0.000842 | | |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000842 | 0.000842 | 0.000000 | | | |
| 2002 | 1 | 2 | 0 | 2 | 30 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.001182 | | |
| | 0.000858 | 0.004082 | 0.004729 | 0.030523 | 0.067394 | 0.109550 | 0.110184 | 0.089225 | | |
| | 0.032782 | 0.020649 | 0.015285 | 0.008277 | 0.001182 | 0.001182 | 0.001182 | 0.001182 | | |
| | 0.000549 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | | |
| 2003 | 1 | 2 | 0 | 2 | 59 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.001776 | 0.001776 | 0.000000 | 0.001298 | | |
| | 0.001731 | 0.004760 | 0.011252 | 0.029861 | 0.055756 | 0.090991 | 0.096869 | 0.114237 | | |
| | 0.035415 | 0.020521 | 0.012118 | 0.004760 | 0.004760 | 0.002597 | 0.001298 | 0.003029 | | |
| | 0.002164 | 0.001731 | 0.000433 | 0.000433 | 0.000433 | 0.000000 | 0.000000 | | | |
| 2004 | 1 | 2 | 0 | 2 | 37 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000629 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | |
| | 0.001887 | 0.005660 | 0.005660 | 0.026415 | 0.045283 | 0.091824 | 0.114465 | 0.084277 | | |
| | 0.055975 | 0.027673 | 0.013836 | 0.005660 | 0.003774 | 0.003774 | 0.002516 | 0.003774 | | |
| | 0.002516 | 0.002516 | 0.000629 | 0.001258 | 0.000000 | 0.000000 | 0.000000 | | | |
| 2005 | 1 | 2 | 0 | 2 | 59 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000708 | | |
| | 0.001769 | 0.003184 | 0.012382 | 0.027884 | 0.070092 | 0.084983 | 0.099023 | 0.079690 | | |
| | 0.044296 | 0.032992 | 0.019167 | 0.007363 | 0.006397 | 0.004811 | 0.001921 | 0.001026 | | |
| | 0.000930 | 0.001026 | 0.000000 | 0.000354 | 0.000000 | 0.000000 | 0.000000 | | | |
| 2006 | 1 | 2 | 0 | 2 | 58 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000275 | 0.000345 | | |
| | 0.000345 | 0.002418 | 0.008245 | 0.030081 | 0.068258 | 0.096389 | 0.095571 | 0.079126 | | |
| | 0.049513 | 0.033727 | 0.020428 | 0.007464 | 0.004728 | 0.001063 | 0.000952 | 0.000725 | | |
| | 0.000345 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | | |
| 2007 | 1 | 2 | 0 | 2 | 33 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000646 | 0.000646 | | |
| | 0.001292 | 0.003231 | 0.010985 | 0.031199 | 0.076749 | 0.090177 | 0.103494 | 0.086810 | | |

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        0.048371       0.021508       0.010652       0.003821       0.002348       0.000826       0.001063       0.001939
        0.001293       0.000000       0.000000       0.002950       0.000000       0.000000       0.000000
2008    1        2         0         2            50      0.000000       0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.000210       0.000484
        0.000624       0.001240       0.009702       0.040261       0.063116       0.082498       0.085947       0.062799
        0.048606       0.026129       0.020588       0.022070       0.007610       0.009494       0.009867       0.005120
        0.000896       0.001770       0.000826       0.000000       0.000000       0.000141       0.000000
2009    1        2         0         2            45      0.000000       0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000436       0.000000       0.001966
        0.002120       0.001642       0.005961       0.024749       0.056112       0.088700       0.099248       0.074831
        0.057636       0.035001       0.022351       0.009698       0.011548       0.002358       0.001795       0.000132
        0.000750       0.002320       0.000000       0.000321       0.000324       0.000000       0.000000
2010    1        2         0         2            47      0.000000       0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.000538       0.000658
        0.001109       0.002372       0.007049       0.024862       0.064282       0.079429       0.090291       0.077094
        0.060447       0.034135       0.024087       0.017910       0.009570       0.003479       0.001480       0.000533
        0.000453       0.000000       0.000000       0.000222       0.000000       0.000000       0.000000
2011    1        2         0         2            75      0.000000       0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.000607       0.000910
        0.002711       0.002224       0.006711       0.012271       0.037318       0.066380       0.086699       0.085543
        0.070738       0.041626       0.022523       0.019404       0.015953       0.009493       0.005824       0.005190
        0.003957       0.000960       0.002196       0.000660       0.000000       0.000102       0.000000
2012    1        2         0         2            62      0.000000       0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000362       0.000000       0.000749       0.000993
        0.001724       0.002068       0.007466       0.018280       0.042035       0.069866       0.078749       0.080496
        0.057462       0.037514       0.028365       0.015743       0.014055       0.009686       0.004476       0.004332
        0.007912       0.007571       0.005113       0.001768       0.002840       0.000372       0.000000
#AT SEA
2003    1        3         0         2            66     0.000000 0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.003229       0.003229
        0.003229       0.012917       0.020452       0.045210       0.069968       0.055974       0.104413       0.155005
        0.111948       0.128095       0.134553       0.057051       0.031216       0.027987       0.026911       0.005382
        0.000000       0.000000       0.000000       0.000000       0.000000       0.003229       0.000000
2004    1        3         0         2            425          0.000000 0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.000000
        0.000933       0.001866       0.007929       0.021766       0.049129       0.136039       0.193252       0.196673
        0.161536       0.099969       0.062189       0.033271       0.017413       0.011194       0.003420       0.002332
        0.000622       0.000466       0.000000       0.000000       0.000000       0.000000       0.000000
2005    1        3         0         2            461          0.000000 0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000126       0.000315       0.000000
        0.000189       0.000504       0.004791       0.020677       0.059699       0.085986       0.156906       0.166803
        0.166992       0.133266       0.088319       0.049864       0.028998       0.019353       0.007880       0.005421
        0.001828       0.001072       0.000315       0.000504       0.000000       0.000189       0.000000
2006    1        3         0         2            305          0.000000 0.000000       0.000000       0.000000       0.000000
        0.000000       0.000000       0.000000       0.000000       0.000000       0.000000       0.001907       0.000000
```

```
        0.000000    0.000000    0.002860    0.014776    0.026692    0.040991    0.070067    0.105338
        0.138704    0.147760    0.139657    0.091992    0.078646    0.056244    0.037655    0.017636
        0.018589    0.007626    0.002860    0.000000    0.000000    0.000000    0.000000
2007    1       3       0       2       572         0.000000 0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000145    0.000145    0.000000
        0.000653    0.001089    0.005153    0.031207    0.067059    0.140939    0.174976    0.177589
        0.148777    0.109297    0.064083    0.037884    0.021192    0.010306    0.003556    0.002177
        0.002395    0.000943    0.000145    0.000145    0.000145    0.000000    0.000000
2008    1       3       0       2       893     0.000000        0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.001890    0.006931    0.020794    0.056081    0.096408    0.134216    0.159420
        0.157530    0.137366    0.102079    0.057971    0.035917    0.019534    0.009452    0.002520
        0.001260    0.000000    0.000000    0.000000    0.000000    0.000000    0.000630
2009    1       3       0       2       284     0.000000        0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.003241    0.001621    0.000000    0.003241    0.003241
        0.000000    0.011345    0.003241    0.011345    0.016207    0.029173    0.061588    0.095624
        0.116694    0.152350    0.132901    0.129660    0.090762    0.043760    0.043760    0.017828
        0.021070    0.001621    0.006483    0.001621    0.000000    0.000000    0.001621
2010    1       3       0       2       380     0.000000        0.001163    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.004651    0.004651    0.003488    0.016279    0.030233    0.074419    0.090698    0.132558
        0.126744    0.137209    0.093023    0.103488    0.077907    0.034884    0.027907    0.012791
        0.016279    0.005814    0.005814    0.000000    0.000000    0.000000    0.000000
2011    1       3       0       2       1091    0.000000        0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000504    0.001512
        0.002016    0.005040    0.009073    0.019153    0.050907    0.090222    0.127520    0.150202
        0.152722    0.127016    0.091230    0.068044    0.038306    0.027722    0.018145    0.011593
        0.003528    0.002520    0.001512    0.001008    0.000504    0.000000    0.000000
2012    1       3       0       2       591     0.000000        0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000972    0.000000    0.000000
        0.001944    0.004859    0.006803    0.028183    0.055394    0.073858    0.128280    0.142857
        0.155491    0.130224    0.093294    0.068999    0.042760    0.032070    0.014577    0.009718
        0.005831    0.000972    0.000972    0.000972    0.000000    0.000972    0.000000
#SURVEY LENGTHS
#TRIENNIAL (ENTERED 6/6 2:00
#year   season fleet  gender partition    Nsamp  U10   U12   U14   U16   U18   U20   U22   U24   U26   U28   U30
        U32   U34   U36   U38   U40   U42   U44   U46   U48   U50   U52   U54   U56   U58   U60   U62   U64
        U66   U68   U70   U72   U74   U76   U78   U80
1980    1       4       0       0           2       0.000000        0.000000    0.000000    0.679231    0.000000
        17.199796   0.000000    26.117407   17.879026   9.596842    2.716924    5.433847    7.471540
        4.754616    7.471540    0.679231    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1986    1       4       0       0       10      1.037004        0.000000    1.005463    4.151721    1.038239
        6.823992    5.265770    12.207883   6.876941    11.305032   14.618919   7.348824    8.396104
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        1.037004    0.000000    0.000000    2.098567    2.098567    4.197134    4.197134    2.098567
        3.147851    1.049284    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1989    1       4       0       0           25      0.779015    1.666042    6.220374    7.981918    15.919405
        16.628479   12.969342   9.067219    5.053114    4.430047    3.899767    1.654732    3.071238
        2.537502    0.946269    3.029772    2.434313    0.000000    0.342290    0.684580    0.684580
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1992    1       4       0       0           25      0.000000    0.139574    1.718305    13.348197   34.199217
        12.880032   11.965429   4.490229    4.999233    2.532290    3.104516    2.223139    2.208953
        2.349933    0.714847    0.000000    0.000000    0.347345    0.347345    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.694690    0.000000    0.347345    0.694690
        0.347345    0.347345    0.000000    0.000000    0.000000    0.000000    0.000000
1995    1       4       0       0           79      0.883220    0.709166    2.130459    2.952595    6.014377
        4.929590    5.558169    9.779610    9.280958    9.535970    6.013618    5.272393    1.400642
        0.994242    0.336759    1.355588    4.452141    7.177413    8.104547    6.681765    3.741311
        1.948442    0.258539    0.266720    0.113285    0.054456    0.054024    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
1998    1       4       0       0           75      0.000000    0.936136    2.242415    3.227967    3.997000
        11.409846   14.601500   9.552928    8.402164    3.924467    3.903377    2.276186    3.208215
        1.716053    0.781392    0.980639    1.911150    5.752133    6.557138    6.457474    5.192346
        1.531845    1.129806    0.000000    0.000000    0.000000    0.307823    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
2001    1       4       0       0           67      2.573861    2.121620    2.714956    8.232089    8.293387
        1.801042    4.461676    7.707757    8.208384    12.408517   4.437424    10.197315   1.206840
        0.545054    1.459650    1.377190    0.990465    2.485814    4.201594    4.254358    3.239166
        2.566250    1.553097    1.106740    0.277306    0.585942    0.091582    0.375176    0.092984
        0.092206    0.000000    0.113519    0.113519    0.113519    0.000000    0.000000
2004    1       4       0       0           48      0.385801    0.781178    3.201205    6.021791    7.505544
        20.175758   22.261066   13.487314   11.458220   3.019538    1.901897    0.926039    0.860373
        0.000000    1.023423    0.925499    0.184123    0.302318    0.873389    1.117653    0.496476
        0.665376    0.665288    0.794146    0.218386    0.450440    0.297761    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
#AKFSC SLOPE (ENTERED 6/6  2:00)


#year season  fleet  gender partition    Nsamp  U10   U12   U14   U16   U18   U20   U22   U24   U26   U28   U30
        U32   U34   U36   U38   U40   U42   U44   U46   U48   U50   U52   U54   U56   U58   U60   U62   U64
        U66   U68   U70   U72   U74   U76   U78   U80
1997  1         5       0       0           10      0.000000 0.000000    0.000000    0.000000    0.000000
        0.000000    3.201643    0.000000    0.000000    3.201643    3.219507    16.795836   9.895573
        3.201643    6.948846    6.688354    13.612089   10.155334   13.124894   0.000000    0.000000
        9.954640    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
        0.000000    0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
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1999  1         5       0       0            11      0.000000 0.000000     0.000000     0.000000     0.000000
      0.000000     14.369710    8.405715     3.619802     0.000000     0.000000     10.408359    0.000000
      3.180497     13.347027    6.648434     3.201815     14.479210    6.666019     3.619802     5.618456
      3.115095     3.320059     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2000  1         5       0       0            13      0.000000 0.000000     0.000000     0.000000     0.000000
      1.443730     0.000000     0.000000     1.854904     0.798651     7.986508     10.382461    10.382461
      16.185168    16.591995    11.136805    4.563197     1.597302     5.760357     3.508510     3.150192
      3.130273     0.000000     0.519974     0.503578     0.000000     0.000000     0.000000     0.503935
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2001  1         5       0       0            10      0.000000 0.000000     0.000000     0.000000     0.000000
      0.000000     0.967170     2.043320     3.868678     1.934339     2.043320     12.695846    11.728676
      10.761507    8.609205     11.534117    8.305665     3.879827     7.108279     5.919308     6.679387
      0.967170     0.954188     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
#NWFSC COMBO
#year   Season  Fleet   gender  partition   nSamps  U10     U12    U14    U16    U18    U20    U22    U24    U26    U28
      U30    U32    U34    U36    U38    U40    U42    U44    U46    U48    U50    U52    U54    U56    U58    U60    U62
      U64    U66    U68    U70    U72    U74    U76    U78    U80
2003    1       7       0       0            34      0.000000       0.000000      0.000000      4.672809      5.191895
      18.651802    16.140644    16.340116    10.463924    1.906190     0.000000     2.269377     0.671420
      0.000000     0.745805     0.745805     1.378481     2.084852     3.968508     4.131994     4.114978
      3.657861     0.000000     0.000000     1.915387     0.948151     0.000000     0.000000     0.000000
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2004    1       7       0       0            27      0.000000       0.000000      0.000000      1.005863      0.886000
      2.639455     4.577936     2.839198     3.664543     0.000000     0.000000     0.801781     0.626453
      0.712883     0.712883     0.886000     5.725865     5.707150     7.608200     9.262889     9.556975
      5.744325     6.999527     2.936773     4.359987     3.531920     2.557448     3.110570     1.656135
      4.766705     4.565090     0.828068     1.729380     0.000000     0.000000     0.000000
2005    1       7       0       0            27      0.000000       0.000000      0.370379      1.859708      2.968929
      4.308524     2.873074     5.103006     5.521933     2.153693     1.448855     1.296066     0.470789
      0.493873     0.000000     0.408990     2.434996     5.269148     8.604730     12.390500    14.073921
      11.057375    7.463005     3.135796     5.122415     0.390098     0.780197     0.000000     0.000000
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2006    1       7       0       0            35      0.000000       1.345818      0.918467      1.879533      3.858781
      9.962854     4.200798     4.073135     12.122676    9.950237     6.214370     8.912926     2.030802
      0.000000     0.985486     1.252615     1.252615     4.313809     3.450423     0.916839     8.013724
      4.151280     3.014932     1.954693     1.037854     0.000000     1.190751     1.037854     1.956728
      0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2007    1       7       0       0            37      0.000000       5.881370      4.794095      1.947722      4.878857
      2.627157     6.155949     9.884856     7.551230     11.626345    11.436975    2.292439     2.493897
      0.000000     2.878158     1.014004     2.707591     1.527944     2.681028     3.363298     5.409660
      1.779393     3.381355     0.834333     0.000000     0.000000     1.735520     0.000000     0.000000
      0.000000     0.000000     1.116822     0.000000     0.000000     0.000000     0.000000
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2008   1      7      0      0          36     0.000000     0.000000     0.000000     6.882140     5.245077
       1.896444     4.817969     7.197912     6.959181     6.003775     7.533971     9.865733     3.597507
       3.337403     2.354706     0.634925     4.989923     3.535440     3.778638     6.608149     0.852524
       6.350339     3.795906     0.000000     0.725491     1.568355     0.000000     0.000000     0.783453
       0.000000     0.685038     0.000000     0.000000     0.000000     0.000000     0.000000
2009   1      7      0      0          27     0.000000     0.000000     0.000000     0.000000     0.000000
       0.664477     0.883817     5.204417     5.275570     6.184757     2.011306     7.324009     2.490348
       3.129339     1.872921     0.000000     3.298053     3.301397     10.378044    11.383409    8.154779
       7.620614     7.030172     3.479798     4.931338     3.456965     1.280866     0.000000     0.643604
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000
2010   1      7      0      0          29     0.000000     0.000000     1.106526     3.919339     1.305678
       0.000000     4.517123     6.029688     6.422396     2.402494     2.403811     3.176223     3.257200
       5.207077     8.017749     5.264847     5.427296     4.557282     6.423713     10.489864    7.014749
       3.400557     2.259467     2.278559     2.115452     2.068709     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.934203
2011   1      7      0      0          28     0.000000     0.000000     0.000000     0.000000     0.986883
       2.762479     0.000000     1.060815     0.000000     2.221782     5.442641     4.373137     7.177232
       8.725238     4.780299     2.141904     4.596764     7.199335     3.448297     5.176790     10.325074
       8.542161     6.478762     3.878172     3.462931     3.450431     0.589325     1.626817     0.000000
       0.589325     0.963407     0.000000     0.000000     0.000000     0.000000     0.000000
2012   1      7      0      0          22     0.000000     0.000000     0.000000     5.338821     0.000000
       12.076144    7.905387     8.864351     7.918872     1.762765     8.660541     1.891127     6.019039
       2.462101     3.713636     1.641401     1.891127     5.143716     3.104767     3.645528     5.545361
       4.065096     4.121255     0.000000     0.000000     4.228963     0.000000     0.000000     0.000000
       0.000000     0.000000     0.000000     0.000000     0.000000     0.000000     0.000000

100 #_N_age_bins
1      2      3      4      5      6      7      8      9      10     11     12     13     14     15     16     17     18
       19     20     21     22     23     24     25     26     27     28     29     30     31     32     33     34     35
       36     37     38     39     40     41     42     43     44     45     46     47     48     49     50     51     52
       53     54     55     56     57     58     59     60     61     62     63     64     65     66     67     68     69
       70     71     72     73     74     75     76     77     78     79     80     81     82     83     84     85     86
       87     88     89     90     91     92     93     94     95     96     97     98     99     100
1 #_N_ageerror_definitions
0.5    1.5    2.5    3.5    4.5    5.5    6.5    7.5    8.5    9.5    10.5   11.5   12.5   13.5   14.5   15.5   16.5   17.5
       18.5   19.5   20.5   21.5   22.5   23.5   24.5   25.5   26.5   27.5   28.5   29.5   30.5   31.5   32.5   33.5   34.5
       35.5   36.5   37.5   38.5   39.5   40.5   41.5   42.5   43.5   44.5   45.5   46.5   47.5   48.5   49.5   50.5   51.5
       52.5   53.5   54.5   55.5   56.5   57.5   58.5   59.5   60.5   61.5   62.5   63.5   64.5   65.5   66.5   67.5   68.5
       69.5   70.5   71.5   72.5   73.5   74.5   75.5   76.5   77.5   78.5   79.5   80.5   81.5   82.5   83.5   84.5   85.5
       86.5   87.5   88.5   89.5   90.5   91.5   92.5   93.5   94.5   95.5   96.5   97.5   98.5   99.5   100.5  101.5  102.5
       103.5  104.5  105.5  106.5  107.5  108.5  109.5  110.5  111.5  112.5  113.5  114.5  115.5  116.5  117.5  118.5  119.5
       120.5  121.5  122.5  123.5  124.5  125.5  126.5  127.5  128.5  129.5  130.5  131.5  132.5  133.5  134.5  135.5  136.5
       137.5  138.5  139.5  140.5
0.0872932    0.0872932    0.253723     0.418989     0.5831 0.746065     0.90789      1.06858      1.22816
       1.38661      1.54396      1.70021      1.85536      2.00944      2.16243      2.31436      2.46522
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	2.61503	2.7638	2.91152	3.05821	3.20387	3.34852	3.49216	3.63479	3.77643
	3.91707	4.05673	4.19542	4.33314	4.46989	4.60569	4.74054	4.87445
	5.00742	5.13946	5.27058	5.40078	5.53008	5.65847	5.78596	5.91256
	6.03827	6.16311	6.28708	6.41017	6.53241	6.6538	6.77433	6.89402	7.01288
	7.13091	7.24811	7.36449	7.48006	7.59482	7.70878	7.82194	7.93431
	8.04589	8.1567	8.26673	8.37599	8.48449	8.59223	8.69922	8.80546	8.91096
	9.01571	9.11974	9.22304	9.32562	9.42748	9.52863	9.62907	9.72882
	9.82786	9.92621	10.0239	10.1209	10.2172	10.3128	10.4078	10.502	10.5957
	10.6887	10.781	10.8727	10.9637	11.0542	11.1439	11.2331	11.3216	11.4095
	11.4968	11.5835	11.6696	11.7551	11.84	11.9242	12.0079	12.0911	12.1736
	12.2555	12.3369	12.4177	12.498	12.5777	12.6568	12.7354	12.8134	12.8909
	12.9679	13.0443	13.1201	13.1955	13.2703	13.3446	13.4184	13.4916
	13.5644	13.6366	13.7083	13.7796	13.8503	13.9205	13.9903	14.0595
	14.1283	14.1966	14.2644	14.3318	14.3986	14.465	14.531	14.5965	14.6615
	14.7261	14.7902	14.8538	14.9171

310 #_N_Agecomp_obs
3 #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
0 #_combine males into females at or below this bin number
#year	Season	Fleet	gender	partition	AgeErr	LbinLo	LbinHi	nSamps	U1	U2	U3	U4	U5	U6	U7	U8
	U9	U10	U11	U12	U13	U14	U15	U16	U17	U18	U19	U20	U21	U22	U23	U24	U25
	U26	U27	U28	U29	U30	U31	U32	U33	U34	U35	U36	U37	U38	U39	U40	U41	U42
	U43	U44	U45	U46	U47	U48	U49	U50	U51	U52	U53	U54	U55	U56	U57	U58	U59
	U60	U61	U62	U63	U64	U65	U66	U67	U68	U69	U70	U71	U72	U73	U74	U75	U76
	U77	U78	U79	U80	U81	U82	U83	U84	U85	U86	U87	U88	U89	U90	U91	U92	U93
	U94	U95	U96	U97	U98	U99	U100	U101	U102	U103	U104	U105	U106	U107	U108	U109	U110
	U111	U112	U113	U114	U115	U116	U117	U118	U119	U120	U121	U122	U123	U124	U125	U126	U127
	U128	U129	U130	U131	U132	U133	U134	U135	U136	U137	U138	U139	U140
#Commercial TWL AatL
2008	1	1	1	0	1	38	38	2	0	0	0	0	0	0	0	0	0
	0	0	0	50	0	0	50	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0
2008	1	1	1	0	1	40	40	4	0	0	0	0	0	0	0	0	0
	25	0	0	0	0	25	0	25	25	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0
2008	1	1	1	0	1	42	42	20	0	0	0	0	0	0	0	0	0
	0	5	0	5	15	10	15	15	5	15	0	5	5	5	0	0	0
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2008 1 1 1 0 1 48 48 60 0 0 0 0 0 0 0 0 0
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3.333333333 10 3.333333333 1.666666667 3.333333333 5 3.333333333 1.666666667 5 5
11.66666667 0 0 0 3.333333333 1.666666667 0 0 1.666666667 1.666666667 0 0
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2008 1 1 1 0 1 60 60 6 0 0 0 0 0 0 0 0 0
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| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2008 | 1 | 1 | 1 | 0 | 1 | 66 | 66 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33.33333333 | | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 33.33333333 | | 0 | 0 | 0 | 0 | 0 | 0 | 33.33333333 | | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | |
| 2008 | 1 | 1 | 1 | 0 | 1 | 68 | 68 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 28 | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 32 | 32 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 34 | 34 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 36 | 36 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 16.66666667 | | 0 | 16.66666667 | | 0 | 0 | 16.66666667 | | 33.33333333 | | 0 | 0 | 0 | 0 | 16.66666667 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1 | 1 | 1 | 0 | 1 | 38 | 38 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 40 | 40 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 42 | 42 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 10 | 10 | 10 | 5 | 0 | 5 | 0 | 10 | 10 | 0 | 0 | 0 | 5 | 10 |
| | 5 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 44 | 44 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 3.125 | 0 | 3.125 | 0 | 3.125 | 3.125 | 12.5 | 0 | 6.25 | 6.25 | 6.25 | 6.25 | 6.25 | 0 | 0 |
| | 3.125 | 3.125 | 3.125 | 0 | 3.125 | 12.5 | 3.125 | 0 | 3.125 | 3.125 | 3.125 | 0 | 0 | 0 | 3.125 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 3.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 46 | 46 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 2.5 | 5 | 5 | 5 | 10 | 10 | 2.5 | 2.5 | 5 | 7.5 |
| | 5 | 2.5 | 2.5 | 0 | 2.5 | 2.5 | 5 | 0 | 0 | 0 | 2.5 | 2.5 | 2.5 | 0 | 0 | 0 | 2.5 |
| | 0 | 0 | 0 | 0 | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 48 | 48 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 1.515151515 | 0 | 0 | 3.03030303 | 1.515151515 | 6.060606061 | 4.545454545 | | | | | |
| | 7.575757576 | 1.515151515 | 7.575757576 | 4.545454545 | 4.545454545 | 9.090909091 | 6.060606061 | 0 | 4.545454545 | | | | | | | | |
| | 3.03030303 | 1.515151515 | 7.575757576 | 4.545454545 | 0 | 6.060606061 | 0 | 0 | 1.515151515 | 0 | 0 | | | | | | |
| | 0 | 0 | 0 | 1.515151515 | 0 | 1.515151515 | 3.03030303 | 0 | 0 | 1.515151515 | 0 | 0 | 0 | | | | |
| | 0 | 0 | 1.515151515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.515151515 | 0 | 0 | | |
| | 0 | 0 | 1.515151515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.515151515 | 0 | 0 | 0 | 0 | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 2011 | 1 | 1 | 1 | 0 | 1 | 50 | 50 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 2.325581395 | 0 | 0 | 0 | 2.325581395 | 4.651162791 | 2.325581395 | | | | | |

6.976744186 0 4.651162791 11.62790698 0 9.302325581 2.325581395 2.325581395 4.651162791
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2011 1 1 1 0 1 54 54 32 0 0 0 0 0 0 0 0 0
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2011 1 1 1 0 1 56 56 27 0 0 0 0 0 0 0 0 0
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2011 1 1 1 0 1 60 60 16 0 0 0 0 0 0 0 0 0
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2011	1	1	1	0	1	62	62	9	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	11.11111111	0	0	0	0	0	0	0	0	0	0	0
	0	11.11111111	11.11111111	11.11111111	0	0	11.11111111	0	0	0	0	0	0
	0	0	0	11.11111111	0	0	0	0	0	0	0	0	0	0	0
	11.11111111	0	0	0	0	0	0	0	0	0	0	0	22.22222222
2011	1	1	1	0	1	64	64	11	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	9.090909091	0	0	0	0	0	0	0
	9.090909091	0	9.090909091	0	0	9.090909091	9.090909091	0	0	0	0	0	0
	0	0	9.090909091	0	0	0	9.090909091	0	0	9.090909091	0	0	0	0
	0	0	9.090909091	0	0	0	0	9.090909091	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.090909091
2011	1	1	1	0	1	66	66	6	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66666667	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66666667	0
	0	0	0	0	0	0	0	0	0	0	0	0	16.66666667	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.66666667	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	33.33333333
2011	1	1	1	0	1	68	68	4	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	25	0	25
2011	1	1	1	0	1	70	70	2	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0
#AtSeaAatL
2008	1	3	1	0	1	38	38	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0
2008	1	3	1	0	1	40	40	4	0	0	0	0	0	0	0	0	0
	0	0	50	0	25	25	0	0	0	0	0	0	0	0	0	0	0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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2008 1 3 1 0 1 42 42 16 0 0 0 0 0 0 0 0 6.25
0 0 6.25 6.25 6.25 6.25 6.25 6.25 43.75 6.25 6.25 0 0 0 0 0 0
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2008 1 3 1 0 1 44 44 36 0 0 0 0 0 0 0 0 0
0 5.555555556 0 5.555555556 5.555555556 8.333333333 5.555555556 11.11111111 16.66666667
8.333333333 5.555555556 5.555555556 8.333333333 2.777777778 8.333333333 0 0 0 2.777777778
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2008 1 3 1 0 1 46 46 54 0 0 0 0 0 0 0 0 0
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9.259259259 5.555555556 5.555555556 1.851851852 3.703703704 1.851851852 1.851851852 5.555555556
7.407407407 1.851851852 0 1.851851852 1.851851852 3.703703704 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0
2008 1 3 1 0 1 48 48 74 0 0 0 0 0 0 0 0 0
0 1.351351351 0 1.351351351 1.351351351 0 8.108108108 4.054054054 2.702702703 5.405405405
5.405405405 4.054054054 2.702702703 6.756756757 4.054054054 5.405405405 4.054054054 8.108108108
4.054054054 5.405405405 4.054054054 1.351351351 0 1.351351351 2.702702703 4.054054054 2.702702703
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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2008 1 3 1 0 1 50 50 87 0 0 0 0 0 0 0 0 0
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1.149425287 3.448275862 3.448275862 4.597701149 5.747126437 3.448275862 6.896551724 2.298850575
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3.448275862 0 1.149425287 0 0 1.149425287 0 1.149425287 0 1.149425287 0 0
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1.149425287
2008 1 3 1 0 1 52 52 80 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1.25 1.25 0 1.25 3.75 1.25 2.5 5 3.75 1.25
5 3.75 3.75 5 6.25 3.75 1.25 5 1.25 1.25 5 3.75 1.25 5 2.5 0 1.25
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2008 1 3 1 0 1 54 54 67 0 0 0 0 0 0 0 0 0
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2.985074627 4.47761194 0 1.492537313 1.492537313 1.492537313 0 0 0 1.492537313
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2008 1 3 1 0 1 56 56 64 0 0 0 0 0 0 0 0 0
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1.5625 4.6875 0 0 1.5625 0 3.125 1.5625 0 1.5625 4.6875 1.5625 3.125 1.5625 1.5625 4.6875 0
0 0 0 3.125 3.125 3.125 1.5625 3.125 4.6875 1.5625 0 0 1.5625 3.125 1.5625 0 3.125
1.5625 0 4.6875 1.5625 0 1.5625 3.125 3.125 0 1.5625 1.5625 0 1.5625 0 0 0 1.5625
0 0 0 0 0 0 0 1.5625 0 0 1.5625 0 1.5625 0 0 1.5625 0
0 0 0 0 0 3.125
2008 1 3 1 0 1 58 58 36 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 2.777777778 0 0 0 0 8.333333333 5.555555556 2.777777778 2.777777778 2.777777778
0 2.777777778 0 2.777777778 2.777777778 0 0 2.777777778 2.777777778 5.555555556
2.777777778 2.777777778 0 2.777777778 0 2.777777778 0 2.777777778 0 5.555555556
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0 0 0 0 0 0 0 2.777777778 0 0 0 0 0 0 0 0
2.777777778
2008 1 3 1 0 1 60 60 19 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 10.52631579 0 0 0 10.52631579 0 5.263157895 0
0 5.263157895 0 0 0 5.263157895 0 0 0 0 5.263157895 5.263157895 0
0 0 5.263157895 10.52631579 0 5.263157895 0 0 0 0 0 0 0 0
5.263157895 0 0 5.263157895 5.263157895 0 0 5.263157895 0 0 0 0
5.263157895 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 5.263157895 0 0 0
2008 1 3 1 0 1 62 62 7 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

```
      0  0  0  0  0  0  14.28571429  0  0  0  0  14.28571429  0  0  0
      0  0  14.28571429  0  0  0  0  0  14.28571429  0  14.28571429  0  0  0
      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  14.28571429  14.28571429
2008  1  3  1  0  1  64  64  6  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
      16.66666667  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  16.66666667  16.66666667  0  0  0  0  0
      0  0  0  16.66666667  0  0  0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0  0  16.66666667  0  0  0  0
      0  0  0  0  0  16.66666667  0  0  0  0  0
2008  1  3  1  0  1  66  66  2  0  0  0  0  0  0  0  0  0
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2008  1  3  1  0  1  68  68  1  0  0  0  0  0  0  0  0  0
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      100  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
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      0  0  0  0  0  0
2008  1  3  1  0  1  80  80  1  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
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      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  100
#2011 1  3  1  0  1  34  34  1  0  0  0  0  0  0  0  0  0
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2011  1  3  1  0  1  36  36  1  0  0  0  0  0  0  0  0  100
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      0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
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2011 1 3 1 0 1 38 38 1 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2011 1 3 1 0 1 40 40 5 0 0 0 0 0 0 0 0 20
0 40 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2011 1 3 1 0 1 42 42 13 0 0 0 0 0 0 0 0 0
7.692307692 30.76923077 7.692307692 0 7.692307692 7.692307692 7.692307692 0 7.692307692
7.692307692 0 7.692307692 0 7.692307692 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2011 1 3 1 0 1 44 44 28 0 0 0 0 0 0 0 0 0
0 0 3.571428571 0 14.28571429 7.142857143 10.71428571 7.142857143 0 3.571428571
7.142857143 28.57142857 7.142857143 3.571428571 3.571428571 3.571428571 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
2011 1 3 1 0 1 46 46 45 0 0 0 0 0 0 0 0 0
0 0 0 6.666666667 0 4.444444444 8.888888889 13.33333333 4.444444444 8.888888889
4.444444444 8.888888889 6.666666667 8.888888889 6.666666667 4.444444444 6.666666667 2.222222222 0
0 0 0 0 0 0 0 2.222222222 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2011 1 3 1 0 1 48 48 63 0 0 0 0 0 0 0 0 0
0 1.587301587 0 0 1.587301587 1.587301587 3.174603175 1.587301587 7.936507937 0
6.349206349 9.523809524 14.28571429 7.936507937 9.523809524 3.174603175 6.349206349 9.523809524
1.587301587 0 1.587301587 1.587301587 1.587301587 1.587301587 1.587301587 1.587301587 0 0
0 1.587301587 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 1.587301587 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2011 1 3 1 0 1 50 50 67 0 0 0 0 0 0 0 0 0
0 0 0 0 1.492537313 1.492537313 2.985074627 1.492537313 2.985074627 0 8.955223881
11.94029851 1.492537313 10.44776119 7.462686567 1.492537313 2.985074627 4.47761194 1.492537313
2.985074627 0 2.985074627 4.47761194 4.47761194 0 1.492537313 2.985074627 1.492537313
1.492537313 0 2.985074627 0 0 0 1.492537313 1.492537313 0 0 1.492537313 0
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2011 1 3 1 0 1 52 52 76 0 0 0 0 0 0 0 0 0
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1.315789474 1.315789474 5.263157895 5.263157895 5.263157895 1.315789474 2.631578947 1.315789474
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2011 1 3 1 0 1 54 54 60 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1.666666667 0 1.666666667 0 3.333333333 0 1.666666667 0
3.333333333 0 5 1.666666667 5 0 3.333333333 3.333333333 1.666666667 8.333333333
3.333333333 1.666666667 1.666666667 3.333333333 0 1.666666667 1.666666667 3.333333333 5 0
0 3.333333333 0 0 5 1.666666667 0 1.666666667 0 1.666666667 1.666666667 0
0 0 0 0 1.666666667 1.666666667 3.333333333 1.666666667 3.333333333 1.666666667
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2011 1 3 1 0 1 56 56 54 0 0 0 0 0 0 0 0 0
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2011 1 3 1 0 1 58 58 39 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 2.564102564 0 0 2.564102564
0 2.564102564 0 0 0 2.564102564 0 0 2.564102564 2.564102564 0 0
5.128205128 5.128205128 5.128205128 0 0 2.564102564 2.564102564 2.564102564 2.564102564 0
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0 0 5.128205128 0 0 0 0 0 0 2.564102564 0 0 0 2.564102564

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0 0 0 5.128205128
2011 1 3 1 0 1 60 60 19 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 5.263157895 0 5.263157895 0 0 0 0 0 0 0 0 0 0 0
5.263157895 0 5.263157895 10.52631579 0 0 0 5.263157895 0 5.263157895 0
5.263157895 5.263157895 0 5.263157895 0 5.263157895 0 0 10.52631579 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 5.263157895 0
0 0 5.263157895 0 5.263157895
2011 1 3 1 0 1 62 62 18 0 0 0 0 0 0 0 0 0
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0 0 0 5.555555556 0 0 0 5.555555556 0 11.11111111 0 0 11.11111111
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0 0 0 5.555555556
2011 1 3 1 0 1 64 64 10 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 10 0 0
10 0 0 0 10 0 0 0 0 0 10 0 10 0 0 10 0
0 0 0 0 0 0 0 0 0 0 0 0 10 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 10 0 0 0 0 0
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0 0 0 0 0 0
2011 1 3 1 0 1 68 68 2 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 50 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 50 0 0 0 0
2011 1 3 1 0 1 70 70 2 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 50 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 50 0 0 0 0 0 0 0 0 0

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      0     0     0     0     0     0
#NWFSC age-at-length
2003  1     7     1     0     1     16    16    6     0.00  0.00  66.67 16.67 16.67 0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
2003  1     7     1     0     1     18    18    4     0.00  0.00  50.00 50.00 0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
2003  1     7     1     0     1     20    20    13    0.00  0.00  0.00  100.00 0.00 0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
2003  1     7     1     0     1     22    22    13    0.00  0.00  7.69  84.62 7.69  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
2003  1     7     1     0     1     24    24    6     0.00  0.00  0.00  50.00 33.33 0.00  0.00  0.00  16.67
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
2003  1     7     1     0     1     26    26    4     0.00  0.00  0.00  0.00  50.00 25.00 25.00 0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
      0.00  0.00  0.00  0.00  0.00  0.00
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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 |
| | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2003 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 2 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 1 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 3 | 0.00 | 0.00 | 0.00 | 33.33 | 66.67 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 75.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 66.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2004 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 |
| | 12.50 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 25.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 |
| | 16.67 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 64 | 64 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 68 | 68 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 70 | 70 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | | | | | | | | | | | |
| 2004 | 1 | 7 | 1 | 0 | 1 | 74 | 74 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 14 | 14 | 1 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 5 | 0.00 | 0.00 | 20.00 | 80.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 8 | 0.00 | 0.00 | 0.00 | 62.50 | 37.50 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 9 | 0.00 | 0.00 | 0.00 | 44.44 | 33.33 | 22.22 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 33.33 | 16.67 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2005 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 58.33 | 8.33 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 46.15 | 23.08 | 15.38 | 7.69 |
| | 0.00 | 0.00 | 7.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 40.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.67 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.67 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 11.11 | 0.00 | 11.11 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 11.11 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 22.22 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 7.14 | 0.00 | 7.14 | 0.00 | 0.00 |
| | 14.29 | 14.29 | 7.14 | 0.00 | 0.00 | 7.14 | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.14 | 0.00 | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 8.33 |
| | 16.67 | 0.00 | 16.67 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 8.33 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.09 | 18.18 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.09 | 9.09 | 0.00 | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.18 | 0.00 |
| | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 12.50 | 0.00 |
| | 12.50 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 12.50 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2005 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 12 | 12 | 2 | 0.00 | 50.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2006 | 1 | 7 | 1 | 0 | 1 | 14 | 14 | 1 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 2 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 75.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 10 | 0.00 | 0.00 | 0.00 | 10.00 | 50.00 | 30.00 | 10.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 4 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 25.00 | 0.00 | 25.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 50.00 | 25.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 58.33 | 0.00 | 8.33 |
| | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 62.50 | 37.50 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 60.00 | 0.00 | 0.00 |
| | 0.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.22 | 11.11 | 11.11 |
| | 22.22 | 22.22 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 |
| | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 14.29 | 0.00 | 14.29 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |

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| 2006 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 64 | 64 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2006 | 1 | 7 | 1 | 0 | 1 | 66 | 66 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 12 | 12 | 6 | 0.00 | 66.67 | 16.67 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 14 | 14 | 5 | 0.00 | 20.00 | 80.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 2 | 0.00 | 0.00 | 50.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 5 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 33.33 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 16.67 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 50.00 | 30.00 | 0.00 |
| | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 28.57 | 28.57 | 28.57 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.38 | 30.77 | 38.46 |
| | 0.00 | 15.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 33.33 | 16.67 |
| | 16.67 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 |
| | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 33.33 |
| | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2007 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 0.00 |
| | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 33.33 | 16.67 |
| | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2007 | 1 | 7 | 1 | 0 | 1 | 72 | 72 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 10 | 10 | 1 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 7 | 0.00 | 0.00 | 85.71 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 5 | 0.00 | 0.00 | 40.00 | 40.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 3 | 0.00 | 0.00 | 33.33 | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 60.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 37.50 | 25.00 | 0.00 |
| | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 37.50 | 0.00 |
| | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 57.14 | 14.29 |
| | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2008 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 44.44 |
| | 22.22 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 27.27 |
| | 9.09 | 54.55 | 0.00 | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 |
| | 0.00 | 25.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 75.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 66.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 14.29 | 14.29 | 0.00 | 0.00 | 0.00 | 14.29 | 14.29 | 14.29 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 11.11 | 11.11 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 11.11 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 |
| | 0.00 | 12.50 | 12.50 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | | | | | | | | | | | |
| 2008 | 1 | 7 | 1 | 0 | 1 | 66 | 66 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2008 | 1 | 7 | 1 | 0 | 1 | 70 | 70 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2009 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 20.00 | 20.00 | 20.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 40.00 | 20.00 | 20.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 20.00 | 20.00 |
| | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 |
| | 0.00 | 37.50 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 33.33 | 0.00 | 0.00 | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 |
| | 25.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 16.67 |
| | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 12.50 | 12.50 | 0.00 | 12.50 | 0.00 |
| | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| 2009 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.57 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 |
| | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 0.00 | 0.00 |
| | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 10.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2009 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2009 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |

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| 2009 | 1 | 7 | 1 | 0 | 1 | 66 | 66 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 14 | 14 | 1 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 3 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 1 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 25.00 | 0.00 | 0.00 |
| | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 40.00 | 0.00 | 40.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 60.00 | 0.00 | 20.00 | 20.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 |
| | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 |
| | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 |
| | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 40.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.57 |
| | 0.00 | 28.57 | 14.29 | 0.00 | 14.29 | 0.00 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 20.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 0.00 | 0.00 | 25.00 | 0.00 | 25.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 11.11 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 16.67 | 16.67 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2010 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2010 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2010 | 1 | 7 | 1 | 0 | 1 | 80 | 80 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 18 | 18 | 1 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 2 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2011 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 50.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 80.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 |
| | 0.00 | 25.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 16.67 |
| | 33.33 | 16.67 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 37.50 | 0.00 | 37.50 | 12.50 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 |
| | 0.00 | 0.00 | 50.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 50.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 33.33 | 0.00 | 11.11 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| 2011 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 16.67 | 16.67 | 0.00 | 0.00 |
| | 0.00 | 16.67 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 0.00 | 0.00 |
| | 8.33 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 |
| | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 |
| | 11.11 | 11.11 | 0.00 | 11.11 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 |
| | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 56 | 56 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.67 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 16.67 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 58 | 58 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 62 | 62 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 64 | 64 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 68 | 68 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2011 | 1 | 7 | 1 | 0 | 1 | 70 | 70 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 10 | 10 | 2 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 16 | 16 | 2 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 20 | 20 | 8 | 0.00 | 0.00 | 0.00 | 75.00 | 12.50 | 12.50 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 22 | 22 | 5 | 0.00 | 0.00 | 0.00 | 60.00 | 20.00 | 0.00 | 20.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 24 | 24 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 75.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 26 | 26 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 60.00 | 0.00 | 20.00 | 20.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 28 | 28 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 30 | 30 | 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.67 | 0.00 |
| | 16.67 | 0.00 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |

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| 2012 | 1 | 7 | 1 | 0 | 1 | 32 | 32 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 34 | 34 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 20.00 |
| | 0.00 | 0.00 | 20.00 | 0.00 | 20.00 | 20.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 36 | 36 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 38 | 38 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 25.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 40 | 40 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 50.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 42 | 42 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 44 | 44 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 60.00 | 0.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

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| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 46 | 46 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 33.33 | 33.33 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 48 | 48 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 25.00 | 0.00 | 0.00 | 50.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 50 | 50 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 0.00 | 20.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 52 | 52 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 54 | 54 | 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | |
| 2012 | 1 | 7 | 1 | 0 | 1 | 60 | 60 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 33.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

```
      0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
      0.00   0.00   0.00   0.00   0.00   0.00
#NWFSC COMBO MARGINAL AGE COMPS
2003  1      -7     0      0      1      -1     -1     1      0      0      11.43890062  56.90658599  11.42682668
      2.251210007  2.251210007  2.251210007  1.672125095  2.251210007  2.750885519  0      1.299225991  0      0
      1.271943522  1.129262015  0      0      0      0      0      0      0      0      0      0      0      0      0
      0      0      1.513190203  0      0      0      0      1.586214343  0      0      0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
      0      0      0      0
2004  1      -7     0      0      1      -1     -1     1      0      0      1.005857863  1.692110855  12.13009798
      0.78484816   0      0      0.626449366  0      0.801776925  0      0.885995403  2.156503453  1.256556706
      0.712879642  0.626449366  0      3.59128007   0      0      2.804985734  1.209173179  0      5.870283127  0
      2.069988107  3.987702401  0      3.865202796  0      3.01646769   2.159565943  1.981090825  3.01646769
      3.68962003   0.901307853  1.706232338  0      3.917775543  0.901307853  3.917775543  0.990205136  1.079782972
      0      1.079782972  0      1.706232338  0      0.901307853  3.01646769   3.01646769   0      0      0      0
      0      0.901307853  0      0      0      0      0      0      0      0      3.01646769   0      0      0      0
      0      0      0.626449366  0      0      0      0      0      0      0      0      0      0      0      0      0
      0      0.626449366  0      0      0      0      0      0      0      0.901307853  0      0      10.85201878
2005  1      -7     0      0      1      -1     -1     1      0      0      0.727867658  5.236061409  5.499507785
      8.614955266  4.948651248  1.640820628  0.49076592   0.370377655  0.493871378  0.45701994   0.49076592
      0.98153184   0.49076592   0.961553392  0.49076592   0      0.817253098  0.947320041  0      0.891111247
      0.354022241  4.050293932  0.424309113  0.891111247  1.774148302  0.896287011  1.816434292  3.503319217
      0.851464896  1.657693618  0.424309113  3.91800141   0.434557125  0.350968541  3.068762092  0.434557125
      3.068762092  3.937876343  0.434557125  7.41381577   0.434557125  3.559528012  0      0      0.424309113
      0.346103323  0      0.434557125  3.503319217  0      9.206286276  0      0      0.434557125  0      0.434557125
      0      0      0      0.467785529  0      3.068762092  0      0      0      0      0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      0.360698977  0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      3.068762092
2006  1      -7     0      0      1      -1     -1     1      0      0      1.930142071  4.229028512  8.002078427
      8.967352964  20.97786448  5.494806647  4.69816686   3.115469355  5.300123729  0.966359877  1.068924536  0
      2.717149462  1.025103921  0      1.358574731  0.994443058  0      0      0      1.358574731  0      0      0
      2.030943052  0      2.554619751  2.214772567  0      0      0      0      0      1.19604502   1.19604502   0
      0      1.19604502   1.19604502   1.19604502   0      0      2.39209004   1.19604502   0.994443058  1.19604502
      1.19604502   0      0      0      0      0      0      0      0      0      0      1.068924536  0      1.19604502
      0      1.190753986  0      2.192794426  1.19604502   0      0      0      0      0      0      0      0      0
      0      0      0      0      0      0      0      0      0      0      0      0      1.19604502   0      0      0
      0      0      0      0      0      0      0      0
2007  1      -7     0      0      1      -1     -1     1      0      5.244669151  5.93604921   6.12437678   2.01325456
      5.52895126   12.44931795  17.18705464  8.862588027  3.695368962  3.674327609  0.854786311  0      1.014014138
      0.940294788  2.665834961  0      0      0.798377577  1.014014138  2.672102598  3.336024438  1.841789918  0
      1.623019539  0.805391362  0.942234771  1.320083748  0.82777578   0      0.834341876  0      0.795243759
      0.866873897  0      0      0.798377577  0      0      0      0      0      0      0      0      0      0      0
      0      0.837177235  0      0      0      0      0      0      0.940294788  0      0      0      0      0      0
```

0 0 0.8385203 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1.116833232 0 0.795243759
0 0 0 0 0 0.805391362
2008 1 -7 0 0 1 -1 -1 1 0 0 8.277836612 2.679902962 3.912805645
6.151471936 4.956244634 9.040280054 8.20164057 6.797266603 7.889248871 3.333667421 1.968538642
0.634926768 1.400872088 1.499286945 0.715832233 2.40917154 0 1.531407622 4.609800188 2.126364676
1.499286945 0 0.713658654 3.006543682 0.796375435 0.830307429 2.28201713 2.116704322 0
0.859650754 0 0.685039855 1.52971706 0 0 0 0 0 0 0.830307429 0 0
0.746383103 0.725492587 0 0 0 0 0 0 0.685039855 0 0 0.685039855 0
0 0 0 0 0 0 0 0 0 0 0 0 0.725492587 0 0.715832233
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0.725492587 0 0 0 0 1.705052486
2009 1 -7 0 0 1 -1 -1 1 0 0 0 0 3.196455507 3.371396809
3.863239032 3.32688307 8.51930697 3.639978412 5.26357669 1.819989206 0.665630319 0.750044975
0.624345556 0 0 2.421040007 5.664085024 0 2.284154493 1.675146572 2.421040007 0
3.064644098 0.681890519 0.908380115 0 0.741395932 2.421040007 0 0.643604091 6.805182045
0.67589385 3.058301466 0.908380115 0 3.064644098 0 0 2.421040007 0 4.339051696
3.889647442 1.287208181 0 0 0 0.731017081 0.664477113 0 0 0 3.708248188 0
0.664477113 0 0.664477113 0 0 1.328954227 1.357784369 0 0 0 0 0 0
2.421040007 0 0 0 0.664477113 0 0 0.664477113 0 0 0 0 0
0.643604091 0 0 0 0 0 0 0.643604091 0 0 0 0 0 0 0
0 0 0 1.426746069
2010 1 -7 0 0 1 -1 -1 1 0 6.331574426 0 0 2.402505703 5.121022295
3.400408839 3.842001139 7.537682653 5.295980407 8.717456639 3.360084533 0.916925346 3.525661072
0.978646223 1.180926109 4.609315079 0 1.50664775 5.475217834 1.979347372 4.311738159 9.301253839
1.121838657 0 1.121838657 2.252400531 3.36551597 0 1.156731526 1.121838657 2.024115581
1.121838657 1.645231692 1.121838657 0 0 0 0 1.121838657 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0.958730953 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 2.071846392
2011 1 -7 0 0 1 -1 -1 1 0 0 0 3.749430253 0 2.443471196 0
3.829309154 4.960876107 2.304750203 9.823275553 4.838466264 6.170645114 1.201994533 5.272007476
0.589335557 1.547120167 0.963424915 2.832957059 2.584478798 3.073508406 1.178671114 1.768006671
3.880376772 1.836300082 0.589335557 1.91297773 3.291955859 1.010529076 1.903373969 1.768006671 0
2.109931051 0.742385971 0.589335557 1.178671114 1.743921048 0 0.589335557 1.768006671 1.768006671
0 0 2.191944121 1.421813952 0 0 0 0 0 0 1.03735863 0.840405309 0
0 0 0 0 0 0 0 0 0 0 0 0.939949054 0 0 1.421813952
1.03735863 0 0 0 0 0 0.939949054 0 0 0 0.931259937 0.589335557 0
0 0 0 1.894684852 0 0 0 0 0 0 0 0 0 0 0 0
0 0.939949054
2012 1 -7 0 0 1 -1 -1 1 0 3.786836431 0 15.77985419 9.46726221
8.43019475 0.856350755 11.17568539 4.656706712 1.96803231 0.822808639 1.927644864 0.822808639
3.291234555 2.468425916 2.718793853 2.969161789 0 1.122805216 3.034192422 3.247937844 2.218400246
3.893965842 0 0 1.677619194 0 4.196016018 0 0 0 0 0 0 1.122805216

```
0	0	0.854468289	0	2.218400246	0	0	0	0	0	0	0	0	0	0
0	1.947496321	0	0	0	0	0	0	0	1.122805216	0	1.169524592	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1.03176233	0	0	0	0	0	0	0	0	0
0	0	0

0 #_N_MeanSize-at-Age_obs
0 #_N_environ_variables
0 #_N_environ_obs
0 # N sizefreq methods to read
0 # no tag data
0 # no morphcomp data

999 # End data file
```

# Appendix C. SS control file

#C 2013 Rougheye assessment (Hicks, Wetzel, Harms)
#Control File
#Rougheye Rockfish 2013
#Allan Hicks, Chantel Wetzel, John Harms
#
1 #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
5 #_Nblock_Patterns
1 2 1 1 1 #_blocks_per_pattern
#begin and end years of blocks
#1930 1994 2011 2012 # Block Years for Retention
#1983 1996 1997 2001 2002 2010 # Block Years for TRAWL Retention No Limits/Sebastes trip limits/Monthly, bimonthly limits/RCA's/Rationalization
#1983 1996 1997 2002 # Block Years for FIXED Retention No Limits/Sebastes trip limits/Monthly, bimonthly limits/RCA's
#1997 2001 2002 2010 # Block Years for TRAWL Retention No Limits/Sebastes trip limits/Monthly, bimonthly limits/RCA's/Rationalization
1916 2001 # Block Years for TRAWL Selectivity before RCA's
2000 2006 2007 2010 # Block Years for TRAWL Retention Sebastes trip limits/Monthly, bimonthly limits (pre-2000 same as post-2010) (2000 was when complex came in and EDCP shows little discard from 1996-1999)
1916 2002 # Block Years for FIXED Selectivity before RCA's
1916 1999 # Block Years for FIXED Retention before Sebastes trip limits/Monthly, bimonthly limits (assume no discards)
1995 2012 # Block Pattern for Triennial Selectivity when they started going deeper

#
0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
 #_no additional input for selected M option; read 1P per morph
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
2 #_Growth_Age_for_L1
80 #_Growth_Age_for_L2 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
4 #_CV_Growth_Pattern: 0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
1 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
#_placeholder for empirical age-maturity by growth pattern
5 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0 #_hermaphroditism option: 0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
2 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)

#_growth_parms
#_LO HI INIT PRIOR PR_TYP SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
0.001 0.2 0.03365 -3.3918 3 0.5424 5 0 0 0 0 0 0 0 #NatM_p_1_Fem_GP_1

```
1 25 11 12 -1 10 2 0 0 0 0 0 0 0 #L_at_Amin_Fem_GP_1
40 90 57 58 -1 10 3 0 0 0 0 0 0 0 #L_at_Amax_Fem_GP_1
0.01 0.15 0.069 0.069 -1 0.8 2 0 0 0 0 0 0 0 #VonBert_K_Fem_GP_1
0.03 0.2 0.09 0.1 -1 0.8 3 0 0 0 0 0 0 0 #CV_young_Fem_GP_1
0.03 0.2 0.09 0.1 -1 0.8 3 0 0 0 0 0 0 0 #CV_old_Fem_GP_1
-3 3 9.60E-06 9.60E-06 -1 0.8 -3 0 0 0 0 0 0 0 #Wtlen_1_Fem
-3 4 3.123 3.123 -1 0.8 -3 0 0 0 0 0 0 0 #Wtlen_2_Fem
1 60 43.87 43.87 -1 0.8 -3 0 0 0 0 0 0 0 #Mat50%_Fem (McDermott)
-30 3 -0.30 -0.25 -1 0.8 -3 0 0 0 0 0 0 0 #Mat_slope_Fem
#Fecundity proportional to body weight
-3 3 1 1 -1 0.8 -3 0 0 0 0 0 0 0
    #Eggs/kg_inter_Fem
-3 3 0 0 -1 0.8 -3 0 0 0 0 0 0 0
    #Eggs/kg_slope_wt_Fem
#Fecundity set equal to POP values from 2011 assessment for exploration (fecundity option = 3)
#0 6 1.08643 1 -1 99 -50 0 0 0 0 0 0 0 #Bases for
fecundity option 3
#-3 3 1.44 1 -1 99 -50 0 0 0 0 0 0 0 #Exponent for
fecundity option 3
#Fecundity set equal to YEYE values from 2011 update assessment for exploration (fecundity option = 3)
#0 300000 137900 137900 -1 99 -50 0 0 0 0 0 0 0 #Bases for
fecundity option 3
#-3 390000 36500 36500 -1 99 -50 0 0 0 0 0 0 0 #Exponent for
fecundity option 3
#-3 3 7.56E-06 7.56E-06 -1 0.8 -3 0 0 0 0 0 0 0 #Wtlen_1_Mal
#-3 4 3.121 3.121 -1 0.8 -3 0 0 0 0 0 0 0 #Wtlen_2_Mal
# Unused recruitment interactions
0 2 1 1 -1 99 -50 0 0 0 0 0 0 0 #RecrDist_GP_1
0 2 1 1 -1 99 -50 0 0 0 0 0 0 0 #RecrDist_Area
0 2 1 1 -1 99 -50 0 0 0 0 0 0 0 #RecrDist_Seas
0 2 1 1 -1 99 -50 0 0 0 0 0 0 0 #CohortGrowDev
#0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 #RecrDist_GP_1
#0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 #RecrDist_Area_1
#0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 #RecrDist_Seas_1
#0 0 0 0 -1 0 -4 0 0 0 0 0 0 0 #CohortGrowDev
#
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#
#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
```

#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase
#

#_Spawner-Recruitment
3 #_SR_function
#_LO HI INIT PRIOR PR_type SD PHASE
1 10 6 6 -1 10 1 #SR_R0
0.25 0.99 0.779 0.779 2 0.152 -3 #SR_steep
0 2 0.4 0.6 -1 0.8 -4 #SR_sigmaR
-5 5 0 0 -1 1 -3 #SR_envlink
-5 5 0 0 -1 1 -4 #SR_R1_offset
0 0 0 0 -1 0 -99 #SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1980 #first year of main recr_devs; early devs can preceed this era
2011 #last year of main recr_devs; forecast devs start in following year
3 #_recdev phase
1 #(0/1) to read 13 advanced options
1900 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
4 #_recdev_early_phase
0 #_forecast_recruitment phase (incl. late recr) (0 value resetsto maxphase+1)
1 #_lambda for fore_recr_like occurring before endyr+1
1978 #_last_early_yr_nobias_adj_in_MPD
1986 #_first_yr_fullbias_adj_in_MPD
2007 #_last_yr_fullbias_adj_in_MPD
2011 #_first_recent_yr_nobias_adj_in_MPD
0.75 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated \ recdevs)
0 #_period of cycles in recruitment (N parms read below)
-5 #min rec_dev
5 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options

#_placeholder for full parameter lines for recruitment cycles
#read specified recr devs
#_Yr Input_value
#
#all recruitment deviations
#
#Fishing Mortality info
0.05 # F ballpark for tuning early phases
-2001 # F ballpark year (neg value to disable)

```
1 # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
0.9 #0.9 # max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
# if Fmethod=3; read N iterations for tuning for Fmethod 3
# 4  # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0 1 0 0.01 0 99 -1 # InitF_1FISHERY1 TRAWL
 0 1 0 0.01 0 99 -1 # InitF_1FISHERY2 FIXED
 0 1 0 0.01 0 99 -1 # InitF_1FISHERY3 ATSEA/FOREIGN FLEET

#_Q_setup
# Q_type options:  <0=mirror, 0=median_float, 1=mean_float, 2=parameter, 3=parm_w_random_dev, 4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
#Den-dep  env-var  extra_se  Q_type
0        0        0        0 # TRAWL
0        0        0        0 # FIXED
0        0        0        0 # ATSEA/FOREIGN
0        0        1        4 # TRIENNIAL
0        0        1        0 # AKFSC SLOPE
0        0        1        0 # NWFSC SLOPE
0        0        1        0 # NWFSC COMBO
#
1 # Par setup: 0=read one parm for each fleet with random q; 1=read a parm for each year of index
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each year of index
#_Q_parms(if_any)
#LO HI INIT PRIOR PR_type SD PHASE

#Extra SD parameters for surveys
#Lo        Hi          Init          Prior  Prior Prior Phase
0   2   0.01    0     -1    99    2   #AFSC slope
0   2   0.01    0     -1    99    2   #Triennial
0   2   0.01    0     -1    99    2   #NWFSC_slope
0   2   0.01    0     -1    99    2   #NWFSC_combo

# Lo    Hi  Init Prior PrType PrSD Phase
# Early period
 -10         2  -2   0    -1           99           1   # Triennial (log) base parameter (1980)
 -4     4   0   0   -1    99          -50 # Triennial 1983 deviation
 -4     4   0   0   -1    99          -50 # Triennial 1986 deviation
 -4     4   0   0   -1    99          -50 # Triennial 1989 deviation
 -4     4   0   0   -1    99          -50 # Triennial 1992 deviation
# Late period
  -4          4            0             0            -1            99           1   # Triennial 1995 deviation
```

```
 -4      4       0          0     -1       99       -50 # Triennial 1998 deviation
 -4      4       0          0     -1       99       -50 # Triennial 2001 deviation
 -4      4       0          0     -1       99       -50 # Triennial 2004 deviation


#_size_selex_types
#_Pattern Discard Male Special
 24 1 0 0 # TRAWL
 24 1 0 0 # FIXED
 24 0 0 0 # ATSEA/FOREIGN
 24 0 0 0 # TRIENNIAL
 24 0 0 0 # AKFSC SLOPE
 5  0 0 5 # NWFSC SLOPE mirrors AKFSC SLOPE
# 24 0 0 0 # NWFSC SLOPE
 24 0 0 0 # NWFSC COMBO
#_age_selex_types
#_Pattern ___ Male Special
 10 0 0 0 # TRAWL
 10 0 0 0 # FIXED
 10 0 0 0 # ATSEA/FOREIGN
 10 0 0 0 # TRIENNIAL
 10 0 0 0 # AKFS SLOPE
 10 0 0 0 # NWFSC SLOPE
 10 0 0 0 # NWFSC COMBO
#
#Size Selectivity Setup
#LO    HI      INIT    PRIOR  PRtype SD    PHASE    env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
#TRAWL
15     70     52.0    45.0  -1     0.05    1      0  0  0  0  0.5  1  2  #PEAK
-5.0   10.0    2.5     5.0  -1     0.05   -3      0  0  0  0  0.5  0  0  #TOP_WIDTH
-4.0   12.0    5.7     3.0  -1     0.05    2      0  0  0  0  0.5  1  2  #ASC_WIDTH
-2.0   10.0    9.0    10.0  -1     0.05   -4      0  0  0  0  0.5  0  0  #DESC_WIDTH
-9     10.0   -4       0.5  -1     0.05    3      0  0  0  0  0.5  0  0  #INIT
-9     9.0     8       0.5  -1     0.05   -4      0  0  0  0  0.5  0  0  #FINAL
#-999   5.0   -999    -999  -1     0.05   -3      0  0  0  0  0.5  0  0  #INIT
#-999  10.0   -999     5.0  -1     0.05   -4      0  0  0  0  0.5  0  0  #FINAL
#RETENTION TRAWL
 5     60     26      34    -1     99      1      0  0  0  0  0  2  2          #inflection
0.01    8      1.2     1.0  -1     99      1      0  0  0  0  0  2  2          #slope
0.5     1      0.99    1    -1     99      3      0  0  0  0  0  2  2  #asymptote
-10    10      0.0     0.0  -1     99     -9      0  0  0  0  0  0  0  #male offset to inflection (arithmetic)
#FIXED GEAR
15     70     48.0    45.0  -1     0.05    1      0  0  0  0  0.5  3  2  #PEAK
-5.0   10.0    2.5     5.0  -1     0.05   -3      0  0  0  0  0.5  0  0  #TOP_WIDTH
-4.0   12.0    2.8     3.0  -1     0.05    2      0  0  0  0  0.5  3  2  #ASC_WIDTH
```

```
-2.0    10.0    9.0    10.0    -1      0.05   -4       0   0   0   0   0.5   0   0  #DESC_WIDTH
-9      10.0    -4      0.5    -1      0.05    3       0   0   0   0   0.5   0   0  #INIT
-9      9.0      8      0.5   -1      0.05     -4      0   0   0   0   0.5   0   0  #FINAL
#-999    5.0    -999    -999    -1      0.05  -2       0   0   0   0   0.5   0   0  #INIT
#-999    10.0   -999     5.0    -1      0.05  -4       0   0   0   0   0.5   0   0  #FINAL
#RETENTION FIXED
 5      60      42      34    -1      99    1      0   0   0   0   0   4   2             #inflection
0.1      8      1.0     1.0   -1      99    1      0   0   0   0   0   4   2             #slope
0.5      1      0.89     1     -1      99    2      0   0   0   0   0   4   2  #asymptote
-10     10      0.0     0.0   -1      99   -9      0   0   0   0   0   0   0  #male offset to inflection (arithmetic)
#ATSEA/FOREIGN
15      70      55.0    50.0   -1      0.05   2       0   0   0   0   0.5   0   0  #PEAK
-5.0    10.0    2.0     2.5    -1      0.05   -3      0   0   0   0   0.5   0   0  #TOP_WIDTH
-4.0    12.0    4.0     4.0    -1      0.05   2       0   0   0   0   0.5   0   0  #ASC_WIDTH
-2.0    10.0    10.0    10.0   -1      0.05  -4       0   0   0   0   0.5   0   0  #DESC_WIDTH
-999.0  5.0    -999    -999    -1      0.05  -2       0   0   0   0   0.5   0   0  #INIT
-999    10.0   -999     5.0    -1      0.05  -4       0   0   0   0   0.5   0   0  #FINAL
#TRIENNIAL
13      50      18.0    25.0   -1      0.05   2       0   0   0   0   0.5   0   0  #PEAK
-5.0    10.0    0.0     5.0    -1      0.05   3       0   0   0   0   0.5   0   0  #TOP_WIDTH
-4.0    12.0    3.0     3.0    -1      0.05   2       0   0   0   0   0.5   0   0  #ASC_WIDTH
-2.0    10.0    4.0     10.0   -1      0.05   3       0   0   0   0   0.5   0   0  #DESC_WIDTH
-9      10.0    -2      0.5    -1      0.05   2       0   0   0   0   0.5   0   0  #INIT
-9      9.0      0      0.5    -1      0.05    4      0   0   0   0   0.5   5   2  #FINAL
#AKFSC SLOPE
13      50      35.0    35.0   -1      0.05   2       0   0   0   0   0.5   0   0  #PEAK
-5.0    10.0    -2.5    5.0    -1      0.05   -3      0   0   0   0   0.5   0   0  #TOP_WIDTH
-4.0    12.0    4.0     5.0    -1      0.05   2       0   0   0   0   0.5   0   0  #ASC_WIDTH
-2.0    10.0    10.0    10.0   -1      0.05  -4       0   0   0   0   0.5   0   0  #DESC_WIDTH
-999    5.0    -999    -999.0  -1      0.05  -2       0   0   0   0   0.5   0   0  #INIT
-1080   10.0   -1025    5.0    -1      0.05  -4       0   0   0   0   0.5   0   0  #FINAL
#NWFSC SLOPE
-2 60 0 0 -1 0.2 -4 0 0 0 0 0.5 0 0 #MinBin
-2 60 0 0 -1 0.2 -4 0 0 0 0 0.5 0 0 #MaxBin
#NWFSC COMBO
13      50      20.0    20.0   -1      0.05   2       0   0   0   0   0.5   0   0  #PEAK
-5.0    10.0    2.5     5.0    -1      0.05   -3      0   0   0   0   0.5   0   0  #TOP_WIDTH
-4.0    12.0    3.0     3.0    -1      0.05   2       0   0   0   0   0.5   0   0  #ASC_WIDTH
-2.0    10.0    10.0    10.0   -1      0.05  -4       0   0   0   0   0.5   0   0  #DESC_WIDTH
-999    5.0    -999    -999    -1      0.05  -2       0   0   0   0   0.5   0   0  #INIT
-999    10.0   -999    -999    -1      0.05  -4       0   0   0   0   0.5   0   0  #FINAL


1 #Custom Block Setup (0/1)
#LO     HI      INIT    PRIOR  PR_TYPE  SD    PHASE
```

```
#RETENTION TRAWL BLOCKS
15      70     48.0    45.0   -1      0.05   1  #PEAK (1930-2001)
-4.0    12.0   5.7     3.0    -1      0.05   2  #ASC_WIDTH (1930-2002)
 5      50     31      34     -1      99     1  #inflection (2000-2006)
 5      50     31      34     -1      99     1  #inflection (2007-2010)
0.01    5      2.4     1.0    -1      99     1  #slope (2000-2006)
0.01    5      2.4     1.0    -1      99     1  #slope (2007-2010)
0.5     1      0.8     1      -1      99     2  #asymptote (2000-2006)
0.5     1      0.8     1      -1      99     2  #asymptote (2007-2010)
#RETENTION HKL BLOCKS
15      70      48.0    45.0   -1      0.05   1   #PEAK  (1930-2002)
-4.0    12.0    2.8     3.0    -1      0.05   2   #ASC_WIDTH (1930-2002)
 5      60      10      34    -1      99    -2   #inflection (1930-1999)
0.1     8       0.2     1.0   -1      99    -3      #slope  (1930-1999)
0.5     1       1.0     1     -1      99    -3      #asymptote  (1930-1999)
#Selectivity Triennial
-9      9.0      5     0.5   -1     0.05    3    #FINAL

#3 #selparm_dev_PH

1 #selparm_adjust_method: 1=standard; 2=logistic trans to keep in base parm bounds

# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3 4 5 6 7
0   0   0   0   0   0   0  #_add_to_survey_CV
0.2 0.1 0   0   0   0   0  #_add_to_discard_stddev
0   0   0   0   0   0   0  #_add_to_bodywt_CV
0.5   0.5   0.03 0.25 0.25 1   0.25  #_mult_by_lencomp_N
0.5   1   0.5   1   1   1   1  #_mult_by_agecomp_N
1   1   1   1   1   1   1  #_mult_by_size-at-age_N#
1 #_maxlambdaphase
1 #_sd_offset
#
0 # number of changes to make to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
# 9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
#like_comp fleet/survey  phase  value  sizefreq_method

0 # (0/1) read specs for more stddev reporting

999
```

## Appendix D. SS starter file

```
#C starter comment here
REYE.dat
REYE.ctl
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
1 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed checkup.sso file (0,1)
0 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
0 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
1 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
0 # Number of bootstrap datafiles to produce
20 # Turn off estimation for parameters entering after this phase
1 # MCeval burn interval
1 # MCeval thin interval
0.01 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-2 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
#vector of year values
0.00001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
10 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
1 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
1 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates)
0 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file
```

## Appendix E. SS forecast file

#Rougheye Rockfish 2013
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.50 # SPR target (e.g. 0.40)
0.40 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0 0 0
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
12 # N forecast years
0.2 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.40 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0.10 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
1 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2013  #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
2013 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2013 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
2 # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x fleet(col) below
2 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F:  rows are seasons, columns are fleets
#_Fleet:  TRAWL FIXED ASF  Based on 5-year averages
0.013  0.0135  0.0135    #input the average catches for 2013-2014 and then see what F's are needed to produce those catches. Then input those F's to keep it constant.
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
 -1 -1 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
 -1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
 0 0 0
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
3 # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
999 # verify end of input

# Consideration of the proportion of rougheye rockfish north and south of the 40° 10' N latitude management line

Allan C. Hicks
8/21/2013

Currently, rougheye rockfish (*Sebastes aleutianus*) are managed as part of the minor slope rockfish complexes north and south of 40º10’ N lat. The 2013 assessment of rougheye and blackspotted (*S. melanostictus*) rockfishes did not attempt to separate these two species due to difficulty in distinguishing between the two species. Therefore, the term “rougheye rockfish” refers to rougheye and blackspotted rockfishes, and the 2013 assessment supplies management advice for these two species combined. Little is known about life-history differences between the two species.

Rougheye rockfish are rare south of 40º10’ N lat., but catches occasionally occur in this area. Therefore, species specific catch limits greater than zero should be determined for south of 40º10’ N lat. Currently, the OFL for rougheye rockfish is 0.5 mt, or less than 1% of the total 78.8 mt OFL.

In only four of the 10 years of data from the NWFSC shelf/slope survey were rougheye rockfish observed south of 40° 10′ N. In these years (2004, 2006, 2009, and 2011), the proportion of biomass estimated south of 40° 10′ N was 0.764%, 0.029%, 2.35%, and 0.022%, respectively.

Landings in California from the trawl commercial fleet averaged 1.03 % of the total landings of rougheye rockfish since 1985, with a median of 0.50% and a maximum of 5.97% in 1994 for the trawl fleet. For the hook & line fleet, since 1985, the average percentage of landings of rougheye rockfish in California is 2.11% with a median of 0.34% and a maximum of 15.17% in 2001. Landings from the trawl fleet in California are almost always a smaller proportion of the total coastwide landings than the hook & line fleet. This type of analysis may be misleading for a number of reasons. First, the California border is at 42° N lat. and a majority of the landings in California occur north of 40º10’ N lat. Second, the proportion of the biomass in California may not be represented by the proportion of the coastwide landings since many other factors determine how much catch is taken. Nevertheless, these averages are an indication that at most, and likely less, the proportion of biomass south of 40º10’ N lat. is 2%.

The effect of the management line at 40º10’ N lat. for rougheye rockfish is that catches south of 40º10’ N lat. may be seriously limited due to the small perceived rougheye rockfish biomass south of that line. Conversely, setting catch levels high enough to not be limiting south of 40º10’ N lat. may result in limiting catches north of 40º10’ N lat. An adaptive approach of assessing the efficacy of the north and south management targets over time by monitoring survey biomass, length, and age data, while also paying attention to catch levels in each area may assist in eventually determining the proper allocation of the OFL to each area.

For management decisions in 2013, I support a proportion of biomass south of 40º10’ N lat. of 2%. This is near the maximum amount observed by the survey, and is supported by the average from the fishery catches (at least in CA). I prefer to use the survey data since that is more random and not subject to market/social influences. Two percent is possibly an overestimate of the proportion of biomass south of 40º10’ N lat., but since rougheye rockfish is a rare species south of 40º10’ N lat. it seems reasonable to me to use the maximum seen in any year of the survey with the additional support of the fishery data. Alternatively, a more detailed and complicated analysis of the fishery data could be performed, with the inclusion of socio-economic considerations.

# Stock Assessment Review (STAR) Panel Report for Rougheye (and Blackspotted) Rockfish

Northwest Fisheries Science Center Auditorium
Montlake Blvd, Seattle, Washington
8-12 July 2013

**STAR Panel Members**

| | |
|---|---|
| David Sampson (Chair) | Oregon State University, PFMC Scientific & Statistical Committee |
| Chris Francis | Center for Independent Experts |
| John Field | NMFS, Southwest Fisheries Science Center |
| Yan Jiao | Center for Independent Experts |

**Pacific Fishery Management Council (PFMC) Advisors**

| | |
|---|---|
| John DeVore | PFMC Staff |
| Colby Brady | NMFS Northwest Region, PFMC Groundfish Management Team |
| Gerry Richter | PFMC Groundfish Advisory Subpanel |

**Stock Assessment Team (STAT)**

| | |
|---|---|
| Allan Hicks | NMFS, Northwest Fisheries Science Center (NWFSC) |
| Chantell Wetzel | NMFS, NWFSC |

## Summary of the STAR Panel Meeting

*Overview*

During 8-12 July 2013 a Stock Assessment Review (STAR) Panel met in Seattle, Washington to review a draft stock assessment for rougheye rockfish (Hicks et. al, 2013) that had been prepared by Hicks, Wetzel and Harms of the Northwest Fisheries Science Center. The Panel operated under the Pacific Fishery Management Council's (PFMC) Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment and Review Process for 2013-2014 (PFMC 2012). This same panel also reviewed a draft assessment for aurora rockfish.

Rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) are two species with very similar appearance that only recently were identified as separate species. Because historic landings and most other sources of information do not distinguish between the species (and even well trained observers have difficulty distinguishing one species from the other), the stock assessment treats these two species as if they were a single species. For simplicity, in the assessment document and in this report references to rougheye rockfish refer to the complex of rougheye rockfish and blackspotted rockfish, unless otherwise noted.

Rougheye rockfish are at the southern extent of their range off the US West Coast and are rarely caught south of Oregon. Despite the fact that two species comprise the rougheye complex the fish of this stock found off the US West Coast are assumed to be a self-sustaining unit. This stock, which has been managed since 2000 as part of the minor slope rockfish complex, has not previously been assessed. Its high score in the Council's productivity and susceptibility analysis (PSA) indicated that it was vulnerable to becoming overfished (Cope et al, 2013).

The draft assessment document and other background materials were made available on the Council's ftp site on 06/25/2013, and the STAR Panelists all had adequate time to review the assessment document in advance of the meeting. The slide presentations prepared by the STAT were also made available from the ftp site, which greatly facilitated the panel's review and subsequent preparation of this STAR Panel report.

Results for the base model developed during the STAR Panel are summarized as follows. The assessment estimates that the spawning stock biomass of rougheye rockfish at the start of 2013 was 2,552 metric tons and was depleted to 47% of its unfished level. There is some small (but non-trivial) chance that the stock's spawning biomass may have dropped below the Council's target level (40% of unfished) around 2000, but there is very little chance that it ever dropped below the minimum stock size threshold (25% of unfished).

The STAR Panel commends the STAT members for their excellent presentations and complete and well-written documentation. Their willingness to respond to STAR Panel requests and to engage in productive discussions greatly contributed to the collegial atmosphere of the STAR meeting. The STAR Panel also extends its thanks to the NWFSC and PFMC staff who provided administrative support and hosted the meeting.

The STAR Panel recommends that the assessment for rougheye rockfish constitutes the best available scientific information on the current status of the stock and that the assessment provides a suitable basis for management decisions.

*Summary of the Assessment Data and Model*

The assessment, which was conducted using the Stock Synthesis software (SS3 version 3.24o), was structured as a single coastwide region with removals taken from 1916 through 2012. The model has three fishing fleets, a bottom-trawl fleet (including the historic foreign bottom-trawl fishery) and a fixed-gear fleet, both of which had discards, and a no-discard fleet that is the combination of the historic foreign and more recent domestic at-sea midwater-trawl fishery for Pacific hake.

In the model the sexes were combined, growth was freely estimated, and the natural mortality rate (constant by age and time) was estimated using a lognormal prior distribution. The steepness parameter for the recruitment versus spawning biomass function was fixed at the mean of its prior distribution (0.779). Fishery selection was length-based and fishery selectivity curves were assumed to be asymptotic. Asymptotic retention curves were estimated for the bottom-trawl and fixed-gear fleets.

The assessment considers biomass indices from four trawl surveys: the Triennial shelf survey, split into an early and late series; the Alaska Fishery Science Center slope survey; the Northwest Fisheries Science Center (NWFSC) slope survey; and the NWFSC shelf-slope survey. Survey length composition data were available for all but NWFSC slope survey. Conditional age-at-length composition data were available for the NWFSC shelf-slope survey.

Fishery length composition data were available for all three fleets but not until relatively recent years. Limited amounts of conditional age-at-length composition data were available from the bottom-trawl and no-discard fleets for two years near the end of the time series. Discard data included observed total discards, length compositions of the discards, and mean body weight observations of the discarded fish.

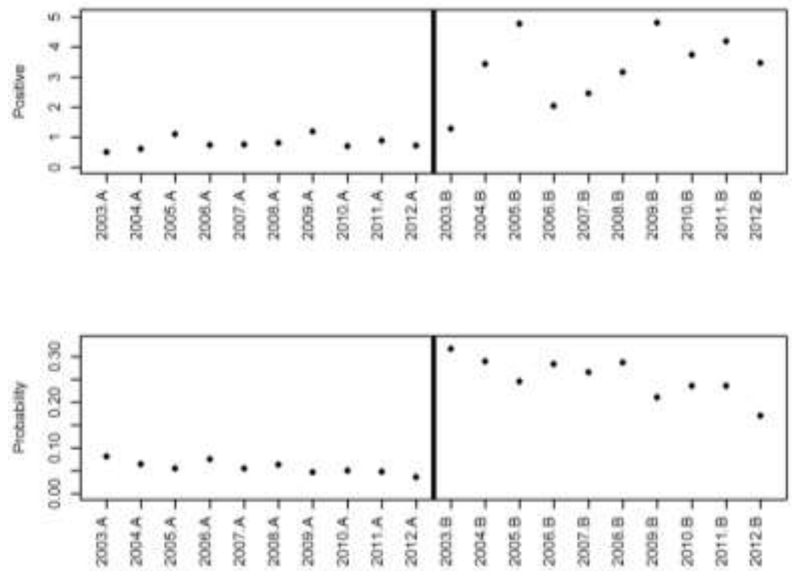
*Analyses Requested by the STAR and the STAT's Responses*

**Request 1:** Report additional diagnostics from the GLMMs, including predictions for model covariates. We would also like to see indices and coefficients of variation from the design and final model outputs in tabular form, as well as summarizing model predictions of the distinct GLM components (positive model and binomial model).

<u>Rationale:</u> Given the potential for trends in the random vessel effects over time, it is important to feel confident that the estimated effects are plausible. Strong effects may also have implications with respect to how length expansions are developed.

<u>Response:</u> Plots were presented of model predictions of stratum-year effects, both combined and separated into components (mean catch of positive tows and probability of a positive tow). These provided useful background information about the surveys. In particular it was of interest that the NWFSC shelf/slope survey showed consistent downward trends in the probability of positive catches and, in the deeper stratum, an upward trend in the mean catch rate from positive catches.

Stratum-Year components for the NWFSC shelf/survey biomass index.



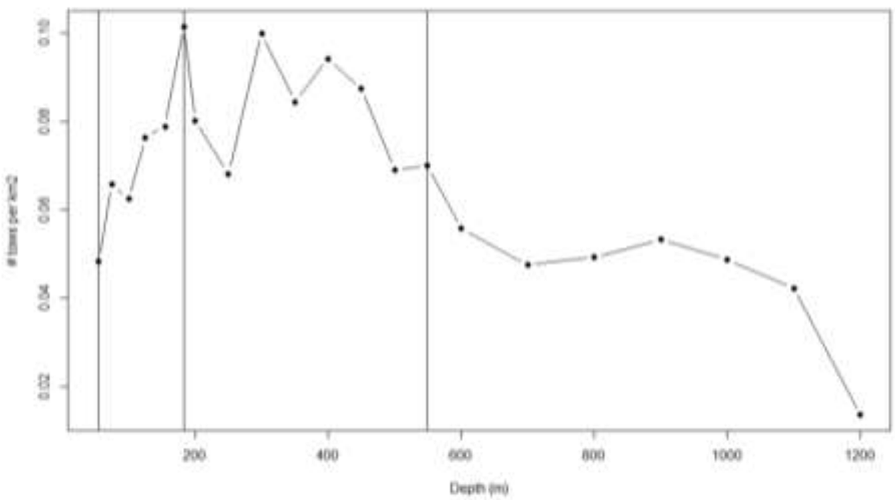

A comparison was presented between the design and model coefficients of variation (CVs) for the survey indices. For the late triennial and NWFSC slope surveys (as well as most years of the AFSC slope survey), the design-based CVs were always lower than the model CVs, whereas in the early Triennial survey they were similar. For the NWFSC shelf/slope survey the average CVs were similar, but the design-based CVs showed much more year-to-year variability.

**Request 2:** If data are available, report the number of tows per square km of habitat (north of 42) in 50 meter depth bins from 100 through 450 meters (include total # tows as well as total habitat area). Provide documentation on survey design (or point to where this exists in the background material).

Rationale: To see if there is an apparent explanation for the paucity of 35-45 cm fish from the combined trawl survey.

Response: The STAT presented a plot (below) of the number of tows per $km^2$ by depth-bin using the NWFSC shelf/slope data. This showed a relatively high density of survey tows in the depth range in which these fish were most likely to occur (250-300 m), and thus did not provide an explanation for the lack of 35-45 cm fish in the survey. However, the plot did show a lower tow density in the deeper bins.

Density of tows by depth in the NWFSC survey north of 42º.



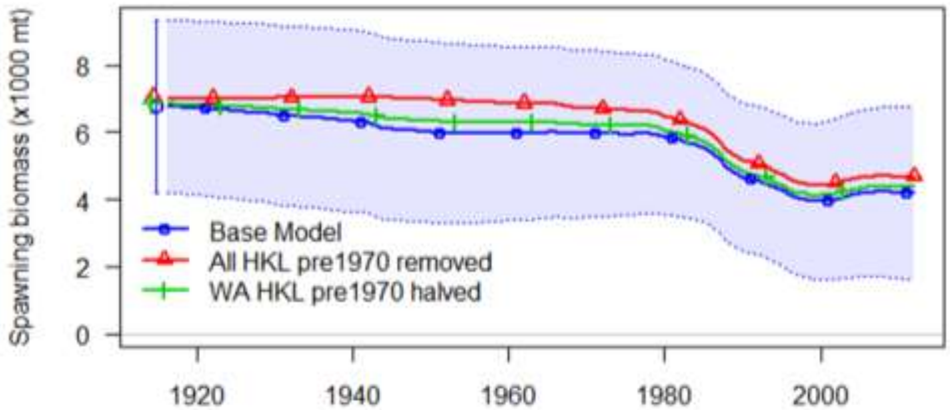

The STAT included a brief but very useful description of the design of each of the four surveys. It would be helpful to provide similar summaries of the survey designs as background information for future STAR Panels.

**Request 3:** Patterns of historical catches are unusual in some parts of the series, particularly where fixed-gear catches drop to nearly zero in the 1960s-70s, then increase again sharply. Two catch scenarios that would be useful would be to 1) remove all hook and line catches prior to 1970, and 2) halve the Washington hook and line catches during the pre-1970 time period (keeping Oregon catches as reported). Summarize the impact on equilibrium yield as well as depletion. If possible, report on trends in hook and line fisheries for other target species (Pacific halibut and sablefish) that may be associated with these trends.

Rationale: To provide a way of evaluating the effect on the assessment of uncertainty in the catch history and to seek an explanation for the reduction in hook and line catches of rougheye rockfish in the 1960s and ‘70s (see Figure 20 in the draft assessment report).

Response: The STAT presented two new runs with alternative catch histories as described in this request. Neither run produced results that differed substantially from the base run. Both showed slightly higher biomass and depletion trajectories (current depletion increased from 63% to 68% and 65%, respectively, see figure below) and slightly higher estimates of $M$ (0.0481 $y^{-1}$ and 0.0465 $y^{-1}$, respectively, compared to 0.0455 $y^{-1}$ for the base run). Estimated SPR yield increased from 284 t to 309 t and 292 t, respectively.

Spawning biomass trajectories for the base model and
two alternative models that have slightly different catch histories.



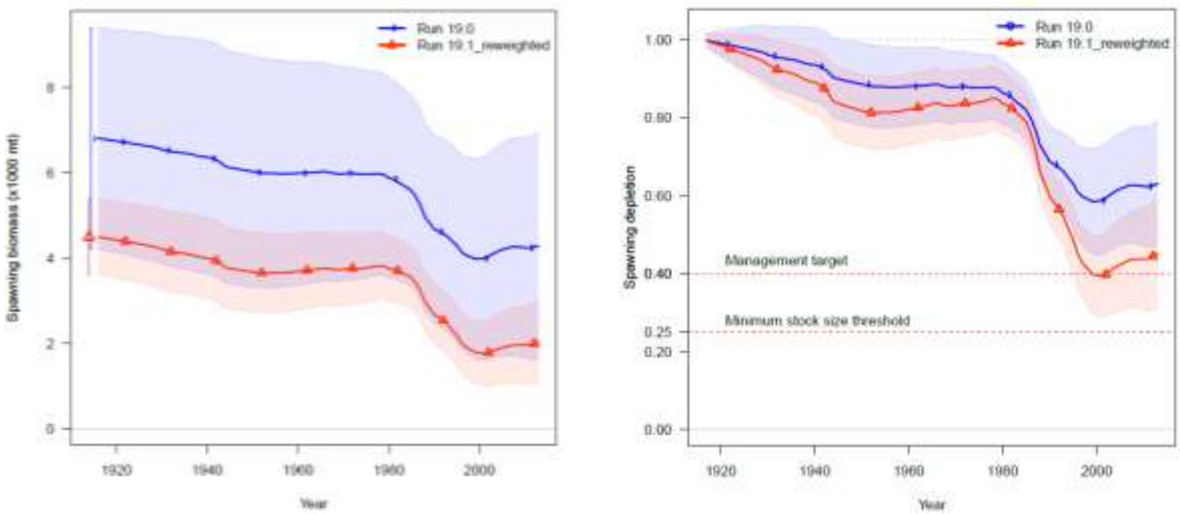

With regard to alternative hook-and-line fisheries, Pacific halibut catches dropped during the 1970s, but there was no substantial change in sablefish catches in this period. Thus fishing effort patterns associated with these two hook-and-line fisheries do not provide an explanation for the near-zero catches of rougheye rockfish during the 1960s and '70s.

**Request 4:** Explore alternative effective sample size iteration methods. Based on the Francis (2011) approach, a new set of effective sample sizes can be jointly developed by the STAR Panel (Francis) and STAT Team. Do new runs with these re-weighted compositional data (as a sensitivity analysis to current base model).

Rationale: The observation that that there is strong autocorrelation in the residuals is an indication of correlations in the data that are not accounted for in estimates of effective sample size. This analysis may need to be done separately for the discard data.

Response: Model 19.0, which used the original data weighting, was compared to run 19.1, in which the composition data were reweighted using method TA1.8 of Francis (2011). This reweighting involved substantial down-weighting of most of the length composition data (e.g., down-weighting factors for the fishery data ranged from 0.07 to 0.30), but much less down-weighting for the conditional age-at-length data. The largest data set – the slope/shelf survey – was not down-weighted, and reweighting factors of 0.55 and 0.71 were applied to the fishery data. The reweighting had a reasonably substantial effect on stock status (see figure below), with current depletion changing from more than 0.6 to less than 0.5 and yield dropping by around 30%.

Base model (Run 19.0) results with Francis reweighting of composition data (Run 19.1).




**Request 5:** Report on the differences between OR and WA length frequency data over the 1995-2012 time period, including the pre-2004 and post-2004 period. Also look at separation of Astoria (port complex, inclusive of Warrenton) length frequencies, which may reflect WA catches. Other possible explorations of port-specific sample distribution can be conducted at the discretion of the STAT.

Rationale: The differences in available length frequency data between OR and WA may be driving unusual residual patterns in the fits to the length composition data.

Response: Before responding to this request the STAT described an error that they had discovered in the weighting by state of the trawl fishery length compositions, and noted that with the corrected compositions both the estimated spawning biomass and depletion were slightly lower.

The length compositions disaggregated by state showed that big fish appeared to be more common in OR than in WA. This was consistent with the pattern of fish length against latitude (shown in Figure 13 in the draft assessment, using the shelf/slope survey data), which showed that mean lengths were higher around 45ºN (OR) than around 48ºN (WA). The proportion of trawl length samples that came from Astoria was very variable, being more than 40% in 1995 and 1996, and less than 5% in other years.

**Request 6:** Report on how survey length compositional data are expanded.

Rationale: How the data were expanded was not entirely clear to STAR Panel. Also, if there are vessel-specific catchabilities (non-random effects), then it might be appropriate to consider this in making expansions.

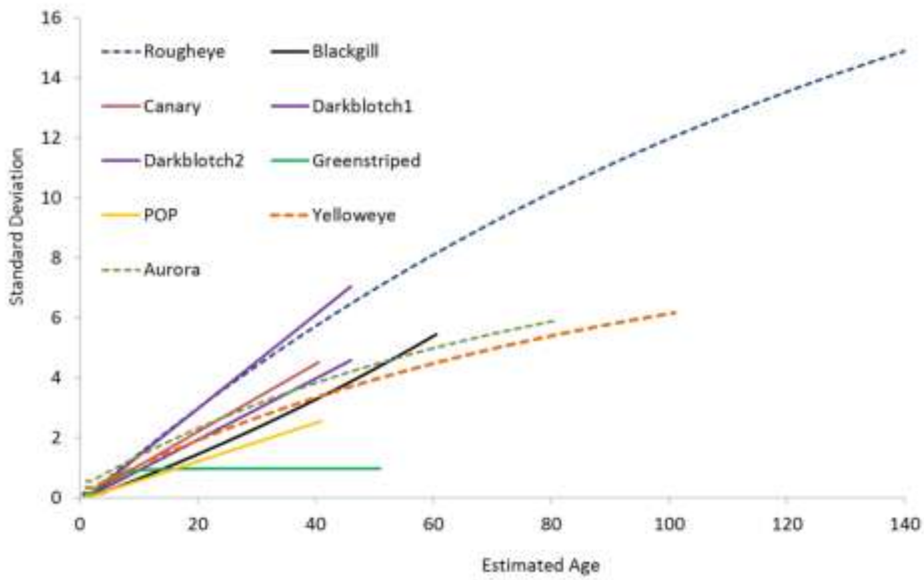
Response: The STAT reported that the survey length compositions were scaled up within strata by number, rather than by weight.

**Request 7:** Look at aging error from other long-lived rockfish species relative to the estimated error for this species.

Rationale: The Panel wanted to know whether the ageing error used in this assessment was consistent with what has been used in assessments of other rockfishes.

Response: A graph of ageing error (standard deviation as a function of age) for nine rockfish species (below) showed that the errors used in the rougheye assessment model were at the upper end of the range of the other species.

Comparison of rockfish ageing error vectors.




**Request 8:** Also report the marginal age composition plots (traditional view), with axes scaled in an easily interpretable manner.

Rationale: The original plot with this information was hard to interpret because of the scaling of the Y-axis.

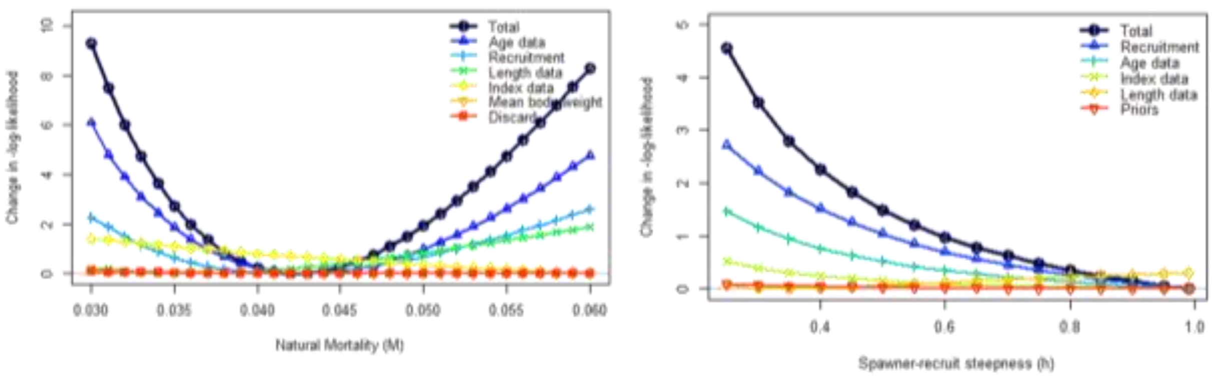
Response: The modified plot was useful, showing much more clearly the relationship between observed and expected ages. In particular, the strong 1999 year class was very evident in both the observed and expected proportions at age.

**Request 9:** With respect to effective sample size reweighting, the STAT is encouraged to consider the results and subsequent discussion of the round 1 request (related to alternative means of sample size reweighting), and provide a model run that incorporates a reasonable approach to conducting the reweighting (for example, doing reweighting in one encompassing round, rather than dataset by dataset). If time allows, include likelihood profiles and residual patterns (and other appropriate diagnostics). Additionally, if possible, investigate why the reweighting appears to result in an effective reduction in model uncertainty.

Rationale: The model is very sensitive to how effective sample sizes are reweighted, and the diagnostic plots of mean length (with error bars) suggest that the effective sample sizes are inconsistent with year to year variation in mean length.

Response: Outputs from the new reweighted model (19.2) were similar to those in the initial reweighted model (see Request 4). Profiles from this model appeared more satisfactory than those from a run with the original data weighting. For example (see figure below), the new profile on natural mortality was dominated by the age-at-length data, rather than the length data (which were dominant in the original profile), and the profile on steepness was much flatter than before reweighting (which is consistent with the view that the data contain very little information about this parameter). The reduction in uncertainty in the new model seemed to be because the reweighting effectively reduced the conflict between the length and age-at-length data sets.

Log-likelihood profiles for *M* and *h* from the base model with Francis reweighting (Run 19.2).




**Request 10:** Prepare a plot of the ratio of effective N versus input N by year from the original base model.

Rationale: This will indicate whether the calculation of the input N's is consistent over time.

Response: The requested plot showed no evidence of inconsistency over time in the calculation of input N values.

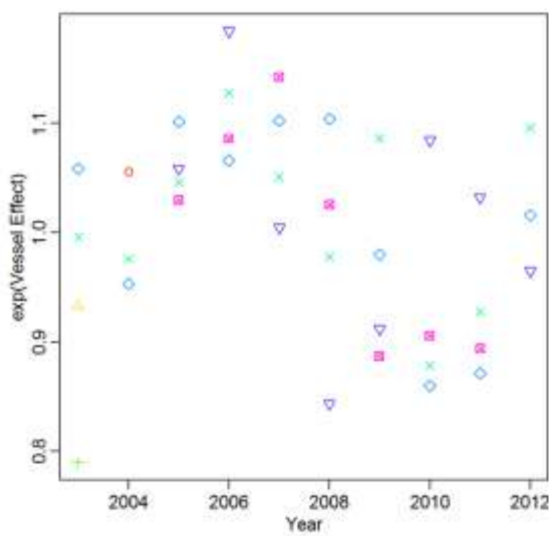
**Request 11:** With respect to plots of vessel effects in the GLMM, a secondary request is to identify which symbols correspond with which vessels (or confirm that the symbols correspond with the same vessels over time). Additionally, provide the *Vessel* effects in arithmetic (or other interpretable) scale.

Rationale: There is confusion regarding what the symbols correspond to, including some concern that the GLMM may be aliasing *Year* effects with *Vessel* effects.

Response: A table of vessels used each year in the slope/shelf survey showed that there had been very little variation, with two vessels participating in all ten surveys, and another two in seven of the ten. The revised *Vessel* effects plot from the GLMM for this survey showed no indication that any vessel produced consistently higher (or lower) catch rates than the others, but this did not remove the Panel's concern about aliasing of *Vessel* and *Year* effects (but see response to Request 12).

There was considerable discussion regarding the fact that the *Vessel* x *Year* effects were all positive in some years (e.g., 2005 and 2006 in the figure below). It was unclear why these positive deviations from the average had not become absorbed in the *Year* effect and hence the survey biomass index values. Dr. Jim Thorson (NWFSC), who had helped develop the GLMM software, explained that with random *Vessel* x *Year* effects one should expect that by chance alone all of the vessels could produce positive deviations from the average in any given year. Discussion of this issue continued after the STAR Panel meeting by email correspondence, with the STAR Panel eventually reaching consensus that in general in the GLMM analyses of survey biomass there should be no issue of aliasing of the *Year* effects with the *Vessel* x *Year* effects.

GLMM *Vessel* x *Year* effects (positive hauls) from the NWFSC slope survey.
(Because the effects are exponentiated, positive effects are those greater than 1 in the plot.)

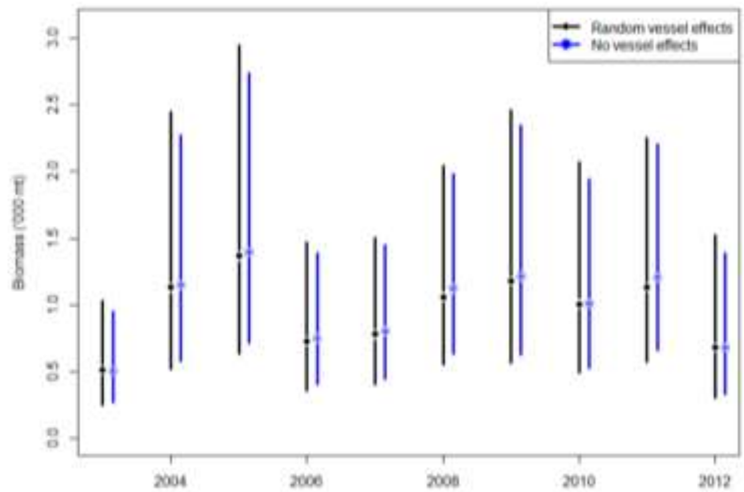



**Request 12:** Run the GLMM without vessel effects.

Rationale: The Panel wants to evaluate the relative influence of vessel effects in the index.

Response: There was virtually no change in the biomass indices from the NWFSC shelf/slope survey when vessel effects were removed from the GLMM. Thus, for this survey at least, there was no evidence of the aliasing mentioned in Request 11.

Biomass indices from the NWFSC slope survey, with and without random *Vessel* effects.


Random vessel effects
No vessel effects
Biomass ('000 mt)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2004
2006
2008
2010
2012

**Request 13:** Plot the mean number of rougheye caught per positive tow in the deep stratum.

Rationale: The Panel wants to better understand trends observed in the different components of GLMM.

Response: This plot (for the slope/shelf survey) showed no trend, which supported the hypothesis that the increasing trend in the mean catch rate from positive tows in the deep stratum (shown in the plot for Request 1 above) was an indication that fish were increasing in size (and thus weight), rather than numbers over the period of this survey (possibly because of growth of the strong 1999 cohort).

**Request 14:** If feasible, find or develop simple plots of length composition by depth (similar to Figure 13 in the draft assessment) for other (ideally northern slope) species.

Rationale: The Panel wants to understand the apparent lack of positive catches in 250-300 meter depths in the NWFSC shelf/slope survey.

Response: These plots were presented for six species (Dover sole, splitnose and darkblotched rockfish, Pacific ocean perch, sablefish and shortspine thornyhead). None showed a lack of positive catches in the 250-300 m depth range. Thus there is no evidence to support the notion that the lack of rougheye rockfish in the 250-300 meter depth range was due to poor performance of the survey gear.

**Request 15:** If feasible, plot the percent positive and average positive biomass by depth, stratum and pass, including the plot of length versus depth by pass (and any other diagnostics the STAT finds informative).

Rationale: The Panel wants to evaluate whether there are seasonal issues related to the vulnerability of rougheye rockfish to the survey gear.

Response: These plots of mean percentage positive tows and of individual catch rates showed no evidence of seasonal effects.

### Description of the Base Model

Although the STAR Panelists were swayed by the evidence from the original base model of residual patterns in the plots of mean length and mean age-at-length and generally supported using the Francis approach for reweighting the composition data, the STAT expressed some reservations about using this approach until they had been able to thoroughly examine all the results of the model run with Francis reweighting. On the last day of the Review the STAT indicated that they had carefully reviewed the results from the run with Francis reweighting and were in agreement with the STAR panelists that this would provide a suitable revised base model for the assessment. Also, after discussion the STAT and STAR agreed that the natural mortality rate (*M*) should form the major axis of uncertainty for constructing the decision table.

The base model has the following structural characteristics.

- The stock is contained in one area, has no seasonality, and is modeled with the sexes combined.
- The stock is unfished in 1915 (but not forced to be at equilibrium) and recruitment deviations start in 1916.

- The rate of natural mortality (*M*) is estimated, based on an assumed lognormal prior distribution having a median value of 0.03365 $y^{-1}$ and log-scale standard deviation of 0.5424.
- The steepness parameter (*h*) for the stock-recruitment function is fixed at the mean value (0.779) of the most recent version of the steepness prior probability distribution for rockfish. The recruitment variability parameter (*sigma-R*) is assumed to be 0.4.
- All parameters for the von Bertalanffy growth model are estimated freely, including the parameters controlling variability in length-at-age.
- There are three fishing fleets operating coastwide. One is conducted with bottom-trawl gear and includes the historic foreign bottom-trawl fishery. A second fixed-gear fleet is conducted primarily with longline gear. These two fleets are modeled as having discards. The third fleet is a combination of the foreign and domestic at-sea midwater trawl fishery that targets Pacific hake.
- Selectivity for all fishing fleets is length-based and has a simple asymptotic form. For the at-sea fleet selectivity is assumed to be time-invariant, but is permitted to vary in time-blocks for the other two fleets (bottom-trawl: 1916-2001 and 2002-2012; fixed-gear: 1916-2002 and 2003-2012).
- The bottom-trawl and fixed-gear fleets each have a length-based logistic retention function that is estimated in time-blocks. For the bottom-trawl fleet there were four time-blocks (1916-1999, 2000-2006, 2007-2010, and 2011-2012) and minimal discards during the first and last blocks, for which the retention functions were linked. For the fixed-gear fleet there were two time-blocks (1916-1999 and 2000-2012) and no discards during the first block.
- There are four fishery-independent trawl surveys: (1) the Triennial shelf survey, split into an early and late series, with separate catchability coefficients and selection curves for each series; (2) the Alaska Fishery Science Center (AFSC) slope survey; (3) the Northwest Fisheries Science Center (NWFSC) slope survey; and (4) the NWFSC shelf-slope survey. The surveys differ slightly from each other in survey design, survey gear, seasonal timing and geographic coverage.
- Selectivity for the surveys is length-based. It is assumed to be asymptotic for all surveys except the Triennial shelf survey, for which selectivity was allowed to be dome-shaped (using the double-normal function). The survey selection curves are independent of one another except for the NWFSC slope survey and the AFSC slope survey, which are assumed to have the same selectivity because no length composition data are available from the NWFSC slope survey to inform a separate selectivity.
- The Francis method is used for reweighting the composition data from the different sources.
- Additional variability added to the year-specific variances of the surveys is estimated to account for inter-annual variability (process error).

The base model is informed by the following data sources.

- Annual landings data from the three fishing fleets (bottom-trawl, fixed-gear, and an at-sea, no-discard fleet) for the period 1916-2012.

- Annual length composition data from the bottom-trawl and fixed-gear fleets starting in 1995, and from the at-sea hake (no-discard) fleet starting in 2003.
- Conditional age-at-length composition data from the bottom-trawl and at-sea hake (no-discard) fleets for two years (2008 and 2011).
- Annual discard biomass amounts for the bottom-trawl and fixed-gear fleets for 2002-2011.
- Annual mean weights of discarded fish for the bottom-trawl fleet for 2002-2011.
- Annual length compositions of discarded fish from the bottom-trawl fleet for 2002-2011, and for the fixed-gear fleet for 2003-2011.
- Annual biomass indices from the early (1980, 1986, 1989, and 1992) and late (1995, 1998, 2001, and 2004) Triennial survey, the AFSC slope survey (1996, 1997, 1999, 2000, and 2001), the NWFSC slope survey (1999, 2000, 2001, and 2002), and the NWFSC shelf-slope survey (2003-2012).
- Annual length composition data from all surveys except the NWFSC slope survey and the AFSC slope survey in 1996.
- Annual conditional age-at-length composition data from the NWFSC shelf-slope survey (2003-2012).

*Alternative Models for Bracketing Uncertainty*

The STAT, in the draft assessment document and in their statements to the STAR, indicated that the results for this assessment were extremely sensitive to the natural mortality coefficient (*M*). The STAR agreed that *M* was the major axis of uncertainty. However, the best approach for quantifying the uncertainty associated with different values of *M* was not clear. The topic generated much discussion among all the STAR and STAT members. The STAT proposed the following method for selecting *M* values to characterize the low and high states of nature. The STAR endorsed this approach.

- Using the base model determine the 12.5 and 87.5 percentiles of spawning biomass in 2013 ($SB_{2013}$), based on the assumption that spawning biomass is lognormally distributed and using the SS3 estimated standard error for the estimate of $SB_{2013}$ (coefficient of variation = 30.6%).
- Determine the fixed *M* values that produce these low ($M$ = 0.037 $y^{-1}$) and high ($M$ = 0.047 $y^{-1}$) estimates of $SB_{2013}$.

One problem with this approach is that it only incorporates the uncertainty associated with the data measurement errors in the base model; the approach does not consider any of the uncertainties associated with the assumed model structure (e.g., the assumptions that steepness $h$ = 0.779 and that the data weightings are correct).

## Comments on Technical Merits and/or Deficiencies

*Technical Merits*

This is the first assessment for this stock and as such it provides a significant improvement on the previous data-poor view of the stock's potential productivity and current status. The preliminary concerns, based on the Council's productivity and susceptibility analysis, that the stock might be in poor condition proved to be unfounded.

The STAT produced a good quality assessment document, presented it clearly to the STAR, and was very responsive at addressing the questions and points raised by the STAR.

*Technical Deficiencies*

Because there were relatively limited age-composition data available and because the stock had not previously been assessed, our state of knowledge regarding this stock is not fully mature. While the natural mortality rate remains the major source of uncertainty regarding this stock, there are several other potential sources of uncertainty that have not yet been fully explored or accounted for (e.g., steepness, the catch history, and the assumption that fishery selectivity is time-invariant). The current assessment almost certainly underestimates the uncertainty of the stock's status and its ability to support harvest.

## Areas of Disagreement

*Between the STAR Panel and STAT*

There were no areas of disagreement between the STAT and the STAR Panel regarding the technical aspects or results of the assessment.

*Among STAR Panel Members*

There were no disagreements among the members of the STAR Panel regarding the technical aspects or results of the assessment.

<u>Concerns Raised by the GMT.</u>

The GMT did not raise any concerns regarding the technical aspects of the assessment.

<u>Concerns Raised by the GAP.</u>

The GAP did not raise any concerns regarding the technical aspects of the assessment.

## Unresolved Problems and Major Uncertainties

The issue of the relative productivity of rougheye rockfish versus blackspotted rockfish remains a very important source of uncertainty with regard to the management of these two stocks. If these two species differ in their biological traits and productivity, then treating them as a single stock could result in great harm to the less productive species. The combined assessment might imply rates of harvest that could not be sustained by the weaker species.

Numerous results presented by the STAT in the draft assessment document and during the review illustrated that the assessment results for rougheye rockfish are very sensitive to the values chosen for the natural mortality coefficient. Natural mortality is always a very problematic parameter for stock assessments, but with very long-lived species such as rougheye rockfish, the presence of very old individuals in composition data can provide strong information regarding the implausibility of large values for *M*. Future assessments of this stock would greatly benefit from an increased number of conditional age-at-length observations and a validation of the ageing method.

Both draft assessments reviewed by the STAR Panel had used the SS3 estimates of effective sample size to iteratively reweight the different sources of composition data. Although this reweighting approach has become a standard feature of most US West Coast assessments, Francis (2011, and in person at the review) provided compelling evidence that this standard approach resulted in implausible residual patterns for the rougheye rockfish assessment and for the aurora rockfish assessment. The Francis approach to reweighting, in contrast, for the most part eliminated these "bad" residual patterns. The Panel endorsed the use of the Francis approach for both assessments. However, it remains to be determined whether the Francis approach is the "best" general approach for deriving reweighting factors. The STAR Panel recommends that a scientific workshop be sponsored to review the state of the art for reweighting stock assessment data, with the aim of preparing a guide to good practices for future assessments.

One issue with the base model for this assessment is its poor ability to fit the length composition data for the NWFSC shelf/slope survey. The model was unable to match the bimodal pattern that was apparent in the length distributions in all years except at the end of the series. The model generally estimated more fish in the 30 to 44 cm length bins than were evident in the data. In this length range the fish would range in age from roughly 10 to 19 years. The absence of these fish may be related to the gap in the fish taken by this survey from the 250 to 300 m depth range. The STAR Panel and STAT attempted to explore the issue of these missing fish in Requests 2 and 14, but were unsuccessful at solving the puzzle.

Another issue that generated considerable discussion amongst the STAR and STAT was how to adequately quantify and balance uncertainty when constructing the decision table. An initial attempt by the STAT, which used the lognormal prior distribution for *M*, resulted in low and high states of nature that seemed implausibly asymmetric with respect to spawning biomass and projected catches. Future stock assessments and STAR Panels would likely benefit if they were provided with more detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

## Issues Raised by the GMT or GAP Representatives

The GMT and GAP did not raise any data or management issues regarding this assessment.

## Prioritized Recommendations for Future Research and Data Collection

*General (affecting more than one assessment)*

1. A workshop should be held to evaluate (a) methods for the iterative reweighting of composition data (e.g., current approach based on SS3 calculation of effective N versus the Francis approach) and (b) methods for developing initial weightings (the initial input N values).

2. A workshop should be held to evaluate methods for constructing survey GLMM estimates. Topics that should be explored include: (a) the effect of treating vessels as random when in fact the vessels hardly vary from one year to the next; (b) possible aliasing of the index values with the *Vessel* x *Year* interactions; and (c) the using information from the GLMM for combining length composition data collected by different vessels. One goal for the workshop should be to provide adequate documentation of the GLMM methods that will be used to produce survey biomass indices for future assessments and guidelines on how the analyses, including diagnostics, should be presented in stock assessment reports.

3. Port sampling programs should continue their routine collection of otoliths of slope rockfish species. A catalog of historical collections that have not been aged should be developed.

4. The series of historical catches of individual rockfish species, which are important sources of uncertainty in stock assessments of rockfish, should be explored in more detail. The STAR Panel agrees with the statement in the draft assessment document that "*A thorough look at historical landings, species compositions, and discarding practices would reduce the potential uncertainty that is not entirely accounted for*".

   Furthermore, catch reconstructions should not just develop best estimates of rockfish catch by species, but should also characterize the uncertainty of historical catch estimates by identifying periods of greater and lesser uncertainty. For example, rockfish species compositions taken during early years when there limited slope fisheries should be very different from species compositions taken during later years when fisheries on the slope were more prevalent.

5. The SSC should develop detailed technical guidance on how to construct decision tables, including a summary of lessons learned from a review of approaches applied in past stock assessments.

6. Investigate better fishery-independent data collection methods for slope rockfish and other species living in untrawlable habitats (e.g., surveys using submersibles or remotely operated vehicles).

*Specific to rougheye rockfish*

1. The STAR Panel agrees with the STAT regarding the importance of collecting additional age data and other information that will improve our understanding of the life-history characteristics of rougheye and blackspotted rockfish, with the aim of reducing the uncertainty regarding natural mortality.

2. The survey and port sampling efforts should collect genetic material in association with otolith sampling to provide a clear basis for distinguishing between rougheye and blackspotted rockfish. Also, researchers in the PFMC arena should collaborate with ongoing AFSC and Department of Fisheries and Oceans Canada genetic studies of rougheye and blackspotted rockfish.

3. Prior to the next assessment of either rougheye or blackspotted rockfish (or their complex), there should be targeted studies or analyses to investigate what caused the lack 30-44 cm fish caught in the 250-300 m depth zone by the NWFSC shelf/slope survey.

4. The STAR Panel agrees with the STAT regarding the importance of additional studies of the maturity and fecundity of rougheye and blackspotted rockfish. Further, any fish used for maturity and fecundity studies should be subjected to genetic analysis to definitively identify what species it is.
5. The STAR Panel agrees with the STAT regarding the importance of validating the ageing method for rougheye and blackspotted rockfish. Further, any fish used for age-validation studies should be subjected to genetic analysis to definitively identify what species it is.
6. The STAR Panel agrees with the STAT regarding the importance of "*understanding the stock structure and biology of rougheye and blackspotted rockfishes*" and their recommendation for "… *additional research that will provide insight into the distribution, life history, biological characteristics, and catch and discard profiles of the two species*".
7. The STAR Panel agrees with the STAT regarding the importance of "*basin-wide understanding of stock structure, connectivity, and distribution*" for rougheye and blackspotted rockfish, with the aim of defining "*the connectivity between rougheye* [and blackspotted] *rockfish north of the U.S.-Canada border*".

*Suitability for an Update Assessment*

Given that this stock had not been previously assessed, given the sensitivity of the assessment results to small structural changes, and given the uncertainty regarding the mix of rougheye and blackspotted rockfish in the historical data, the Panel recommends that the next assessment of this stock be a conducted as a full assessment.

## References

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Pacific Fishery Management Council (2012). Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment and Review Process for 2013-2014.

Agenda Item G.3.a
Attachment 5 (Full Version, Electronic Only)
September 2013

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# Stock Assessment of Shortspine Thornyhead in 2013

by

Ian G. Taylor
Andi Stephens

Northwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

DRAFT SAFE
August 21, 2013

# Table of Contents

# Executive Summary

## Stock

This assessment applies to shortspine thornyhead (*Sebastolobus alascanus*) off of the west coast of the United States from the U.S.-Canadian border in the north to the U.S.-Mexico border in the south. Shortspine thornyheads have been reported as deep as 1,524 m, and this assessment applies to their full depth range although survey and fishery data are only available down to 1,280 m. This resource is modeled as a single stock because genetic analyses do not indicate significant stock structure within this range. This is the same stock assumption made in the most recent assessment of shortspine thornyhead in 2005 (Hamel, 2005).

## Catches

Landings of shortspine are estimated to have risen to a peak of 4,815 mt in 1989, followed by a sharp decline during a period of trip limits and other management measures imposed in the 1990s. Since the institution of separate trip limits for shortspine and longspine thornyheads, the fishery had more moderate removals of between 1,000 and 2,000 mt per year from 1995 through 1998. Landings fell below 1,000 mt per year from 1999 through 2006, then rose to 1,531 in 2009 and have declined since that time. Recreational fishery landings of thornyheads were negligible, so only commercial landings were included in the model. Trawl landings represent only bottom trawl gear and non-trawl landings include all other gears, the majority of which is longline, with some catch by pot gear. Both trawl and non-trawl landings are divided into North (the waters off Washington and Oregon) and South (the waters off California) fleets although they are assumed to be fishing on the same unit stock. Discard rates (landings divided by total catch) for shortspine have been estimated as high as 43% per year, but are more frequently below 20%. Discard rates in the trawl fisheries declined over the period where they are available from West Coast Groundfish Observer Program (WCGOP) from 2003–2011 and dropped to less than 1% in 2011, the only estimate available under catch shares system that began that year.

**Table a: Recent Landings**

| Year | Landings (mt) | | | | |
|---|---|---|---|---|---|
| | Trawl N | Trawl S | Non-trawl N | Non-trawl S | Total |
| 2003 | 270 | 364 | 11 | 155 | 800 |
| 2004 | 295 | 323 | 11 | 129 | 757 |
| 2005 | 255 | 250 | 11 | 139 | 654 |
| 2006 | 296 | 248 | 15 | 144 | 703 |
| 2007 | 562 | 285 | 16 | 143 | 1006 |
| 2008 | 902 | 330 | 20 | 175 | 1427 |
| 2009 | 948 | 383 | 29 | 172 | 1531 |
| 2010 | 770 | 355 | 22 | 206 | 1353 |
| 2011 | 424 | 288 | 24 | 237 | 974 |
| 2012 | 381 | 323 | 36 | 155 | 894 |

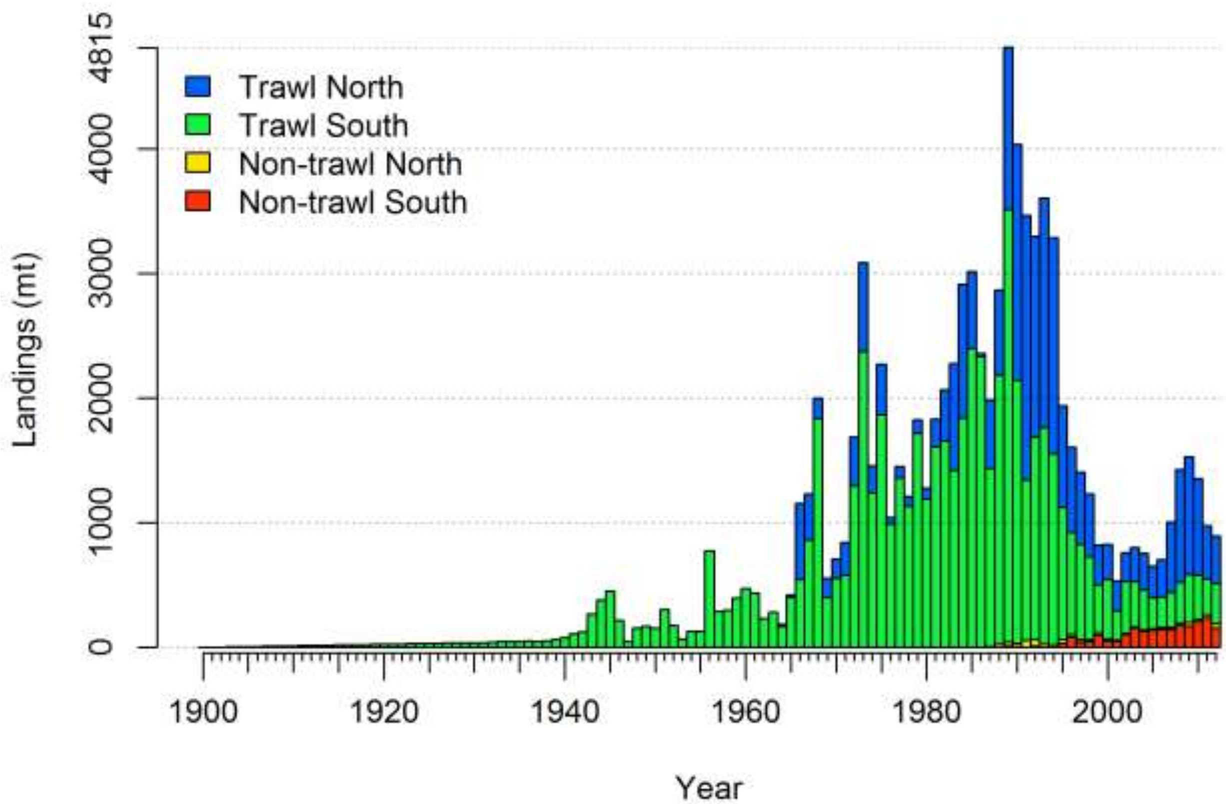


**Figure a: Landings History**

## Data and assessment

The most recent assessment for shortspine thornyhead was conducted in 2005 (Hamel, 2005). Stock status was determined to be above the target biomass and catches did not attain the full management limits so reassessment of thornyheads has not been a higher priority.

This new assessment used Stock Synthesis (SS, Methot, 2012) Version 3.24o used in other recent west coast assessments. Additional sensitivities were conducted using Version 3.24q, which has more flexible options to model maturity at length, a change that was made to explore new data for shortspine thornyheads (R. Methot, pers. comm.).

The data are divided into four fisheries: trawl and non-trawl gears, which are each divided into North (the waters off Washington and Oregon) and South (the waters off California) and five surveys: the Alaska Fisheries Science Center (AFSC) triennial shelf survey from 55-366 meters (1980-2004), the deeper range of triennial shelf survey from 366-500 meters for the later years (1995-2004), the AFSC slope survey (1997, 1999-2001), the Northwest Fisheries Science Center (NWFSC) slope survey (1998-2002) and the NWFSC combined shelf-slope survey (2003-2012).

Most of the data used in the previous assessment has been newly extracted and processed, including length compositions from each fishing fleet and survey, indices of abundance derived from new GLMM analyses of survey data, discard rates from both a 1980s Oregon State University observer study (Pikitch et al., 1988) and the current West Coast Groundfish Observer Program (WCGOP), and the time series of catch from 1981-2012. Data retained from the previous assessment without reanalysis are the estimated historic catch for the years up to 1980 and discard rates from the Enhanced Data Collection Project (EDCP) study in the 1990s. Shortspine ovaries were collected in 2011 and 2012 from the NWFSC shelf-slope survey which allowed an exploration of alternative maturity assumptions from those used in the previous assessment. However, additional sampling and further analysis of maturity patterns is needed before revising the assumptions about maturity used in the assessment.

As in the previous assessment, no age data are used in this analysis and growth parameters are fixed at the same values used in 2005. Parameters for steepness of the stock-recruit relationship and natural mortality are likewise fixed in this assessment. There are 223 estimated parameters in the assessment. The log of the unfished equilibrium recruitment, log($R_0$), controls the scale of the population, annual deviations around the stock-recruit curve (163 parameters) allow for more uncertainty in the population trajectory, and selectivity and retention of the 4 fishing fleets and 5 surveys, including estimates of changes in retention over time (58 parameters). Finally, there is a single parameter which represents additional variability in one of the surveys that is added to the estimate of sampling error for that index.

## Stock biomass

Unfished equilibrium spawning biomass ($B_0$) is estimated to be 189,765 mt, with a 95% confidence interval of 57,435 – 322,095 mt. The $B_0$ estimate represents an increase from the 130,646 mt estimate for $B_0$ in the previous assessment although this previous estimate falls well within the uncertainty interval around the current estimate. Spawning biomass is estimated to have remained stable until the mid-1970s and then declined from the 1970s to about 80% in the 1990s, followed by a slower decline under the lower catch levels in the 2000s (Figure 36). The estimated spawning biomass in 2013 is 140,753 mt, which represents a stock status or “depletion” (represented as spawning biomass in 2013, $B_{2013}$, divided by $B_0$) of 74.2% (Figure 37). The depletion estimated for 2005 is 76.4%, which is higher than the 62.9% estimated for 2005 in the previous assessment. The standard deviation of the log of spawning biomass in 2013 is $\sigma = 0.45$, which is greater than the 0.36 minimum assumed for use in $p^*$ adjustments to OFL values.

**Table b: Recent trend in beginning of the year biomass and depletion**

| Year | Spawning biomass (1000 mt) | ~95% confidence interval | Estimated depletion | ~95% confidence interval |
|---|---|---|---|---|
| 2003 | 146.0 | 16.1 – 275.8 | 76.9% | 61.3% – 92.5% |
| 2004 | 145.5 | 15.5 – 275.5 | 76.7% | 60.8% – 92.5% |
| 2005 | 145.0 | 15.0 – 275.1 | 76.4% | 60.4% – 92.5% |
| 2006 | 144.7 | 14.5 – 274.8 | 76.2% | 60.0% – 92.4% |
| 2007 | 144.3 | 14.1 – 274.6 | 76.1% | 59.7% – 92.4% |
| 2008 | 143.8 | 13.4 – 274.2 | 75.8% | 59.2% – 92.4% |
| 2009 | 143.1 | 12.6 – 273.7 | 75.4% | 58.4% – 92.4% |
| 2010 | 142.3 | 11.6 – 273.0 | 75.0% | 57.7% – 92.3% |
| 2011 | 141.6 | 10.8 – 272.5 | 74.6% | 57.0% – 92.3% |
| 2012 | 141.2 | 10.2 – 272.1 | 74.4% | 56.5% – 92.3% |
| 2013 | 140.8 | 9.7 – 271.8 | 74.2% | 56.1% – 92.3% |

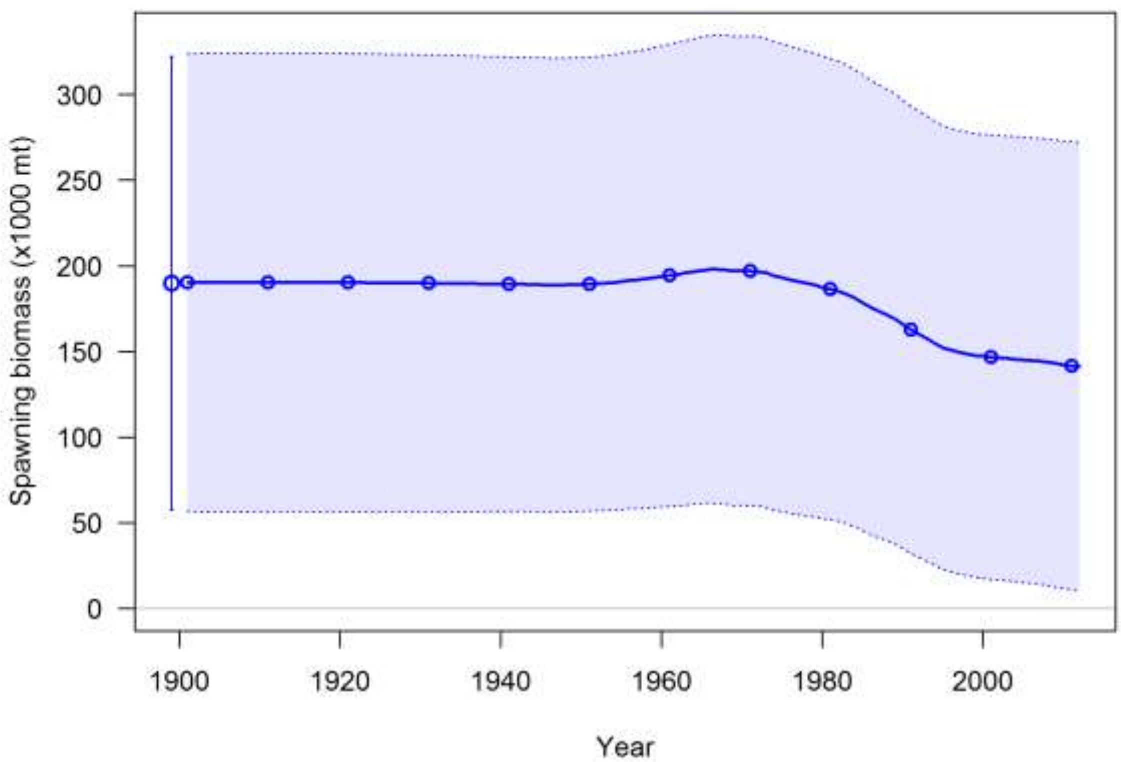


**Figure b: Biomass trajectory**

## Recruitment

This assessment assumed a Beverton-Holt stock recruitment relationship. Steepness (the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass) was kept at the value of 0.6 that was assumed in the previous assessment, although the results were relatively insensitive to alternative assumptions about steepness. The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$). Recruitment deviations were estimated for the years 1850 through 2012, where the values estimated in the years 1850 through 1900 are used to estimate a non-equilibrium age-structure in 1901, which is the first year of the population projection. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates.

**Table c: Recent recruitment**

| Year | Estimated recruitment (millions) | +-~95% confidence interval |
|---|---|---|
| 2003 | 20.6 | 7.3 - 57.9 |
| 2004 | 22.5 | 7.9 - 64.1 |
| 2005 | 27.2 | 9.3 - 79.5 |
| 2006 | 32.7 | 10.9 - 98.5 |
| 2007 | 33.0 | 10.8 - 100.8 |
| 2008 | 30.9 | 10.1 - 94.3 |
| 2009 | 30.2 | 9.9 - 92.4 |
| 2010 | 30.5 | 9.9 - 93.5 |
| 2011 | 27.4 | 9.0 - 83.7 |
| 2012 | 28.8 | 9.3 - 89.3 |

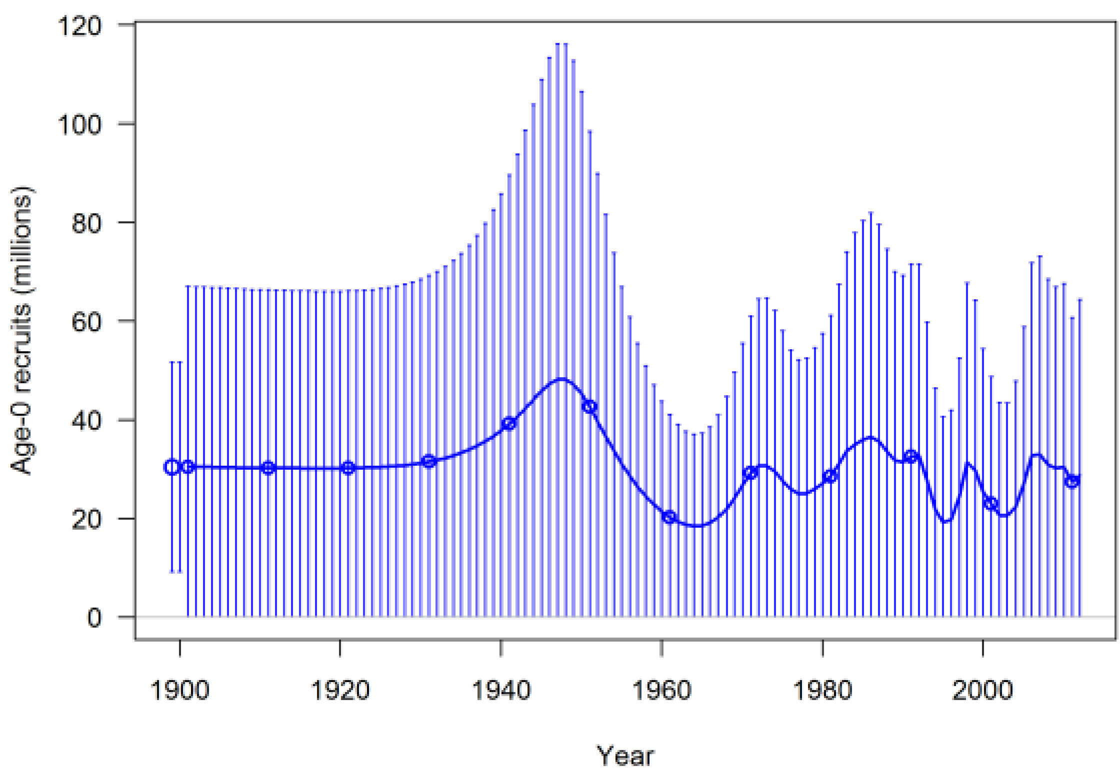


**Figure c: Recruitment**

## Exploitation status

The summary harvest rate (total catch divided by age-1 and older biomass) closely follows the patterns of landings. The harvest rates are estimated to have never exceeded 2% and have remained below 1% in the past decade. Expressing exploitation rates in terms of spawning potential ratio (SPR) indicates that the exploitation slightly exceeded the target reference point associated with $SPR_{50\%}$ for a single year in 1985 and then for the period 1989-1994. However, the stock status is estimated to have never fallen below the $B_{40\%}$ management target.

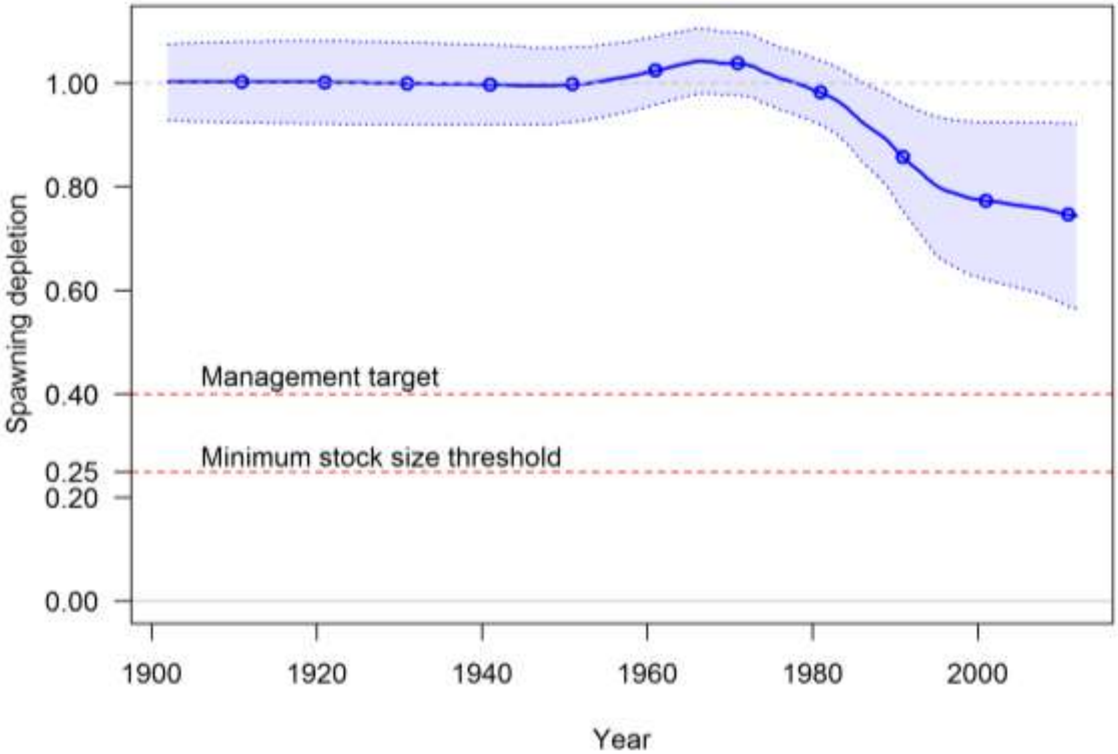


**Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (shaded area) for the base case assessment model.**

**Table d. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate (catch divided by biomass of age-1 and older fish).**

| Year | Estimated 1–SPR (%) | ~95% confidence interval | Harvest rate (proportion) | ~95% confidence interval |
|---|---|---|---|---|
| 2001 | 13.0% | 2.2% - 23.8% | 0.0024 | 0.0002 - 0.0045 |
| 2002 | 17.4% | 3.4% - 31.4% | 0.0034 | 0.0003 - 0.0064 |
| 2003 | 18.4% | 3.6% - 33.2% | 0.0036 | 0.0004 - 0.0068 |
| 2004 | 17.6% | 3.3% - 31.8% | 0.0034 | 0.0003 - 0.0064 |
| 2005 | 15.5% | 2.7% - 28.3% | 0.0029 | 0.0003 - 0.0056 |
| 2006 | 16.6% | 3.0% - 30.2% | 0.0032 | 0.0003 - 0.0060 |
| 2007 | 21.8% | 4.6% - 39.0% | 0.0042 | 0.0004 - 0.0081 |
| 2008 | 29.7% | 7.6% - 51.8% | 0.0061 | 0.0005 - 0.0116 |
| 2009 | 31.4% | 8.2% - 54.5% | 0.0065 | 0.0005 - 0.0126 |
| 2010 | 28.3% | 6.7% - 49.8% | 0.0058 | 0.0004 - 0.0112 |
| 2011 | 20.3% | 3.7% - 36.9% | 0.0041 | 0.0003 - 0.0078 |
| 2012 | 18.7% | 3.1% - 34.2% | 0.0037 | 0.0002 - 0.0072 |

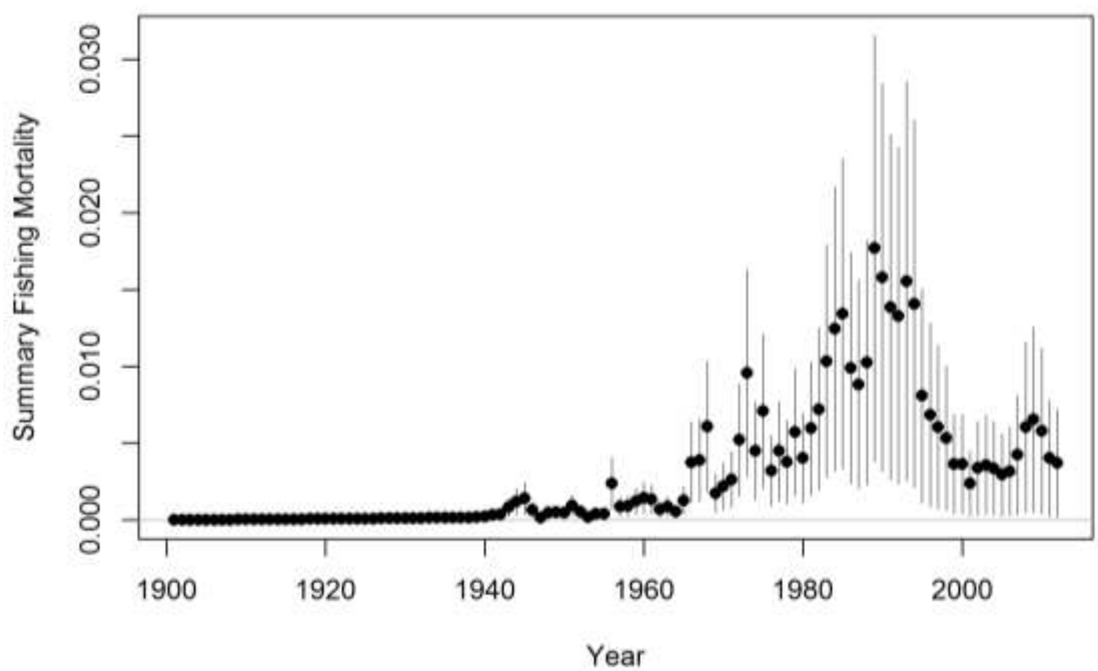


**Figure e. Time-series of estimated summary harvest rate (total catch divided by age-1 and older biomass) for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines).**

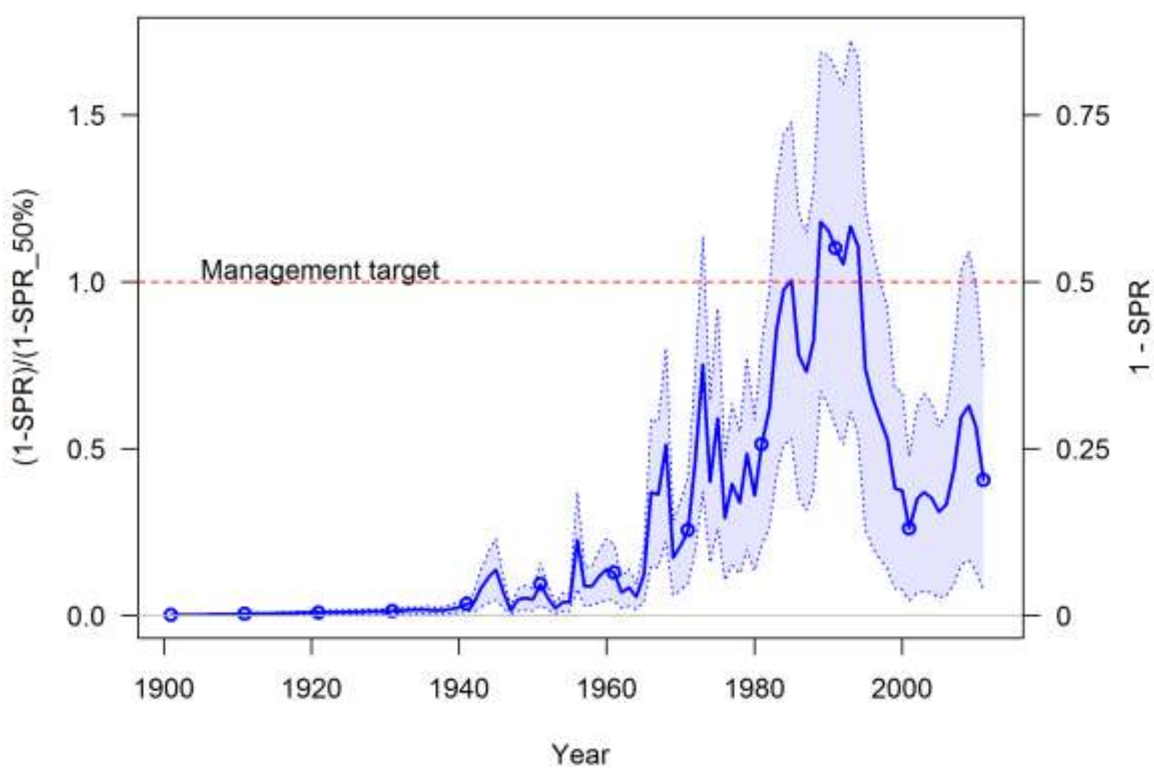


**Figure f. Estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. Both one minus SPR (right y-axis) and the ratio of this quantity to the associated target (1 - $SPR_{50\%}$) (left y-axis) are shown. These quantities are chosen so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.**

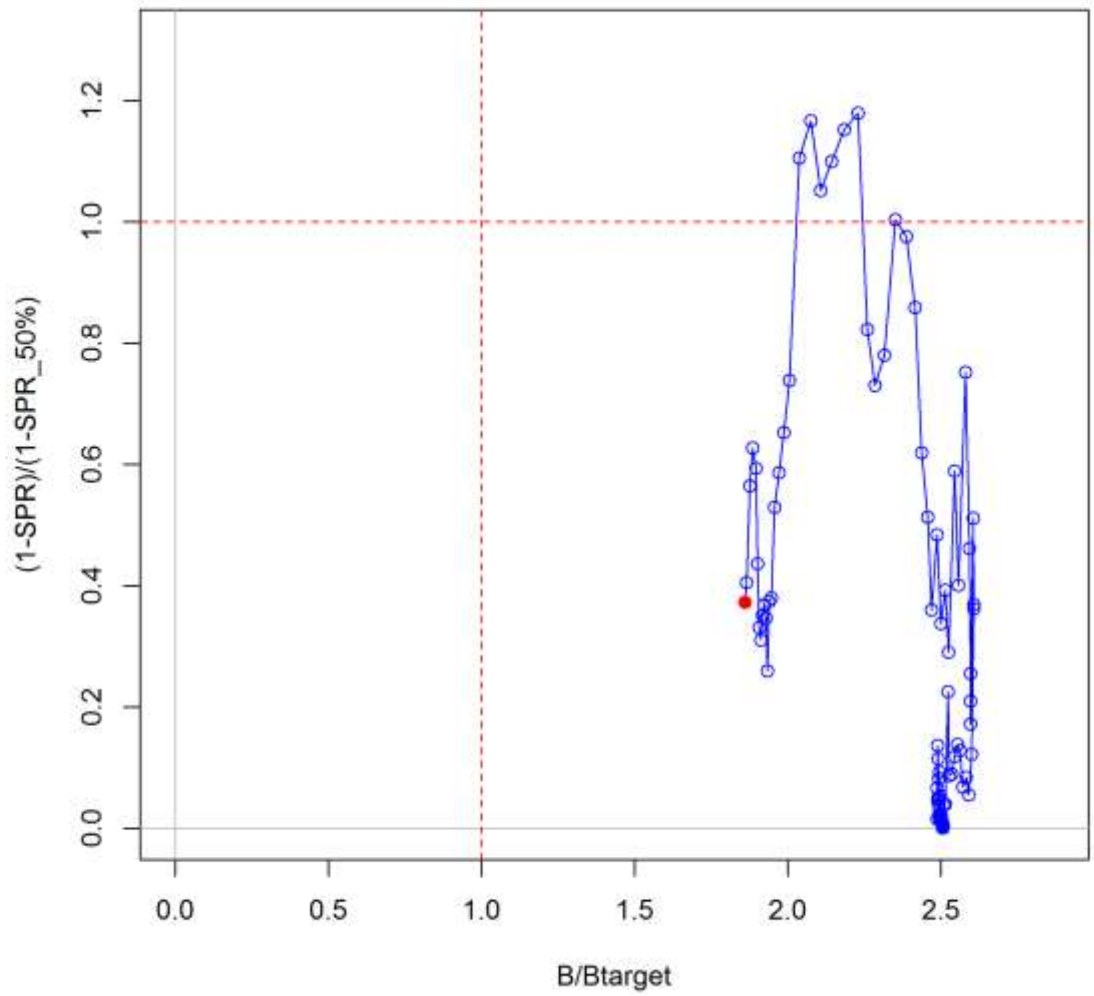


**Figure g. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 50% of the unfished spawning biomass. The red point indicates the year 2012.**

## Ecosystem considerations

Shortspine and longspine thornyheads have historically been caught with each other and with Dover sole and sablefish, making up a "DTS" fishery. Other groundfishes that frequently co-occur in these deep waters include a complex of slope rockfishes, rex sole, longnose skate, roughtail skate, Pacific grenadier, giant grenadier, Pacific flatnose as well as non-groundfish species such as Pacific hagfish and a diverse complex of eelpouts. Shortspine thornyheads typically occur in shallower water than the shallowest longspine thornyheads, and migrate to deeper water as they age. When shortspines have reached a depth where they overlap with longspines, they are typically larger than the largest longspines. Shortspine thornyhead stomachs have been found to include longspine thornyheads, suggesting a predator-prey linkage between the two species.

Thornyheads spawn gelatinous masses of eggs which float to the surface. This may represent a significant portion of the upward movement of organic carbon from the deep ocean (Wakefield, 1990). Thornyheads have been observed in towed cameras beyond the 1280 meter limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown.

## Reference points

Reference points were calculated using the estimated catch distribution among fleets in the last year of the model (2012), and the estimated values are dependent on this assumption. In general, the population is at a healthy status relative to the reference points. Sustainable total yield (landings plus discards) was estimated at 2,034 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 633 – 3,435 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished spawning output ($B_{40\%}$) was 75,906 mt. The most recent catches (landings plus discards) have been lower than the estimated long-term yields calculated using an $SPR_{50\%}$ reference point, but not as low as the lower bound of the 95% uncertainty interval. However, this is due to the fishery not fully attaining the full ACL. The OFL and ACL values over the past 6 years have been approximately 2,400 mt and 2,000 mt, respectively. Both of those values are lower than the OFL and ACL values predicted in short-term forecasts, which are around 3,200 mt and 3,000 mt respectively for 2015–2016.

**Table e. Summary of reference points and management outputs for the base case model.**

| Quantity | Estimate | ~95% confidence interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 189,765 | (57,435 – 322,095) |
| Unfished age 1+ biomass (mt) | 331,047 | (100,196 – 561,898) |
| Unfished recruitment (R0, millions) | 30.4 | (15.2 – 61.1) |
| Depletion (2013) | 74.2% | (56.1% – 92.3%) |
| Spawning Biomass (2013) | 140,753 | (9,673 – 271,833) |
| SD of log Spawning Biomass (2013) | 0.45 | – |
| ***Reference points based on $B_{40\%}$*** | | |
| Proxy spawning biomass ($B_{40\%}$) | 75,906 | (22,974 – 128,838) |
| SPR resulting in $B_{40\%}$ ($SPR_{SB40\%}$) | 50.0% | – |
| Exploitation rate resulting in $B_{40\%}$ | 0.015 | (0.015 – 0.016) |
| Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt) | 2,034 | (633 – 3,435) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 75,906 | (22,974 – 128,838) |
| $SPR_{proxy}$ | 50.0% | – |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.015 | (0.015 – 0.016) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 2,034 | (633 – 3,435) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at $MSY$ ($SB_{MSY}$) | 64,600 | (19,517 – 109,683) |
| $SPR_{MSY}$ | 45.0% | (44.9% – 45.2%) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.018 | (0.018 – 0.019) |
| $MSY$ (mt) | 2,062 | (642 – 3,482) |

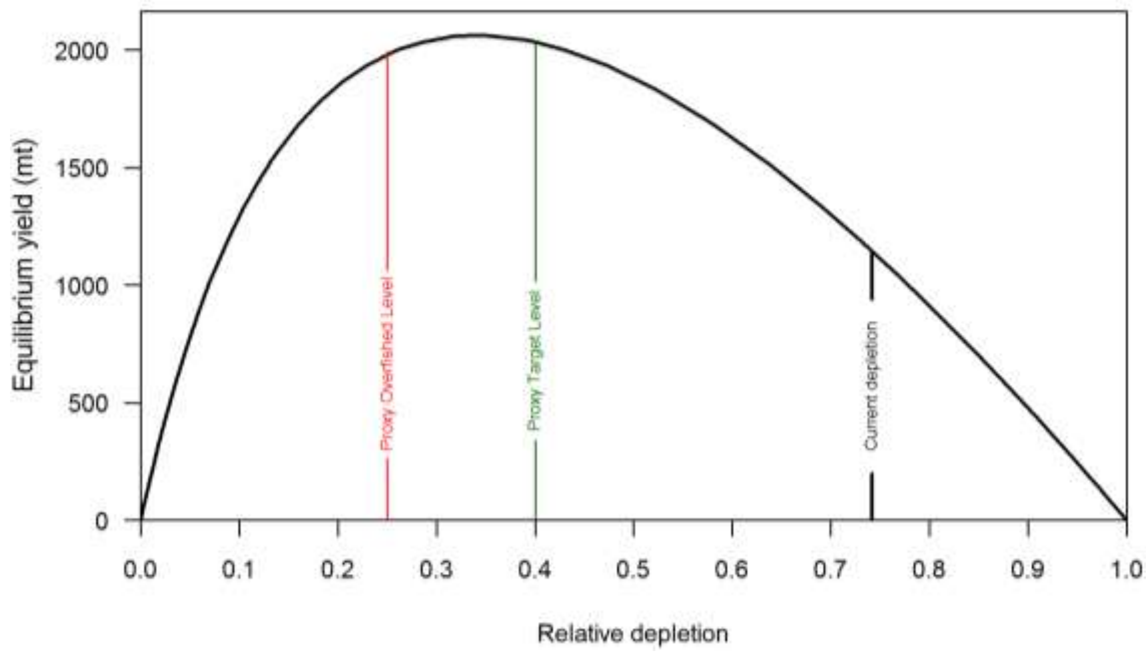


**Figure h. Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2012 relative catch among fleets. The depletion is relative to unfished spawning biomass.**

## Management performance

Catches for shortspine thornyheads have not fully attained the catch limits in recent years. Increases in ACLs in 2007 was associated with higher catch levels in 2006–2010, but in 2011 and 2012, catches were about half of the allowed limit. The fishery for shortspine thornyhead may be limited more by the ACLs on sablefish with which they co-occur and by the challenging economics of deep sea fishing, than by the management measures currently in place.

**Table f. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.**

| Year | OFL (mt) | ACL (mt) | Commercial Landings (mt) | Estimated Total Catch (mt) |
|---|---|---|---|---|
| 2001 | 880 | 751 | 532 | 602 |
| 2002 | 1,004 | 955 | 762 | 855 |
| 2003 | 1,004 | 955 | 800 | 903 |
| 2004 | 1,030 | 983 | 757 | 846 |
| 2005 | 1,055 | 999 | 654 | 739 |
| 2006 | 1,077 | 1,018 | 703 | 792 |
| 2007 | 2,476 | 2,055 | 1,006 | 1,058 |
| 2008 | 2,476 | 2,055 | 1,427 | 1,507 |
| 2009 | 2,437 | 2,022 | 1,531 | 1,619 |
| 2010 | 2,411 | 2,001 | 1,353 | 1,431 |
| 2011 | 2,384 | 1,978 | 974 | 994 |
| 2012 | 2,358 | 1,957 | 894 | 911 |

## Unresolved problems and major uncertainties

The absence of a reliable ageing method provides a significant hindrance to estimating growth and natural mortality of shortspine thornyhead. New maturity data made available for this assessment indicate puzzling patterns of maturity, with higher rates of maturity in the north than in the south and a higher fraction of mature fish in the samples with length 20–30 cm than in the samples from 30–40cm. The relative distribution of different sizes of shortspine thornyheads, with smaller fish occurring shallower and further the north, suggests an ontogenetic migration pattern to deeper and more southern waters, with a potentially J-shaped pattern of migration. Understanding the rates and patterns of thornyhead migration and any potential interaction or confounding with spatial patterns of fishing would be valuable for understanding better appropriate ways to model this stock.

The indices of abundance are all relatively flat, providing little information about the scale of the population (other than providing evidence that it has not been declining). The current NWFSC index has the largest number of data points of any available index on the west coast, and each additional year of this index will be valuable for understanding any changes in size composition or abundance. However, in the absence of large changes in shortspine catch, the population is estimated to remain similar to its current state.

## Projections and Decision table

The standard deviation of the log of spawning biomass in 2013 is σ = 0.45. This value is in the adjustment of quotas based on scientific uncertainty (a process referred to by the notation "*p**") when the value is greater than an assumed 0.36 minimum, as it is in this case. The associated offset would therefore be a multiplication of the OFL by 94.5%, which is the 45% quantile of a log-normal distribution with the associated $\sigma$. Twelve-year projections were conducted with a total catch assumed equal to the ACL calculated by applying this adjustment to the estimated OFL for each year. The retention function and allocation of catch among fleets was assumed to match the average values for 2011–2012 (the only years in which the trawl fishery was operating under IFQs). This allocation between fleets was 43% for Trawl North, 32% for Trawl South, 3% for Non-trawl North, and 22% for Non-trawl South. Catch for 2013–2014, the limits on which have already been set, were assumed to equal the averages over 2011–2012, which correspond to a total catch of 952 mt and landings of 933 mt after applying the estimated retention function to the age structure of the population in 2013. The 933 mt value is identical to the average of the retained catch for the years 2011–2012, suggesting that the choice to model forecast catches in terms of total catch rather than landings has little influence on the forecast results.

This default harvest rate projection applied to the base model indicated that the stock status would slowly decline from 74.2% in 2013 to 67.2% in 2024, still far above the 40% biomass target and 25% minimum stock size threshold. The associated OFL values over the period 2015–2024 would average 3,053 mt and the average ACL would be 2,885. These values are above recent catch limits, which have not been fully attained in recent years. In these projections, the stock status was always above 40%, so the 40-10 adjustment in the control rule had no impact on the projections.

**Table g. Projection of potential OFL, landings, and catch, summary biomass (age-1 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2013 and 2014, and catches at the *p** offset (94.5%) from the OFL from 2015 onward. The 2013 and 2014 OFL's are values specified by the PFMC and not predicted by this assessment. The OFL for 2015 and onward is the calculated total catch determined by $F_{SPR}$.**

| Year | Predicted OFL (mt) | ACL Catch (mt) | Landings (mt) | Age 1+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 2,333 | 1,836 | 933 | 243,824 | 140,753 | 74.2% |
| 2014 | 2,333 | 1,836 | 933 | 243,316 | 140,342 | 74.0% |
| 2015 | 3,203 | 3,027 | 2,968 | 242,845 | 139,977 | 73.8% |
| 2016 | 3,167 | 2,993 | 2,934 | 240,160 | 138,449 | 73.0% |
| 2017 | 3,131 | 2,959 | 2,901 | 237,526 | 136,971 | 72.2% |
| 2018 | 3,097 | 2,927 | 2,869 | 234,948 | 135,533 | 71.4% |
| 2019 | 3,064 | 2,895 | 2,838 | 232,425 | 134,127 | 70.7% |
| 2020 | 3,032 | 2,865 | 2,808 | 229,960 | 132,747 | 70.0% |
| 2021 | 3,001 | 2,836 | 2,779 | 227,554 | 131,391 | 69.2% |
| 2022 | 2,971 | 2,808 | 2,751 | 225,206 | 130,063 | 68.5% |
| 2023 | 2,943 | 2,781 | 2,725 | 222,918 | 128,763 | 67.9% |
| 2024 | 2,916 | 2,756 | 2,700 | 220,689 | 127,494 | 67.2% |

Additional projections were conducted for the base model and low and high states of nature (columns) under three catch streams (rows). The uncertainty in spawning biomass associated with the base model was very broad, so states of nature were chosen based on this range. The low state of nature was chosen from a profile over the equilibrium recruitment parameter as a model which had an estimate of 2013 spawning biomass closest to the 12.5$^{th}$ percentile of the spawning biomass distribution in the base model. This represents the middle of the lower 25% of probabilities in the base model. The high state of nature was not chosen in the same way, however, as 87.5$^{th}$ percentile of the base model did not encompass the range of models seen in sensitivity analyses as plausible alternatives. Instead, the high state of nature was taken as the model in the profile over the equilibrium recruitment that had a change in negative log-likelihood equal to 1.2 units, which is an alternative way to calculate the approximate center of the upper 25% of probable possibilities. This high state better reflected the asymmetry in uncertainty about the scale of the population (with more information about the lower range than the upper range of probable population sizes).

The catch streams chosen for the decision table were represented as total catch rather than landed catch, but discard rates were low under IFQs, so the difference in between total catch and landings is small. The low catch stream was assumed to have total catch equal to the average over the years 2011–2012, the years in which the trawl fishery was operating under IFQs was used as a low catch stream. This was a total catch of 952 mt divided among the fleets by the fraction. The high catch stream was chosen based on applying the SPR = 50% default harvest control rule to the base model, including a *p** offset which reduced the catch to 94.5% of the OFL. The middle catch stream was associated with SPR = 65% instead of the default SPR = 50%. This provided an intermediate level of catch while stabilizing the population at a stock status of approximately 60% (based on an exploratory 100 year forecast). The average total catch for the years 2015–2024 was 952 mt for the low catch stream, 1,795 for the middle catch stream, and 2,827 for the high catch stream.

The most pessimistic forecast scenario, combining the low state of nature with the high catch stream, resulted in a projected stock status of 39.9%, very close to the target value. All other projections led to a higher projected status, with a maximum of 89.1% for the combination of the high state of nature and low catch. Forecasts under the base case led to estimated status ranging from 2024 spawning depletion values of 67.2% in the high catch stream to 72.9% in the low catch stream.

No projections were done to explore changes in ratio of trawl to non-trawl or north to south. Due to differences in selectivity and retention among the fleets, these projections could be expected to provide slightly different results, although the general pattern of the projections suggesting stocks above target levels as described above is unlikely to change as a result of alternative ratios among the fleets.

**Table h. Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.**

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base case | | High | |
| **Relative probability of log($R_0$)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Total catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| Status quo catches | 2015 | 952 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 952 | 54.1 | 53.2% | 139.7 | 73.6% | 405.1 | 88.8% |
| | 2017 | 952 | 53.7 | 52.8% | 139.4 | 73.5% | 405.1 | 88.9% |
| | 2018 | 952 | 53.3 | 52.4% | 139.2 | 73.3% | 405.2 | 88.9% |
| | 2019 | 952 | 52.9 | 52.0% | 139.0 | 73.2% | 405.4 | 88.9% |
| | 2020 | 952 | 52.6 | 51.7% | 138.8 | 73.1% | 405.5 | 88.9% |
| | 2021 | 952 | 52.2 | 51.4% | 138.6 | 73.1% | 405.7 | 89.0% |
| | 2022 | 952 | 51.9 | 51.0% | 138.5 | 73.0% | 405.8 | 89.0% |
| | 2023 | 952 | 51.6 | 50.8% | 138.4 | 72.9% | 406.0 | 89.0% |
| | 2024 | 952 | 51.4 | 50.5% | 138.2 | 72.9% | 406.1 | 89.1% |
| Catch associated with SPR = 65%, stabilizing population around 60% of $B_0$ | 2015 | 1,828 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 1,819 | 53.6 | 52.7% | 139.2 | 73.3% | 404.6 | 88.7% |
| | 2017 | 1,812 | 52.7 | 51.8% | 138.4 | 72.9% | 404.1 | 88.6% |
| | 2018 | 1,804 | 51.8 | 50.9% | 137.6 | 72.5% | 403.7 | 88.5% |
| | 2019 | 1,797 | 50.9 | 50.0% | 136.9 | 72.1% | 403.3 | 88.5% |
| | 2020 | 1,790 | 50.0 | 49.1% | 136.2 | 71.8% | 402.9 | 88.4% |
| | 2021 | 1,784 | 49.1 | 48.3% | 135.5 | 71.4% | 402.6 | 88.3% |
| | 2022 | 1,778 | 48.3 | 47.5% | 134.9 | 71.1% | 402.2 | 88.2% |
| | 2023 | 1,773 | 47.5 | 46.7% | 134.2 | 70.7% | 401.8 | 88.1% |
| | 2024 | 1,768 | 46.7 | 45.9% | 133.6 | 70.4% | 401.5 | 88.1% |
| OFL (associated with SPR = 50%), including *p** offset (94.5%) | 2015 | 3,027 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 2,993 | 52.9 | 52.0% | 138.4 | 73.0% | 403.9 | 88.6% |
| | 2017 | 2,959 | 51.3 | 50.4% | 137.0 | 72.2% | 402.7 | 88.3% |
| | 2018 | 2,927 | 49.7 | 48.8% | 135.5 | 71.4% | 401.6 | 88.1% |
| | 2019 | 2,895 | 48.1 | 47.3% | 134.1 | 70.7% | 400.6 | 87.9% |
| | 2020 | 2,865 | 46.5 | 45.7% | 132.7 | 70.0% | 399.5 | 87.6% |
| | 2021 | 2,836 | 45.0 | 44.2% | 131.4 | 69.2% | 398.5 | 87.4% |
| | 2022 | 2,808 | 43.5 | 42.7% | 130.1 | 68.5% | 397.5 | 87.2% |
| | 2023 | 2,781 | 42.0 | 41.3% | 128.8 | 67.9% | 396.4 | 87.0% |
| | 2024 | 2,756 | 40.6 | 39.9% | 127.5 | 67.2% | 395.5 | 86.7% |

**Table i. Summary table of the results.**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 800 | 757 | 654 | 703 | 1,006 | 1,427 | 1,531 | 1,353 | 974 | 894 | NA |
| Estimated Total catch (mt) | 903 | 846 | 739 | 792 | 1,058 | 1,507 | 1,619 | 1,431 | 994 | 911 | NA |
| OFL (mt) | 1,004 | 1,030 | 1,055 | 1,077 | 2,476 | 2,476 | 2,437 | 2,411 | 2,384 | 2,358 | 2,333 |
| ACL (mt) | 955 | 983 | 999 | 1,018 | 2,055 | 2,055 | 2,022 | 2,001 | 1,978 | 1,957 | 1,937 |
| 1-SPR | 18% | 18% | 16% | 17% | 22% | 30% | 31% | 28% | 20% | 19% | NA |
| Exploitation rate (catch/ age 1+ biomass) | 0.0036 | 0.0034 | 0.0029 | 0.0032 | 0.0042 | 0.0061 | 0.0065 | 0.0058 | 0.0041 | 0.0037 | NA |
| Age 1+ biomass (1000 mt) | 252.0 | 251.2 | 250.6 | 250.0 | 249.5 | 248.7 | 247.4 | 246.1 | 245.0 | 244.3 | 243.8 |
| Spawning Biomass (1000 mt) | 146.0 | 145.5 | 145.0 | 144.7 | 144.3 | 143.8 | 143.1 | 142.3 | 141.6 | 141.2 | 140.8 |
| ~95% Confidence Interval | 16.1 – 275.8 | 15.5 – 275.5 | 15.0 – 275.1 | 14.5 – 274.8 | 14.1 – 274.6 | 13.4 – 274.2 | 12.6 – 273.7 | 11.6 – 273.0 | 10.8 – 272.5 | 10.2 – 272.1 | 9.7 – 271.8 |
| Recruitment (millions) | 20.6 | 22.5 | 27.2 | 32.7 | 33.0 | 30.9 | 30.2 | 30.5 | 27.4 | 28.8 | NA |
| ~95% Confidence Interval | 7.3 – 57.9 | 7.9 – 64.1 | 9.3 – 79.5 | 10.9 – 98.5 | 10.8 – 100.8 | 10.1 – 94.3 | 9.9 – 92.4 | 9.9 – 93.5 | 9.0 – 83.7 | 9.3 – 89.3 | NA |
| Depletion (%) | 76.9% | 76.7% | 76.4% | 76.2% | 76.1% | 75.8% | 75.4% | 75.0% | 74.6% | 74.4% | 74.2% |
| ~95% Confidence Interval | 61.3% – 92.5% | 60.8% – 92.5% | 60.4% – 92.5% | 60.0% – 92.4% | 59.7% – 92.4% | 59.2% – 92.4% | 58.4% – 92.4% | 57.7% – 92.3% | 57.0% – 92.3% | 56.5% – 92.3% | 56.1% – 92.3% |

## Research and data needs

Research and data needs for future assessments include the following:

1) More investigation into maturity of shortspine is necessary to understand the patterns in maturity observed in the samples collected in 2011 and 2012.
2) Information on possible migration of shortspine thornyheads would be valuable for understanding stock dynamics. Analysis of trace elements and stable isotopes in shortspine otoliths may provide valuable information on the extent of potential migrations. Possible connections between migration and maturity could likewise be explored.
3) A greater understanding of catchability of thornyheads would help define the scale of the populations. This could include a survey using a towed camera to assess the abundance in water beyond the 1280 m range of the trawl surveys. Further exploration of perceived differences in catchability between towed cameras and trawl nets could also be explored. Understanding the relative catchability of shortspine and longspine thornyhead, which are difficult to distinguish in camera observations, would have to be a component of such investigations. Differences in selectivity between the AFSC Slope survey and the NWFSC surveys may be the result of behavioral interactions with different footropes. Understanding these interactions would also improve understanding of catchability.
4) Age data would be valuable for future stock assessments. Otoliths have been collected in good quantities from the NWFSC survey, but at this time the ageing methods are not believed to be reliable. Additional research on ageing methods for thornyheads would be valuable.
5) A greater understanding of the connection between thornyheads and bottom type could be used to refine the indices of abundance. Thornyheads are very well sampled in trawlable habitat, but the extrapolation of density to a survey stratum could be improved by accounting for the proportion of different bottom types within a stratum and the relative density of thornyheads within each bottom type.
6) A comprehensive catch reconstruction for shortspine and longspine thornyheads should be completed to estimate landings for each species prior to 1981 in each of the three states.
7) Exploration of simpler assessment methods for thornyheads and evaluation of whether such methods would provide a more robust management strategy than the current approach. It is likely that any significant reduction in the size of the shortspine thornyhead population would be apparent in the NWFSC Combo Survey index. A method for setting and/or adjusting catch limits based on either absolute values or trends in the survey has the potential to be much less labor intensive than the current assessment approach.
8) More tows or visual surveys south of 34.5 deg. N. lat. including the large Cowcod Conservation Area. Because the southern Conception Area is a large potential habitat for thornyheads, more sampling effort would help refine the estimations of their abundance in this area.

# 1 Introduction

## 1.1 Distribution

Shortspine thornyhead (*Sebastolobus alascanus*) are found in the waters off of the West Coast of the United States from northern Baja California to the Bering Sea. They are found from 20 to over 1,500 meters in depth. The majority of the spawning biomass occurs in the oxygen minimum zone between 600 and 1,400 meters, where longspine thornyheads are most abundant (Jacobson and Vetter 1996, Bradburn et al. 2011). The distribution of the smallest shortspine thornyheads suggests that they tend to settle at around 100–400 meters and are believed to have ontogenetic migration down the slope, although large individuals are found across the depth range.

Shortspine thornyhead do not appear to be distributed evenly across the West Coast, with higher densities (kg/ha) of thornyheads in shallower areas (under 500 meters) off of Oregon and Washington, and higher densities in deeper areas off of California (Figure 4–Figure 9). The mean latitude of the largest shortspine is slightly further north than of the medium sizes, suggesting the possibility of either a J-shaped migration, differential patterns of recruitment, or regional differences in exploitation history (Figure 9).

Although their densities vary, shortspine thornyheads are present in almost all trawlable areas below 500 m. They are caught in 91% of the trawl survey hauls below 500 m and 94% of the commercial bottom trawl hauls below 500 m. In camera-tows, thornyheads are seen to be spaced randomly across the sea floor (Wakefield 1990), indicating a lack both of schooling and territoriality.

## 1.2 Stock structure

Genetic studies of stock structure do not suggest separate stocks along the west coast. Siebenaller (1978) and Stepien (1995) found few genetic differences among shortspine thornyheads along the Pacific coast. Stepien (1995), however, did suggest that there may be a separate population of shortspine thornyhead in the isolated area around Cortes Bank off San Diego, California. Stepien (1995) also suggested that juvenile dispersion might be limited in the area where the Alaska and California currents split. This occurs towards the northern boundary of the assessment area, near 48° N.

Stepien et al. (2000), using a more discerning genetic material (mtDNA), found evidence of a pattern of genetic divergence corresponding to geographic distance. However, this study, which included samples collected from southern California to Alaska, did not identify a clear difference between stocks even at the extremes of the range. No such pattern was seen in longspine thornyhead, which suggests that the shorter pelagic stage (~1 yr vs. ~2 yrs) of shortspine may contribute to an increased genetic separation with distance.

## 1.3 Life History

Shortspine thornyheads along the West Coast spawn pelagic, gelatinous masses between December and May (Wakefield, 1990; Erickson and Pikitch, 1993; Pearson and Gunderson, 2003). Juveniles settle at around 1 year of age (22- 27 mm in length), likely in the range of 100-200 m (Vetter and Lynn 1997), and migrate down the slope with age and size, although large individuals are found across the depth range.

Estimates of natural mortality for shortspine thornyhead range from 0.013 (Pearson and Gunderson 2003) to 0.07 (Kline 1996). However, Pearson and Gunderson’s estimate is based upon a regression model, using the gonadosomatic index as a proxy. Butler et al. (1995) estimated M to be 0.05 based upon a maximum lifespan of over 100 years for shortspine thornyhead. Butler et al. also suggested that M is lower for older, larger shortspine thornyhead residing in the oxygen minimum zone due to lack of predators. All estimates of $M$ for thornyheads are highly uncertain.

Shortspine thornyhead grow very slowly, but may continue growing throughout their lives, reaching maximum lengths of over 70 cm. Females appear to reach larger sizes than do males. Maturity in females has been estimated as occurring near 18 cm, at 8-10 years of age (Pearson and Gunderson 2003), although new information suggests that patterns of maturity may be more complex.

## 1.4 Ecosystem Considerations

Shortspine and longspine thornyheads have historically been caught with each other and with Dover sole and sablefish, making up a "DTS" fishery. Other groundfishes that frequently co-occur in these deep waters include a complex of slope rockfishes, rex sole, longnose skate, roughtail skate, Pacific grenadier, giant grenadier, Pacific flatnose as well as non-groundfish species such as Pacific hagfish and a diverse complex of eelpouts. Shortspine thornyheads typically occur in shallower water than the shallowest longspine thornyheads, and migrate to deeper water as they age. When shortspines have reached a depth where they overlap with longspines, they are typically larger than the largest longspines. Shortspine thornyhead stomachs have been found to include longspine thornyheads, suggesting a predator-prey linkage between the two species.

Thornyheads spawn gelatinous masses of eggs which float to the surface. This may represent a significant portion of the upward movement of organic carbon from the deep ocean (Wakefield, 1990). Thornyheads have been observed in towed cameras beyond the 1280 meter limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown.

## 1.5 Fishery Information

The history of fishing for thornyheads has seen fluctuations due to a combination of increasing depth range of the fisheries, variable markets, and changes in fisheries management.

There were few markets for thornyheads in the early part of the century. Landings were minimal until the 1930's when thornyheads started to be landed as incidental catch from the sablefish fishery off California. In the early years, there was relatively little trawling in the depths where the majority of thornyheads occur. The first significant market for thornyheads began in northern California in the early 1960's. At first, larger (30-35 cm) thornyhead were sold as "ocean catfish". The minimum size decreased to 25 cm by the early 1980's. In the late 1980's a market for small thornyheads (~20 cm) developed because of the depletion of a related species (*Sebastolobus machrochir*) off of Japan. The fishery started moving into deeper waters with the demand for smaller (and thus longspine) thornyheads increased over time. This can be seen as the proportion of shortspine in the total thornyhead landings decreased from around 90% in 1981 to 40% in 1994 (before regulation lowered it even more in 1995) (Figure 3).

Landings of shortspine thornyheads off the coast of California peaked around 3,500 mt in 1989, and have exceeded those from further north in most years. In the northern area off of Oregon and Washington, the fishery became significant in the early 1980's, with landings peaking in 1991 at around 2200 mt.

Non-trawl landings of shortspine thornyheads were relatively low prior to the mid-1990s, at which point the non-trawl (mostly longline) landings in California began to increase steadily from less than 5 mt in 1994 to 237 mt in 2011. This increase, combined with decreases in trawl landings in California, has made these two components similar in magnitude in that area. The increase in non-trawl landings has been driven by the development of live-fish markets for thornyheads, and the ex-vessel prices associated with the non-trawl landings are much higher than those for the trawl fishery. Nominal prices for line-caught shortspines increased steadily from $0.69/lb in 1993 to $3.81/lb in 2008, and have remained near or above that level, since. Trawl prices, on the other hand were $0.46/lb and $0.72/lb at the beginning and end of that same period, though they were commonly in the $0.80–1.06/lb range in the interim, when Japanese demand was stronger. Non-trawl landings of shortspine in Washington and Oregon have not seen a similar increase, and have remained below the estimated peak of 54 mt in 1991 since that time.

The foreign fishery off of the West Coast is estimated to have caught approximately 7,400 mt of shortspine thornyhead during the 11 year period from 1966-1976 (Rogers, 2003), which is on the order of the estimate of domestic catch (~8,600 mt) during that same period.

Management measures contributed to a decline in coastwide landings from an estimated peak of 4,815 in 1989 to between 1,000 and 2,000 mt per year from 1995 through 1998. Landings fell below 1,000 mt per year from 1999 through 2006, then rose to 1,531 in 2009 and have declined since that time (Table 1).

### 1.6 Summary of Management History

Beginning in 1989, both thornyhead species were managed as part of the deepwater complex with sablefish and Dover sole (DTS). In 1991, the Pacific Fishery Management Council (PFMC) first adopted separate ABC levels for thornyheads and catch limits were imposed on the thornyhead group. Harvest guidelines (HG) were instituted in 1992 along with an increase in the minimum mesh size for bottom trawl fisheries. In 1995 separate landing limits were placed on shortspine and longspine thornyheads and trip limits became more restrictive. Trip limits (predominantly 2-month limits on cumulative vessel landings) have often been adjusted during the year since 1995 in order to not exceed the HG or OY for that year. At first, the HG for shortspine thornyhead was set higher than the ABC (1,500 vs. 1,000 mt in 1995-1997) in order to allow a greater catch of longspine thornyhead, which was considered relatively undepleted. In 1999 the OY was set at less than 1,000 mt and remained close to that level through 2006. As a result of the 2005 shortspine assessment, catch limits increased to about 2,000 mt per year and have remained near that level to the present.

Since early 2011, trawl harvest of each thornyhead species has been managed under the PFMC's catch share, or individual fishing quota (IFQ), program. Whereas the trip limits previously used to limit harvest restricted only the amount of fish each vessel could land, individual vessels fishing under the catch-share program are now held accountable for all of the quota-share species they catch.

### 1.7 Management Performance

Landings of shortspine thornyhead have been below the catch limits since 1999. Estimated total catch, including discards, has likewise remained below the limit during this period.

### 1.8 Fisheries off Canada, Alaska, and/or Mexico

The Alaska Fishery Science Center conducts assessments of thornyheads as a mixed stock complex, including shortspine and longspine thornyheads. The 2011 assessment reports that "It is unlikely that thornyheads are overfished or approaching overfished condition", however noting that fishing in the Western Gulf of Alaska approaches the ABC for the complex (Murphy and Ianelli, 2011).

## 2 Assessment

### 2.1 Data

An overview of the data sources available for each combination of fleet and year is provided in Figure 15.

#### 2.1.1 Biology

***Natural mortality and longevity***

Butler et al. (1995) estimated the lifespan of shortspine thornyhead to exceed 100 years, and suggested that $M$ was likely less than 0.05. $M$ may decrease with age as shortspine migrate ontogenetically down the slope to the oxygen minimum zone, which is largely devoid of predators for fish of their body size. The previous assessment fixed the natural mortality parameter at 0.05. For this assessment, a prior on natural mortality was developed based on a maximum age of 100 years which had a mean of 0.0505 and a standard deviation on a log scale of 0.5361 (Hamel, pers. comm.). For the base case, natural mortality was fixed at the mean of this prior distribution.

***Length-weight relationship***

The length-weight relationship for shortspine thornyhead was calculated from 10,787 fish collected in the NWFSC trawl survey over the years 1999-2012. Males and females showed very similar patterns so a single relationship was used for both sexes. Unsexed fish were excluded from the analysis. The unsexed fish were primarily small fish which have little influence on the conversion of numbers to biomass in the model, but including them in the estimation resulted in a reduction of fit to the larger fish. This may have been caused by less relative precision in the scale for weights below 0.05 kg. The estimated mean weight at length (Figure 11) is

$W(L) = 4.771\text{E-}6 \cdot L^{3.263}$,

where L is length in cm and W is weight in kg. This is very similar to the values from Jacobson (1990) used in the previous assessment,

$W(L) = 4.9\text{E-}6 \cdot L^{3.264}$.

***Length at age***

No new age data or information on growth or length at age has been developed since the previous assessment. Therefore, growth parameters were fixed at the same values used in 2005. These parameters were based on the Kline (1996) data, while accounting for differences in maximum size between the sexes by setting the length at age 100 for males to be 90% of that of females. The Von Bertalanffy K parameter is set to 0.018, a choice that fit the data well, while accounting for biases towards larger individuals among the younger ages (Hamel, 2005). Length at age 2 is set to 7 cm for both males and females, and average length at age 100 is 75 cm and 67.5 cm respectively.

***Maturation and fecundity***

Pearson and Gunderson (2003) estimated length at 50% maturity to be 18.2 cm on the West coast. With most females maturing between 17 and 19 cm. This was represented in the previous assessment by the logistic function,

$M(L) = (1 + e^{-2.3 \cdot (L-18.2)})^{-1}$,

where $L$ is the length in cm.

Shortspine thornyhead ovaries were collected for maturity analysis on the NWFSC trawl survey in 2011 (N = 130) and 2012 (N = 160). Histological analysis of these samples (M. Head, pers. comm.) indicated puzzling patterns of spawning, with a higher fraction of fish spawning within most size bins in the north than in the south, and a higher fraction of spawning fish in the samples with length 20-30 cm than in the larger fish in the 30-40cm range (Figure 10, Figure 12). In general it is difficult to differentiate immature thornyheads from mature thornyheads that were not spawning (Pearson and Gunderson, 2003), so in this assessment "maturity" is used to indicate fish that were both mature and showed indication of spawning, and "immature" may refer to fish that are resting. Atresia was observed in relatively few samples. One hypothesis that could explain the spatial patterns in spawning would be different migration directions associated with mature and immature fish. Alternatively, environmental conditions could have influenced the growth and maturity in different locations and depths.

The complexity of the observed patterns of maturity suggest that the 290 samples collected in 2011 and 2012 were not adequate to estimate a new maturity curve to be used as representative of the shortspine thornyhead population throughout the assessment period, and more ovaries are expected to be collected in the 2013 survey. Ovaries from winter months, when the survey is not operating, may also be needed to understand the ability to accurately estimate maturity throughout the year. For the base model, the maturity curve was retained from the previous assessments. Sensitivity analyses were conducted using alternative maturity curves based on the new samples. In the most extreme sensitivity, the empirical estimates of maturity in each 2cm length bin were used in the alternative model. An intermediate pattern was also developed by multiplying the logistic maturity ogive used in the previous assessment by a maximum fraction of mature or spawning fish which was assumed to increase linearly from 50% at 20 cm to 100% at 70cm,

$$f(L) = 0.3 + 0.01 \cdot L.$$

The maturity ogive used in this alternative was the product of the linear and logistic functions,

$$M(L) = (0.3 + 0.01 \cdot L) \cdot (1 + e^{-2.3 \cdot (L-18.2)})^{-1}.$$

Sizes beyond 70cm were assumed to be 100% mature.

These base model and alternative maturity curves are shown in Figure 12. The spawning output of each size used in the calculation of spawning biomass is the product of the length-weight relationship and the maturity ogive under the assumption that fecundity of mature, spawning fish is proportional to weight (Figure 13). The slow but steady rate of growth for shortspine thornyheads, with growth still occurring at age 100, reduces the importance of assumptions about maturity because older individuals will have significantly higher spawning output due to their much larger size, regardless of the fraction spawning.

### 2.1.2 Catch History

PacFIN data from 1981-present was used to estimate landings in the north and south (Table 1, Table 2, Figure 1). All landings reported for the shortspine and nominal shortspine categories were considered shortspine, whereas landings placed in the thornyheads category were split between longspine and shortspine by the ratio of specified longspine and shortspine landings for the entire coast. The values of this ratio from 1981-2012 are shown in Figure 3. The fraction of unspecified thornyheads in the landings was around 20% in the 1980s, but has averaged 2% of the landings from 1988 onward (Figure 3).

Catches prior to 1981 were set equal to those used in the previous model, rather than to the reconstructed history provided by CDFW and ODFW for most West Coast assessments. The California catch reconstruction did not split unspecified thornyheads into the two species. Furthermore, the recordings of longspine thornyhead prior to 1981 (e.g. 0.2 mt in 1977) are so low that the ratio of specified catch is not likely to be representative of the true ratio. The impact on the shortspine assessment of assuming all pre-PacFIN catch was shortspine is smaller than the impact of this assumption on the longspine assessment, but using the catch reconstruction for one species and the values from the previous assessment for another would risk double counting catch. Therefore, the catch from the previous assessments, both of which had a thorough independent review, were used for both species in the current assessments for the years prior to 1981. A sensitivity analysis indicated that the differences in these alternative assumptions about historical catch had very little impact on the model results (Figure 62, Figure 63).

### 2.1.3 Discards and retention

Discard rates were estimated from three periods. The first estimates for the years 1985–1987 were calculated from Oregon State University observer study (Pikitch et al., 1988), which included data from only the Trawl North fleet. The second set covered the years 1995–1999 using the Enhanced Data Collection Project (EDCP), which again only included data from the Trawl North fleet. The third, and most precise set of estimates covered the years 2002–2011 using the ongoing West Coast Groundfish Observer Program (WCGOP), which included samples from all four fleets used in the base model.

Discard rates and associated uncertainty were newly calculated from the early discard study (J. Wallace, pers. comm.) and the WCGOP data (J. Jannot, pers. comm.). The EDCP discard rates and uncertainty intervals were retained from the previous assessment as the raw data were not obtained in time to do a reanalysis of these rates. For the other three fleets, discard rates were only available for the years 2002–2011 from the WCGOP database.

### 2.1.4 Fishery Length Compositions

Fishery size-composition data were obtained from PacFIN for 1978-2012. The number of fish sampled by port samplers from different trips has not been proportional to the amount of landed catch in these trips. Sampling effort has also varied among the states. In order to account for non-proportional sampling and generate more representative length-frequency distributions, the observed length data were expanded using the following algorithm:

1. Length data were acquired at the trip level by sex, year and state.
2. The raw numbers in each trip were scaled by a per-trip expansion factor calculated by dividing the total weight of trip landings by the total weight of the species sampled.
3. A per-year, per-state expansion factor was computed by dividing the total weight of state landings by the total weight of the species sampled for length in the state.
4. The per-trip expanded numbers were multiplied by the per-state expansion factor and summed to provide the coastwide length-frequency distributions by year.

Only randomly collected samples were used. The sample sizes associated with the length compositions from the fishing fleets are shown in Table 3 (landings) and Table 4 (discards). The length samples from the Trawl North fleet in the years 1994 and 1995 showed a very different pattern than the surrounding years (and different from each-other). The sample sizes for these years was lower than most other years, so the observed differences are more likely due to non-representative than changes in the fishery or population. Therefore these two years were not included in the base model. This change made very little difference in model results.

In camera-tows, thornyheads are seen to be spaced randomly across the sea floor (Wakefield 1990), indicating a lack both of schooling and territoriality. This likelihood contributes to the conclusion in a bootstrapping analysis by Stewart and Hamel (2013), that "thornyheads had the highest average effective sample size per haul…and also the greatest independence among fish within tows". Based on these findings, the input samples sizes for both fishery and survey length compositions were calculated from the number of fish sampled in each year, independent of the number of hauls from which these fish were collected. The input sample sizes were set to $N_{input} = N_{sampled}{}^{0.6}$, which is an approximation to the pattern found by Stewart and Hamel (2013; their figure 4D). The input sample sizes were further tuned in the manner suggested by Stewart and Hamel (2013). This involved adjusting the input sample size so that the arithmetic mean of the input length composition sample sizes for each fleet was similar to the harmonic mean of the estimated effective sample sizes for that fleet (Table 7). The tuning was not updated after changes to the model were made in the review panel, but the resulting differences in adjusted input and effective samples sizes were viewed by the reviewers as small enough to remain present in the final base model.

All length data from commercial fisheries included in the model with sexes combined. This avoids the possibility of bias due to difficulty in sex determination of thornyheads (also see notes below on sex ratios in survey data).

### 2.1.5 Age Compositions

No age composition data was used for this assessment, because thornyheads have proven very difficult to age (P. MacDonald, pers. comm.). Even in directed studies such as those done by Kline (1996) and Butler et al. (1995) there are large inter-reader differences and a second reading by the same ager can produce a markedly different result. Kline (1996) reported only about 60% of the multiple reads were within 5 years of each other and inter-reader differences were as large as 24 years for a sample of 50 otoliths. No production ageing of thornyheads is undertaken at this time for the west coast, although shortspine thornyhead otoliths are routinely collected in the NWFSC trawl survey.

### 2.1.6 NMFS Surveys

Four trawl surveys have been conducted on the U.S. west coast over the past four decades. The Alaska

Fisheries Science Center (AFSC), conducted a triennial groundfish trawl survey on the continental shelf, from 1977 to 2001, although the 1977 survey had incomplete coverage and is not believe to be comparable to the later years. A final survey was conducted in 2004 by the NWFSC using the same survey design. In 1995, the timing of the survey shifted so that instead of occurring between mid-July and late September, it was conducted from early June through mid-August. The years 1980–1992 had a maximum depth of 366 m, while from 1995 onward, the maximum depth was extended to 500 m. The shallow limit of the survey was 55 m in all years, but for purposes of computing indices, only tows deeper than 100 m were used as shortspines are rarely seen at less than this depth.

For some species the shift in timing between the 1992 and 1995 surveys would be expected to influence their catchability, availability, or distribution. However, thornyheads are believed to be sedentary enough that the change in timing would not be as influential. However, the increase in depth is expected to significantly increase the range of shortspine thornyhead habitat covered by the survey. In order to preserve a time-series of maximum length while eliminating the influence of the increase depth range, the triennial survey was split into two time series, separated by the 366 m depth contour. The first, here referred to as "AFSC Triennial Shelf Survey 1", consists of 9 data points, every third year spanning the range 1980–2004 covering the depths 100–366 m. The second, "AFSC Triennial Shelf Survey 2", consists of 4 data points spanning the years 1995–2004 and covering the depths 366–500 m. This second time series is recognized as providing little information about stock status due to the limited number of points and limited depth range, but there is no compelling reason to exclude it from the assessment.

Starting in the late 1990s, two slope surveys were conducted on the west coast, one using the research vessel Miller Freeman, "AFSC Slope Survey", which ended in 2001, and the other a cooperative survey using commercial fishing vessels, conducted by the Northwest Fisheries Science Center, "NWFSC Slope Survey" which covered the years 1998–2002. The AFSC Slope Survey was a source of valuable information on the depth distribution and overlap of shortspine and longspine thornyheads in the 1980s, but the early years had very limited latitudinal range. This survey also had a different net and larger roller gear than the NWFSC Slope Survey.

In 2003, the design of the NWFSC Slope Survey was modified and the survey was expanded to cover the shelf and slope between 50 m and 1280 m. This combination shelf-slope survey, "NWFSC Combo Survey", has been conducted every year from 2003 to the present with consistent design. Data for the years 2003–2012 were available for this assessment. The NWFSC Combo Survey now represents the largest number of survey observations, the largest depth range, and the most consistent groundfish sampling program in the history of west coast fisheries. Continuing this time series in a consistent manner is vital for improving estimates of current stock status and detecting any future changes in size distribution or abundance of west coast groundfish.

The results from these four (nominally five) fishery-independent surveys are used in this assessment (Figure 18; Table 6). Indices of abundance for all of the surveys were derived using a delta-generalized linear mixed model (GLMM) following the methods of Thorson and Ward (2013). The surveys were stratified by latitude and depth, and vessel-specific differences in catchability (via inclusion of random effects for the NWFSC surveys and fixed effects for the AFSC and Triennial survey) were estimated for each survey time series. The Delta-GLMM approach explicitly models both the zero and non-zero catches and allows for skewness in the distribution of catch rates. Gamma error structures were assumed for the positive tows although log-normal error produced essentially identical results. Model convergence was evaluated using the effective sample size of all estimated parameters (typically >500 of more than 1000 kept samples would indicate convergence).

The stratification for the surveys was as follows. A single stratum was used for each of the AFSC Triennial Shelf Survey time series, as these had a narrow depth range. The AFSC Slope Survey was split into two strata: shallower and deeper than 500 m. The NWFSC Slope Survey was divided into 6 strata, with breaks dividing a southern, central, and northern strata at 40.5º N and 43º N, each of which was further divided with a break at 550 m. The NWFSC Combo Survey was divided into 7 strata, with two southern strata below 34.5º N, one covering 183–550 m and the other covering 550–1280 m. Two central strata between 34.5º N and 40.5º N, had the same depth ranges. North of 40.5º N, three strata were used, covering the ranges 100–183 m, 183–550 m and the other covering 550–1280 m. The depth breaks at 183 m and 550 m are associated with changes in sampling intensity of the survey and are recommended to be used. South of 40.5º N, there are very few shortspine thornyheads shallower than 183 m so no shallow stratum was used in these latitudes.

The frequency of occurrence of both shortspine and longspine thornyheads in trawl surveys and fishery is extremely high. 91% of the tows in the NWFSC Combo Survey below 500 m have at least one shortspine thornyhead in the catch (and 97% have at least one longspine). This is similar to the rate for commercial trawl fisheries, which is greater than 94% (a value that doesn't include for trips in which shortspines were landed but not recorded by the observer as associated with a particular tow). The distribution of catch rates among the frequent tows that included shortspine thornyheads showed no evidence of extreme catch events, a pattern which is consistent with the conclusion of Wakefield (1990), that thornyheads in camera-tows are seen to be spaced randomly across the sea floor. Together, the high frequency of occurrence and the low variability in catch between tows lead to model-based (GLMM) index estimates that are very similar to the design-based (raw) estimates (Table 6).

Length-composition data were available for each year of each survey. However, the length data for the triennial survey were collected from a single tow in both 1980 and 1983, so these samples were not included in the model. In all cases, the length compositions were calculated by weighting length compositions in each tow by the estimated catch per unit effort (in terms of numbers rather than biomass) and then weighting the length composition in each chosen stratum.

The number of survey hauls and shortspine thornyheads sampled available for this assessment is described in Table 5. All samples were included in the model with sexes combined with the exception of the NWFSC Combo survey for the years 2005–2012, as this period had a much lower rate of unsexed fish (averaging 16% per year compared to 67% in 2004), suggesting that sexes determination was being done in a more systematic way. This improvement in sex determination was likely informed by the comparison of visual estimates with laboratory analysis described in Fruh et al. (2010) which was based associated with data collected during the 2003 NWFSC Combo survey. The sex ratio of all samples with sex determined collected in 2005 and onward was 50.04%.

### 2.1.7 Changes in data from the 2005 assessment

Most of the data used in the previous assessment has been newly extracted and processed, including length compositions from each fishing fleet and survey, indices of abundance derived from new GLMM analyses of survey data, discard rates from both the 1980s Pikitch study and the current West Coast Groundfish Observer Program (WCGOP), and the time series of catch from 1981-2012. Data retained from the previous assessment without reanalysis are the estimated historic catch for the years up to 1980 and the discard rates from the EDCP study in the 1990s.

New data for this assessment include the maturity data collected from the NWFSC survey in 2011 and 2012 for use in a sensitivity analysis, the additional WCGOP observations of discards and length compositions from retained and discarded fish. For the 2005 assessment, the NWFSC Combo Survey had just begun in its current configuration, so the data from 2003–2004 were used as an extension of the NWFSC Slope Survey. The NWFSC Combo Survey now has 10 years of observations and was treated as an independent survey for this assessment. Length compositions were developed from this survey and observations of weight-at-length were used in revising the weight-length relationship used in the assessment.

### 2.1.8 Environmental and Ecological Data

No ecological or environmental information was used in this assessment.

## 2.2 Model

### 2.2.1 Overview

The most recent assessment for shortspine thornyhead was conducted in 2005 (Hamel, 2005). Stock status was determined to be above the target biomass and catches did not attain the full management limits so reassessment of thornyheads has not been a higher priority. The current assessment model adds new data from the past 8 years, refines the indices of abundance, separates trawl and non-trawl data and uses a different functional form for selectivity, but otherwise does not diverge in any large way from the previous assessment. This is both testament to the high quality of the work conducted by Hamel (2005) and the absence of any information to suggest that the model structure and assumptions made in 2005 were incorrect.

This new assessment used Stock Synthesis (SS, Methot, 2012) Version 3.24o used in other recent west coast assessments. Additional sensitivities were conducted using Version 3.24q, which has more flexible options to model maturity at length, a change that was made to explore new data for shortspine thornyheads (R. Methot, pers. comm.).

### 2.2.2 Fishing fleets and surveys

The commercial landings and other data were divided into four fisheries: trawl and non-trawl gears, which are each divided into North (the waters off Washington and Oregon) and South (the waters off California).

Five surveys were represented in the model: a shallower subset of the Alaska Fisheries Science Center (AFSC) triennial shelf survey from 100-366 meters (1980-2004), the deeper range of triennial shelf survey from 366-500 meters for the later years (1995-2004), the AFSC slope survey (1997, 1999-2001), the Northwest Fisheries Science Center (NWFSC) slope survey (1998-2002) and the NWFSC combined shelf-slope survey (2003-2012).

### 2.2.3 Parameters

#### *2.2.3.1 Overview*

There are 223 estimated parameters in the assessment. The log of the unfished equilibrium recruitment, log($R_0$), controls the scale of the population, annual deviations around the stock-recruit curve (163 parameters) allow for more uncertainty in the population trajectory, and selectivity and retention of the 4 fishing fleets and 5 surveys, including estimates of changes in retention over time (58 parameters). Finally, there is a single parameter which represents additional variability in one of the surveys that is added to estimated sampling error for that index.

#### *2.2.3.2 Growth, mortality, and recruitment*

Growth parameters are fixed at the same values used in 2005 (Table 8, Figure 14). With no age data in the model, the ability to estimate a growth curve is limited, and there was no apparent lack of model fit that indicated that growth was mis-specified. A likelihood profile exploring alternative growth parameters was conducted to estimate the influence of this assumption (Figure 56).

For this assessment, a prior distribution on natural mortality was developed based on a maximum age of 100 years which had a mean of 0.0505 and a standard deviation on a log scale of 0.5361 (Hamel, pers.

comm., Figure 45). For the base case, natural mortality was fixed at the mean of this prior distribution. A likelihood profile exploring alternative natural mortality parameters was conducted (Figure 54).

As in the previous shortspine thornyhead assessment, a Beverton-Holt stock recruitment relationship was assumed with steepness (the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass) fixed at 0.6. A likelihood profile exploring alternative steepness parameters was conducted and the model results were found to be relatively insensitive to the assumed value (Figure 52).

The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$). Recruitment deviations were estimated for the years 1850 through 2012, where the values estimated in the years 1850 through 1900 are used to estimate a non-equilibrium age-structure in 1901, which is the first year of the population projection and first year of catch data. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates. The $\sigma_R$ parameter which controls the variability in recruitment deviations was fixed at 0.5 as in the previous assessment. Methot and Taylor (2011) suggested that $\sigma_R^2$ could be tuned to match the sum of the variance of the estimate recruitment deviations and the square of the average standard error of these estimates. Applying this method to the estimated values and their uncertainty for the base model provided a value of 0.526, which was seen as similar enough to the assumed value of $\sigma_R = 0.5$ that no additional tuning was applied. A sensitivity to alternative values of $\sigma_R$ was conducted including the alternative model with no deviations in recruitment around the stock-recruit curve. These alternative models had similar overall patterns to the base case (Figure 60).

#### *2.2.3.3 Selectivity and retention*

Gear selectivity parameters used in this assessment were specified as a function of size with the additional assumption that age 0 fish were not selected, regardless of their size. Separate size-based selectivity curves were fit to each fishery fleet and survey.

The selectivity curves for all fisheries and surveys were allowed to be dome-shaped and modeled with double-normal selectivity. The double-normal selectivity curve was used in a configuration that has four parameters, including: 1) peak, which is the length at which selectivity is first fully selected, 2) width of the plateau on the top, 3) width of the ascending part of the curve, 4) width of the descending part of the curve. For some fleets, the plateau of fully selected lengths was estimated to be of negligible width. In these cases, the 2$^{nd}$ parameter described above often hit the lower bound. Having these parameters against the bound did not appear to lead to convergence problems for any other parameter, and previous attempts to fix these parameters at the lower bound led to the use of incorrect values and necessitated a presentation of errata to the review panel. Therefore, all selectivity parameters remained estimated whether they hit a bound or not.

Retention curves are defined as a logistic function of size. These are controlled by four parameters: (1) inflection, (2) slope, (3) asymptotic retention, and (4) male offset to inflection. Male offset to retention was fixed at 0 (i.e. no male offset was applied). The parameters for inflection and asymptotic retention were modeled as time-varying quantities via use of time blocks, where the definition of the time blocks was chosen to match the data available for each fleet. Although the North Trawl fleet had observed discard rates going back to 1985, there was not clear evidence in the data for a change in retention prior to the 2000s. Therefore, both North Trawl and South Trawl fleets were broken into three periods: (1) 1901–2006, (2) 2007–2010, (3) 2011–2012. The first break was based on observation of a strong reduction in discard rates for both North and South Trawl in this year, while the later break was associated with the beginning of the IFQ program.

The Non-trawl North fleet showed little change in discard rates and has been associated with low levels of landings and small sample sizes of the composition data. Therefore, a single retention function was used for all years for this fleet. Retention for the Non-trawl South fleet was divided into two periods: (1) 1901–2006, and (2) 2007–2012. Like the trawl fleets, this fleet had a reduction in discards in 2007, but the non-trawl catch of thornyheads was not subject to the changes associated with the IFQ program and therefore did not exhibit a further reduction in discards in 2011.

Alternative retention blocking, including breaks in 1989 and 1996 were explored as well as having blocks for every 2-year period starting in 2005. However, the more parsimonious set of blocks chosen for the base model had a very similar fit to the data with many fewer parameters. Selectivity would be expected to shift when larger mesh sizes were adopted by the trawl fishery in the early 1990s. However, exploration of time-varying selectivity did not lead to plausible estimates. In general, changes in markets, gear, and fishery distribution are likely to have occurred far more frequently than what is captured in the base model. However, for the years prior to the WCGOP program, there is little data to accurately capture a larger set of such changes within the assessment model. This suggests that the continued collection of large numbers of length observations from both fishery discards and landings will be valuable to understand any future changes in fishery dynamics and the impact that they may have on thornyhead populations.

The changes between blocks are represented as random walks with normal prior distributions that cause the retention parameters to remain constant across blocks in the absence of additional information suggesting changes over time.

This model depends on the assumptions that thornyheads are long-lived, slow-growing, and relatively sedentary groundfish. They are assumed to represent a single stock within the area considered for this assessment. If the assumptions about growth, natural mortality, or stock structure turn out to be far from the true life history and ecology of shortspine thornyheads, this assessment will be highly inaccurate.

## 2.3 Model Selection and Evaluation

A variety of model configurations were explored on the way to choosing the base model presented here. The following assumptions were considered but not retained:

- Asymptotic selectivity rather than dome-shaped selectivity. This was associated with poor fits to the length compositions.
- Splitting the AFSC Triennial Survey into an early and a late period with different depth ranges in each, rather than a long shallow time series and a shorter deeper time series. This was associated with large changes in the estimated catchability between the two time periods in spite of similar length compositions.
- Modeling the retention and selectivity as having more frequent changes as described above.

### 2.3.1 Model Convergence

The ADMB search for maximum likelihood estimates indicated a well-converged model. The base model had a small maximum gradient component of (0.00006) and a positive definite Hessian matrix, both of which are associated with converged models.

Runs with 100 alternative sets of starting parameter values jittered from the base model found no model with a better likelihood (Table 15). Out of the 100 model runs, only 27 returned to the best estimates associated with the base model. This may be an indication that the data do not provide very strong information population dynamics of shortspine thornyheads and a wide range of model estimates can have a somewhat similar likelihood. It may also be related to selectivity parameters hitting bounds as described above.

### 2.3.2 Stock assessments in Alaska

The stock assessment for shortspine thornyheads in the Gulf of Alaska (Murphy and Ianelli, 2011) is classified as "Tier 5" under the North Pacific Fishery Management Council system. This assessment is based on a swept area biomass estimate from a groundfish trawl survey. The use of this approach is essentially assuming a catchability of 1.0, depending on the interpretation of selectivity (which is not estimated in the assessment). The estimated biomass is 78,795 mt, which is slightly higher in magnitude to the index values estimated from the NWFSC Combo Survey (44,137–58,430). Murphy and Ianelli use a value of $M = 0.03$ to calculate an OFL value of 2,360 mt.

## 2.4 Response to STAR Panel Recommendations

The STAR panel report associated with the previous shortspine thornyhead assessment in 2005 outlined a number of research and modeling recommendations (Barnes et al. 2005). These are listed below along with notes on what progress has been made toward meeting these recommendations..

1. *Better age information is needed for this stock. As well as more samples, research is needed on how to age this species accurately.*
   **Response**: no progress has been made toward improved ageing methods for thornyheads. This has been retained as a research recommendation but reduced in priority in recognition that progress in the near future is unlikely.

2. *A survey using a towed camera to assess the abundance in deeper water. The proportion of the stock and its size range in deeper water is unknown.*
   **Response:** use of towed cameras as well as cameras mounted on AUV and ROV devices has continued in various locations on the west coast. But no systematic survey has been developed, likely due to both the costs involved and the need to work out technical challenges. It is uncertain whether the water beyond 1280 m (700 fathoms), where trawling is currently prohibited would be a high priority if and when the finances and technology were available to conduct such a survey. Better understanding of the density of thornyheads in deeper water has been retained as a research recommendation along with other issues related to the catchability of the populations.

3. *More tows or visual surveys south of 34.5 deg. N. lat. including the area closed for cowcod. Because the southern Conception Area is a large potential habitat for thornyheads, more effort is required to define their distribution in this area.*
   **Response:** the NWFSC Combo survey has provided much more detail on the abundance and distribution of thornyheads south of Point Conception than any previous survey. However, this survey has not entered the Cowcod Conservation Area. More detailed maps of bottom type and estimates of associations of thornyheads with different sediment types could improve the estimation of thornyheads within the Cowcod Conservation Area even in the absence of additional survey data.

4. *Length frequencies for discards are needed. As well, SS2 should be enhanced to include a more sophisticated description of the discard fraction at length.*
   **Response**:the WCGOP program has provided excellent information on discards length frequencies and discard rates. This data has been particularly detailed in 2011 due to the increase to full observer coverage of the trawl fishery under the IFQ program. The IFQ program has also led to very low discard rates, which reduces the impact of discarded fish on the dynamics of the population. The options for modeling retention in Stock Synthesis have been enhanced since 2005 and at this point are likely to have more than enough flexibility to capture patterns in the data available.

5. *A critical evaluation of the significance at q's for surveys of absolute abundance when they are far from 1, especially those greater than 1.*
   **Response**:the interpretation of catchability remains a vexing problem for many west coast groundfish species along with almost every other fish stock assessment around the world. This assessment differed from the previous one in freely estimating the catchability for all surveys. This led to a larger, more realistic portrayal of the uncertainty in population size. Thornyheads are particularly well sampled by trawl surveys, however, and it would be expected that catchability of shortspine and longspine thornyhead might be somewhat comparable if the interaction between selectivity and catchability could be better understood. Research into survey catchability remains a high priority research recommendation.

## 2.5 Base-Model Results

### 2.5.1 Spawning biomass and depletion

Unfished equilibrium spawning biomass ($B_0$) is estimated to be 189,765 mt, with a 95% confidence interval of 57,435 – 322,095 mt. The $B_0$ estimate represents an increase from the 130,646 mt estimate for $B_0$ in the previous assessment although this previous estimate falls well within the uncertainty interval around the current estimate. Spawning biomass is estimated to have remained stable until the mid-1970s and then declined from the 1970s to about 80% in the 1990s, followed by a slower decline under the lower catch levels in the 2000s (Table 11, Figure 36). The estimated spawning biomass in 2013 is 140,753 mt, which represents a stock status or "depletion" (represented as spawning biomass in 2013, $B_{2013}$, divided by $B_0$) of 74.2% (Figure 37). The depletion estimated for 2005 is 76.4%, which is higher than the 62.9% estimated for 2005 in the previous assessment. The standard deviation of the log of spawning biomass in 2013 is $\sigma = 0.45$, which is greater than the 0.36 minimum assumed for use in $p^*$ adjustments to OFL values.

The parameter with the greatest influence on population scale is log($R_0$), which was estimated at 10.32 in the base model (in units of 1000s of fish on a log scale). This corresponds to $R_0$ = 30.4 million age 0 recruits at unfished equilibrium. A full list of parameter estimates for the base model is provided in Table 8–Table 10.

### 2.5.2 Selectivity and retention

Selectivity was estimated as dome-shaped for all fleets, with the highest degree of dome-shape occurring in the AFSC Triennial Shelf Survey (1 and 2) and for the AFSC Slope Survey. It is not clear why the AFSC Slope Survey, which includes deep waters in which larger shortspines occur, would have such a high degree of dome-shape. However, the footrope and roller gear used by this survey may play a role in the catchability of thornyheads. The length compositions observed for these three fleets with strongly dome-shaped selectivity show a much smaller proportion of large fish than the other fleets.

The estimated selectivity patterns for the four components of the fishery seem reasonable (Table 9, Figure 16). The Trawl North fleet selects smaller fish than the other components, which is consistent with the higher presence of small fish off the coasts of Washington and Oregon where this fleet is designated. Both non-trawl fleets select fewer small fish than the trawl fleets, which is consistent with the expectation that the hooks used in longline gear (which makes up the majority of non-trawl catch) would not select the smallest shortspines. The degree of dome-shape of the fisheries may be somewhat confounded with the assumptions about natural mortality and growth. However, some extent of dome-shaped selectivity is expected to occur for both fisheries and surveys due to the ontogenetic migration of shortspines to deeper water, combined with the lower rates of fishing effort in the deepest waters and the presence of shortspines beyond the deepest extent of the fishery.

Retention is generally estimated to peak at about 40 cm in the early period of the fishery and then shift toward higher retention of smaller fish in the most recent years (Figure 17). The trawl fleets were estimated to have 100% retention of the largest fish while the non-trawl fleets were estimated to have an asymptote slightly below 100%, indicating that a small fraction of all sizes is discarded. This is consistent with the understanding that the landings from non-trawl fisheries are primarily occurring in the live-fish fishery, which represents a relatively small fraction of the fleet operating primarily in Southern California.

### 2.5.3 Recruitment

This assessment assumed a Beverton-Holt stock recruitment relationship. Steepness (the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass) was kept at the value of 0.6 that was assumed in the previous assessment, although the results were relatively insensitive to alternative assumptions about steepness. The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$). Recruitment deviations were estimated for the years 1850 through 2012, where the values estimated in the years 1850 through 1900 are used to estimate a non-equilibrium age-structure in 1901, which is the first year of the population projection. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates (Figure 38, Figure 39).

Recruitment deviations were modeled as recommended by Methot and Taylor (2011). This involved estimating the uncertainty associated with the recruitment deviates and using this uncertainty to adjust the lognormal recruitment distributions to account for differences between the median and mean. The values used in this bias adjustment (Figure 40) were estimated by a function in the R4SS software package (Taylor et al., 2013). With no age data and relatively little signal in the length data about variability in recruitment, the bias adjustment was very small. As noted in the section on parameters above, the model did not show evidence that the assumed variability in recruitment, $\sigma_R = 0.5$, was inconsistent with the data, so this value was retained from the previous assessment.

### 2.5.4 Fit to data

#### *2.5.4.1 Indices of abundance*

The base model had reasonable fits to all indices of abundance (Figure 18). The AFSC Triennial Shelf Survey 1, which had the longest time series, had the lowest index values during the middle period of the survey (1986–1992) and highest estimate in the final year. The expected index values from the base model showed a slow decline from 1980–1995 and a slight increase over the period 1995–2004. This index was the only one where a parameter was used to estimate additional variance beyond what was estimated by the GLMM. The additional parameter increased the mean CV from 16% to 26%. This additional variance caused the variance of the index residuals to be of similar magnitude to the index uncertainty. This index was associated with the shallowest depth range (100–366 m) and samples primarily smaller fish. The additional variance may be accounting for processes such as variability in the settlement of young shortspines in or outside the survey range. It also may be caused by variability in survey design that is not captured in the GLMM analysis.

All other indices were relatively flat and the model expectations fell within the 95% intervals of all observations with no additional variance component estimated.

#### *2.5.4.2 Discard fractions*

The base model had relatively good fit to the estimated discard fractions (Figure 19). The three time blocks chosen for the Trawl North fleet allowed it to capture the decreasing discard fractions in recent years. The fleet with the least good fit to the discard fractions was Trawl South where in spite of the presence of a time block allowing separate retention prior to 2007, the estimated discard rates were similar before and after this break point and the discard fractions from WCGOP for the years 2002–2006 are significantly higher than the model expectation. This is likely the result of the length data of the discarded fish not showing a similar change. The net result is that the total mortality estimated within the model (the combination of retained and discarded catch shown in Figure 1 and Figure 2) may be slightly lower than the actual mortality experienced by the population. This is likely to have a relatively minor impact on the over results, however.

#### 2.5.4.3 Mean body weight

Mean weight of discarded fish followed the same trend as discard fraction. However, there was greater variability in the mean weight estimates from the data so the base model estimates did not fit the data as closely. In general, the base model's expected mean individual weight is slightly lower than the observed values (Figure 20).

#### 2.5.4.4 Length compositions

In general, none of the sources of length composition data for shortspine thornyhead showed large changes over the time periods for which data were available (Figure 21–Figure 24). The trawl fleets showed a slight shift toward smaller fish, but this appears to have been fit well by increased retention of small fish rather than estimates of large removals of the larger fish (Figure 25–Figure 29). Time-varying selectivity was not included in the model, as there was no clear lack of fit that suggested that this process was occurring. The years and fleets that had the greatest lack of fit to the length data were typically those with the smallest sample sizes. The Trawl South fleet, however, showed relatively large variability between years over the past decade, with some years showing a bimodal distribution.

The fit to the length compositions of the discarded fish was of similar quality as discards of retained fish. Discards in the trawl fisheries were characterized by a size composition with a mode around 20 cm and few fish greater than 40cm, while the non-trawl fisheries had few fish below 20 cm in either discards or retained, and the discards showed a long tail of larger fish extending above 60 cm (Figure 25).

Fits to the survey length compositions were generally adequate (Figure 30–Figure 31). The survey data from 2005–2012, in which the length data was separated by sex, showed that the slightly larger proportion of females at lengths greater than 50cm was fit reasonably well the assumptions about differences in growth between the two sexes. The split-sex data are represented in the model as a single vector stretching across the length bins for both sexes in each year with observations. In this context, a mismatch between the sex-ratios of the data and the expected sex-ratios in the model would appear as a mis-fit to the length compositions. However, no such mis-fit was apparent.

In general, the effective sample sizes of the length data were higher than the input sample sizes and the Pearson residuals did not show any obviously bad patterns (Figure 32–Figure 35).

## 2.6 Uncertainty and Sensitivity Analyses

The scale of the population is very imprecisely estimated, with a CV around the 2013 spawning biomass of 47.5%. This large amount of uncertainty occurred in spite of a large number of simplifying assumptions and fixed parameters that were made in the absence of data that would allow a more complex model or one with more estimated quantities.

However, sensitivity analyses provide a valuable exploration of alternative scenarios and the robustness of the base model results to alternative assumptions about population dynamics. In general, the alternative model runs from likelihood profiles, sensitivities and retrospective analyses showed that the stock status of shortspine thornyheads is currently above the $B_{40\%}$ target biomass (Table 16, Figure 64).

### 2.6.1 Likelihood profiles

Likelihood profiles were conducted to look at the sensitivity of the model to assumptions about steepness ($h$), natural mortality ($M$), and growth (by varying the parameter controlling the length at age 100).

A likelihood profile over the log($R_0$) parameter was conducted to explore the influence of different data sources on the scale of the population and stock status (Figure 46–Figure 51). This indicated that there is some tension between data sources, but generally very little information in any data source about the scale of the population. The abundance indices, which are all relatively flat, were best fit by large populations with little depletion. The discard data and length compositions were best fit at lower $R_0$ values, although the length data had very similar likelihood contribution over a broad range of population sizes. At low $R_0$ values, the total likelihood is dominated by the recruitment likelihood. This is driven by the penalty associated with the estimation of an increasingly large recruitment event in the early years that serves to increase spawning biomass above $B_0$ in the 1960s which serves to offset the impact of a fishery on a lower initial population.

Examination of likelihood contributions by each fleet (Figure 47, Figure 48) indicated that the length data for the Trawl South fleet was fit best at high biomass and the other fleets at lower biomass. The AFSC Triennial Survey 1 had a larger contribution to the changes in likelihood than any other index, and it's best fit occurred at high biomass where the fishery had little impact on the population. This is consistent with the large time-period spanned by this index and its coverage of the years in which the fishery was at its peak. The NWFSC Combo Survey has better depth and latitudinal coverage, more consistent design, more tows per year and more years of observations, but it has occurred during a period of lower fishing intensity in which the population is less likely to have experienced any large changes in abundance. Therefore, this survey will likely be more influence in future years, especially if catches for thornyheads increase to a point that the population exhibits larges changes in abundance that what has been estimated in this assessment.

The likelihood profile over log($R_0$) allows a consideration of the relationship between stock status and catchability of the NWFSC Combo Survey (Figure 51). As expected, larger populations are associated with lower catchability values. Interpretation of catchability is generally difficult. However, comparisons between camera sleds and trawl surveys (Lauth et al., 2004) and the presence of fish beyond the deepest extent of the survey both suggest that catchability is likely to be less than 1.0. The base model catchability for this survey is 0.43 and catchability estimates less than 1.0 are associated with spawning biomass that is above 50% of $B_0$. The catchability values are dependent on the estimated selectivity, so interpretation of these values can be difficult.

Likelihood values and model results were relatively insensitive to changes in steepness (Figure 52, Figure 53). The change in negative log likelihood over the range of $h$ = 0.3–0.9 was less than 1.5 units with the largest contribution coming from the discard fractions. No other likelihood component had a change of greater than 1 unit. The lowest $B_0$ and depletion values were associated with the least productive population, with $h$ = 0.3, but there was little qualitative difference between any of these cases. The influence of $h$ on population dynamics for shortspine thornyhead is likely the result of the relatively high stock status associated with most model configurations. That is, assumptions about the stock-recruit relationship are less influential when the population remains relatively close to $B_0$ and the expected recruitments in each year therefore remain closer to the equilibrium recruitment, $R_0$, regardless of the steepness value.

Likelihood values and model results were much more sensitive to changes in natural mortality (Figure 54, Figure 55). A range of $M$ = 0.02 – 0.08 was explored (relative to a base model value of 0.0505), but the models with $M$ = 0.07 and 0.08 did not converge so results are only reported for values in the range 0.02 – 0.06. The change in negative log likelihood over these $M$ values was over 30 units, with the largest change occurring in the likelihood contribution for the fit to the length composition data. The lowest negative log likelihood was associated with $M$ = 0.02. The $B_0$ values estimated in this profile ranged from 126,245 mt to 1,691,150 mt and the depletion in 2013 ranged from 41.8% to 95.6%. The lowest $B_0$ and depletion values were associated with $M = 0.03$. The lowest mortality value considered, $M = 0.02$, had slightly higher estimated stock status and equilibrium biomass.

A likelihood profile over the parameter for mean length at age 100 indicated that the fit to the length composition data was improved slightly with a lower rate of growth. However, the difference in negative log likelihood between the base model with this parameter fixed at 75 cm and the best fit alternative with the parameter at 70 cm was only 0.12 units (Figure 56), which did not suggest compelling reason to change the assumptions about growth in the base model away from the values used in the previous assessment. In all cases, the mean length at age 100 for males was set to 90% of the value for females. The smaller growth parameter was associated with a higher stock status, while the higher value had a very similar status to the base model (Figure 57).

### 2.6.2 Sensitivity analyses

Several sensitivity analyses were conducted for quantities that aren't amenable to likelihood profiles. In the first two, the maturity ogive was changed to one of two the alternative maturity curves associated with the ovaries collected in 2011 and 2012 (Figure 12). In these cases, the scale of the spawning biomass changed slightly (Figure 58), but the spawning depletion showed almost no difference between maturity assumptions (Figure 59). The lack of sensitivity to alternative maturity assumptions is likely due to the relatively high stock status and short history of fishing pressure. Under these circumstances, there has been no opportunity for reductions in recruitment associated with declining spawning biomass to feed back into lower numbers growing into maturity. Furthermore, the steady growth assumed for shortspine thornyheads causes the increase in spawning contribution due to increase in body mass to be more significant than the effect of either of the alternative assumptions about fecundity (Figure 13).

The next sensitivity analyses looked at the impact of assuming a higher or lower value for $\sigma_R$, the parameter controlling the variability of recruitment around the stock-recruit curve. The base model assumed a value of $\sigma_R = 0.5$ as was used in the previous assessment. Alternatives explored were $\sigma_R = 0.25$ and $\sigma_R = 0.75$ as well as deterministic recruitment (no deviations from the stock-recruit curve, equivalent to $\sigma_R = 0$). In all cases, the estimated spawning biomass time series was similar to the base model (Figure 60). The cases with $\sigma_R > 0$ had lower variability between years than the uncertainty within each of the estimated deviations (Figure 61).

The final sensitivity analysis examined the effect of using an alternative timeseries of catch for the years prior to 1981 (Figure 62, discussed under Catch History above). The model was found to be very insensitive to the differences in early catch, with equilibrium spawning biomass and 2013 depletion estimates changing by less than 1% (Figure 63).

### 2.6.3 Retrospective analyses

Retrospective analysis indicates that removing the most recent years of data a large impact on the estimates of spawning biomass (Figure 65). This is consistent with the results of the likelihood profile over $R_0$ (Figure 46) which showed that the data provide very little information about the scale of the population. In this context, small changes in the data have the potential to cause large changes in the best estimates of $R_0$ and hence population scale. However, all estimates of spawning biomass in the retrospective analysis fell within the wide 95% uncertainty interval around the base model spawning biomass timeseries (Figure 65).

An examination of the fit to the NWFSC Combo survey by the models in the retrospective analysis (Figure 66) did not reveal any patterns which indicate that the survey index was the primary cause of differences between these models. Therefore, removal of the most recent years of length composition data may be presumed to be the primary cause of the changes in the retrospective analysis.

Most models in the retrospective analysis had lower estimates of spawning biomass, but removing the most recent 2 years of data led to higher estimates.

### 2.6.4 Comparison to previous assessment

Comparing the time series of spawning biomass and depletion from the 2005 assessment with the base model indicates that the 95% confidence interval around the base model spawning biomass includes the values from the 2005 assessment, but the lower uncertainty associated with the 2005 assessment (which had fixed catchability for one of the surveys) does not encompass the base model estimates (Figure 67). The spawning depletion values in the current assessment are slightly higher than the previous assessment for the overlapping years, but both show the population at a high stock status (Figure 68).

### 2.6.5 Axis of uncertainty and states of nature

The uncertainty in spawning biomass associated with the base model was very broad (Figure 36), so the $\log(R_0)$ parameter, which controls the scale of the population, was chosen as the axis of uncertainty, and states of nature were chosen based on this range. The low state of nature was chosen from a profile over the equilibrium recruitment parameter as a model which had an estimate of 2013 spawning biomass closest to the 12.5$^{th}$ percentile of the spawning biomass distribution in the base model This represents the middle of the lower 25% of probabilities in the base model. The high state of nature was not chosen in the same way, however, as 87.5$^{th}$ percentile of the base model did not encompass the range of models seen in sensitivity analyses as plausible alternatives. Instead, the high state of nature was taken as the model in the profile over the equilibrium recruitment that had a change in negative log-likelihood equal to 1.2 units, which is an alternative way to calculate the approximate center of the upper 25% of probable possibilities. This high state better reflected the asymmetry in uncertainty about the scale of the population (with more information about the lower range than the upper range of probable population sizes).

# 3 Reference Points

Reference points were calculated using the estimated catch distribution among fleets in the last year of the model (2012), and the estimated values are dependent on this assumption. In general, the population is at a healthy status relative to the reference points (Figure 44). Sustainable total yield (landings plus discards) was estimated at 2,034 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 633 – 3,435 mt based on estimates of uncertainty (Table 12). The spawning biomass equivalent to 40% of the unfished spawning output ($B_{40\%}$) was 75,906 mt. The most recent catches (landings plus discards) have been lower than the estimated long-term yields calculated using an $SPR_{50\%}$ reference point, but not as low as the lower bound of the 95% uncertainty interval. However, this is due to the fishery not fully attaining the full ACL. The OFL and ACL values over the past 6 years have been approximately 2,400 mt and 2,000 mt, respectively. Both of those values are lower than the OFL and ACL values predicted in short-term forecasts, which are around 3,200 mt and 3,000 mt respectively for 2015–2016 (Table 13). This is reflected in the timeseries of low harvest rates (Figure 41), low 1-SPR values (Figure 42), and the phase plot showing the history of being above the target biomass and below the target fishing intensity reference points (Figure 43).

# 4 Harvest Projections and Decision Tables

The standard deviation of the log of spawning biomass in 2013 is $\sigma = 0.45$. This value is in the adjustment of quotas based on scientific uncertainty (a process referred to by the notation "$p^*$") when the value is greater than an assumed 0.36 minimum, as it is in this case. The associated offset would therefore be a multiplication of the OFL by 94.5%, which is the 45% quantile of a log-normal distribution with the associated $\sigma$. Twelve-year projections were conducted with a total catch assumed equal to the ACL calculated by applying this adjustment to the estimated OFL for each year. The retention function and allocation of catch among fleets was assumed to match the average values for 2011–2012 (the only years in which the trawl fishery was operating under IFQs). This allocation between fleets was 43% for Trawl North, 32% for Trawl South, 3% for Non-trawl North, and 22% for Non-trawl South. Catch for 2013–2014, the limits on which have already been set, were assumed to equal the averages over 2011–2012, which correspond to a total catch of 952 mt and landings of 933 mt after applying the estimated retention function to the age structure of the population in 2013. The 933 mt value is identical to the average of the retained catch for the years 2011–2012, suggesting that the choice to model forecast catches in terms of total catch rather than landings has little influence on the forecast results.

This default harvest rate projection applied to the base model indicated that the stock status would slowly decline from 74.2% to 67.2% in 2024, still far above the 40% biomass target and 25% minimum stock size threshold. The associated OFL values over this period would average 3,053 mt and the average ACL would be 2,885. These values are above recent catch limits, which have not been fully attained in recent years. In these projections, the stock status was always above 40%, so the 40-10 adjustment in the control rule had no impact on the projections.

A decision table (Table 14) was assembled using the projection described above along with projections associated with the high and low states of nature (columns) under three catch streams (rows).

The catch streams chosen for the decision table were represented as total catch rather than landed catch, but discard rates were low under IFQs, so the difference in between total catch and landings is small. The low catch stream was assumed to have total catch equal to the average over the years 2011–2012, the years in which the trawl fishery was operating under IFQs was used as a low catch stream. This was a total catch of 952 mt divided among the fleets by the fraction. The high catch stream was chosen based on applying the SPR = 50% default harvest control rule to the base model, including a *p** offset which reduced the catch to 94.5% of the OFL. The middle catch stream was associated with SPR = 65% instead of the default SPR = 50%. This provided an intermediate level of catch while stabilizing the population at a stock status of approximately 60% (based on an exploratory 100 year forecast). The average total catch for the years 2015–2024 was 952 mt for the low catch stream, 1,795 for the middle catch stream, and 2,827 for the high catch stream.

The most pessimistic forecast scenario, combining the low state of nature with the high catch stream, resulted in a projected stock status in 2024 of 39.9%, very close to the target value. All other projections led to a higher projected status in 2024, with a maximum of 89.1% for the combination of the high state of nature and low catch. Forecasts under the base case led to estimated status ranging from 67.2% in the high catch stream to 72.9% in the low catch stream.

No projections were done to explore changes in ratio of trawl to non-trawl or north to south. Due to differences in selectivity and retention among the fleets, these projections could be expected to provide slightly different results, although the general pattern of the projections suggesting stocks above target levels as described above is unlikely to change as a result of alternative ratios among the fleets.

# 5 Regional Management Considerations

Currently both shortspine and longspine thornyheads have a management boundary at Pt. Conception, 34º27’ N latitude. There is no evidence of stock structure associated with this line and the amount of data associated with fishery to the south of this boundary is unlikely to justify any effort to develop a spatial model with explicit accounting for this boundary. The choice to implement this boundary as a management line was made during a period when the surveys did not extend south of Pt. Conception and the assessment did not include this region. Thus, estimated quotas were not applicable to the southern area.

At this point, however, the NWFSC Combo survey has been consistently sampling between the Mexican border and Pt. Conception (though not in the Cowcod Conservation Area), and the assessment is applied to all thornyheads within the boundaries of the west coast of the continental United States. Therefore, there no longer appears to be any scientific basis for maintaining separate quotas north and south of the 34º27' N latitude boundary.

If this boundary is maintained for social or political reasons, the best method for apportioning the quotas between areas is the fraction of the population observed in the trawl survey. The fraction of the total estimated biomass south of 34º27' N in the NWFSC Combo Survey is 34.6% based on the median GLMM results. This is very similar to 34.3% of the raw, swept area biomass. The survey trends associated with the two subsets of the coast are similarly flat (Figure 69). Due to the smaller size of the southern area with fewer survey stations, the uncertainty in the south is higher, with a mean CV of 19.3% compared to a 7.6% CV in the north. These estimates include extrapolation of observed densities south of 34º27' N into the large, unobserved, Cowcod Conservation Area (indicated by the absence of tows centered around 33º N, 119º W in Figure 5). The uncertainty associated with that extrapolation is difficult to quantify at this point. However, the uncertainty in the fraction of the population north or south of Pt. Conception is likely lower than the uncertainty in the size of the total coastwide population. Therefore, if separate quotas are to be maintained, it does not appear necessary to include a higher buffer for scientific uncertainty in the southern quota on the scale of what has been done in the past.

# 6 Research Needs

Research and data needs for future assessments include the following:

1) More investigation into maturity of shortspine is necessary to understand the patterns in maturity observed in the samples collected in 2011 and 2012.
2) Information on possible migration of shortspine thornyheads would be valuable for understanding stock dynamics. Analysis of trace elements and stable isotopes in shortspine otoliths may provide valuable information on the extent of potential migrations. Possible connections between migration and maturity could likewise be explored.
3) A greater understanding of catchability of thornyheads would help define the scale of the populations. This could include a survey using a towed camera to assess the abundance in water beyond the 1280 m range of the trawl surveys. Further exploration of perceived differences in catchability between towed cameras and trawl nets could also be explored. Understanding the relative catchability of shortspine and longspine thornyhead, which are difficult to distinguish in camera observations, would have to be a component of such investigations. Differences in selectivity between the AFSC Slope survey and the NWFSC surveys may be the result of behavioral interactions with different footropes. Understanding these interactions would also improve understanding of catchability.
4) Age data would be valuable for future stock assessments. Otoliths have been collected in good quantities from the NWFSC survey, but at this time the ageing methods are not believed to be reliable. Additional research on ageing methods for thornyheads would be valuable.
5) A greater understanding of the connection between thornyheads and bottom type could be used to refine the indices of abundance. Thornyheads are very well sampled in trawlable habitat, but the extrapolation of density to a survey stratum could be improved by accounting for the proportion of different bottom types within a stratum and the relative density of thornyheads within each bottom type.
6) A comprehensive catch reconstruction for shortspine and longspine thornyheads should be completed to estimate landings for each species prior to 1981 in each of the three states.
7) Exploration of simpler assessment methods for thornyheads and evaluation of whether such methods would provide a more robust management strategy than the current approach. It is likely

that any significant reduction in the size of the shortspine thornyhead population would be apparent in the NWFSC Combo Survey index. A method for setting and/or adjusting catch limits based on either absolute values or trends in the survey has the potential to be much less labor intensive than the current assessment approach.

8) More tows or visual surveys south of 34.5 deg. N. lat. including the large Cowcod Conservation Area. Because the southern Conception Area is a large potential habitat for thornyheads, more sampling effort would help refine the estimations of their abundance in this area.

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# 9 Tables

**Table 1: Estimated landings history for shortspine thornyhead. Note that fleets are only shown for range of years in which they had non-zero landings.**

| Year | Catch (mt) | |
|---|---|---|
| | Trawl S | Total |
| 1901 | 2 | 2 |
| 1902 | 2 | 2 |
| 1903 | 4 | 4 |
| 1904 | 5 | 5 |
| 1905 | 6 | 6 |
| 1906 | 8 | 8 |
| 1907 | 9 | 9 |
| 1908 | 10 | 10 |
| 1909 | 11 | 11 |
| 1910 | 13 | 13 |
| 1911 | 14 | 14 |
| 1912 | 15 | 15 |
| 1913 | 17 | 17 |
| 1914 | 17 | 17 |
| 1915 | 19 | 19 |
| 1916 | 20 | 20 |
| 1917 | 21 | 21 |
| 1918 | 23 | 23 |
| 1919 | 24 | 24 |
| 1920 | 25 | 25 |
| 1921 | 26 | 26 |
| 1922 | 28 | 28 |
| 1923 | 29 | 29 |
| 1924 | 30 | 30 |
| 1925 | 32 | 32 |
| 1926 | 32 | 32 |
| 1927 | 34 | 34 |
| 1928 | 35 | 35 |
| 1929 | 36 | 36 |
| 1930 | 38 | 38 |
| 1931 | 39 | 39 |
| 1932 | 40 | 40 |
| 1933 | 49 | 49 |
| 1934 | 49 | 49 |
| 1935 | 49 | 49 |
| 1936 | 51 | 51 |
| 1937 | 47 | 47 |
| 1938 | 53 | 53 |
| 1939 | 63 | 63 |
| 1940 | 76 | 76 |

| Year | Catch (mt) | | |
|---|---|---|---|
| | Trawl N | Trawl S | Total |
| 1941 | - | 109 | 109 |
| 1942 | - | 122 | 122 |
| 1943 | - | 269 | 269 |
| 1944 | - | 380 | 380 |
| 1945 | - | 453 | 453 |
| 1946 | - | 216 | 216 |
| 1947 | - | 48 | 48 |
| 1948 | - | 152 | 152 |
| 1949 | - | 168 | 168 |
| 1950 | - | 153 | 153 |
| 1951 | - | 305 | 305 |
| 1952 | - | 176 | 176 |
| 1953 | - | 68 | 68 |
| 1954 | - | 128 | 128 |
| 1955 | - | 128 | 128 |
| 1956 | - | 776 | 776 |
| 1957 | - | 286 | 286 |
| 1958 | - | 296 | 296 |
| 1959 | - | 398 | 398 |
| 1960 | - | 472 | 472 |
| 1961 | - | 437 | 437 |
| 1962 | - | 230 | 230 |
| 1963 | - | 285 | 285 |
| 1964 | 12 | 172 | 184 |
| 1965 | 20 | 400 | 420 |
| 1966 | 612 | 543 | 1,155 |
| 1967 | 369 | 864 | 1,233 |
| 1968 | 168 | 1,835 | 2,003 |
| 1969 | 155 | 400 | 555 |
| 1970 | 149 | 557 | 706 |
| 1971 | 260 | 582 | 842 |
| 1972 | 389 | 1,297 | 1,686 |
| 1973 | 712 | 2,377 | 3,089 |
| 1974 | 215 | 1,244 | 1,459 |
| 1975 | 405 | 1,867 | 2,272 |
| 1976 | 52 | 992 | 1,044 |
| 1977 | 91 | 1,359 | 1,450 |
| 1978 | 76 | 1,136 | 1,212 |
| 1979 | 109 | 1,720 | 1,829 |
| 1980 | 87 | 1,192 | 1,279 |

| Year | Catch (mt) | | | | |
|---|---|---|---|---|---|
| | Trawl N | Trawl S | Non-trawl N | Non-trawl S | Total |
| 1981 | 242 | 1,623 | - | 1 | 1,830 |
| 1982 | 554 | 1,655 | - | 1 | 2,069 |
| 1983 | 1,493 | 1,562 | - | 1 | 2,279 |
| 1984 | 1,681 | 1,961 | - | 1 | 2,914 |
| 1985 | 1,346 | 2,560 | - | 2 | 3,016 |
| 1986 | 458 | 2,422 | - | 3 | 2,362 |
| 1987 | 558 | 1,953 | 4 | 3 | 1,984 |
| 1988 | 696 | 2,163 | 23 | 2 | 2,868 |
| 1989 | 1,340 | 3,506 | 29 | 10 | 4,815 |
| 1990 | 1,918 | 2,228 | 27 | 3 | 4,036 |
| 1991 | 2,157 | 1,306 | 54 | 2 | 3,467 |
| 1992 | 1,669 | 1,625 | 52 | 9 | 3,299 |
| 1993 | 2,037 | 1,774 | 24 | 1 | 3,609 |
| 1994 | 1,835 | 1,538 | 20 | 3 | 3,287 |
| 1995 | 815 | 1,064 | 28 | 32 | 1,940 |
| 1996 | 686 | 831 | 21 | 81 | 1,608 |
| 1997 | 580 | 771 | 23 | 40 | 1,406 |
| 1998 | 505 | 669 | 17 | 47 | 1,232 |
| 1999 | 319 | 398 | 18 | 99 | 824 |
| 2000 | 282 | 490 | 14 | 53 | 824 |
| 2001 | 236 | 241 | 13 | 46 | 532 |
| 2002 | 231 | 428 | 10 | 104 | 762 |
| 2003 | 270 | 374 | 11 | 155 | 800 |
| 2004 | 295 | 319 | 11 | 129 | 757 |
| 2005 | 255 | 252 | 11 | 139 | 654 |
| 2006 | 296 | 247 | 15 | 144 | 703 |
| 2007 | 562 | 279 | 16 | 143 | 1,006 |
| 2008 | 902 | 325 | 20 | 175 | 1,427 |
| 2009 | 948 | 382 | 29 | 172 | 1,531 |
| 2010 | 770 | 357 | 22 | 206 | 1,353 |
| 2011 | 424 | 287 | 24 | 237 | 974 |
| 2012 | 381 | 323 | 36 | 155 | 894 |

**Table 2. Recent trend in commercial landings (mt) relative to the management guidelines.**

| Year | OFL (mt) | ACL (mt) | Commercial Landings (mt) |
|---|---|---|---|
| 2001 | 880 | 751 | 532 |
| 2002 | 1,004 | 955 | 762 |
| 2003 | 1,004 | 955 | 800 |
| 2004 | 1,030 | 983 | 757 |
| 2005 | 1,055 | 999 | 654 |
| 2006 | 1,077 | 1,018 | 703 |
| 2007 | 2,476 | 2,055 | 1,006 |
| 2008 | 2,476 | 2,055 | 1,427 |
| 2009 | 2,437 | 2,022 | 1,531 |
| 2010 | 2,411 | 2,001 | 1,353 |
| 2011 | 2,384 | 1,978 | 974 |
| 2012 | 2,358 | 1,957 | 894 |

**Table 3: Summary of sampling effort of landings data (number of hauls and fish sampled) used to create length compositions. The samples from the Trawl North in 1994 and 1995 appeared to be outliers associated with small sample sizes taken from hauls that were not representative of the population and were excluded from the base model.**

| Year | Trawl N | | Trawl S | | Non-trawl N | | Non-trawl S | |
|---|---|---|---|---|---|---|---|---|
| | Hauls | Samples | Hauls | Samples | Hauls | Samples | Hauls | Samples |
| 1978 | | | 861 | 1,188 | | | | |
| 1979 | 268 | 447 | 488 | 649 | | | | |
| 1980 | 175 | 268 | 243 | 298 | | | | |
| 1981 | 119 | 180 | 75 | 88 | | | | |
| 1982 | 133 | 180 | 341 | 405 | | | | |
| 1983 | | | 961 | 1,230 | | | | |
| 1984 | | | 1,958 | 2,755 | | | | |
| 1985 | | | 2,311 | 3,176 | | | 3 | 3 |
| 1986 | | | 739 | 978 | | | 9 | 9 |
| 1987 | | | 289 | 343 | | | 46 | 54 |
| 1988 | | | 91 | 140 | | | 8 | 8 |
| 1989 | | | 505 | 741 | | | 18 | 18 |
| 1990 | 299 | 510 | 392 | 517 | | | 22 | 24 |
| 1991 | 785 | 1,060 | 390 | 532 | | | | |
| 1992 | 733 | 1,227 | 339 | 448 | | | 48 | 75 |
| 1993 | 225 | 293 | 649 | 993 | | | 3 | 3 |
| 1994 | 20 | 40 | 819 | 1,367 | | | 36 | 46 |
| 1995 | 19 | 24 | 1,260 | 2,248 | | | 23 | 36 |
| 1996 | 265 | 497 | 1,188 | 2,062 | | | 15 | 26 |
| 1997 | 1,036 | 2,322 | 1,101 | 1,720 | | | 27 | 36 |
| 1998 | 543 | 757 | 659 | 1,130 | | | 71 | 130 |
| 1999 | 621 | 819 | 524 | 821 | | | 883 | 1,852 |
| 2000 | 498 | 660 | 695 | 1,027 | 3 | 3 | 228 | 444 |
| 2001 | 990 | 1,632 | 841 | 1,413 | 21 | 30 | 59 | 102 |
| 2002 | 1,216 | 2,313 | 1,565 | 2,320 | 9 | 10 | 447 | 1,026 |
| 2003 | 1,537 | 2,461 | 1,130 | 1,909 | | | 373 | 834 |
| 2004 | 1,074 | 1,509 | 628 | 1,073 | 1 | 1 | 93 | 132 |
| 2005 | 1,094 | 1,649 | 912 | 1,393 | | | 353 | 620 |
| 2006 | 1,120 | 1,573 | 2,268 | 3,109 | 2 | 2 | 306 | 594 |
| 2007 | 1,708 | 2,432 | 1,297 | 1,893 | 77 | 115 | 149 | 278 |
| 2008 | 1,933 | 2,631 | 1,458 | 2,212 | 152 | 251 | 732 | 1,786 |
| 2009 | 1,986 | 2,854 | 1,201 | 2,137 | 106 | 130 | 565 | 1,168 |
| 2010 | 1,981 | 2,980 | 1,057 | 1,720 | 161 | 210 | 588 | 1,136 |
| 2011 | 1,600 | 2,381 | 1,583 | 2,950 | 284 | 515 | 1,550 | 2,762 |
| 2012 | 1,608 | 2,262 | 1,385 | 2,423 | 323 | 538 | 1,119 | 1,881 |

**Table 4: Summary of sampling effort of discard data (fish sampled, hauls not reported here) used to create length compositions.**

| Year | Trawl N | | Trawl S | | Non-trawl N | | Non-trawl S | |
|---|---|---|---|---|---|---|---|---|
| | Hauls | Samples | Hauls | Samples | Hauls | Samples | Hauls | Samples |
| 1985 | | 208 | | | | | | |
| 1986 | | 2,551 | | | | | | |
| 1987 | | 435 | | | | | | |
| 2005 | | | | | | 7 | | |
| 2006 | | 708 | | 247 | | 112 | | 200 |
| 2007 | | 1,124 | | 338 | | 245 | | 273 |
| 2008 | | 1,712 | | 326 | | 67 | | 177 |
| 2009 | | 2,423 | | 495 | | 50 | | 108 |
| 2010 | | 1,281 | | 201 | | 73 | | 200 |
| 2011 | | 1,446 | | 441 | | 236 | | 183 |

**Table 5: Summary of sampling effort of survey data (number of hauls and fish sampled) used to create length compositions. Samples from the 1980 and 1983 (AFSC Triennial Shelf Survey 1) were excluded from the base model as they represented only a single tow in each case. Sex-specific numbers are not shown, but for the years 2005 and onward, the NWFSC Combo samples included a total of 17,599 females, 17,572 males, and 6,715 unsexed shortspine thornyheads.**

| Year | AFSC Triennial Shelf Survey 1 | | AFSC Triennial Shelf Survey 2 | | AFSC Slope Survey | | NWFSC Slope Survey | | NWFSC Combo Survey | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hauls | Samples | Hauls | Samples | Hauls | Samples | Hauls | Samples | Hauls | Samples |
| 1980 | 1 | 153 | | | | | | | | |
| 1983 | 1 | 78 | | | | | | | | |
| 1986 | 10 | 246 | | | | | | | | |
| 1989 | 54 | 1,877 | | | | | | | | |
| 1992 | 29 | 1,254 | | | | | | | | |
| 1995 | 145 | 4,027 | 145 | 7,235 | | | | | | |
| 1997 | | | | | 171 | 7,454 | | | | |
| 1998 | 161 | 4,515 | 161 | 6,109 | | | 210 | 7,827 | | |
| 1999 | | | | | 188 | 6,752 | 300 | 10,042 | | |
| 2000 | | | | | 196 | 7,017 | 288 | 7,932 | | |
| 2001 | 198 | 4,255 | 198 | 6,220 | 196 | 6,072 | 294 | 8,076 | | |
| 2002 | | | | | | | 371 | 11,761 | | |
| 2003 | | | | | | | | | 289 | 7,685 |
| 2004 | 137 | 3,400 | 137 | 5,108 | | | | | 213 | 6,692 |
| 2005 | | | | | | | | | 314 | 8,046 |
| 2006 | | | | | | | | | 332 | 6,198 |
| 2007 | | | | | | | | | 367 | 5,499 |
| 2008 | | | | | | | | | 361 | 4,712 |
| 2009 | | | | | | | | | 340 | 4,195 |
| 2010 | | | | | | | | | 358 | 3,841 |
| 2011 | | | | | | | | | 347 | 4,697 |
| 2012 | | | | | | | | | 349 | 4,678 |

**Table 6: Final design and model (GLMM)-based abundance indices for shortspine thornyhead.**

| | AFSC Triennial Shelf Survey 1 | | |
|---|---|---|---|
| Year | Design | Model | log_SD |
| 1980 | 2,627 | 2,660 | 0.144 |
| 1983 | 3,406 | 3,415 | 0.118 |
| 1986 | 1,628 | 1,636 | 0.133 |
| 1989 | 2,015 | 2,010 | 0.139 |
| 1992 | 2,069 | 2,064 | 0.177 |
| 1995 | 3,483 | 3,480 | 0.152 |
| 1998 | 3,056 | 3,076 | 0.152 |
| 2001 | 3,690 | 3,698 | 0.142 |
| 2004 | 4,128 | 4,117 | 0.181 |

| | AFSC Triennial Shelf Survey 2 | | |
|---|---|---|---|
| Year | Design | Model | log_SD |
| 1995 | 3,494 | 3,523 | 0.122 |
| 1998 | 2,809 | 2,815 | 0.126 |
| 2001 | 3,353 | 3,384 | 0.124 |
| 2004 | 3,485 | 3,504 | 0.129 |

| | AFSC Slope Survey | | |
|---|---|---|---|
| Year | Design | Model | log_SD |
| 1997 | 27,068 | 27,148 | 0.084 |
| 1999 | 25,525 | 25,641 | 0.082 |
| 2000 | 31,912 | 31,971 | 0.083 |
| 2001 | 31,377 | 31,567 | 0.081 |

| | NWFSC Slope Survey | | |
|---|---|---|---|
| Year | Design | Model | log_SD |
| 1998 | 27,512 | 27,416 | 0.086 |
| 1999 | 28,213 | 28,311 | 0.079 |
| 2000 | 30,673 | 30,897 | 0.081 |
| 2001 | 26,192 | 26,376 | 0.080 |
| 2002 | 32,562 | 32,404 | 0.080 |

| | NWFSC Combo Survey | | |
|---|---|---|---|
| Year | Design | Model | log_SD |
| 2003 | 51,666 | 52,474 | 0.103 |
| 2004 | 53,181 | 53,885 | 0.105 |
| 2005 | 48,162 | 48,155 | 0.091 |
| 2009 | 58,273 | 58,430 | 0.096 |
| 2010 | 46,229 | 46,489 | 0.090 |
| 2011 | 48,095 | 48,556 | 0.089 |
| 2009 | 58,273 | 58,430 | 0.096 |
| 2010 | 46,229 | 46,489 | 0.090 |
| 2011 | 48,095 | 48,556 | 0.089 |
| 2012 | 53,426 | 53,045 | 0.101 |

**Table 7: Summary of input and effective sample sizes and sample size adjustments.**

| Fleet | Arithmetic mean of adjusted input N | Harmonic mean of effective N | Sample size adjustment | Ratio of harmonic to adjusted input N |
|---|---|---|---|---|
| Trawl North | 38.8 | 37.5 | 0.56 | 0.97 |
| Trawl South | 66.0 | 70.8 | 0.98 | 1.07 |
| Non-trawl North | 9.1 | 8.8 | 0.54 | 0.97 |
| Non-trawl South | 13.2 | 13.4 | 0.40 | 1.02 |
| AFSC Triennial Shelf Survey 1 | 75.4 | 78.9 | 0.68 | 1.05 |
| AFSC Triennial Shelf Survey 2 | 121.9 | 150.8 | 0.65 | 1.24 |
| AFSC Slope Survey | 199.6 | 473.1 | 1.00 | 2.37 |
| NWFSC Slope Survey | 121.5 | 136.6 | 0.51 | 1.12 |
| NWFSC Combo Survey | 176.6 | 573.3 | 1.00 | 3.25 |

**Table 8: Parameters related to biology, stock-recruit relationship and index variance. Only log($R_0$) and the Extra SD parameter (shown in bold) are estimated so the prior distribution on *M* had no impact on model results.**

| Parameter | Value | Min | Max | Prior | | |
|---|---|---|---|---|---|---|
| | | | | Type | Mean | SD (of log) |
| Natural mortality (*M*) | 0.0505 | 0.01 | 0.15 | Log-normal | 0.0505 | 0.5361 |
| Length at age 2 | 7.0 | | | | | |
| Length at age 100 (females) | 75.0 | | | | | |
| Length at age 100 (males) | 67.5 | | | | | |
| von Bertalanffy K | 0.018 | | | | | |
| Length CV at age 2 | 0.125 | | | | | |
| Length CV at age 100 | 0.125 | | | | | |
| Weight-Length a | $4.7707 \times 10^{-6}$ | | | | | |
| Weight-Length b | 3.2630 | | | | | |
| log($R_0$) | **10.32** | 7 | 13 | | | |
| Steepness (*h*) | 0.6 | | | | | |
| $\sigma_R$ | 0.5 | | | | | |
| Extra SD for AFSC Triennial Shelf Survey 1 | **0.113** | 0.01 | 0.50 | | | |

**Table 9: Parameters related to selectivity and retention for each fishing fleet. Estimated quantities are indicated in bold.**

| | Prior | | | | | Fleet | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | Type | Mean | SD | Min | Max | Trawl N | Trawl S | Non-trawl N | Non-trawl S |
| Double-normal 1 (peak) | | | | 10 | 60 | **23.53** | **28.05** | **40.81** | **30.93** |
| Double-normal 2 (plateau width) | | | | -7 | 7 | **-7.00** | **-0.30** | **-7.00** | **-2.12** |
| Double-normal 3 (ascending slope) | | | | -5 | 10 | **3.77** | **4.25** | **4.55** | **3.41** |
| Double-normal 4 (descending slope) | | | | -5 | 10 | **6.78** | **4.85** | **6.29** | **5.72** |
| Double-normal 5 (optional initial) | | | | | | -999 | -999 | -999 | -999 |
| Double-normal 6 (optional final) | | | | | | -999 | -999 | -999 | -999 |
| Retention curve inflection | | | | 5 | 70 | **28.11** | **23.74** | **21.75** | **26.18** |
| Retention curve slope | | | | 0.1 | 40 | **3.43** | **2.42** | **4.87** | **2.87** |
| Retention curve asymptote | | | | 0.0001 | 1 | **1.00** | **1.00** | **0.94** | **0.95** |
| Retention curve male-offset | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| Retention inflection offset 2007-2010 | Normal | 0 | 5 | -10 | 10 | **-0.23** | **-0.04** | - | - |
| Retention inflection offset 2011-2012 | Normal | 0 | 5 | -10 | 10 | **-0.53** | **-0.18** | - | - |
| Retention inflection offset 2007-2012 | Normal | 0 | 5 | -10 | 10 | - | - | - | **-0.23** |
| Retention asymptote offset 2007-2010 | Normal | 0 | 0.2 | -0.5 | 0.5 | **0.00** | **0.01** | - | - |
| Retention asymptote offset 2011-2012 | Normal | 0 | 0.2 | -0.5 | 0.5 | **0.00** | **0.00** | - | - |
| Retention asymptote offset 2007-2012 | Normal | 0 | 0.2 | -0.5 | 0.5 | - | - | - | **0.03** |

**Table 10: Parameters related to selectivity and retention for each survey. Estimated quantities are indicated in bold.**

| | | | Survey | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Min | Max | AFSC Triennial Shelf Survey 1 | AFSC Triennial Shelf Survey 2 | AFSC Slope Survey | NWFSC Slope Survey | NWFSC Combo Survey |
| Double-normal 1 (peak) | 10 | 60 | **22.90** | **21.36** | **20.61** | **22.63** | **24.73** |
| Double-normal 2 (plateau width) | -7 | 7 | **-7.00** | **-7.00** | **-7.00** | **-7.00** | **-7.00** |
| Double-normal 3 (ascending slope) | -5 | 10 | **3.67** | **3.82** | **3.43** | **4.06** | **4.52** |
| Double-normal 4 (descending slope) | -5 | 10 | **4.04** | **4.50** | **4.26** | **6.77** | **6.77** |
| Double-normal 5 (optional initial) | | | -999 | -999 | -999 | -999 | -999 |
| Double-normal 6 (optional final) | | | -999 | -999 | -999 | -999 | -999 |

**Table 11: Time-series of total biomass, summary (age 1+) spawning biomass, spawning output, depletion (stock status), recruitment, and exploitation rate estimated in the model.**

| Year | Total biomass (1000 mt) | Summary biomass (age 1+, 1000 mt) | Spawning biomass (1000 mt) | Depletion | Age-0 recruits (millions) | Total catch (mt) | 1 - SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1901 | 331.9 | 331.8 | 190.2 | 100.2% | 30.5 | 2 | 0.0% | 0.000 |
| 1902 | 331.9 | 331.9 | 190.2 | 100.2% | 30.4 | 2 | 0.0% | 0.000 |
| 1903 | 331.9 | 331.9 | 190.2 | 100.2% | 30.4 | 4 | 0.1% | 0.000 |
| 1904 | 331.9 | 331.9 | 190.2 | 100.3% | 30.4 | 5 | 0.1% | 0.000 |
| 1905 | 331.9 | 331.9 | 190.3 | 100.3% | 30.4 | 6 | 0.1% | 0.000 |
| 1906 | 331.9 | 331.9 | 190.3 | 100.3% | 30.3 | 8 | 0.1% | 0.000 |
| 1907 | 331.9 | 331.9 | 190.3 | 100.3% | 30.3 | 9 | 0.1% | 0.000 |
| 1908 | 332.0 | 331.9 | 190.3 | 100.3% | 30.3 | 10 | 0.2% | 0.000 |
| 1909 | 332.0 | 331.9 | 190.3 | 100.3% | 30.2 | 11 | 0.2% | 0.000 |
| 1910 | 332.0 | 331.9 | 190.3 | 100.3% | 30.2 | 13 | 0.2% | 0.000 |
| 1911 | 331.9 | 331.9 | 190.3 | 100.3% | 30.2 | 14 | 0.2% | 0.000 |
| 1912 | 331.9 | 331.9 | 190.3 | 100.3% | 30.2 | 15 | 0.2% | 0.000 |
| 1913 | 331.9 | 331.9 | 190.3 | 100.3% | 30.2 | 18 | 0.3% | 0.000 |
| 1914 | 331.9 | 331.9 | 190.3 | 100.3% | 30.2 | 18 | 0.3% | 0.000 |
| 1915 | 331.9 | 331.9 | 190.3 | 100.3% | 30.2 | 20 | 0.3% | 0.000 |
| 1916 | 331.9 | 331.8 | 190.2 | 100.2% | 30.2 | 21 | 0.3% | 0.000 |
| 1917 | 331.8 | 331.8 | 190.2 | 100.2% | 30.1 | 22 | 0.3% | 0.000 |
| 1918 | 331.8 | 331.8 | 190.2 | 100.2% | 30.1 | 24 | 0.4% | 0.000 |
| 1919 | 331.8 | 331.7 | 190.2 | 100.2% | 30.2 | 25 | 0.4% | 0.000 |
| 1920 | 331.7 | 331.7 | 190.2 | 100.2% | 30.2 | 26 | 0.4% | 0.000 |
| 1921 | 331.7 | 331.6 | 190.1 | 100.2% | 30.2 | 27 | 0.4% | 0.000 |
| 1922 | 331.6 | 331.6 | 190.1 | 100.2% | 30.2 | 29 | 0.4% | 0.000 |
| 1923 | 331.6 | 331.5 | 190.1 | 100.2% | 30.3 | 30 | 0.5% | 0.000 |
| 1924 | 331.5 | 331.5 | 190.1 | 100.2% | 30.3 | 31 | 0.5% | 0.000 |
| 1925 | 331.5 | 331.4 | 190.0 | 100.1% | 30.4 | 33 | 0.5% | 0.000 |
| 1926 | 331.4 | 331.4 | 190.0 | 100.1% | 30.5 | 33 | 0.5% | 0.000 |
| 1927 | 331.3 | 331.3 | 189.9 | 100.1% | 30.6 | 35 | 0.5% | 0.000 |
| 1928 | 331.2 | 331.2 | 189.9 | 100.1% | 30.8 | 36 | 0.5% | 0.000 |
| 1929 | 331.2 | 331.1 | 189.9 | 100.0% | 31.0 | 37 | 0.6% | 0.000 |
| 1930 | 331.1 | 331.1 | 189.8 | 100.0% | 31.2 | 39 | 0.6% | 0.000 |
| 1931 | 331.0 | 331.0 | 189.8 | 100.0% | 31.5 | 40 | 0.6% | 0.000 |
| 1932 | 331.0 | 330.9 | 189.7 | 100.0% | 31.9 | 41 | 0.6% | 0.000 |
| 1933 | 330.9 | 330.8 | 189.7 | 99.9% | 32.3 | 50 | 0.8% | 0.000 |
| 1934 | 330.8 | 330.8 | 189.6 | 99.9% | 32.7 | 50 | 0.8% | 0.000 |
| 1935 | 330.7 | 330.7 | 189.6 | 99.9% | 33.3 | 50 | 0.8% | 0.000 |
| 1936 | 330.7 | 330.6 | 189.5 | 99.9% | 33.9 | 53 | 0.8% | 0.000 |
| 1937 | 330.6 | 330.6 | 189.5 | 99.8% | 34.7 | 48 | 0.7% | 0.000 |
| 1938 | 330.6 | 330.5 | 189.4 | 99.8% | 35.6 | 55 | 0.8% | 0.000 |
| 1939 | 330.5 | 330.5 | 189.4 | 99.8% | 36.6 | 65 | 1.0% | 0.000 |
| 1940 | 330.5 | 330.5 | 189.3 | 99.8% | 37.8 | 78 | 1.2% | 0.000 |

**Table 11 continued**

| Year | Total biomass (1000 mt) | Summary biomass (age 1+, 1000 mt) | Spawning biomass (1000 mt) | Depletion | Age-0 recruits (millions) | Total catch (mt) | 1 - SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1941 | 330.5 | 330.5 | 189.3 | 99.8% | 39.2 | 112 | 1.7% | 0.000 |
| 1942 | 330.5 | 330.5 | 189.3 | 99.7% | 40.7 | 126 | 1.9% | 0.000 |
| 1943 | 330.5 | 330.5 | 189.2 | 99.7% | 42.3 | 277 | 4.1% | 0.001 |
| 1944 | 330.4 | 330.4 | 189.1 | 99.7% | 44.1 | 392 | 5.8% | 0.001 |
| 1945 | 330.2 | 330.2 | 189.0 | 99.6% | 45.7 | 467 | 6.8% | 0.001 |
| 1946 | 330.0 | 330.0 | 188.8 | 99.5% | 47.2 | 223 | 3.3% | 0.001 |
| 1947 | 330.2 | 330.1 | 188.8 | 99.5% | 48.1 | 50 | 0.8% | 0.000 |
| 1948 | 330.5 | 330.5 | 188.9 | 99.5% | 48.1 | 157 | 2.4% | 0.000 |
| 1949 | 330.9 | 330.9 | 189.0 | 99.6% | 47.1 | 174 | 2.6% | 0.001 |
| 1950 | 331.3 | 331.3 | 189.2 | 99.7% | 45.2 | 158 | 2.4% | 0.000 |
| 1951 | 331.9 | 331.8 | 189.4 | 99.8% | 42.6 | 315 | 4.7% | 0.001 |
| 1952 | 332.3 | 332.3 | 189.6 | 99.9% | 39.7 | 182 | 2.7% | 0.001 |
| 1953 | 333.0 | 333.0 | 189.9 | 100.1% | 36.7 | 70 | 1.1% | 0.000 |
| 1954 | 333.9 | 333.9 | 190.4 | 100.3% | 33.8 | 133 | 2.0% | 0.000 |
| 1955 | 334.9 | 334.9 | 190.9 | 100.6% | 31.1 | 133 | 2.0% | 0.000 |
| 1956 | 335.9 | 335.9 | 191.5 | 100.9% | 28.6 | 806 | 11.3% | 0.002 |
| 1957 | 336.3 | 336.2 | 191.8 | 101.1% | 26.4 | 297 | 4.3% | 0.001 |
| 1958 | 337.2 | 337.2 | 192.4 | 101.4% | 24.5 | 308 | 4.5% | 0.001 |
| 1959 | 338.2 | 338.2 | 193.1 | 101.8% | 22.8 | 414 | 5.9% | 0.001 |
| 1960 | 339.1 | 339.1 | 193.8 | 102.1% | 21.4 | 491 | 6.9% | 0.001 |
| 1961 | 340.0 | 339.9 | 194.5 | 102.5% | 20.2 | 455 | 6.4% | 0.001 |
| 1962 | 340.8 | 340.8 | 195.2 | 102.8% | 19.3 | 239 | 3.4% | 0.001 |
| 1963 | 341.9 | 341.9 | 195.9 | 103.3% | 18.7 | 297 | 4.2% | 0.001 |
| 1964 | 342.8 | 342.8 | 196.7 | 103.6% | 18.4 | 193 | 2.8% | 0.001 |
| 1965 | 343.8 | 343.8 | 197.4 | 104.0% | 18.5 | 440 | 6.1% | 0.001 |
| 1966 | 344.5 | 344.5 | 197.9 | 104.3% | 19.1 | 1,299 | 18.5% | 0.004 |
| 1967 | 344.2 | 344.1 | 197.9 | 104.3% | 20.2 | 1,336 | 18.1% | 0.004 |
| 1968 | 343.7 | 343.6 | 197.7 | 104.2% | 21.9 | 2,097 | 25.6% | 0.006 |
| 1969 | 342.2 | 342.2 | 197.0 | 103.8% | 24.1 | 596 | 8.6% | 0.002 |
| 1970 | 342.3 | 342.3 | 197.1 | 103.9% | 26.7 | 749 | 10.5% | 0.002 |
| 1971 | 342.1 | 342.0 | 197.1 | 103.8% | 29.2 | 903 | 12.8% | 0.003 |
| 1972 | 341.5 | 341.5 | 196.8 | 103.7% | 30.6 | 1,784 | 23.1% | 0.005 |
| 1973 | 340.0 | 339.9 | 195.9 | 103.2% | 30.7 | 3,260 | 37.6% | 0.010 |
| 1974 | 336.7 | 336.7 | 194.1 | 102.3% | 29.5 | 1,521 | 20.0% | 0.005 |
| 1975 | 335.2 | 335.1 | 193.2 | 101.8% | 27.7 | 2,373 | 29.5% | 0.007 |
| 1976 | 332.6 | 332.6 | 191.7 | 101.0% | 25.9 | 1,074 | 14.5% | 0.003 |
| 1977 | 331.4 | 331.4 | 190.9 | 100.6% | 25.0 | 1,492 | 19.7% | 0.005 |
| 1978 | 329.6 | 329.6 | 189.8 | 100.0% | 25.1 | 1,247 | 16.9% | 0.004 |
| 1979 | 328.0 | 328.0 | 188.8 | 99.5% | 26.0 | 1,880 | 24.2% | 0.006 |
| 1980 | 325.7 | 325.7 | 187.5 | 98.8% | 27.1 | 1,316 | 18.0% | 0.004 |

**Table 11 continued**

| Year | Total biomass (1000 mt) | Summary biomass (age 1+, 1000 mt) | Spawning biomass (1000 mt) | Depletion | Age-0 recruits (millions) | Total catch (mt) | 1 - SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|---|
| 1981 | 323.9 | 323.9 | 186.4 | 98.3% | 28.6 | 1,933 | 25.7% | 0.006 |
| 1982 | 321.4 | 321.3 | 185.0 | 97.5% | 31.1 | 2,319 | 31.0% | 0.007 |
| 1983 | 318.4 | 318.4 | 183.4 | 96.6% | 33.6 | 3,288 | 43.0% | 0.010 |
| 1984 | 314.3 | 314.3 | 181.2 | 95.5% | 35.0 | 3,916 | 48.8% | 0.012 |
| 1985 | 309.5 | 309.4 | 178.5 | 94.1% | 36.0 | 4,156 | 50.2% | 0.013 |
| 1986 | 304.4 | 304.4 | 175.7 | 92.6% | 36.6 | 3,010 | 39.0% | 0.010 |
| 1987 | 300.6 | 300.5 | 173.5 | 91.4% | 35.6 | 2,652 | 36.5% | 0.009 |
| 1988 | 297.1 | 297.1 | 171.5 | 90.4% | 33.6 | 3,049 | 41.1% | 0.010 |
| 1989 | 293.3 | 293.3 | 169.2 | 89.2% | 31.8 | 5,191 | 59.0% | 0.018 |
| 1990 | 287.2 | 287.2 | 165.7 | 87.3% | 31.5 | 4,541 | 57.6% | 0.016 |
| 1991 | 281.8 | 281.8 | 162.6 | 85.7% | 32.5 | 3,907 | 55.0% | 0.014 |
| 1992 | 277.1 | 277.0 | 160.0 | 84.3% | 32.7 | 3,684 | 52.6% | 0.013 |
| 1993 | 272.7 | 272.6 | 157.5 | 83.0% | 27.7 | 4,239 | 58.3% | 0.016 |
| 1994 | 267.7 | 267.7 | 154.7 | 81.5% | 21.8 | 3,769 | 55.3% | 0.014 |
| 1995 | 263.3 | 263.3 | 152.2 | 80.2% | 19.2 | 2,129 | 36.9% | 0.008 |
| 1996 | 260.7 | 260.7 | 150.8 | 79.5% | 19.8 | 1,787 | 32.6% | 0.007 |
| 1997 | 258.6 | 258.6 | 149.6 | 78.8% | 24.5 | 1,561 | 29.3% | 0.006 |
| 1998 | 256.8 | 256.8 | 148.6 | 78.3% | 31.4 | 1,371 | 26.5% | 0.005 |
| 1999 | 255.2 | 255.2 | 147.7 | 77.8% | 29.8 | 928 | 19.0% | 0.004 |
| 2000 | 254.2 | 254.2 | 147.2 | 77.6% | 25.4 | 925 | 18.7% | 0.004 |
| 2001 | 253.3 | 253.3 | 146.7 | 77.3% | 22.9 | 602 | 13.0% | 0.002 |
| 2002 | 252.8 | 252.8 | 146.4 | 77.1% | 20.6 | 855 | 17.4% | 0.003 |
| 2003 | 252.0 | 252.0 | 146.0 | 76.9% | 20.6 | 903 | 18.4% | 0.004 |
| 2004 | 251.3 | 251.2 | 145.5 | 76.7% | 22.5 | 846 | 17.6% | 0.003 |
| 2005 | 250.6 | 250.6 | 145.0 | 76.4% | 27.2 | 739 | 15.5% | 0.003 |
| 2006 | 250.1 | 250.0 | 144.7 | 76.2% | 32.7 | 792 | 16.6% | 0.003 |
| 2007 | 249.5 | 249.5 | 144.3 | 76.1% | 33.0 | 1,058 | 21.8% | 0.004 |
| 2008 | 248.7 | 248.7 | 143.8 | 75.8% | 30.9 | 1,507 | 29.7% | 0.006 |
| 2009 | 247.5 | 247.4 | 143.1 | 75.4% | 30.2 | 1,619 | 31.4% | 0.007 |
| 2010 | 246.1 | 246.1 | 142.3 | 75.0% | 30.5 | 1,431 | 28.3% | 0.006 |
| 2011 | 245.0 | 245.0 | 141.6 | 74.6% | 27.4 | 994 | 20.3% | 0.004 |
| 2012 | 244.4 | 244.3 | 141.2 | 74.4% | 28.8 | 911 | 18.7% | 0.004 |

**Table 12: Summary of reference points and management outputs for the base case model.**

| Quantity | Estimate | ~95% confidence interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 189,765 | (57,435 – 322,095) |
| Unfished age 1+ biomass (mt) | 331,047 | (100,196 – 561,898) |
| Unfished recruitment (R0, millions) | 30.4 | (15.2 – 61.1) |
| Depletion (2013) | 74.2% | (56.1% – 92.3%) |
| Spawning Biomass (2013) | 140,753 | (9,673 – 271,833) |
| SD of log Spawning Biomass (2013) | 0.45 | – |
| ***Reference points based on $B_{40\%}$*** | | |
| Proxy spawning biomass ($B_{40\%}$) | 75,906 | (22,974 – 128,838) |
| SPR resulting in $B_{40\%}$ ($SPR_{SB40\%}$) | 50.0% | – |
| Exploitation rate resulting in $B_{40\%}$ | 0.015 | (0.015 – 0.016) |
| Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt) | 2,034 | (633 – 3,435) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 75,906 | (22,974 – 128,838) |
| $SPR_{proxy}$ | 50.0% | – |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.015 | (0.015 – 0.016) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 2,034 | (633 – 3,435) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 64,600 | (19,517 – 109,683) |
| $SPR_{MSY}$ | 45.0% | (44.9% – 45.2%) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.018 | (0.018 – 0.019) |
| *MSY* (mt) | 2,062 | (642 – 3,482) |

**Table 13: Projection of potential OFL, landings, and catch, summary biomass (age-1 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2013 and 2014, and catches at the *p** offset (94.5%) from the OFL from 2015 onward. The 2013 and 2014 OFL's are values specified by the PFMC and not predicted by this assessment. The OFL for 2015 and onward is the calculated total catch determined by $F_{SPR}$.**

| Year | Predicted OFL (mt) | ACL Catch (mt) | Landings (mt) | Age 1+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 2,333 | 1,836 | 933 | 243,824 | 140,753 | 74.2% |
| 2014 | 2,333 | 1,836 | 933 | 243,316 | 140,342 | 74.0% |
| 2015 | 3,203 | 3,027 | 2,968 | 242,845 | 139,977 | 73.8% |
| 2016 | 3,167 | 2,993 | 2,934 | 240,160 | 138,449 | 73.0% |
| 2017 | 3,131 | 2,959 | 2,901 | 237,526 | 136,971 | 72.2% |
| 2018 | 3,097 | 2,927 | 2,869 | 234,948 | 135,533 | 71.4% |
| 2019 | 3,064 | 2,895 | 2,838 | 232,425 | 134,127 | 70.7% |
| 2020 | 3,032 | 2,865 | 2,808 | 229,960 | 132,747 | 70.0% |
| 2021 | 3,001 | 2,836 | 2,779 | 227,554 | 131,391 | 69.2% |
| 2022 | 2,971 | 2,808 | 2,751 | 225,206 | 130,063 | 68.5% |
| 2023 | 2,943 | 2,781 | 2,725 | 222,918 | 128,763 | 67.9% |
| 2024 | 2,916 | 2,756 | 2,700 | 220,689 | 127,494 | 67.2% |

**Table 14: Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.**

| | | | State of nature | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | | Base case | | High | |
| **Relative probability of log($R_0$)** | | | 0.25 | | 0.5 | | 0.25 | |
| **Management decision** | Year | Total catch (mt) | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion | Spawning biomass (mt) | Depletion |
| Status quo catches | 2015 | 952 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 952 | 54.1 | 53.2% | 139.7 | 73.6% | 405.1 | 88.8% |
| | 2017 | 952 | 53.7 | 52.8% | 139.4 | 73.5% | 405.1 | 88.9% |
| | 2018 | 952 | 53.3 | 52.4% | 139.2 | 73.3% | 405.2 | 88.9% |
| | 2019 | 952 | 52.9 | 52.0% | 139.0 | 73.2% | 405.4 | 88.9% |
| | 2020 | 952 | 52.6 | 51.7% | 138.8 | 73.1% | 405.5 | 88.9% |
| | 2021 | 952 | 52.2 | 51.4% | 138.6 | 73.1% | 405.7 | 89.0% |
| | 2022 | 952 | 51.9 | 51.0% | 138.5 | 73.0% | 405.8 | 89.0% |
| | 2023 | 952 | 51.6 | 50.8% | 138.4 | 72.9% | 406.0 | 89.0% |
| | 2024 | 952 | 51.4 | 50.5% | 138.2 | 72.9% | 406.1 | 89.1% |
| Catch associated with SPR = 65%, stabilizing population around 60% of $B_0$ | 2015 | 1,828 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 1,819 | 53.6 | 52.7% | 139.2 | 73.3% | 404.6 | 88.7% |
| | 2017 | 1,812 | 52.7 | 51.8% | 138.4 | 72.9% | 404.1 | 88.6% |
| | 2018 | 1,804 | 51.8 | 50.9% | 137.6 | 72.5% | 403.7 | 88.5% |
| | 2019 | 1,797 | 50.9 | 50.0% | 136.9 | 72.1% | 403.3 | 88.5% |
| | 2020 | 1,790 | 50.0 | 49.1% | 136.2 | 71.8% | 402.9 | 88.4% |
| | 2021 | 1,784 | 49.1 | 48.3% | 135.5 | 71.4% | 402.6 | 88.3% |
| | 2022 | 1,778 | 48.3 | 47.5% | 134.9 | 71.1% | 402.2 | 88.2% |
| | 2023 | 1,773 | 47.5 | 46.7% | 134.2 | 70.7% | 401.8 | 88.1% |
| | 2024 | 1,768 | 46.7 | 45.9% | 133.6 | 70.4% | 401.5 | 88.1% |
| OFL (associated with SPR = 50%), including *p** offset (94.5%) | 2015 | 3,027 | 54.6 | 53.6% | 140.0 | 73.8% | 405.1 | 88.9% |
| | 2016 | 2,993 | 52.9 | 52.0% | 138.4 | 73.0% | 403.9 | 88.6% |
| | 2017 | 2,959 | 51.3 | 50.4% | 137.0 | 72.2% | 402.7 | 88.3% |
| | 2018 | 2,927 | 49.7 | 48.8% | 135.5 | 71.4% | 401.6 | 88.1% |
| | 2019 | 2,895 | 48.1 | 47.3% | 134.1 | 70.7% | 400.6 | 87.9% |
| | 2020 | 2,865 | 46.5 | 45.7% | 132.7 | 70.0% | 399.5 | 87.6% |
| | 2021 | 2,836 | 45.0 | 44.2% | 131.4 | 69.2% | 398.5 | 87.4% |
| | 2022 | 2,808 | 43.5 | 42.7% | 130.1 | 68.5% | 397.5 | 87.2% |
| | 2023 | 2,781 | 42.0 | 41.3% | 128.8 | 67.9% | 396.4 | 87.0% |
| | 2024 | 2,756 | 40.6 | 39.9% | 127.5 | 67.2% | 395.5 | 86.7% |

**Table 15: Change in likelihood associated with model estimates using 100 alternative starting values for all parameters.**

| Difference in likelihood from base model | Number of occurrences | Difference in likelihood from base model | Number of occurrences |
|---|---|---|---|
| 0 | 27 | 12.01 | 1 |
| 0.54 | 34 | 21.83 | 1 |
| 0.57 | 11 | 24.13 | 1 |
| 1.21 | 12 | 26.25 | 1 |
| 2.78 | 1 | 31.28 | 1 |
| 2.79 | 1 | 31.59 | 1 |
| 2.92 | 1 | 40.07 | 1 |
| 2.97 | 1 | 77.46 | 1 |
| 3.38 | 1 | 140.89 | 1 |
| 3.53 | 1 | 267.70 | 1 |

**Table 16: Summary of results for likelihood profiles and sensitivity analyses. Likelihood values are change relative to base model with larger values indicating a worse fit.**

| Quantity | Base model | Low state of nature log($R_0$) = 9.7 | High state of nature log($R_0$) = 11.2 | Low steep. $h$=0.4 | High steep. $h$=0.8 | Low mort. $M$=0.04 | High mort. $M$=0.06 | Alt. maturity 1 | Alt. maturity 2 | No recruit var. | Low recruit var. $\sigma_R$=0.25 | High recruit var. $\sigma_R$=0.75 | Alt. early catch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Likelihood values relative to base model** | | | | | | | | | | | | | |
| Total likelihood | 0.00 | 3.65 | 1.17 | -0.92 | -0.61 | -7.29 | 7.46 | -0.03 | -0.06 | 53.91 | 9.96 | -4.25 | -0.63 |
| Survey indices | 0.00 | 2.18 | -0.41 | 0.27 | -0.09 | 1.74 | -0.34 | -0.01 | -0.02 | 1.88 | 0.00 | 0.52 | -0.01 |
| Length data | 0.00 | -1.41 | 0.57 | -0.01 | -0.02 | -5.86 | 4.80 | -0.02 | -0.04 | 59.56 | 14.63 | -4.87 | 0.05 |
| Discard fractions | 0.00 | -1.00 | 1.30 | -0.51 | 0.22 | -0.57 | 0.49 | 0.02 | 0.05 | -2.70 | -0.84 | 0.13 | 0.00 |
| **Quantities of interest** | | | | | | | | | | | | | |
| Unfished Spawning biomass (1000 mt) | 189.8 | 101.7 | 455.9 | 167.9 | 201.3 | 126.8 | 1691.2 | 159.5 | 141.3 | 129.6 | 198.2 | 153.8 | 190.9 |
| Unfished recruitment (R0, millions) | 30.4 | 16.3 | 73.1 | 26.9 | 32.3 | 10.9 | 442.4 | 30.6 | 30.8 | 20.8 | 31.8 | 24.7 | 30.6 |
| Depletion (2013) | 74.2% | 54.6% | 88.9% | 69.6% | 76.2% | 53.6% | 95.6% | 74.2% | 73.8% | 59.8% | 74.1% | 69.0% | 74.6% |
| Catchability for NWFSC Combo Survey | 0.43 | 1.04 | 0.15 | 0.52 | 0.40 | 1.21 | 0.03 | 0.43 | 0.42 | 0.69 | 0.40 | 0.58 | 0.43 |

# 10 Figures
## 10.1 Catch history

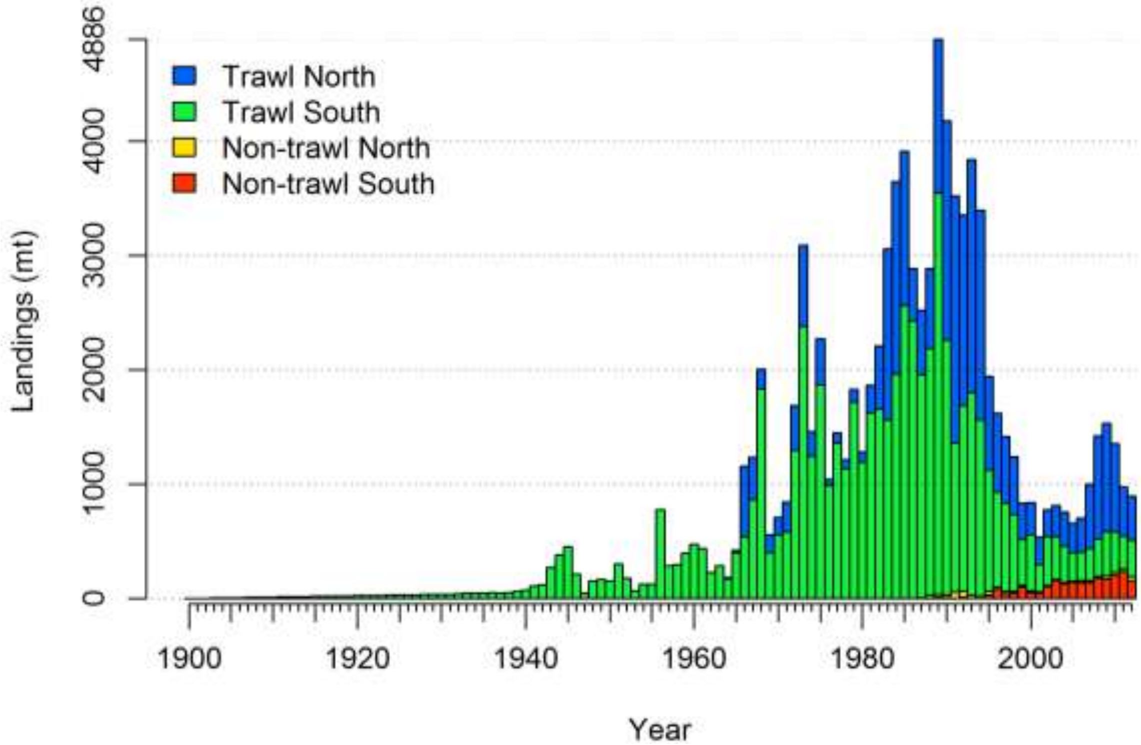


**Figure 1: Estimated landings history for shortspine thornyhead.**

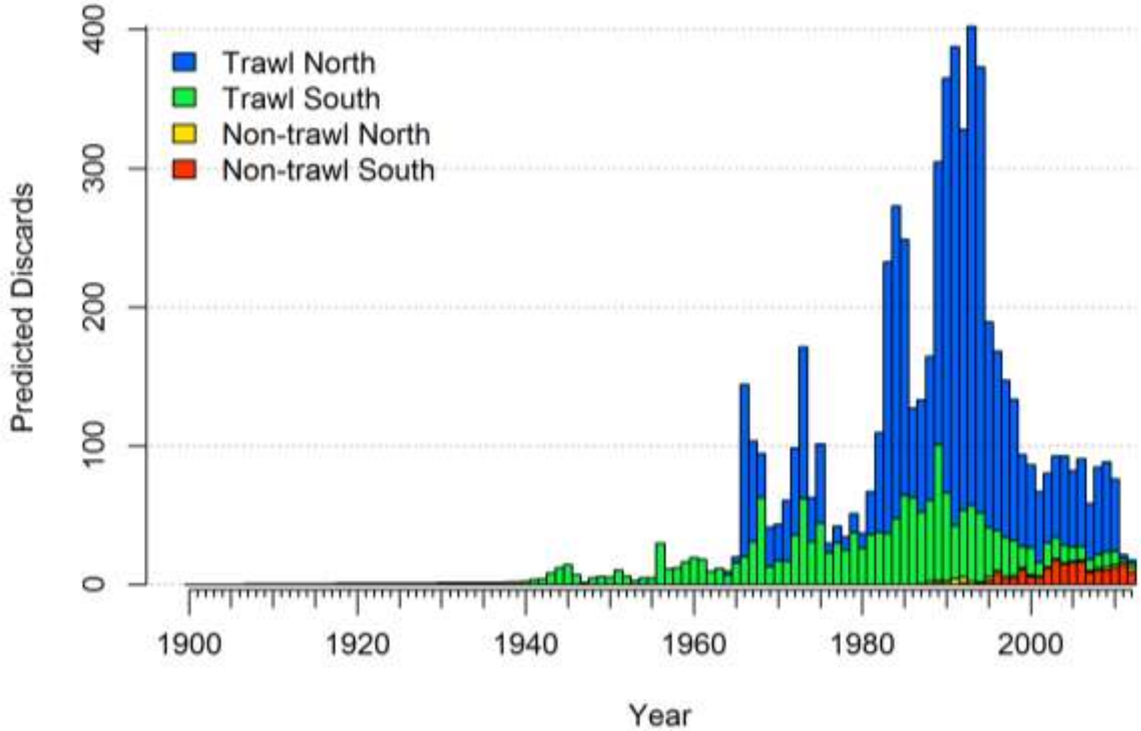


**Figure 2: Predicted discards based estimated retention and selectivity for each fleet.**

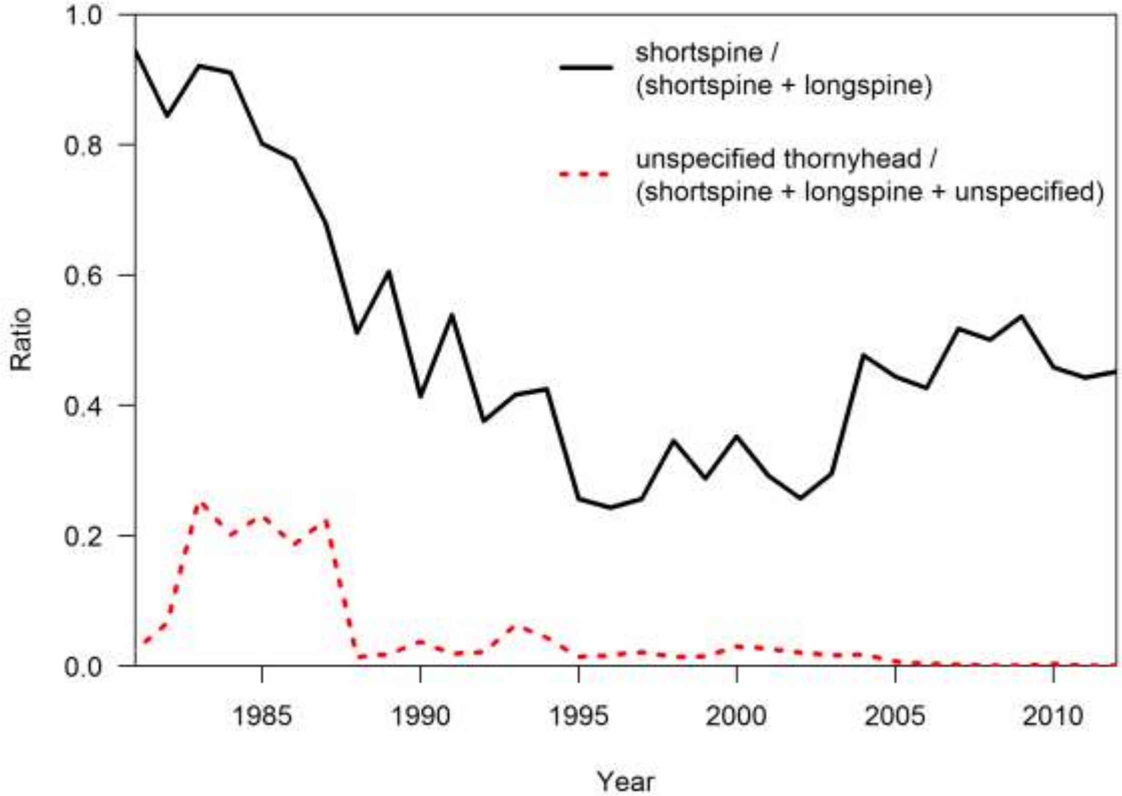


**Figure 3: Ratio of shortspine to combined thornyheads in the subset of the landings for which the species was identified (solid black line), and the ratio of unspecified landings to total landings of both thornyhead species (dotted red line). The ratio of specified thornyheads was used to apportion the unspecified landings into estimates of the landings for each species.**

## 10.2 Distribution, Ecology and Life history

**Figure 4: Occurrence and abundance of shortspine thornyhead found in the NWFSC annual survey (2003-2012) north of 40º10' N latitude.**

The image part with relationship ID rId21 was not found in the file.

**Figure 5: Occurrence and abundance of shortspine thornyhead found in the NWFSC annual survey (2003-2012) south of 40º10' N latitude.**

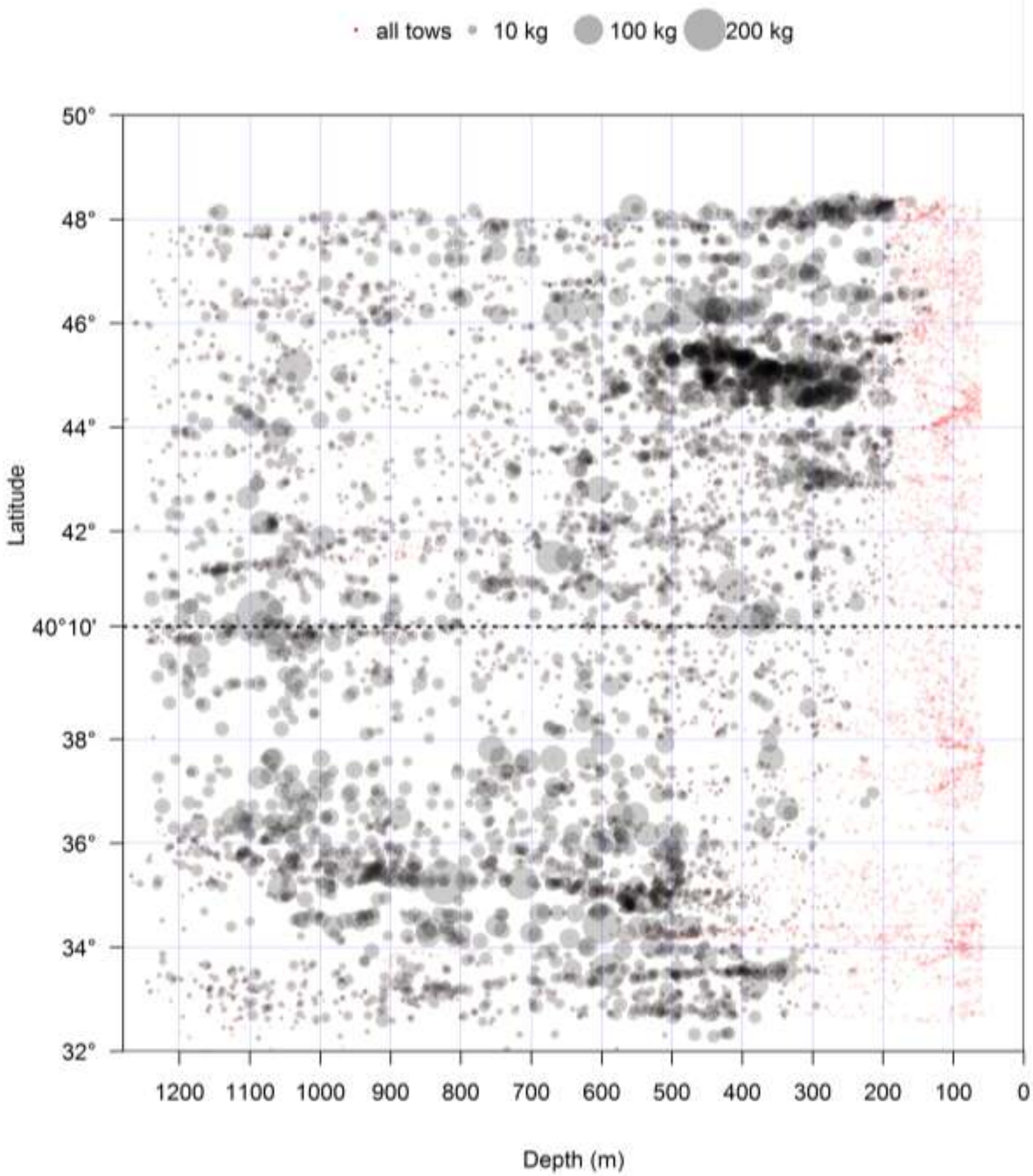


**Figure 6: Spatial distribution of shortspine thornyhead in NWFSC shelf-slope survey data (2003 – 2012). Red points indicate location of all tows. Grey points indicate location of shortspine thornyheads with area of circle proportional to biomass of catch with scale indicated in key at the top. Swept area is not accounted for in this figure, but tows typically cover similar area.**

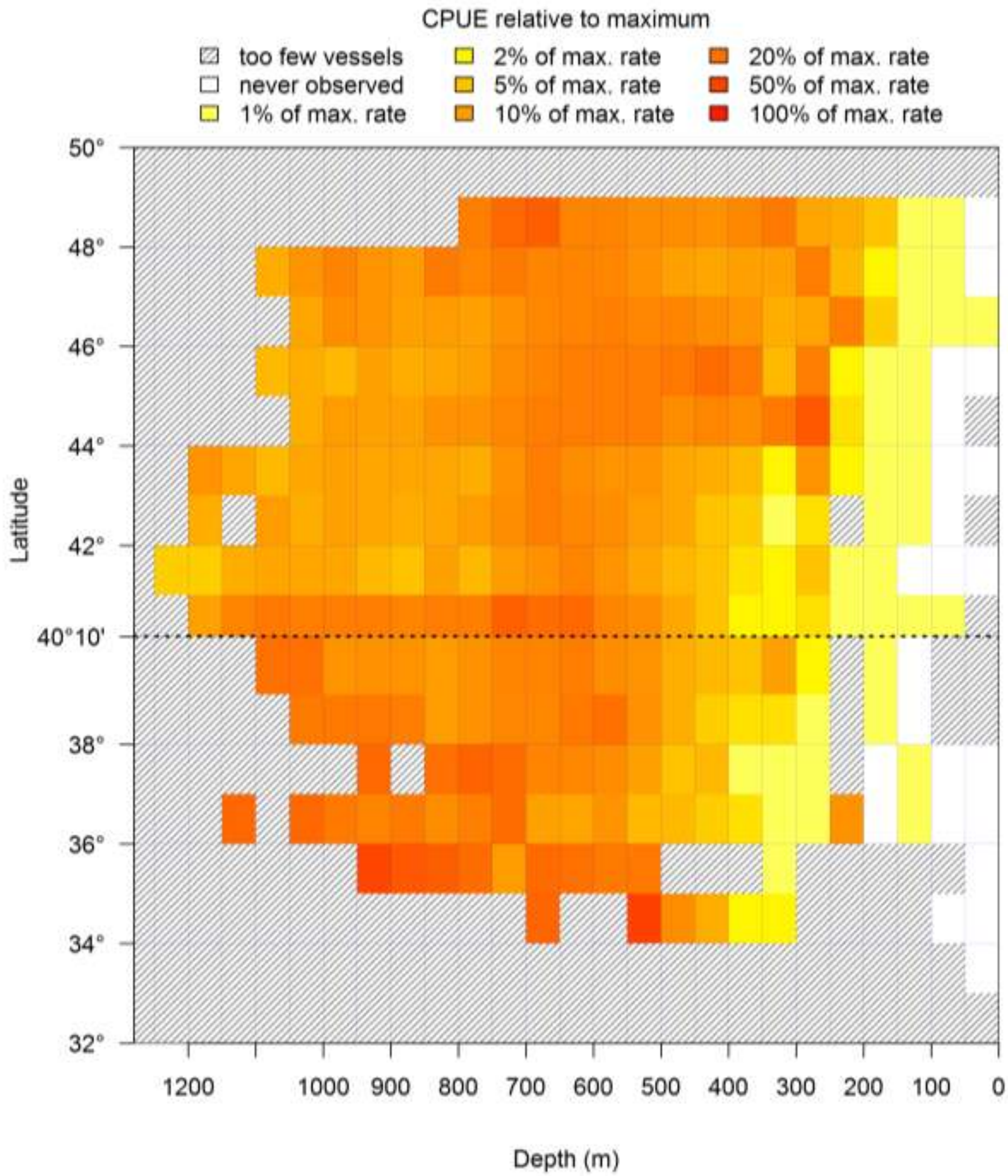


**Figure 7: Spatial distribution of shortspine thornyhead in WCGOP trawl data (2002 – 2011). Colors represent CPUE relative to the maximum. Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught. CPUE represented here is the sum of the observed catch across all years divided by the sum of the trawl durations during observed hauls within each cell.**

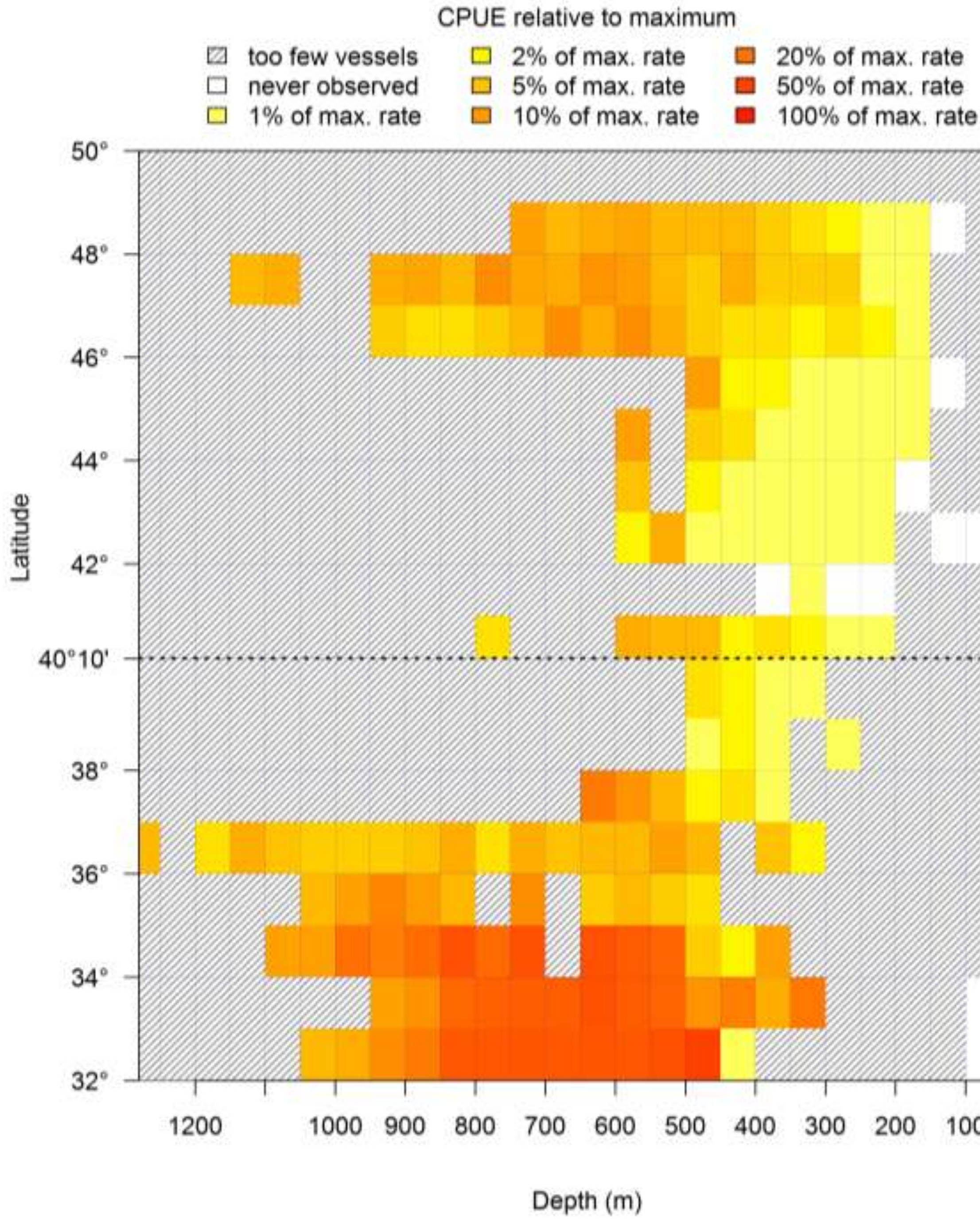


**Figure 8: Spatial distribution of shortspine thornyhead in WCGOP hook and line fishery data (2002 – 2011). Colors represent CPUE relative to the maximum. Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished with hook and line in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught. CPUE represented here is the sum of the observed catch across all years divided by the sum of the number of hooks set hauls within each cell.**

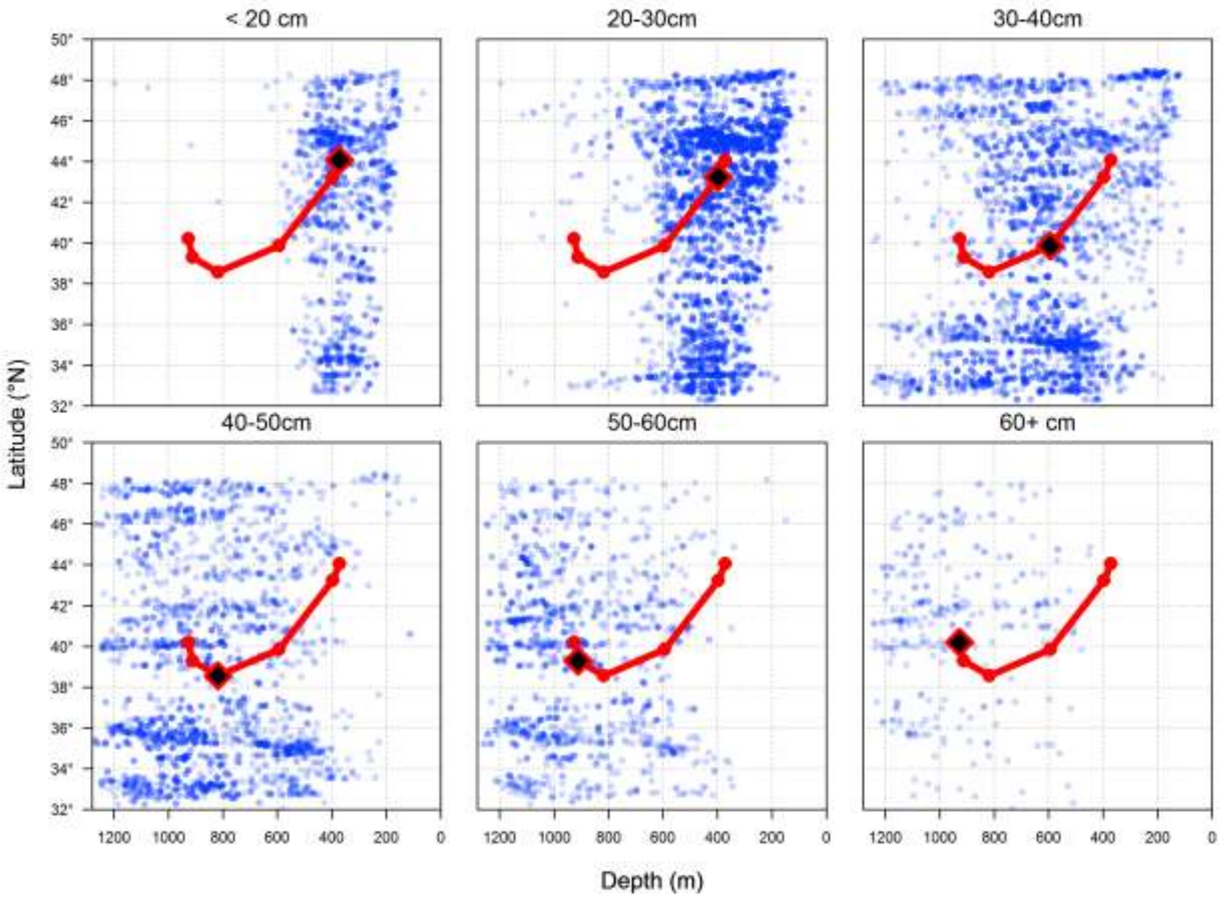


**Figure 9: Distribution of different size groups of shortspine thornyheads. Blue points represent location of samples in each size bin. Black diamonds indicate the weighted average of depth and latitude for each bin, and the red lines show the connected series of average values across bins.**

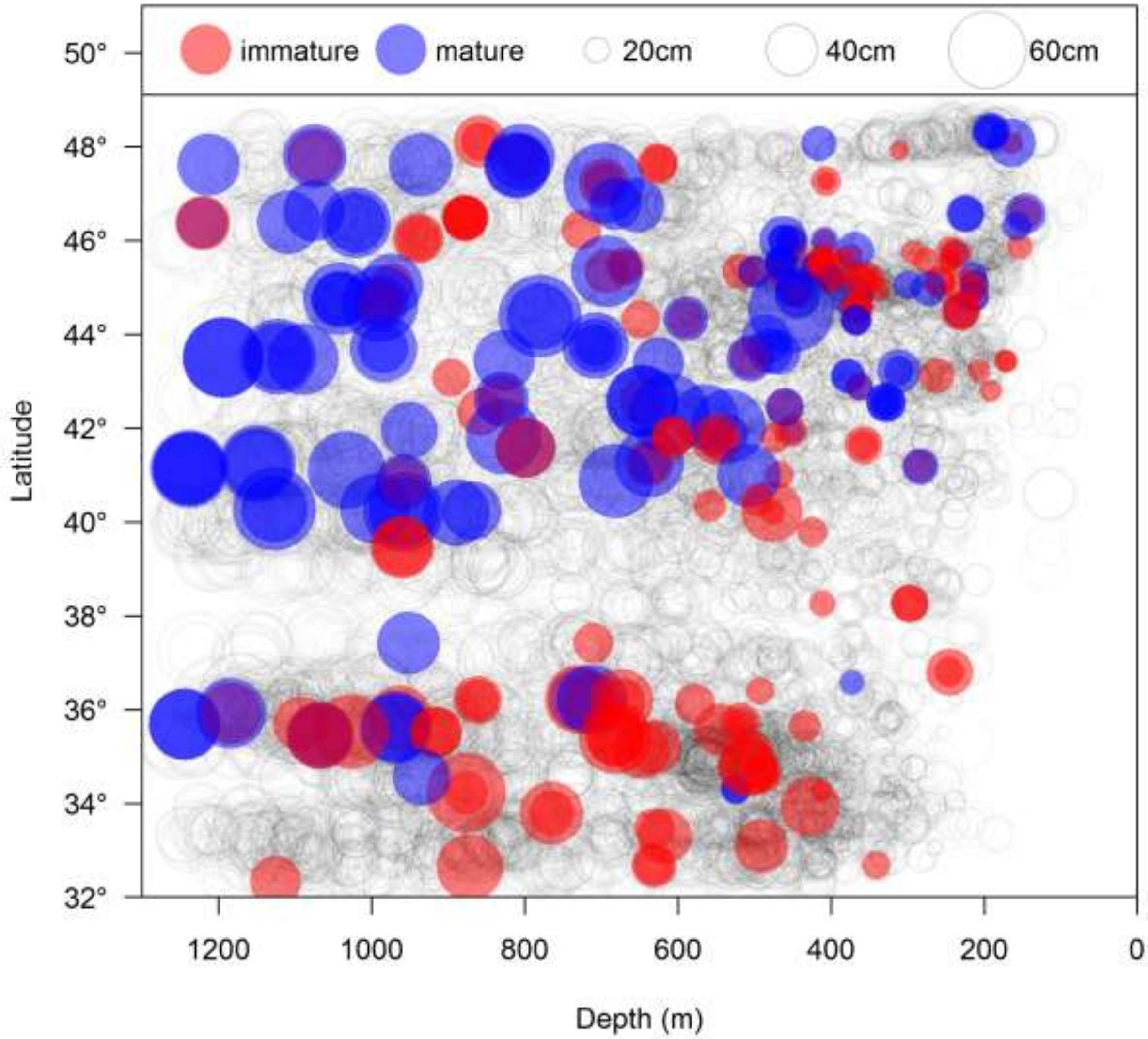


**Figure 10: Distribution of mature and immature shortspine thornyheads based on ovaries collected in the NWFSC Combo Survey in 2011 and 2012. Due to difficulty in determining maturity of individuals that are not spawning, immature samples may include fish that were skipping spawning. Open circles indicate all length samples. Filled circles represent locations where ovaries were collected. Circle Diameter of circles is proportional to observed length.**

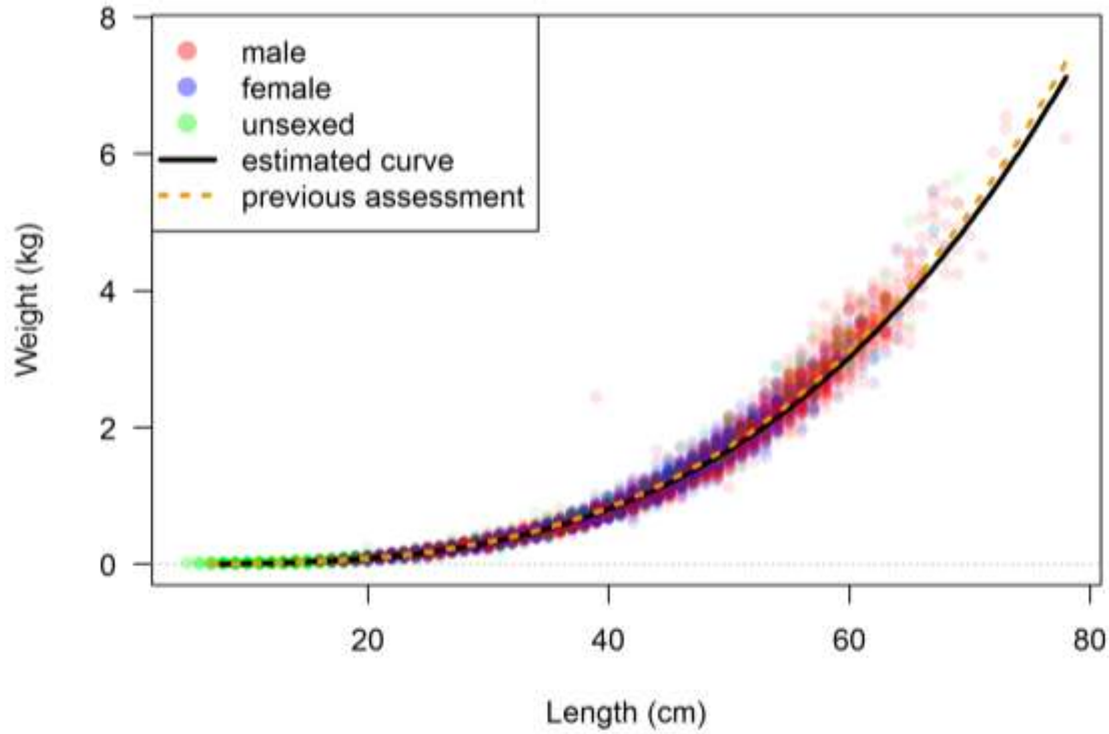


**Figure 11: Weight at length observations and estimation mean relationship used in the assessment.**

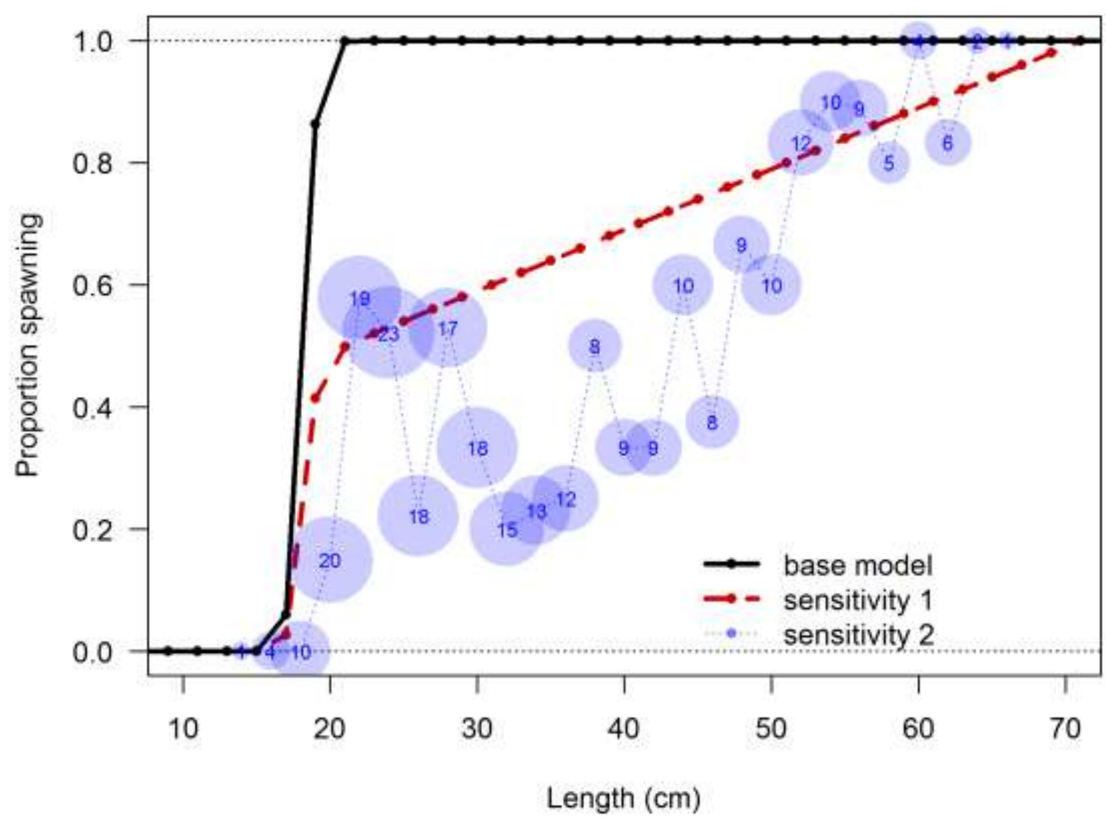


**Figure 12: Recently collected data on proportion spawning by length bin (circles) with sample size indicated by area of circle and number within. Maturity schedules for the base model and sensitivity analyses are shown by the solid and dashed lines.**

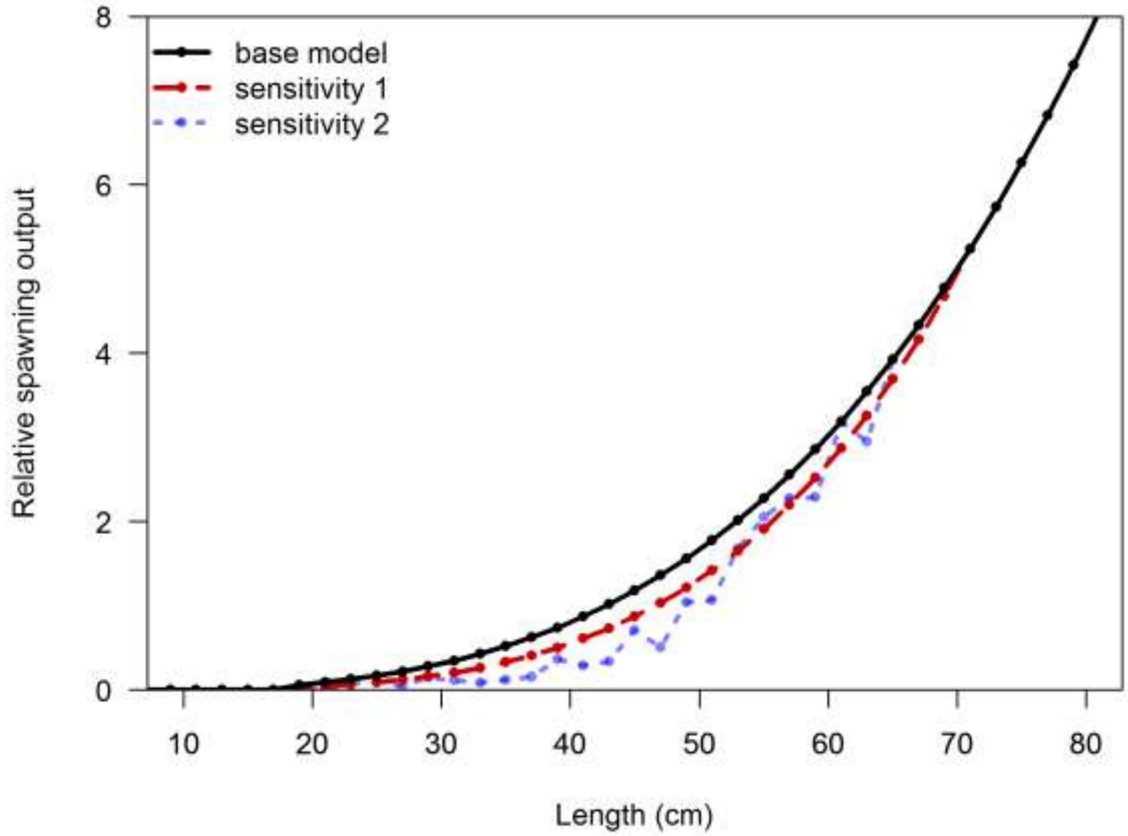


**Figure 13: Spawning output as a function of length for the base model and the sensitivity analyses. This is the product of fraction spawning and fecundity (assumed proportional to weight).**

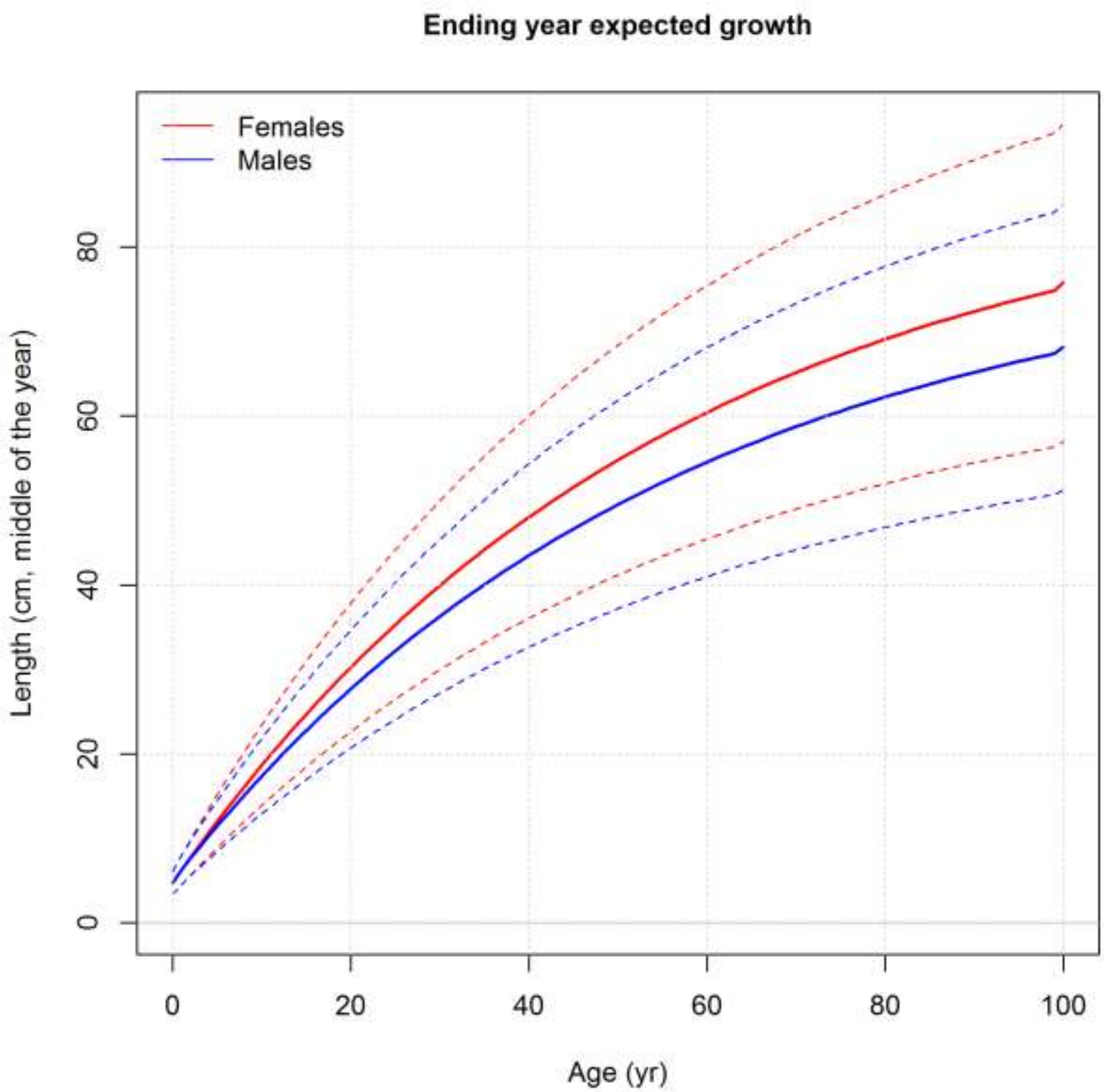


**Figure 14: Growth curves (solid lines) and 95% variability in length-at-age used in the model.**

## 10.3 Data and model fits
### 10.3.1 Data summary

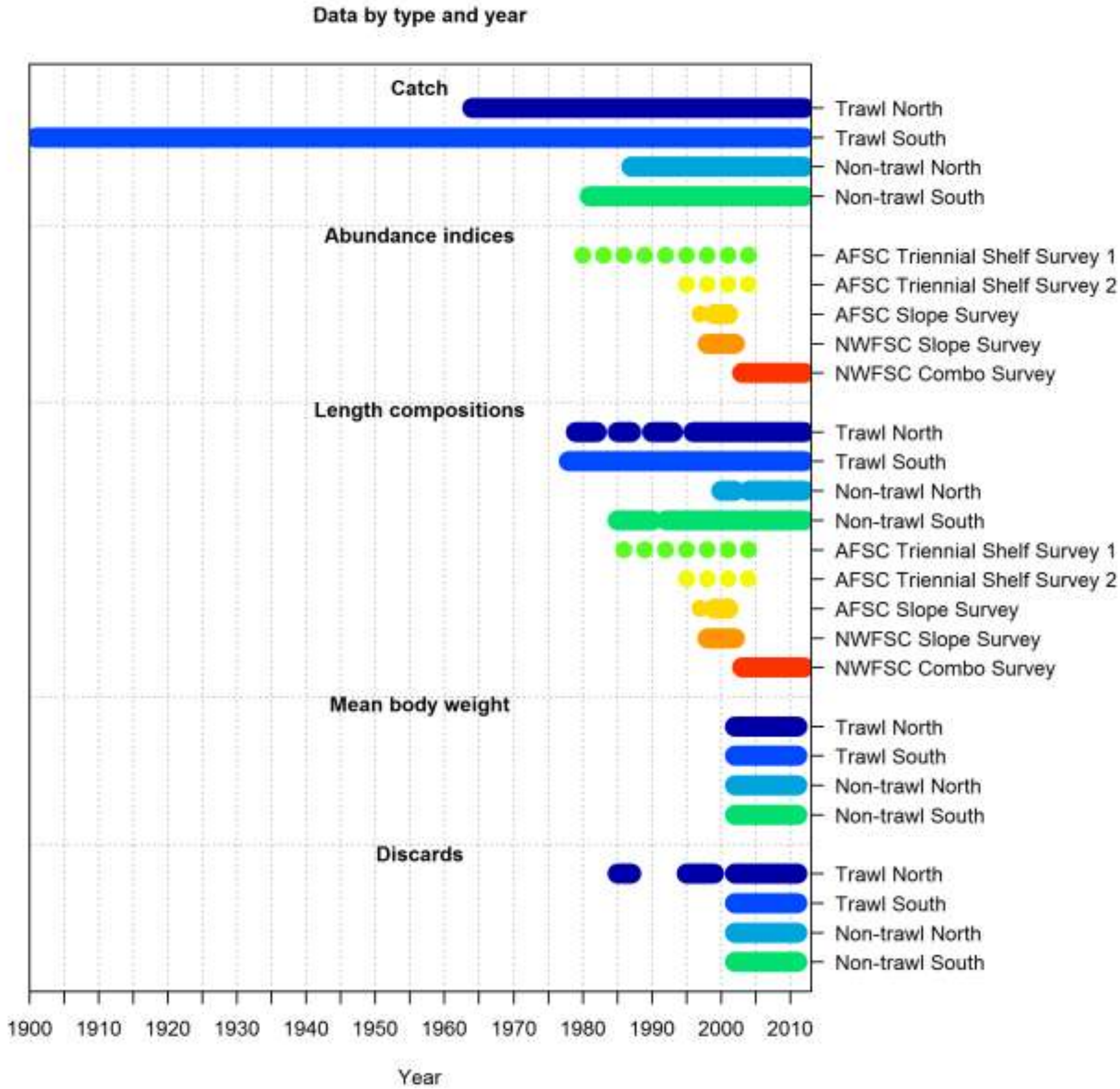


**Figure 15: Chart of data availability by year for each fleet.**

### 10.3.2 Selectivity and retention

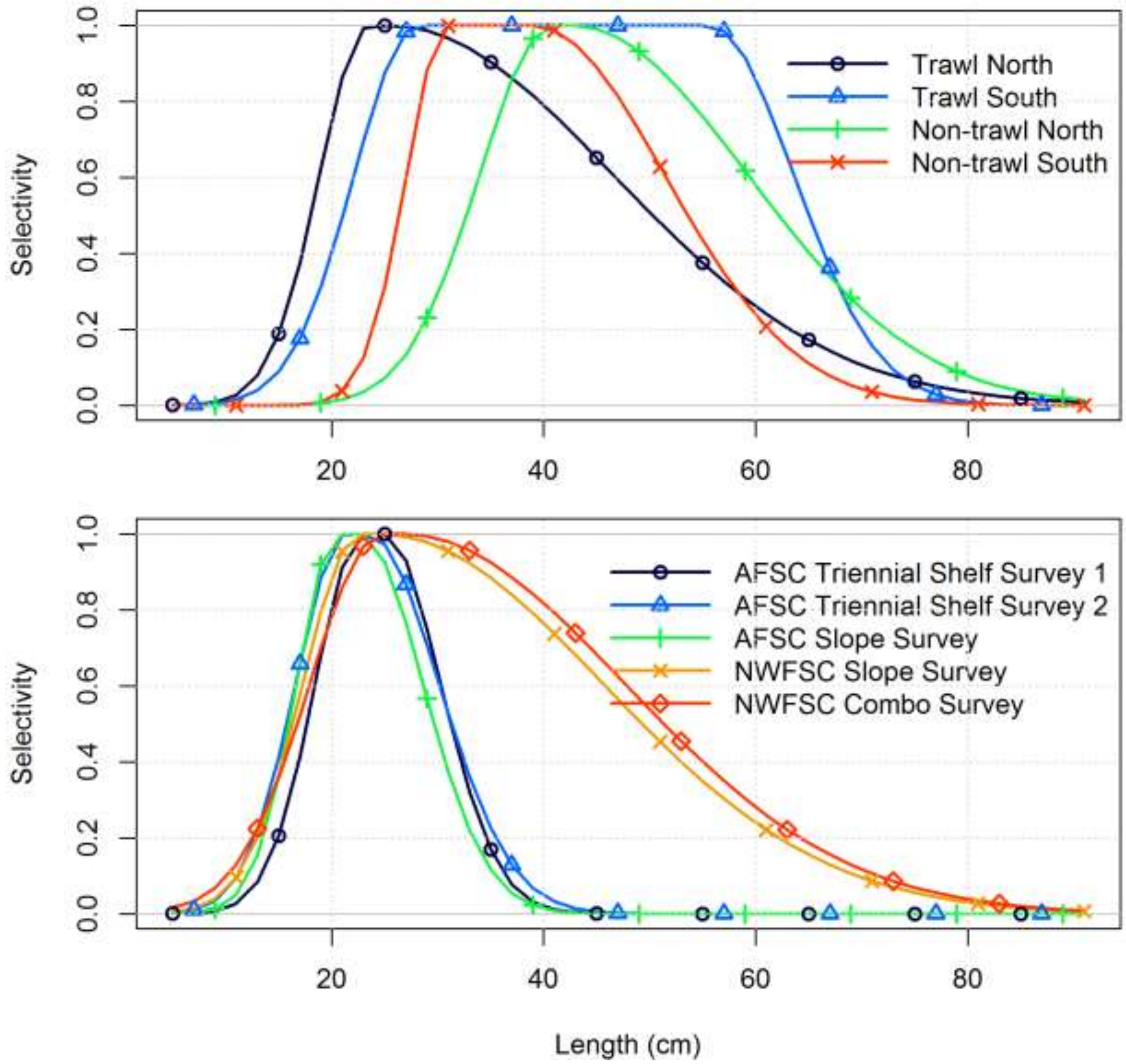


**Figure 16: Selectivity for each fishing fleet (upper panel) and survey (lower panel).**

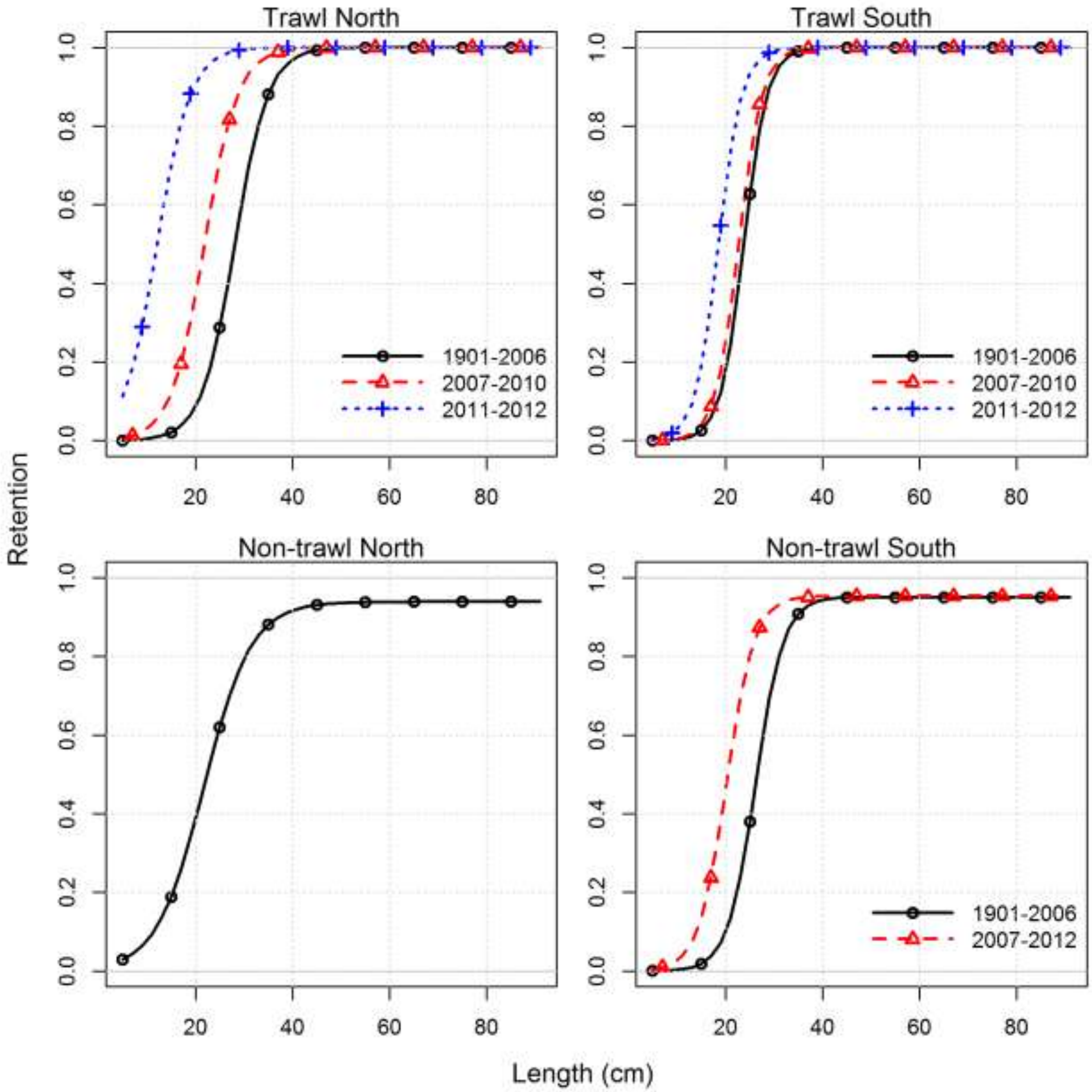


**Figure 17: Retention functions for each fleet in the base model indicating increased retention of smaller fish in more recent years.**

### 10.3.3 Indices and discard data

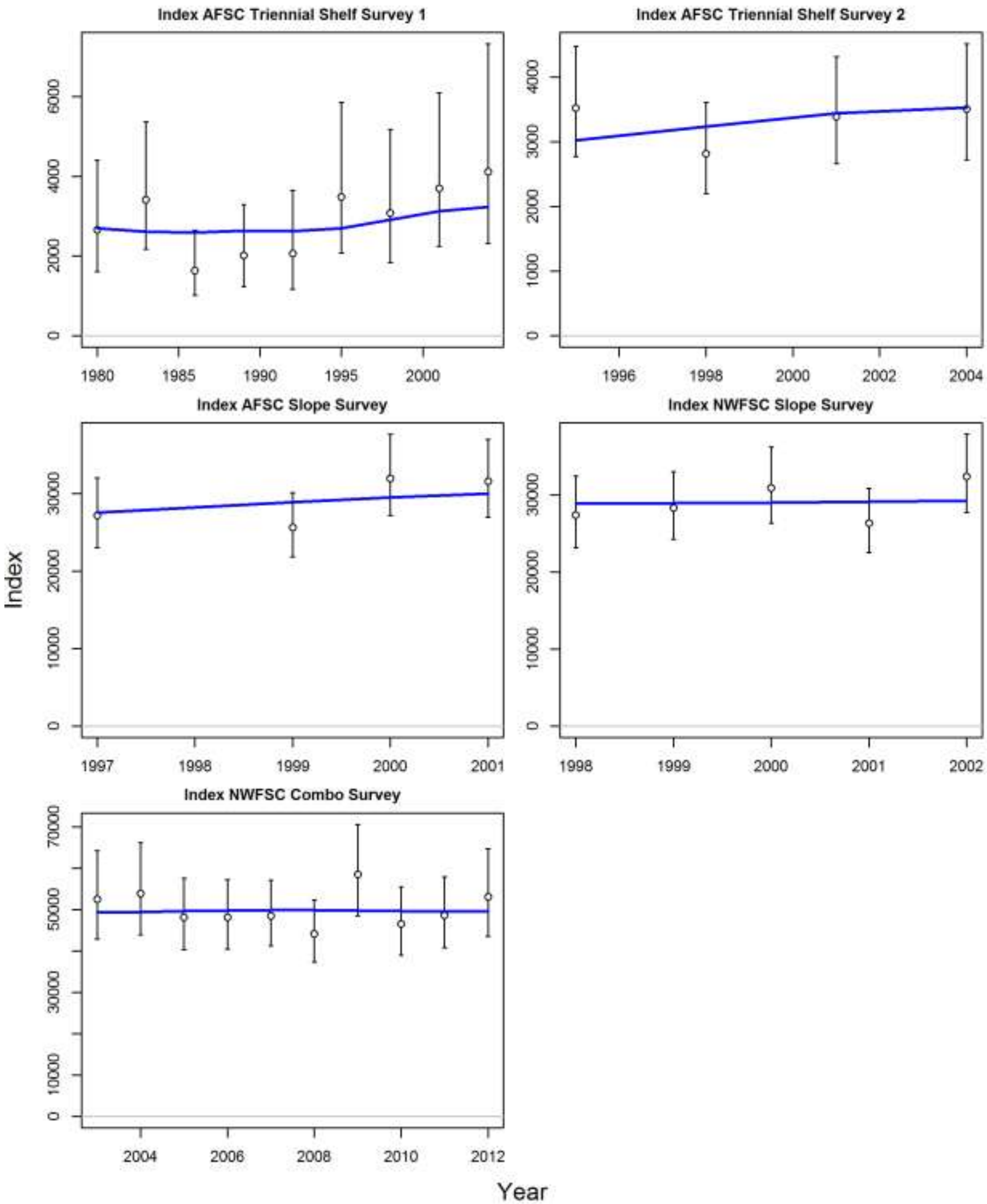


**Figure 18: Indices of abundance used in the assessment (open circles) shown with 95% intervals (black vertical lines) and model fits (blue lines).**

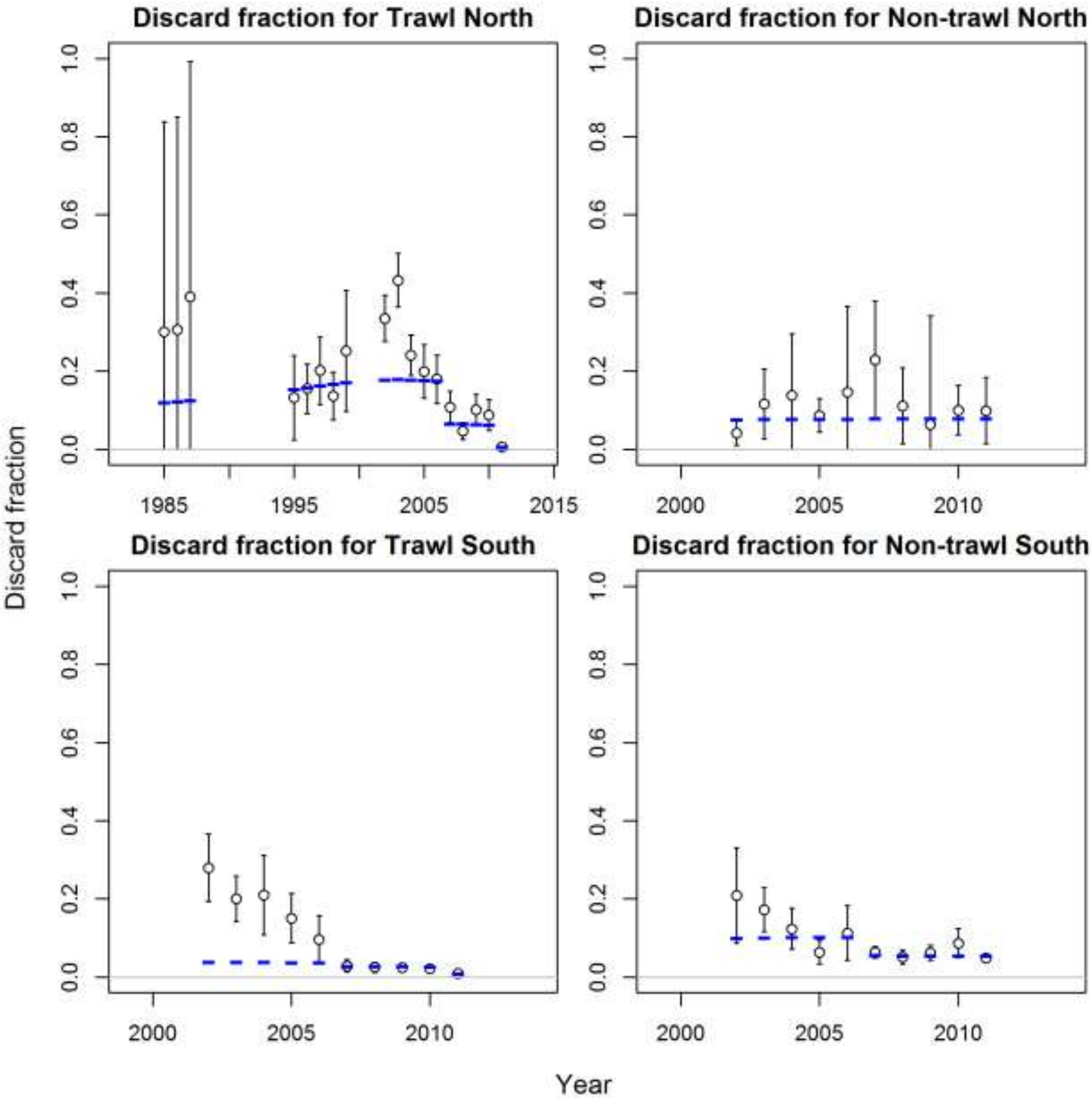


**Figure 19: Discard fractions estimated for each fleet (open circles) shown with 95% intervals (black vertical lines) and model fits (blue lines).**

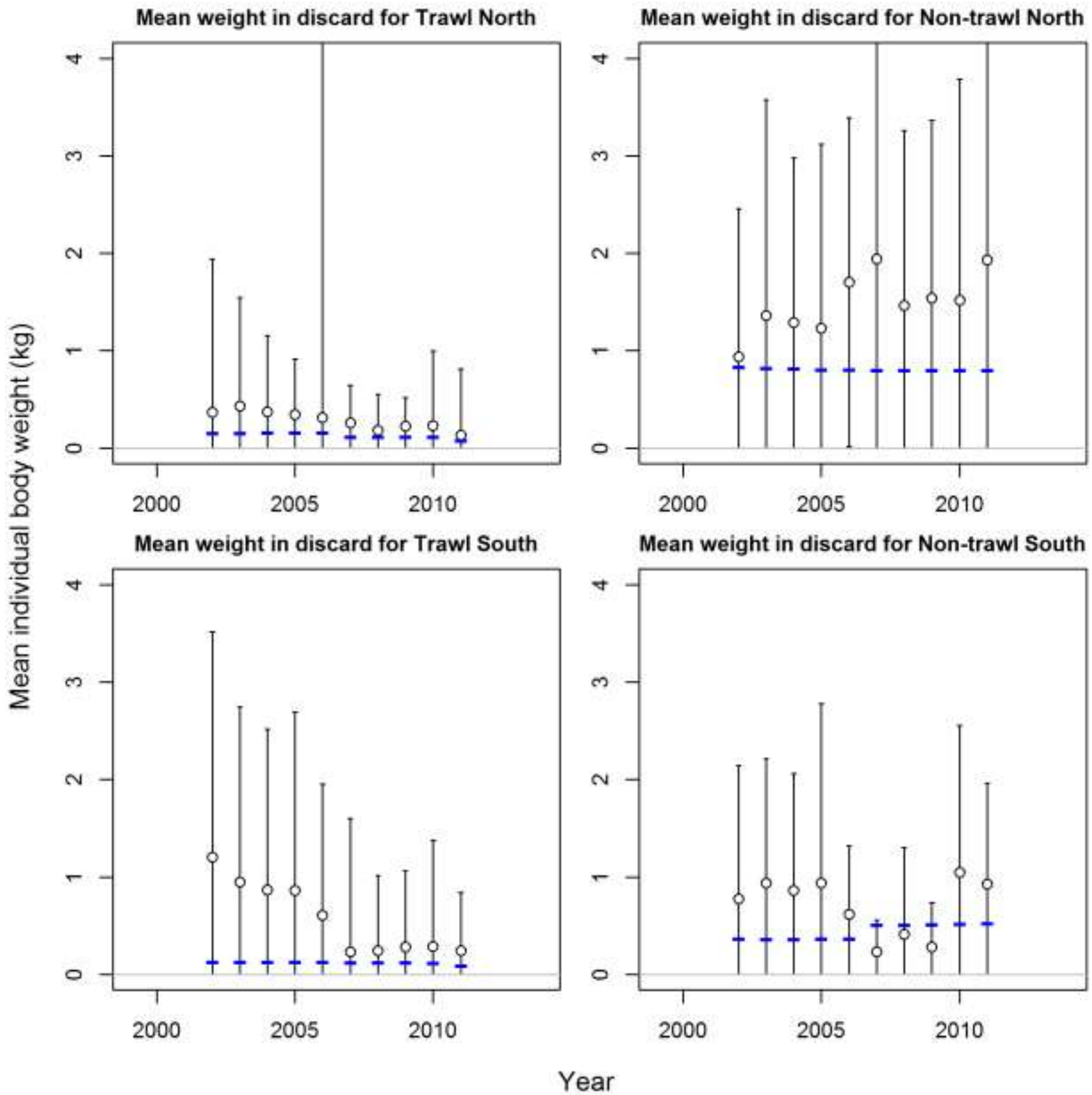


**Figure 20: Mean weight of discard data for each fleet (open circles) shown with 95% intervals (black vertical lines) and model fits (blue lines).**

### 10.3.4 Length compositions

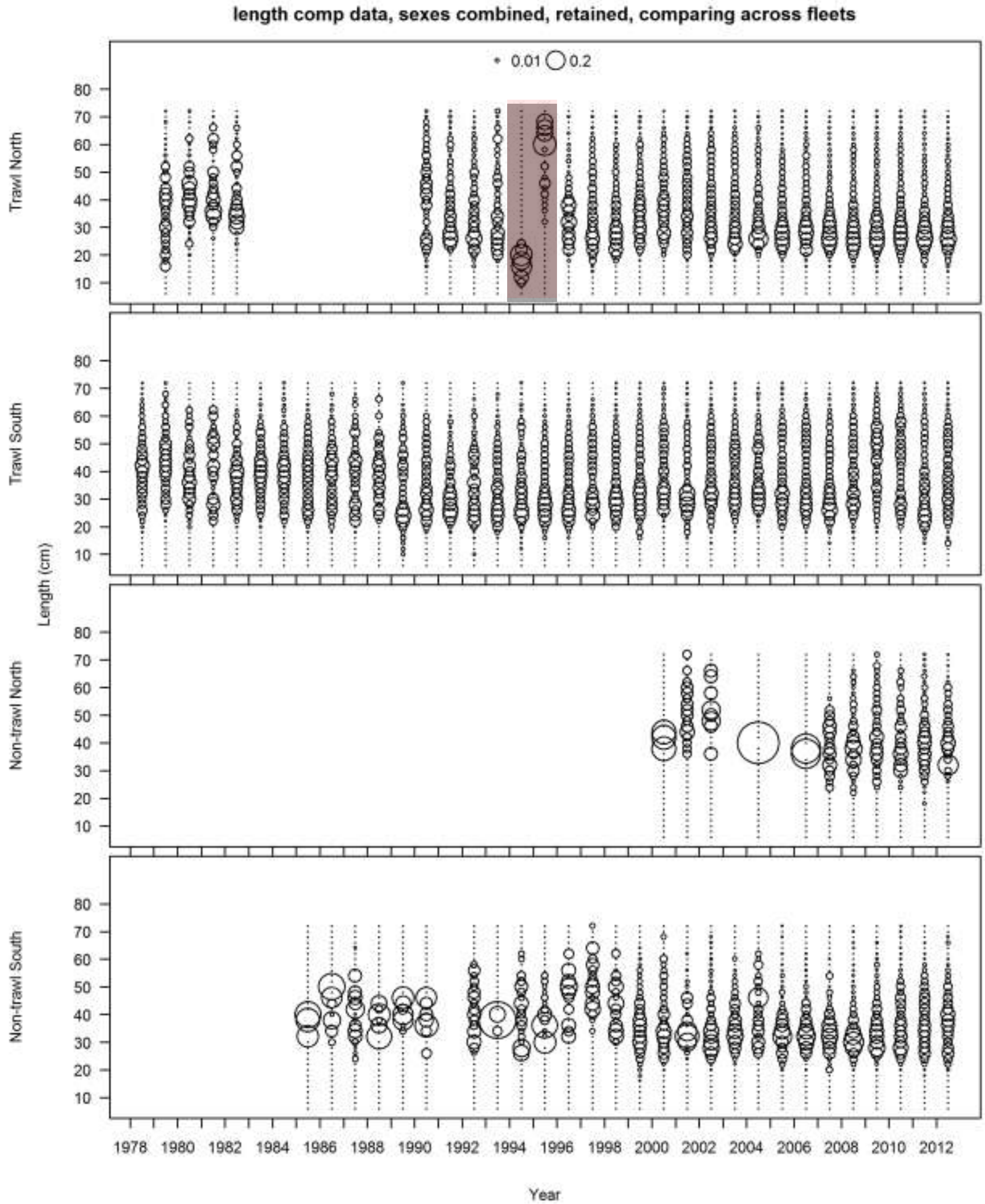


**Figure 21: Fishery length compositions calculated from landed catch. Bubble sizes indicate proportion in each length bin. Sexes are combined. Shaded section in top panel indicates observations from 1994–95 that were considered outliers and removed from base model.**

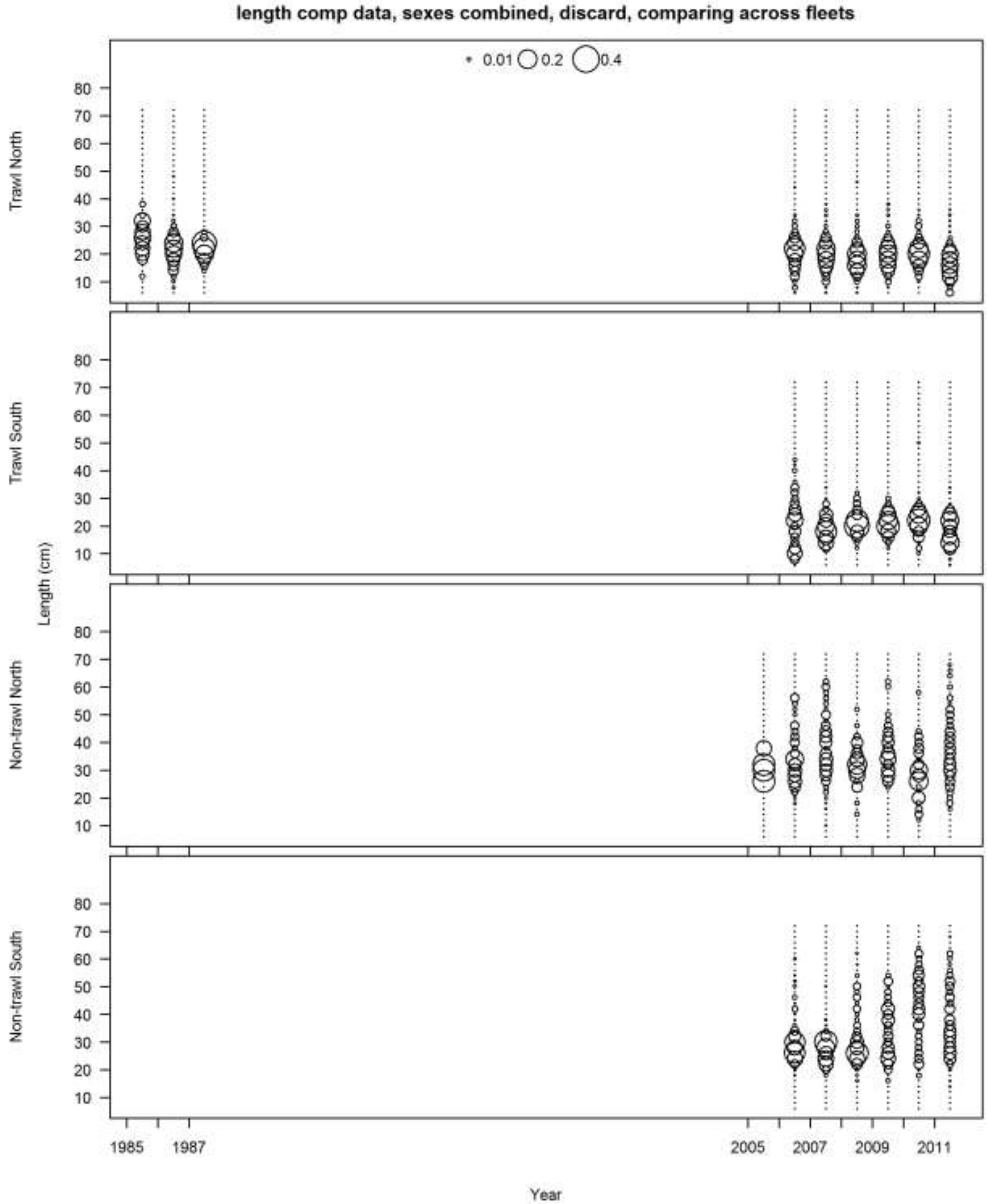


**Figure 22: Fishery length compositions calculated from discards. Sexes are combined.**

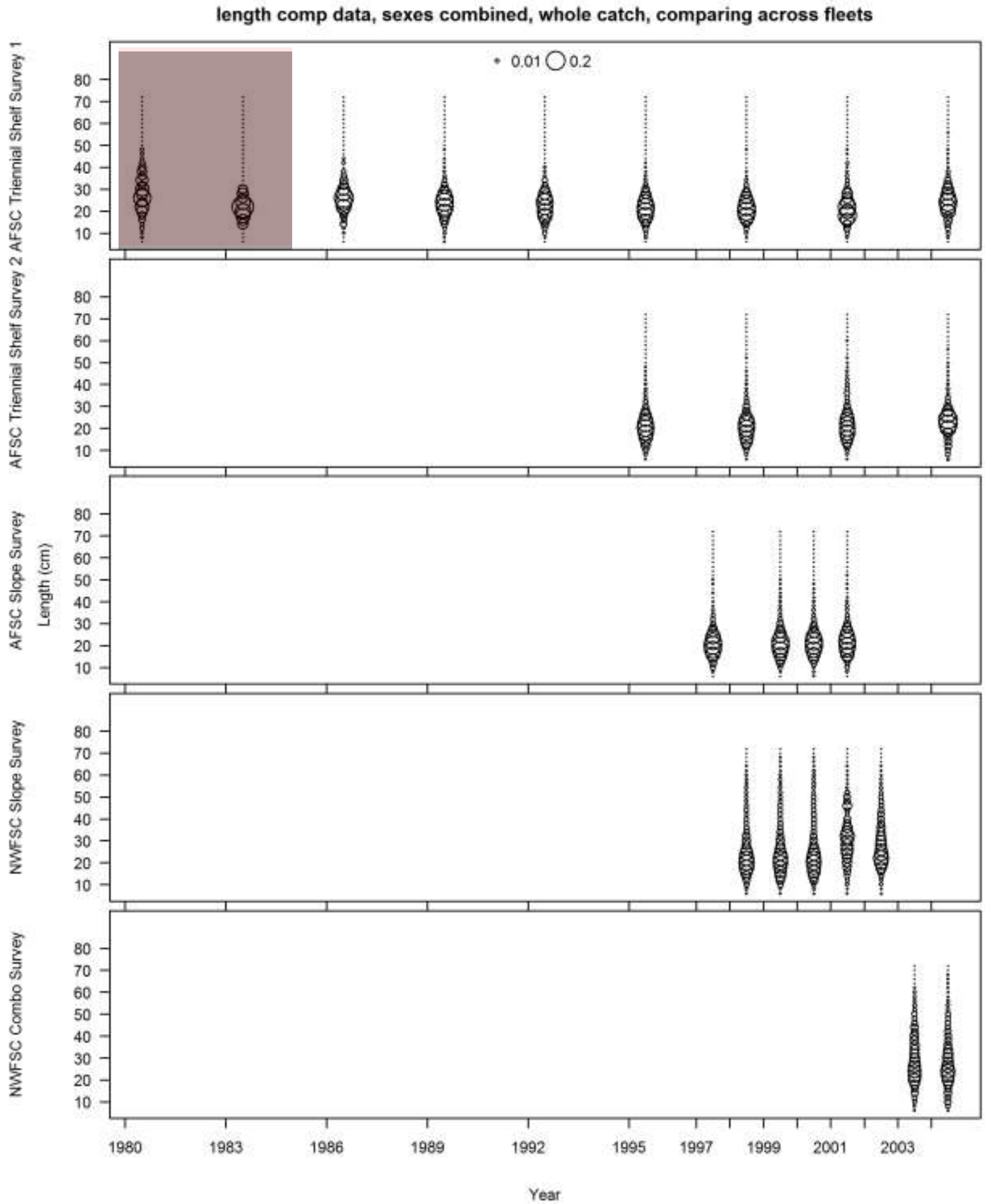


**Figure 23: Survey length compositions for years with combined sex data. Shaded region in top panel indicates observations that were associated with only a single tow and removed from the base model.**

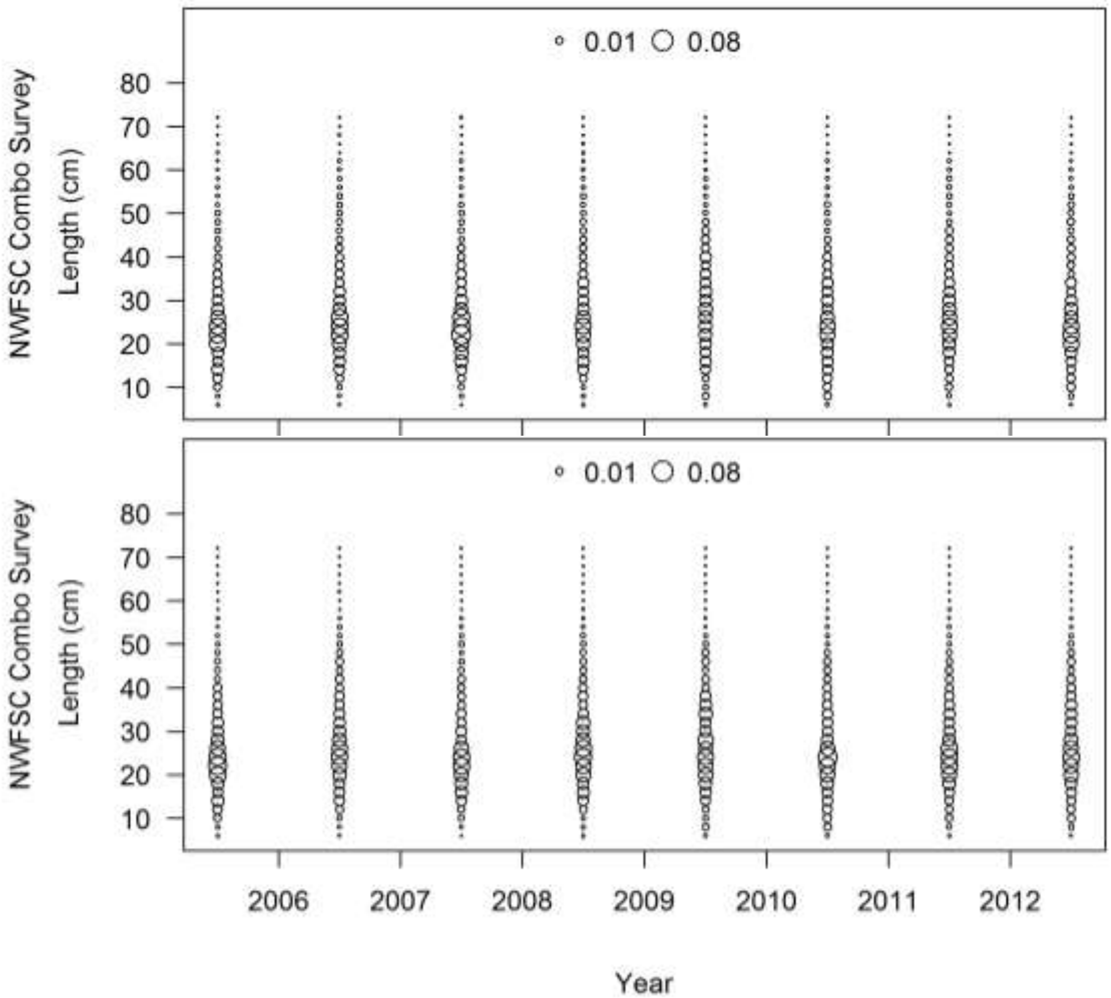


**Figure 24: Survey length compositions for females (top) and males (bottom) for the NWFSC Combo Survey.**

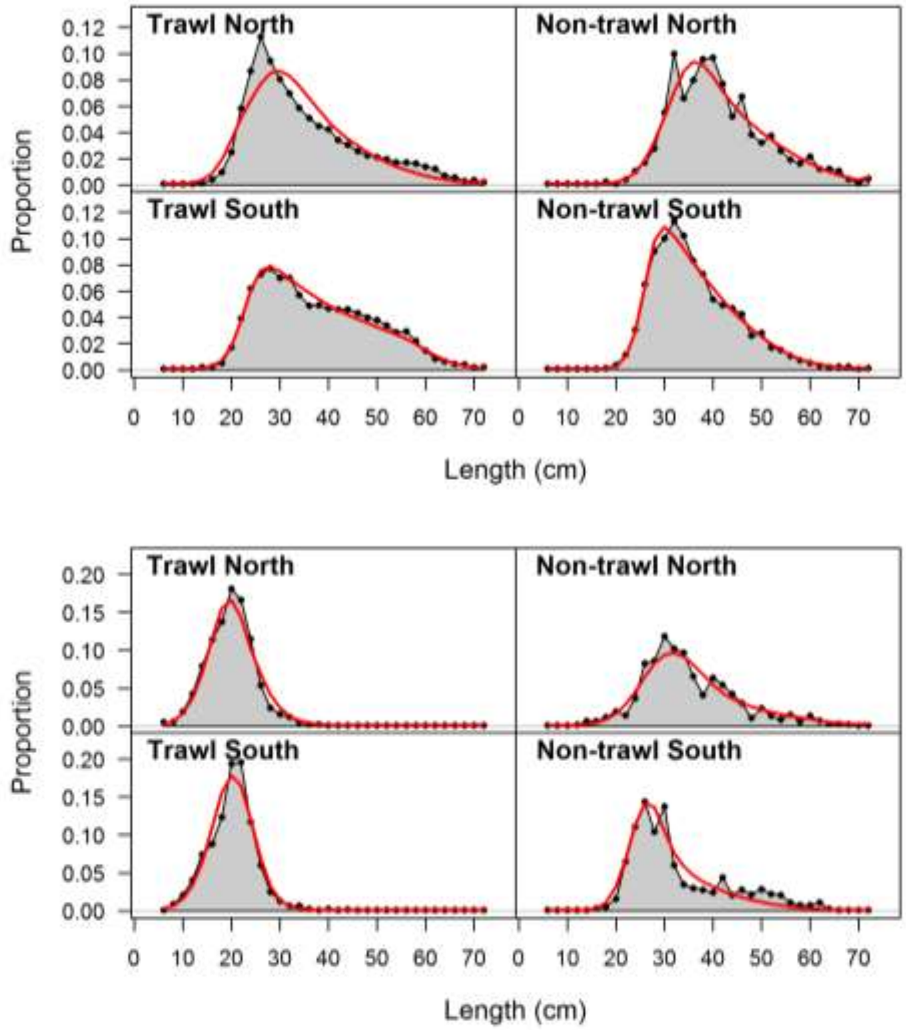


**Figure 25: Fits to fishery length compositions aggregated across all years for each fleet. Top panels show retained catch and bottom panels show discarded catch. Grey polygons indicate aggregated observed length compositions and red lines indicate aggregated model fit.**

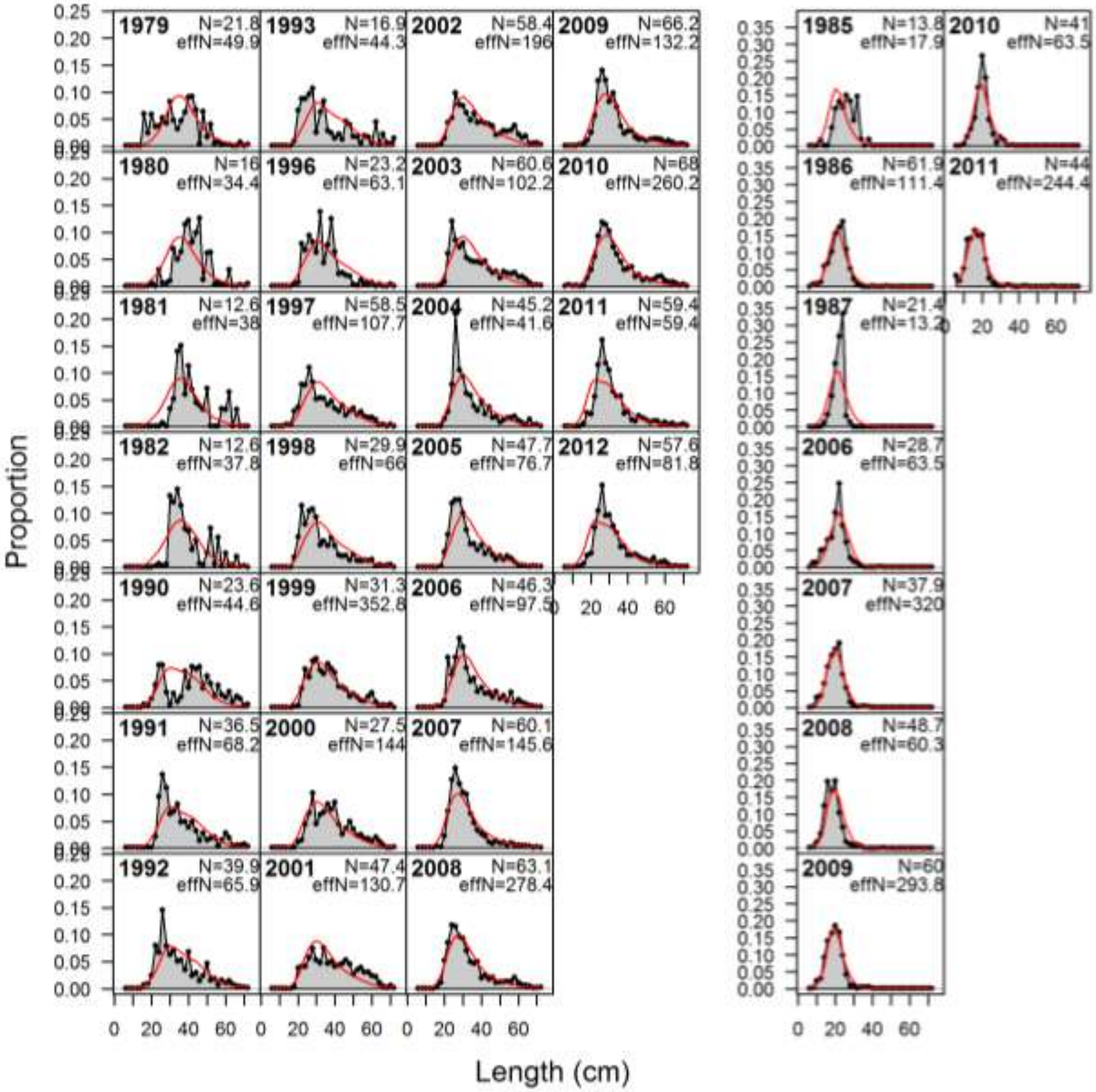


**Figure 26: Fits to fishery length compositions for the Trawl North fishery. Retained catch is shown for the years 1979–2012 in the panels on the left (with outliers in 1994–95 removed). Discards are shown for the years 1985–1987 and 2006–2011 in the panels on the right. Grey polygons indicate observed length compositions and red lines indicate model fit. Numeric values labeled "N" and "effN" indicate the input sample sizes and the estimated effective sample sizes associated with each composition.**

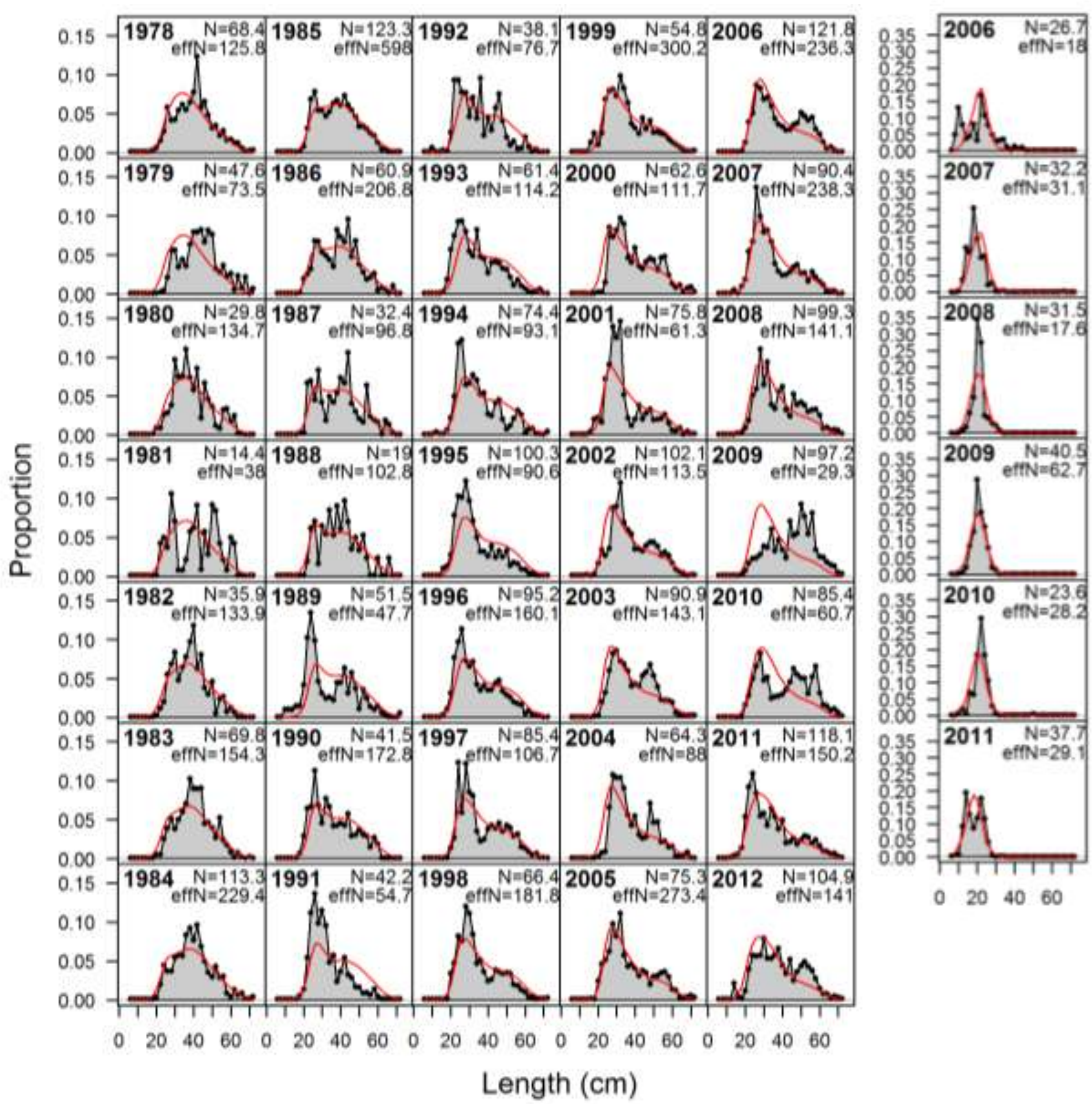


**Figure 27: Fits to fishery length compositions for the Trawl South fishery. Retained catch is shown for the years 1978–2012 in the panels on the left. Discards are shown for the years 2006–2011 in the panels on the right. Plot details are provided under Figure 26.**

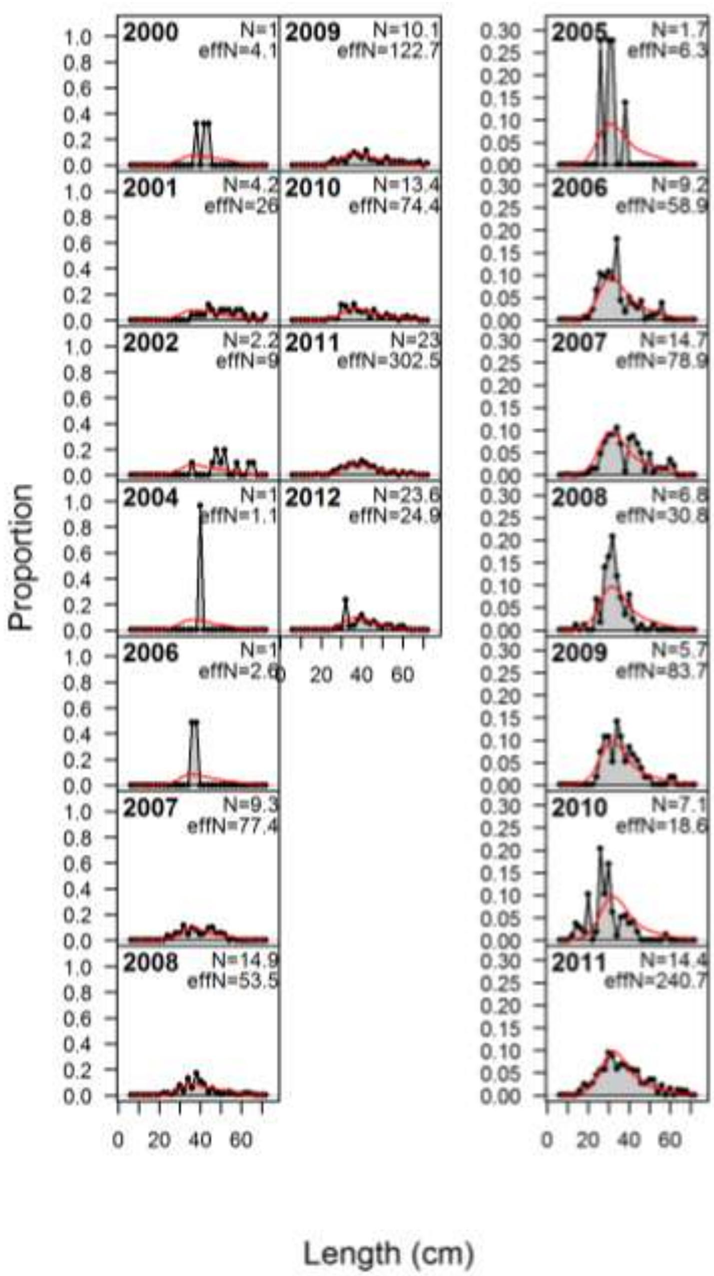


**Figure 28: Fits to fishery length compositions for the Non-Trawl North fishery. Retained catch is shown for the years 2000–2012 (no data for 2003 or 2005) in the panels on the left. Discards are shown for the years 2005–2011 in the panels on the right. Plot details are provided under Figure 26.**

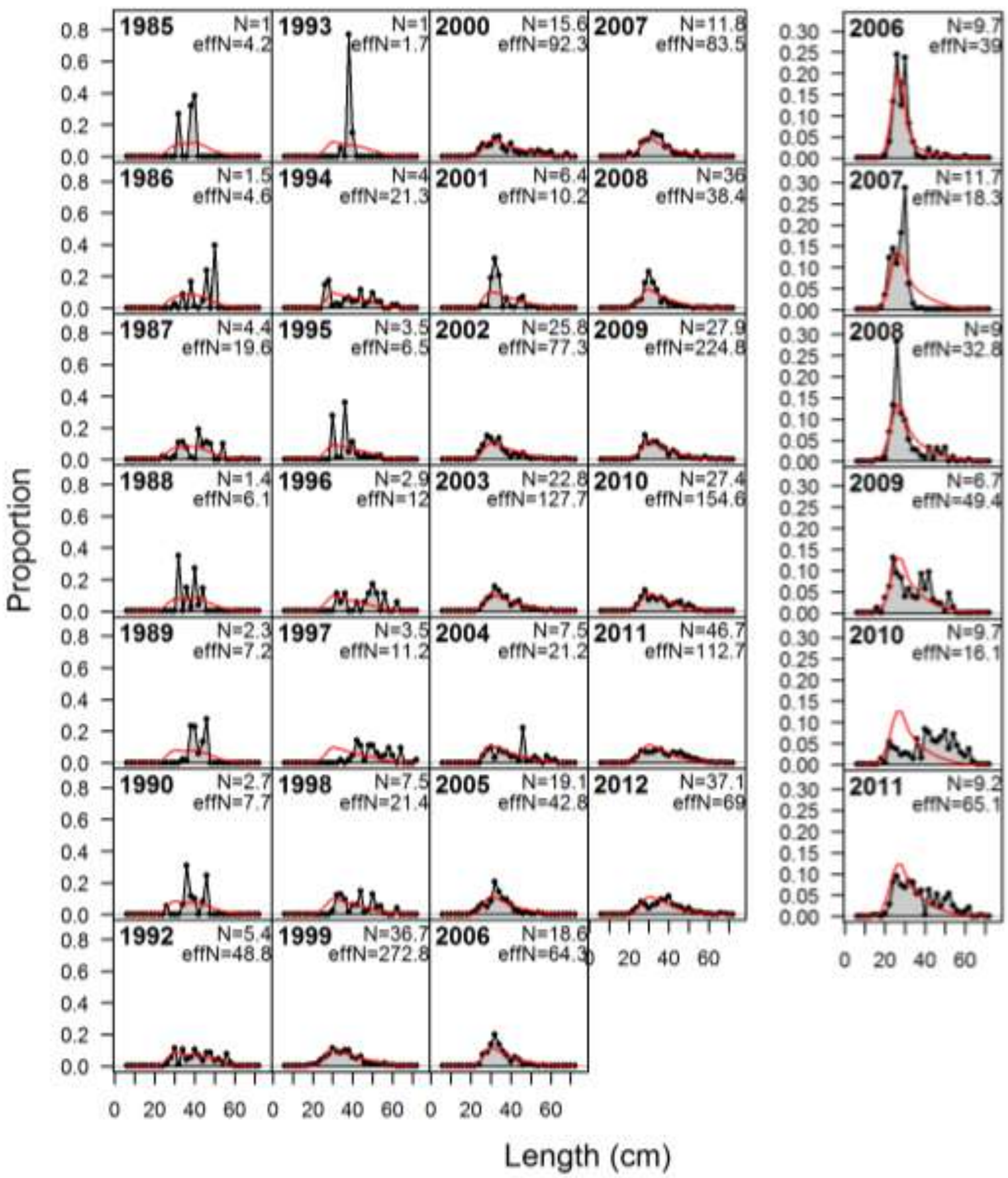


**Figure 29: Fits to fishery length compositions for the Non-Trawl North fishery. Retained catch is shown for the years 1985–2012 (no data for 1991) in the panels on the left. Discards are shown for the years 2006–2011 in the panels on the right. Plot details are provided under Figure 26.**

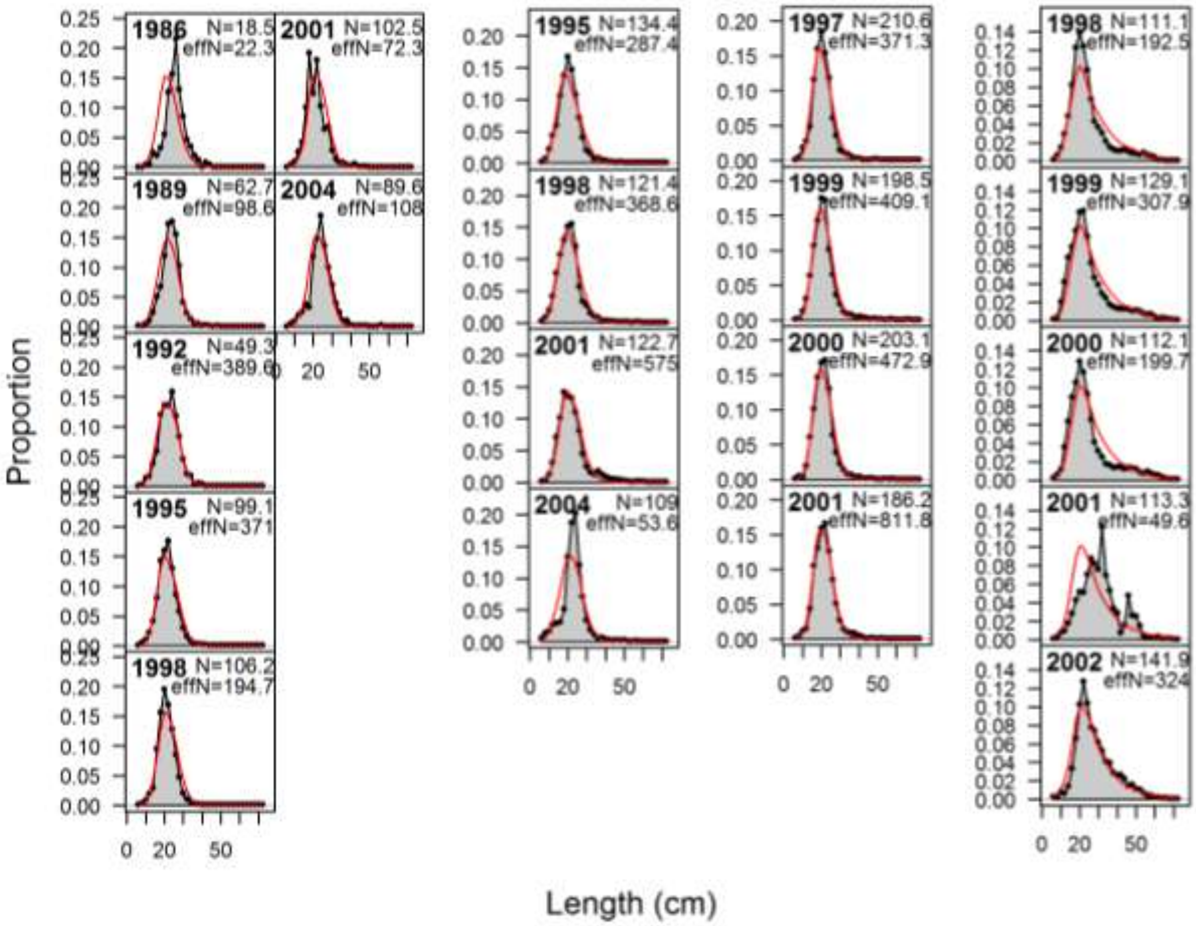


**Figure 30: Fits to survey length compositions for the AFSC Triennial Survey 1 (far left, 1986–2004, samples from 1980 and 1983 not shown), AFSC Triennial Survey 2 (center-left, 1995–2004), AFSC Slope Survey (center-right, 1997–2001) and NWFSC Slope Survey (far right, 1998–2002). Plot details are provided under Figure 26.**

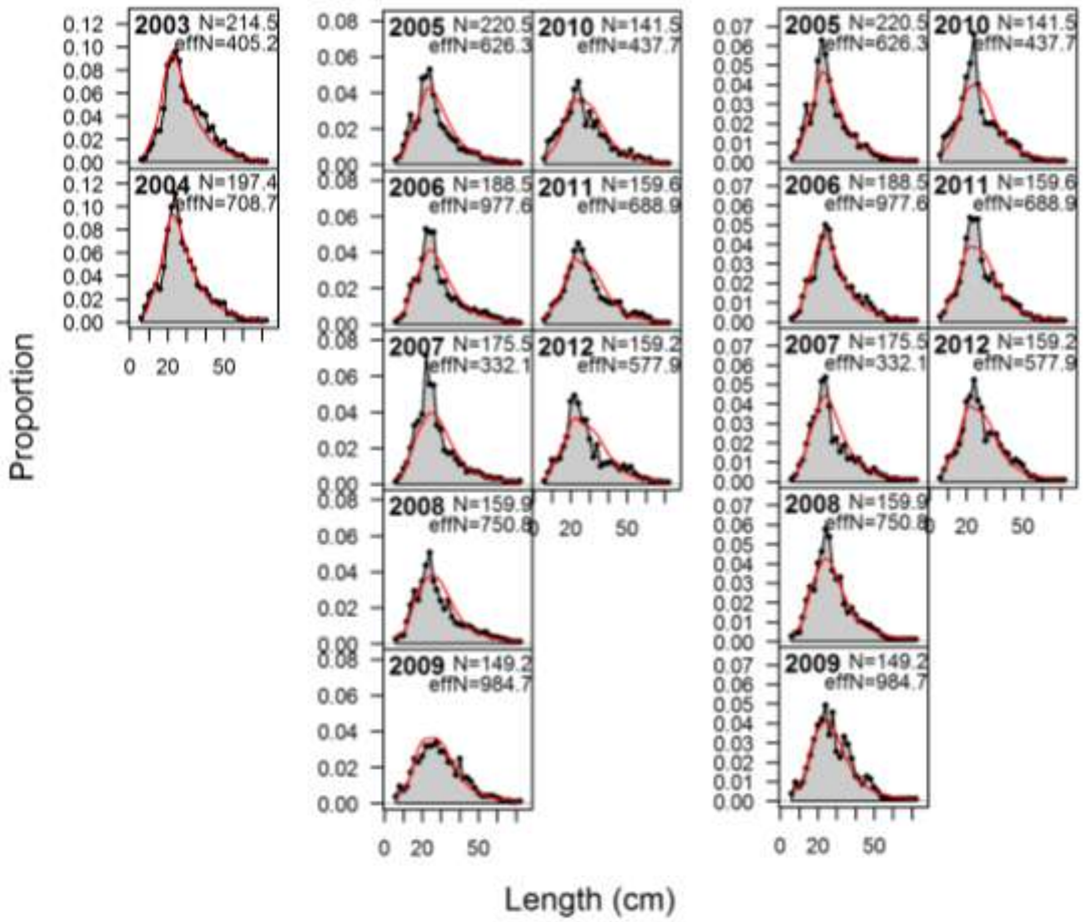


**Figure 31: Fits to survey length compositions for combined sexes (left) females (center) and males (right) for the NWFSC Combo Survey.**

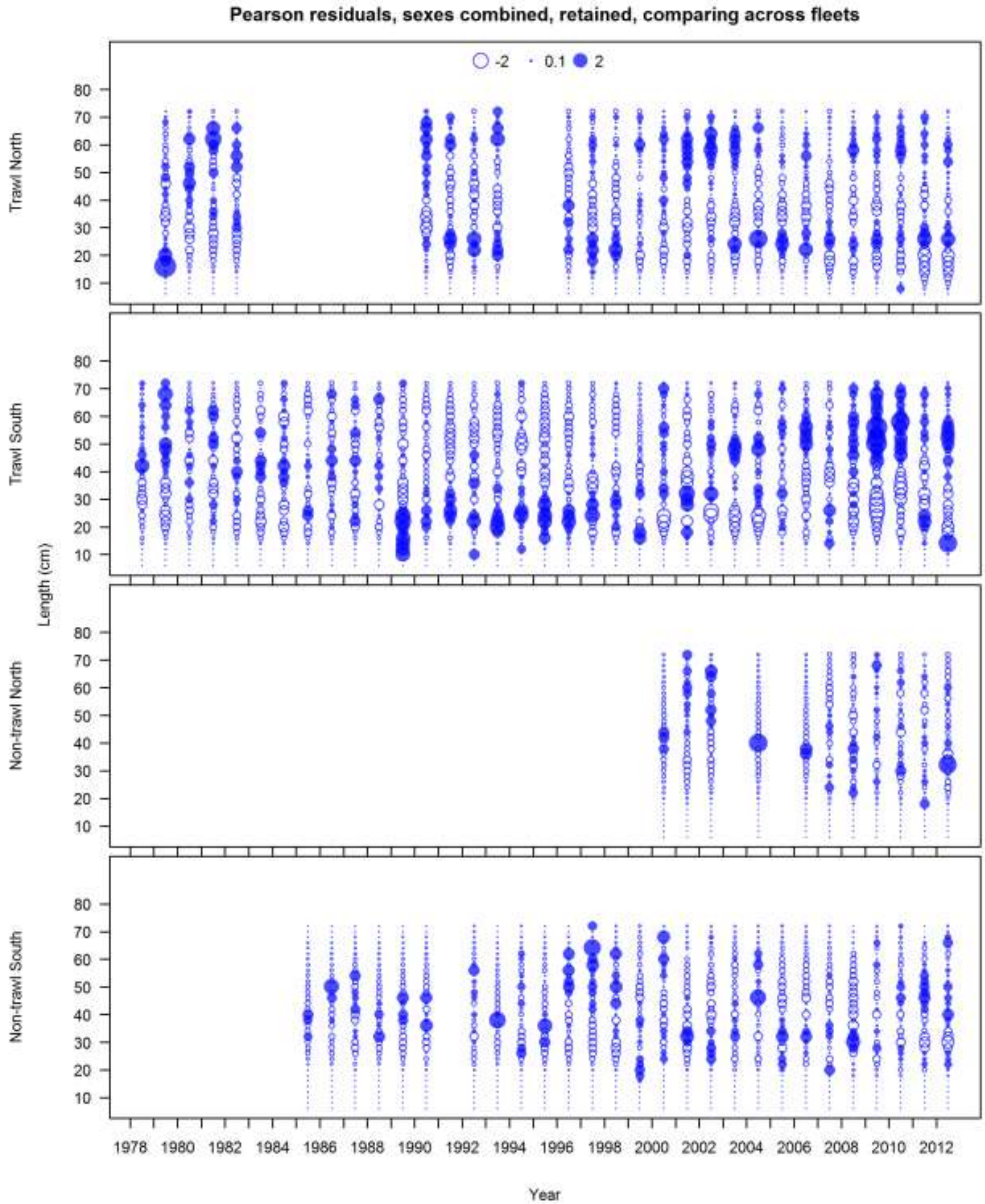


**Figure 32: Pearson residuals for fits to fishery length compositions calculated from landed catch. Bubble sizes indicate proportion in each length bin. Sexes are combined. Closed circles represent observations that are larger than the expectation.**

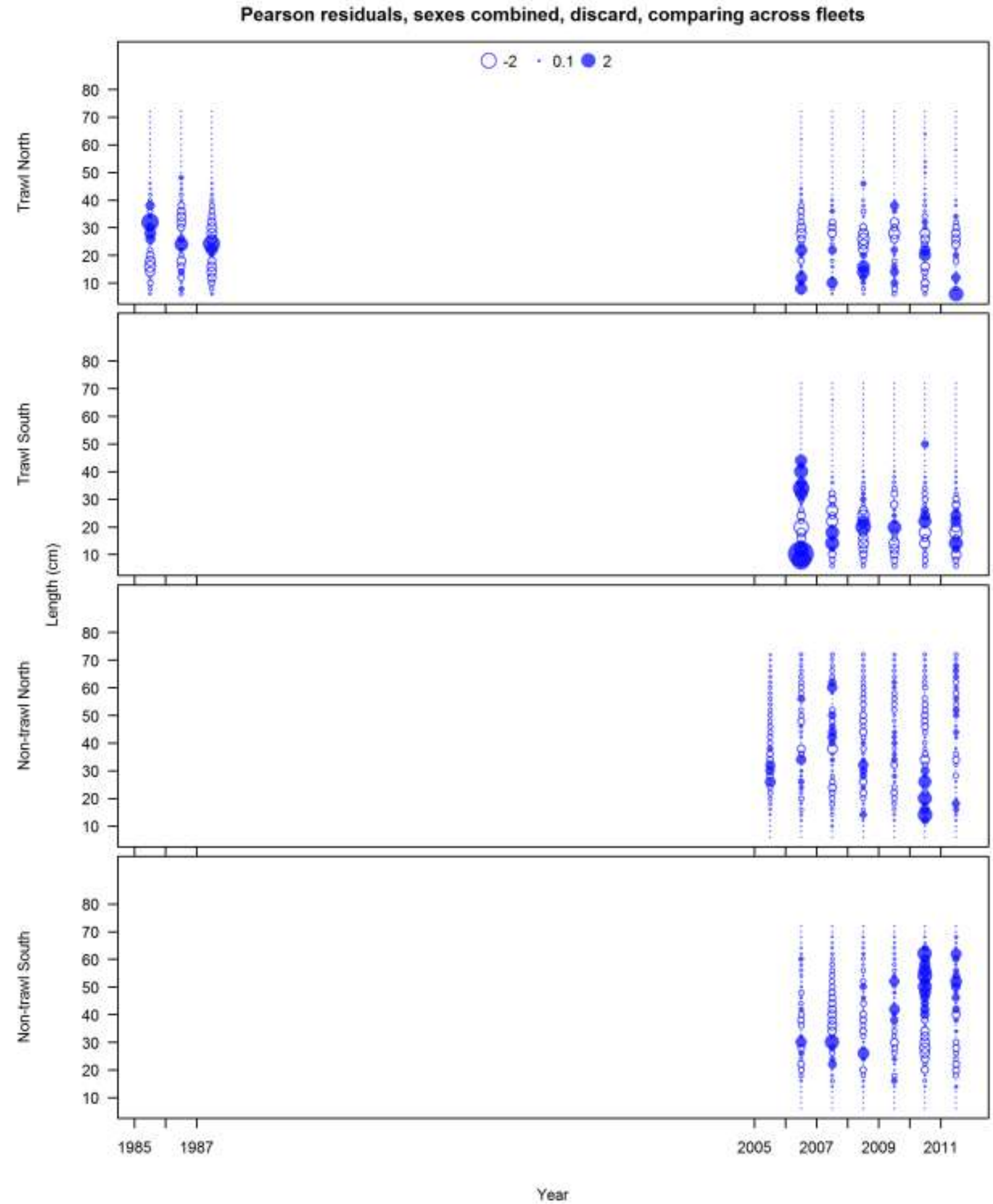


**Figure 33: Pearson residuals for fits to fishery length compositions calculated from discards. Sexes are combined. Closed circles represent observations that are larger than the expectation.**

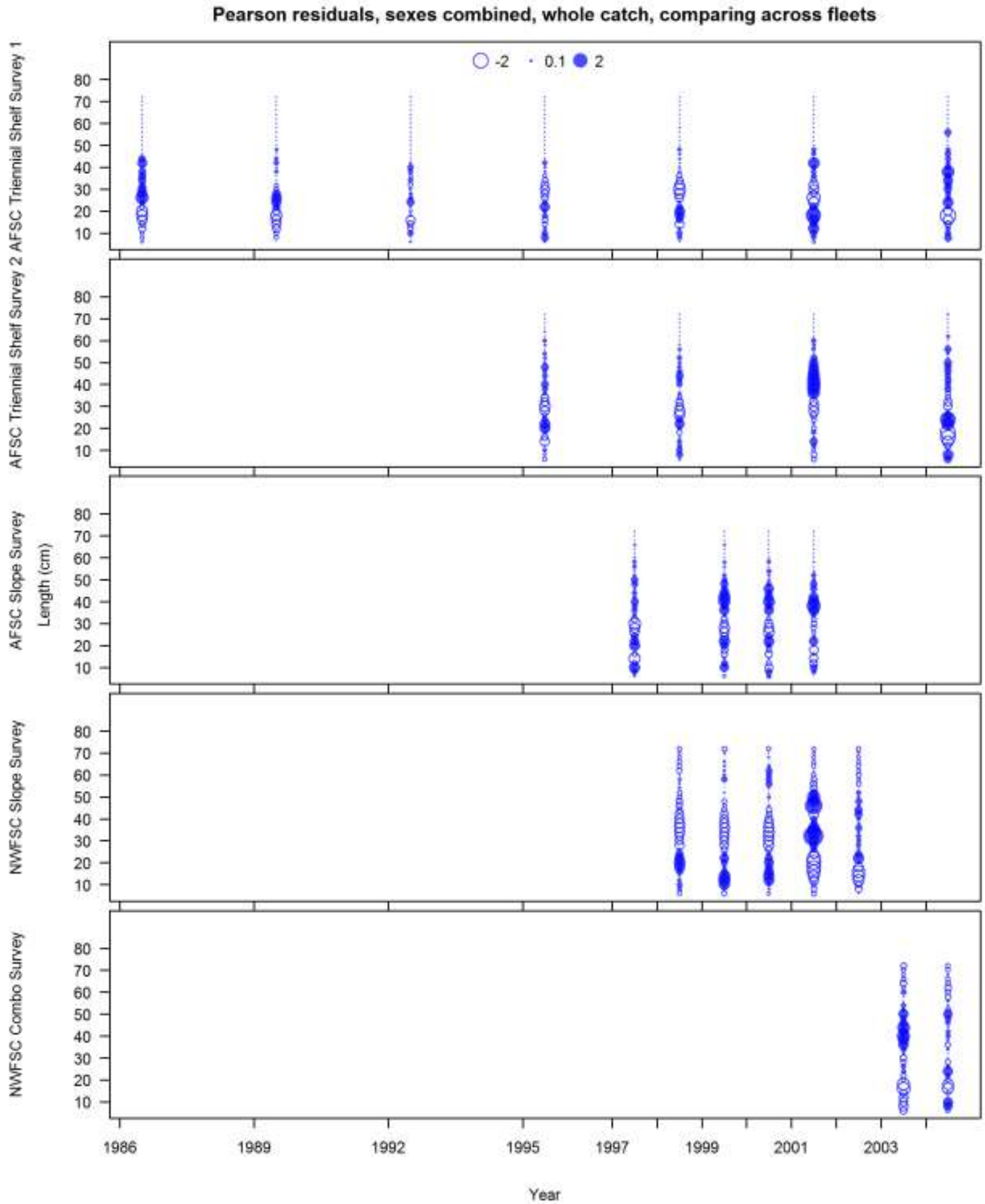


**Figure 34: Pearson residuals for fits to survey length compositions for years with combined sex data. Closed circles represent observations that are larger than the expectation.**

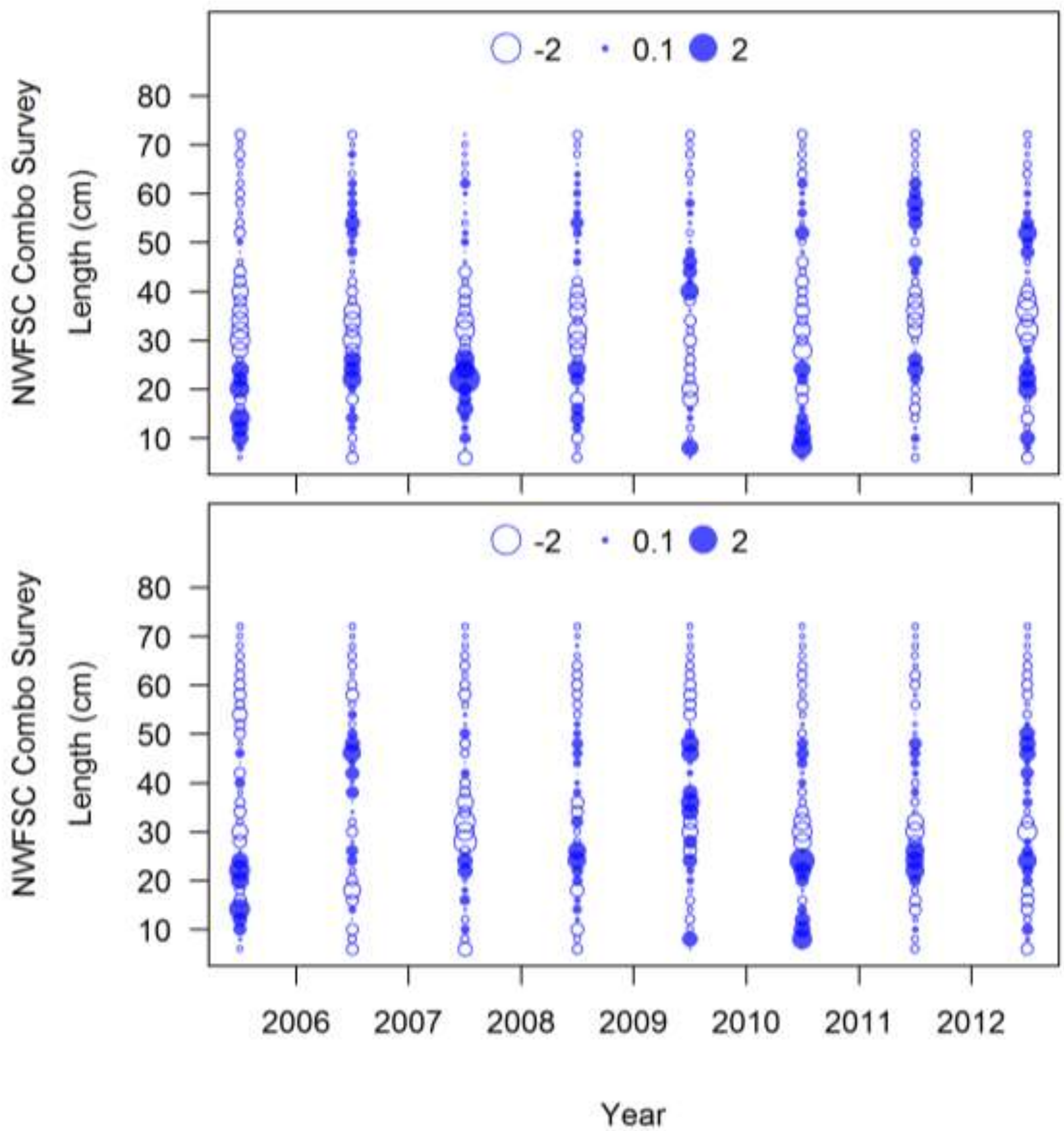


**Figure 35: Pearson residuals for fits to survey length compositions for females (top) and males (bottom) for the NWFSC Combo Survey. Closed circles represent observations that are larger than the expectation.**

## 10.4 Model results
### 10.4.1 Base model results

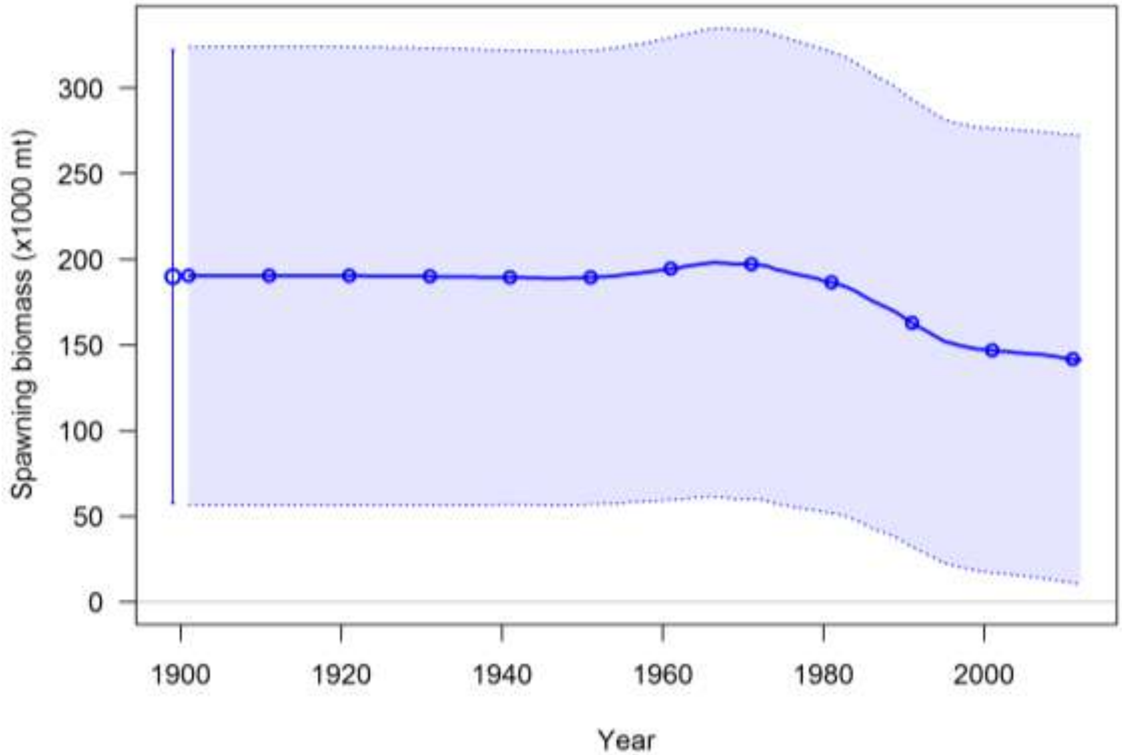


**Figure 36: Trajectory of spawning biomass. The disconnected point at the left represents the unfished equilibrium estimate and its associated uncertainty.**

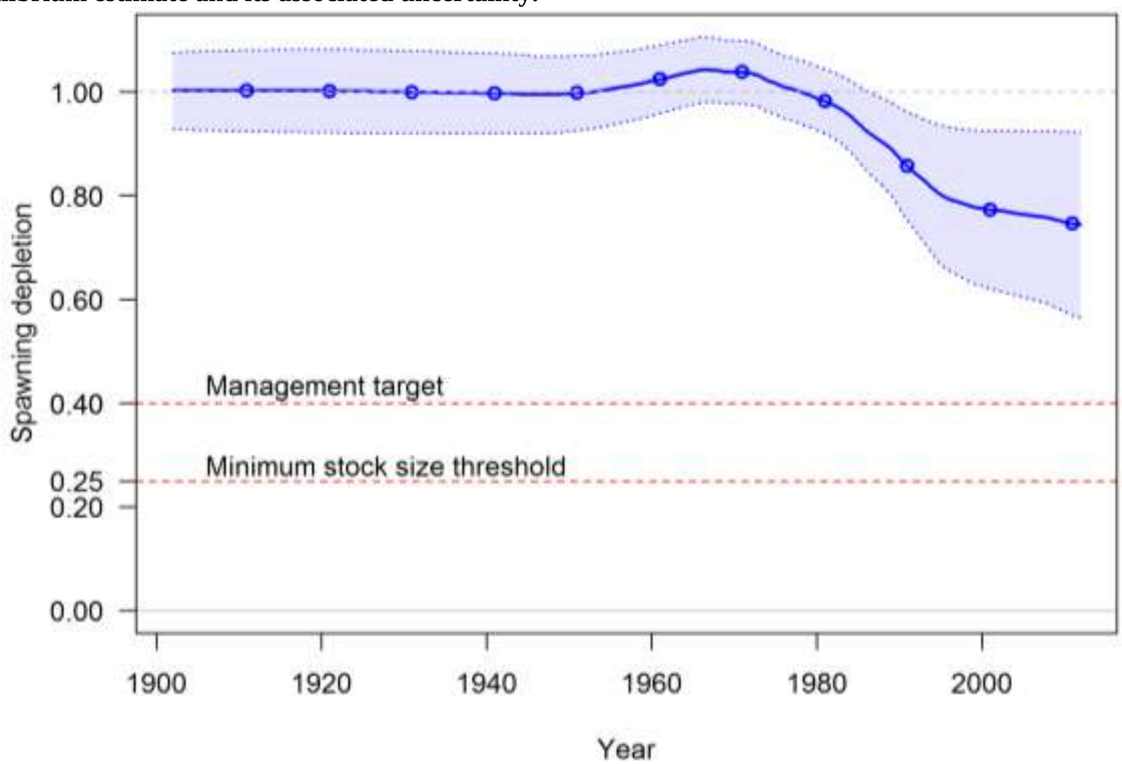


**Figure 37: Estimated relative depletion with approximate 95% asymptotic confidence intervals (shaded area) for the base case assessment model.**

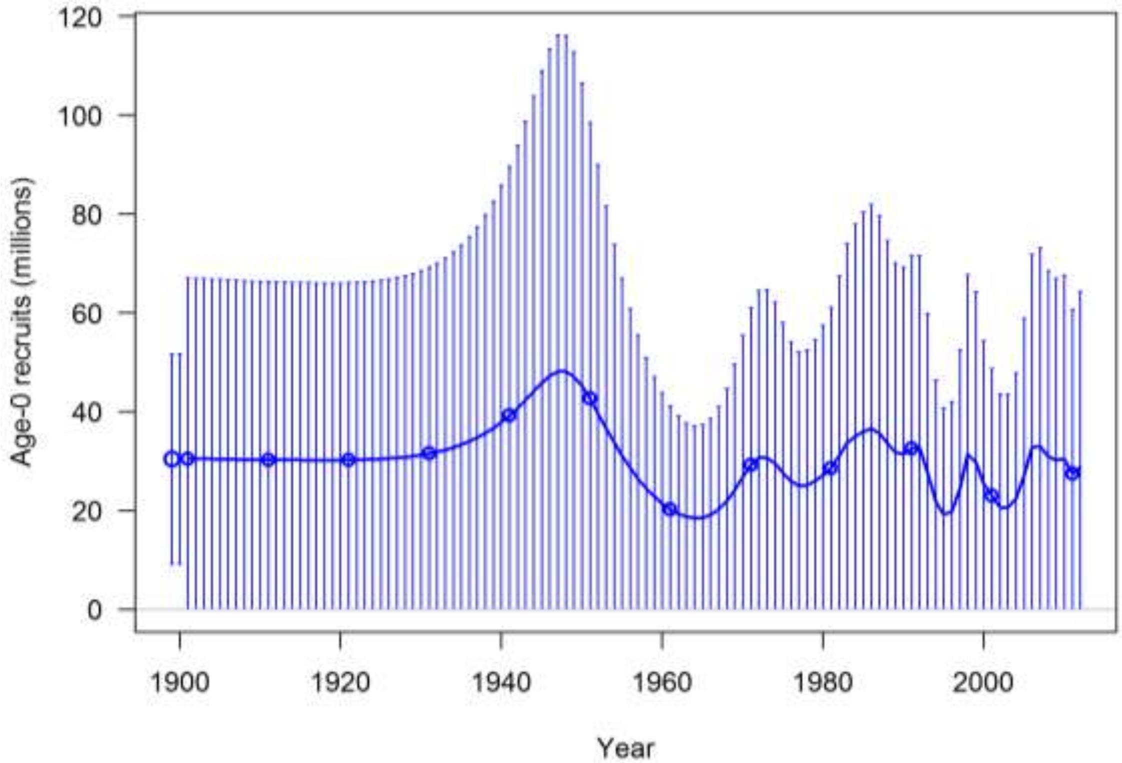


**Figure 38: Time series of recruitment. The disconnected point at the left represents the unfished equilibrium estimate and its associated uncertainty.**

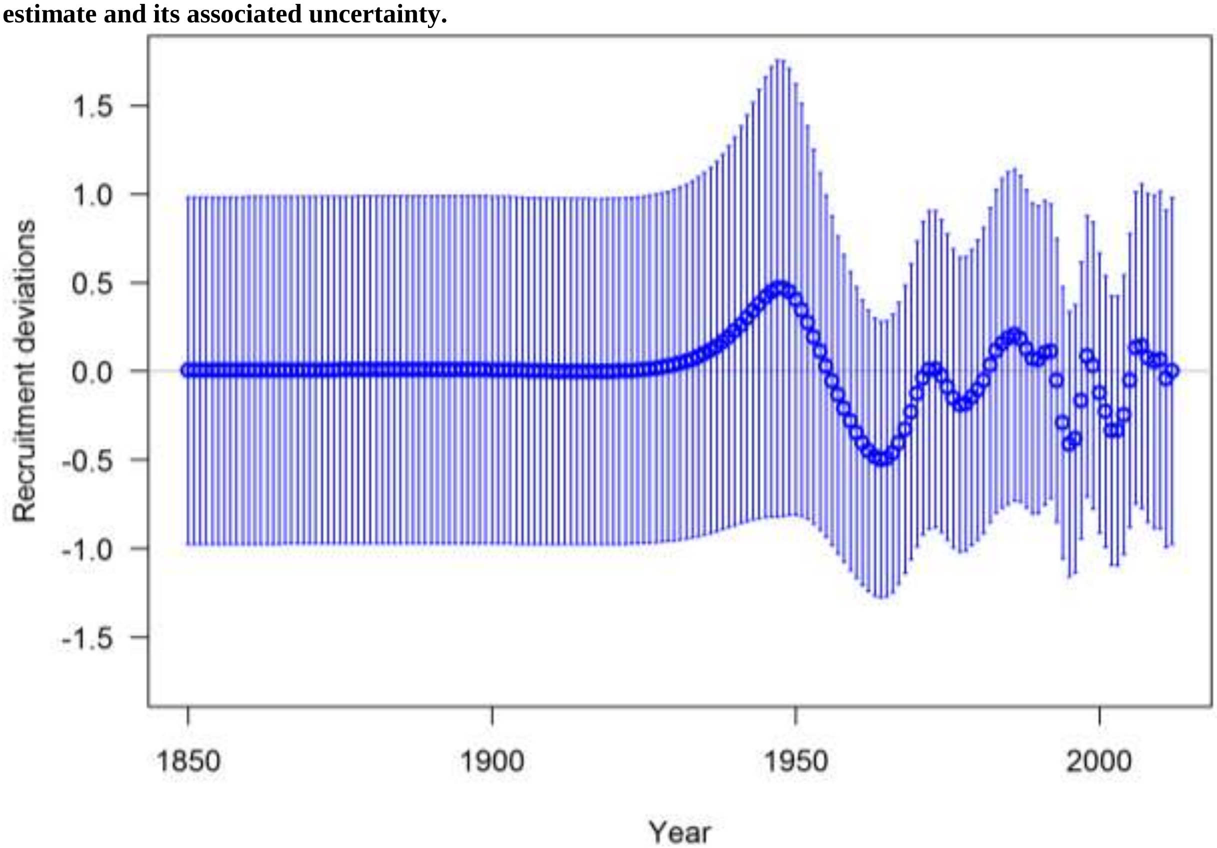


**Figure 39: Time series of recruitment deviations with 95% intervals. Circles represent the difference between estimated recruitment and the expectation associated with the stock-recruit relationship on a log scale.**

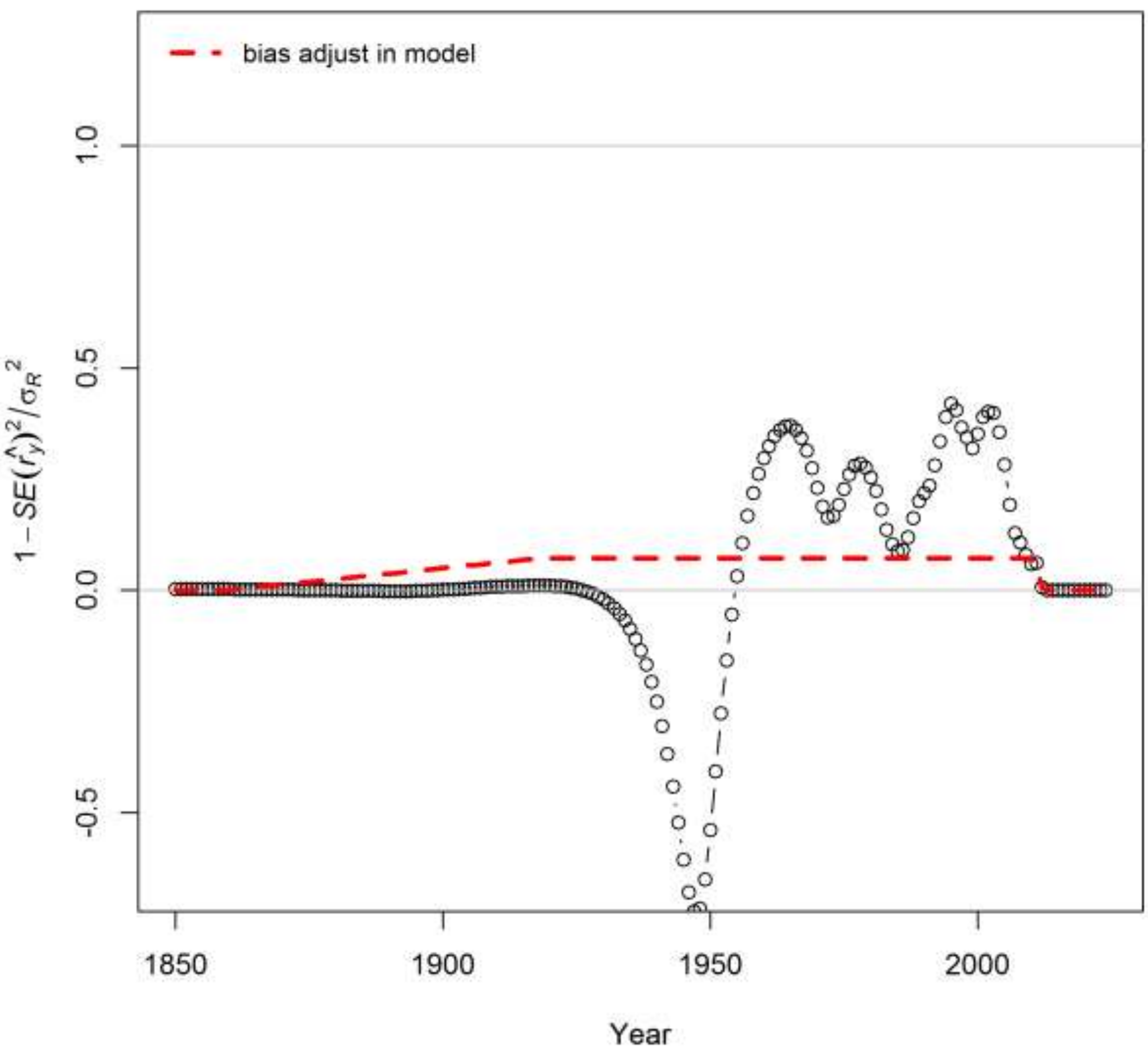


**Figure 40: Transformed recruitment deviation uncertainty estimates used to adjust for differences between median and mean of the lognormal distribution of recruitment.**

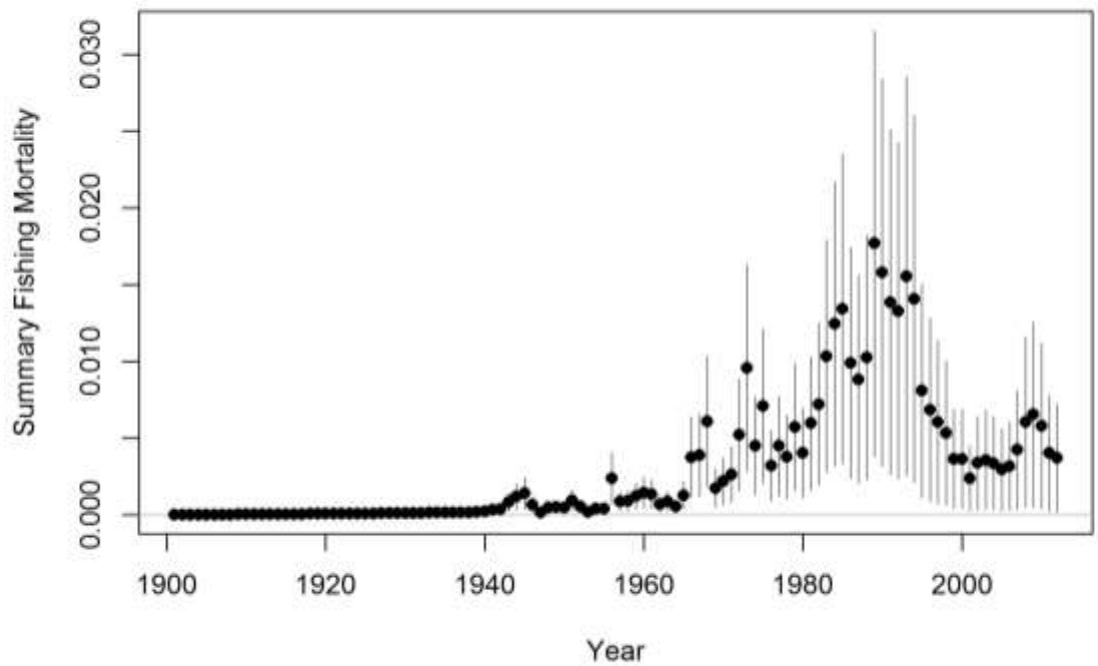


**Figure 41: Time-series of estimated summary harvest rate (total catch divided by age-1 and older biomass) for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines).**

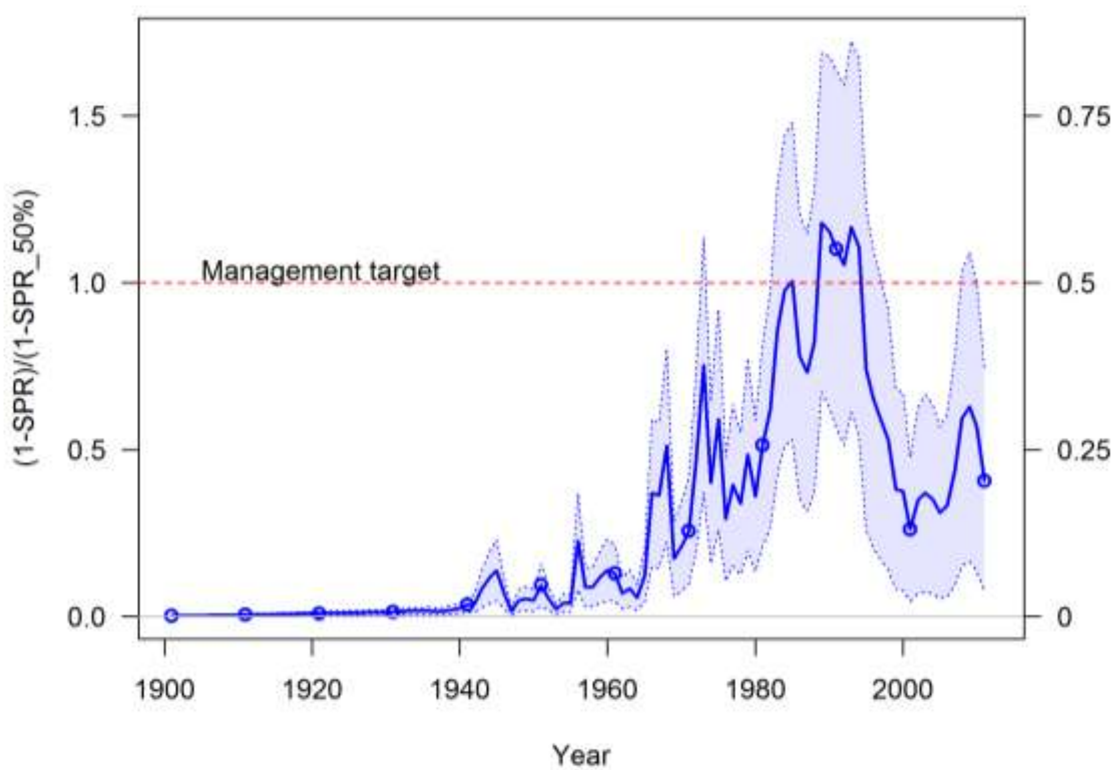


**Figure 42: Estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. Both one minus SPR (right y-axis) and the ratio of this quantity to the associated target (1 - $SPR_{50\%}$) (left y-axis) are indicated. These quantities are chosen so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.**

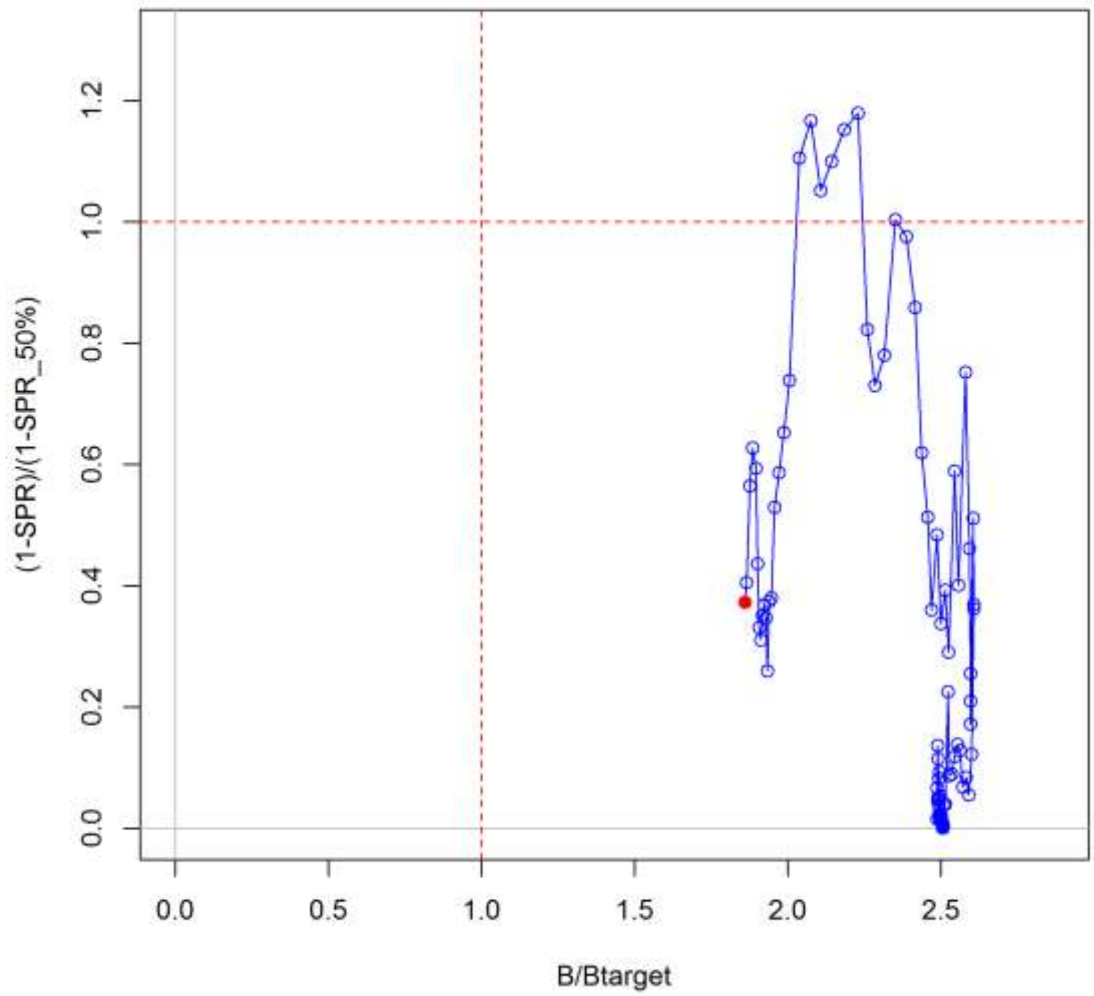


**Figure 43: Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 50% (the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 50% of the unfished spawning biomass. The red point indicates the year 2012.**

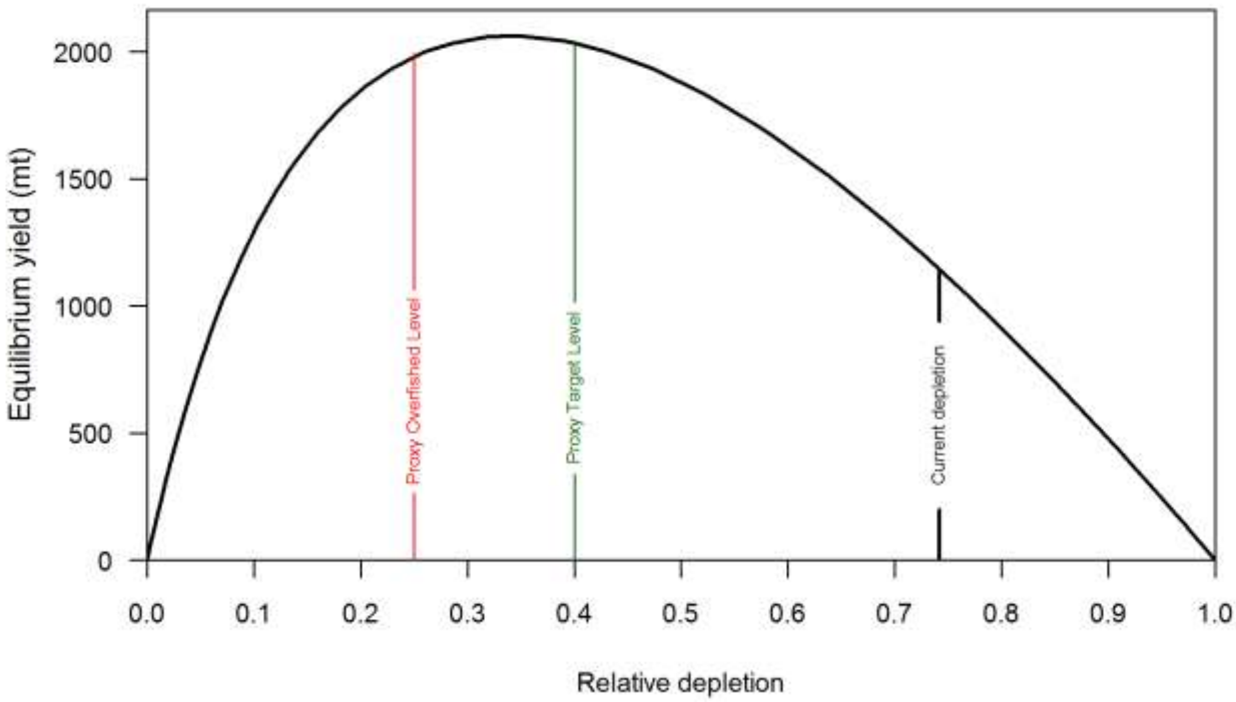


**Figure 44: Equilibrium yield curve (derived from reference point values reported in Table 12) for the base case model. Values are based on 2012 relative catch among fleets. The depletion is relative to unfished spawning biomass.**

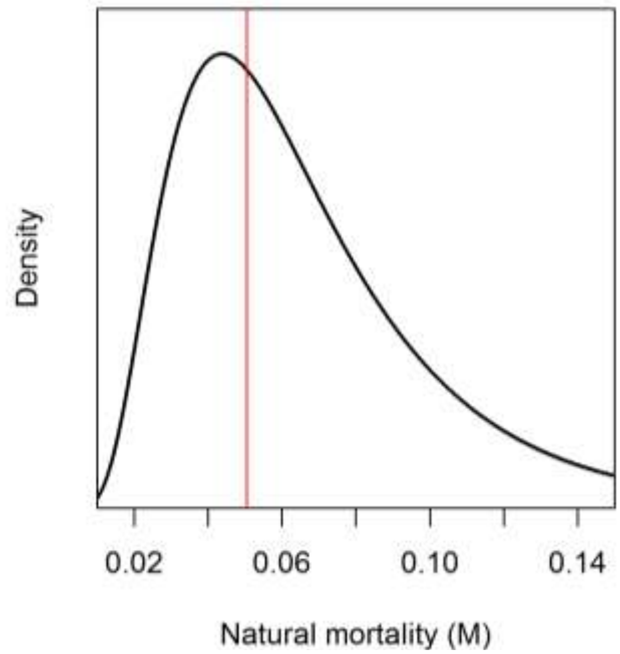


**Figure 45: Prior distributions for natural mortality (*M*). The base model has natural mortality fixed at the mean of the distribution indicated by the red vertical line (*M* = 0.0505).**

### 10.4.2 Likelihood profiles, sensitivities, and retrospective analyses

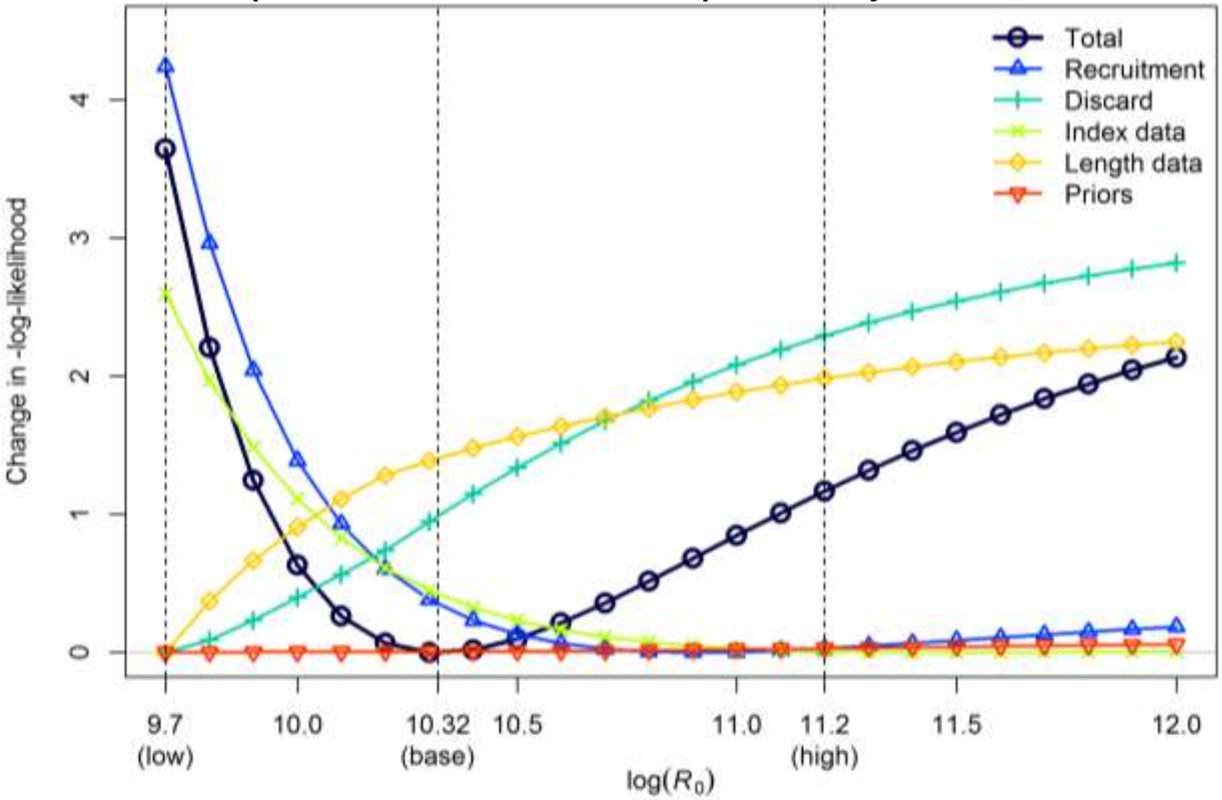


**Figure 46: Likelihood profile over the log of equilibrium recruitment, log($R_0$). Vertical lines and axis labels indicate the base model with log(R0) estimated at 10.32 and the low and high states of nature used in the decision table (Table 14).**

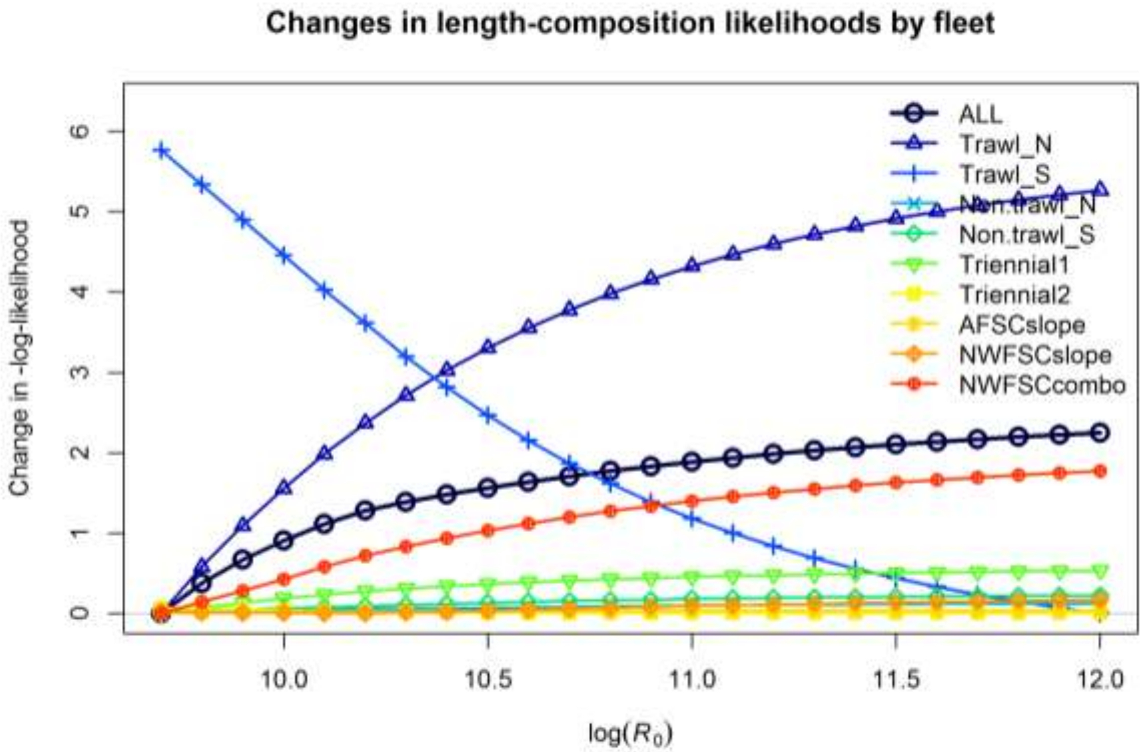


**Figure 47: Likelihood contributions by fleet to the length data likelihood component (orange line with diamonds in Figure 46) of the likelihood profile over the log of equilibrium recruitment, log($R_0$).**

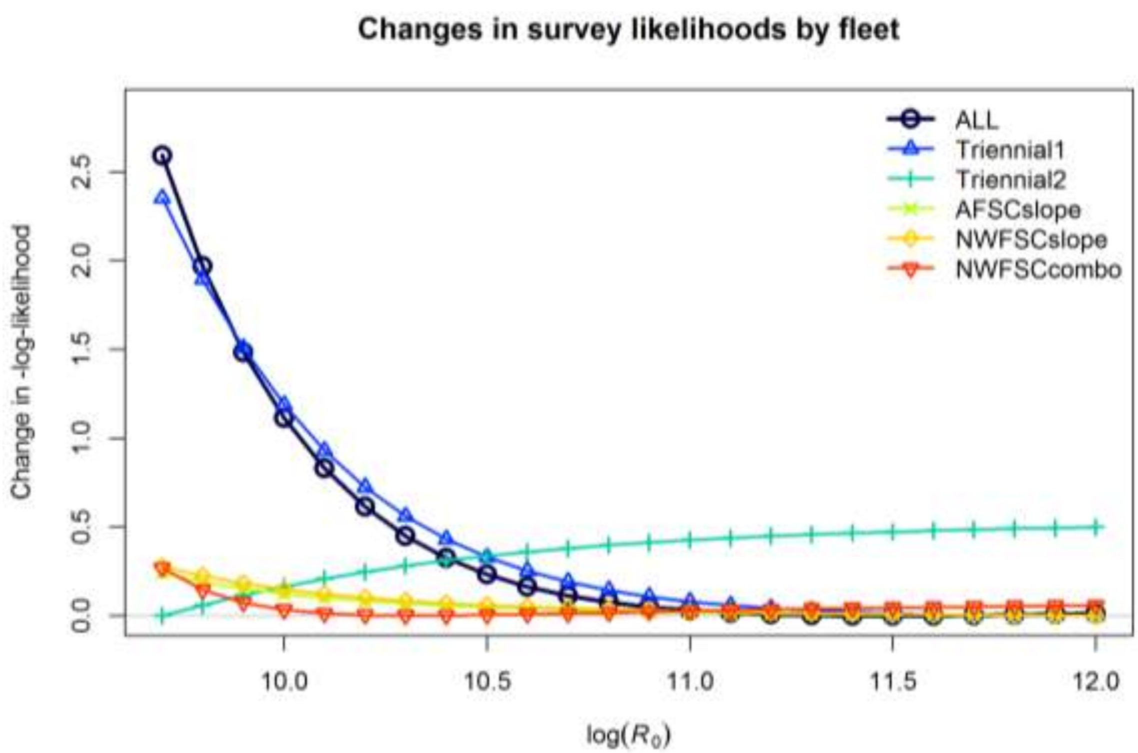


**Figure 48: Likelihood contributions by fleet to the survey data likelihood component (light green line with Xs in Figure 46) of the likelihood profile over the log of equilibrium recruitment, log($R_0$).**

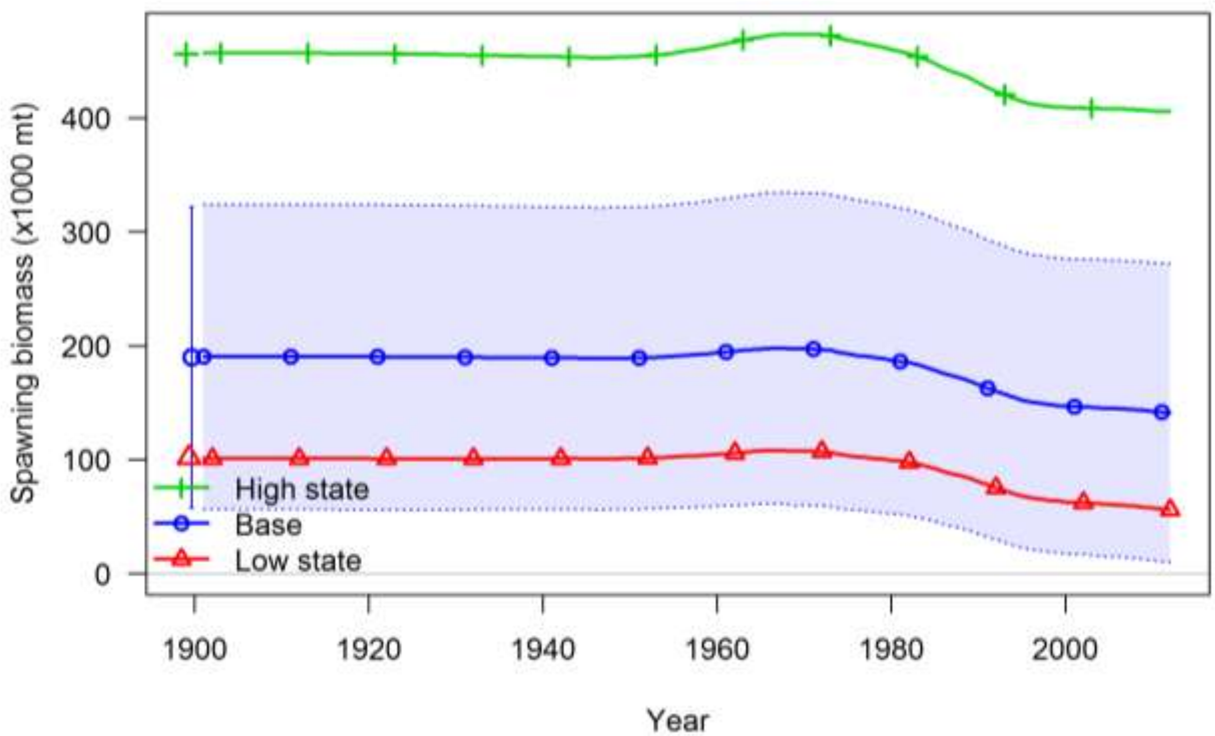


**Figure 49: Time series of spawning biomass for low and high states of nature taken from the log($R_0$) profile. The base model has log(R0) estimated at 10.32 while the low and high states of nature have log(R0) = 9.7 and 10.2 respectively. Uncertainty is only shown for the base model as the fixed log($R_0$) values in the other cases limits the portrayal of uncertainty.**

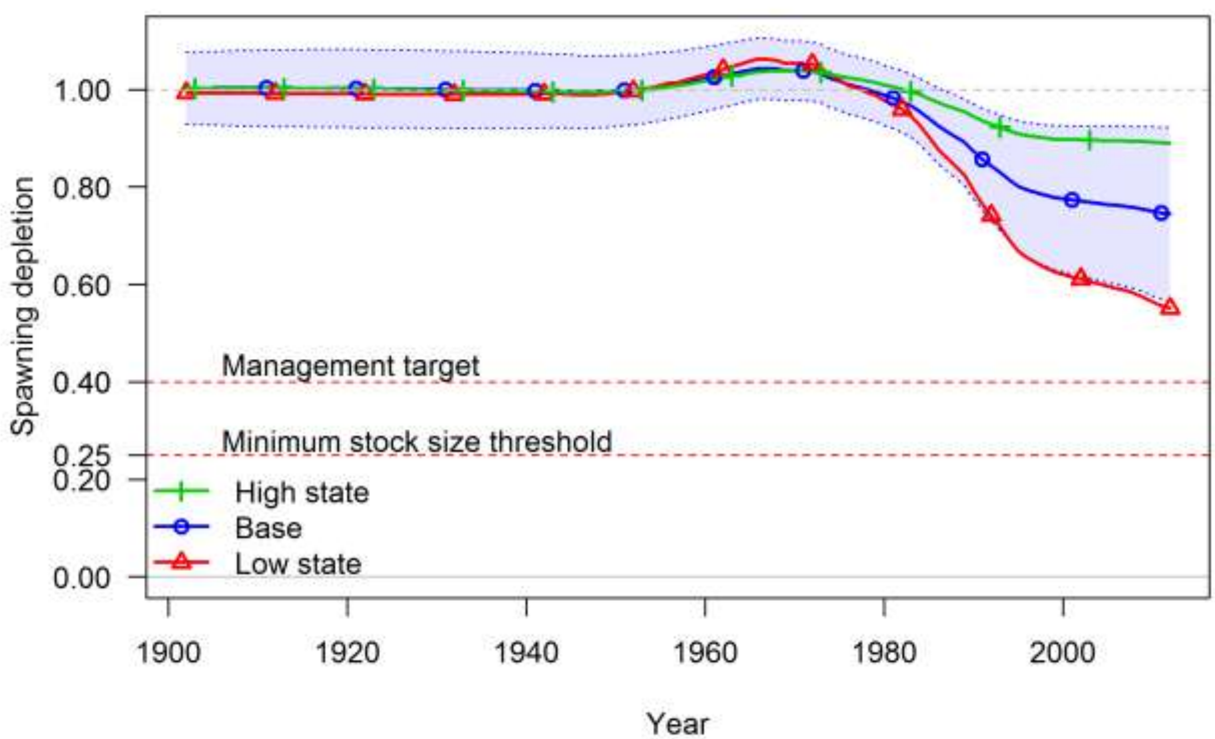


**Figure 50: Time series of spawning depletion for low and high states of nature as described in the caption for Figure 49 above.**

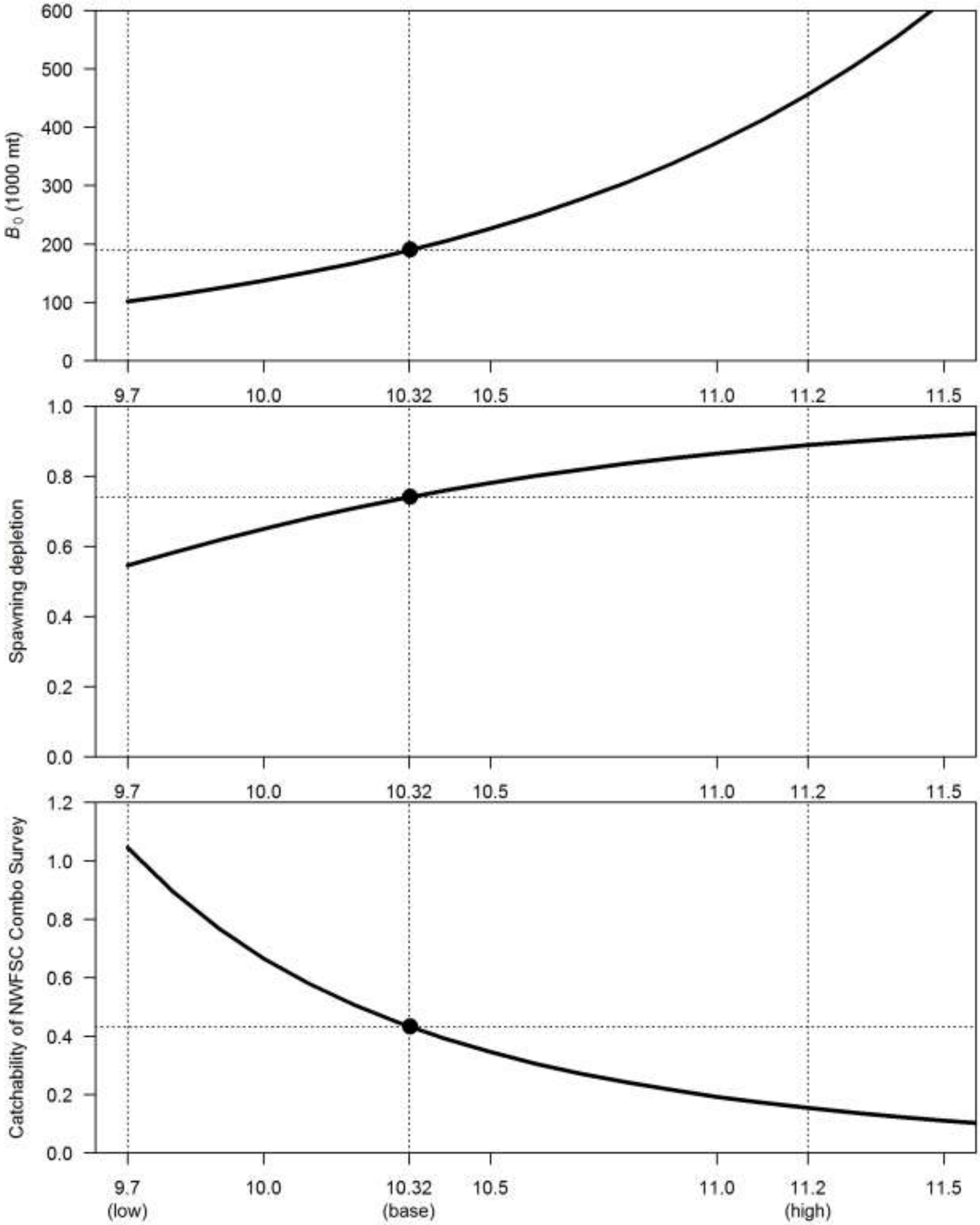


**Figure 51: Relationship between log($R_0$) and equilibrium spawning biomass (top), depletion (middle), and catchability of the NWFSC Combo Survey (bottom).**

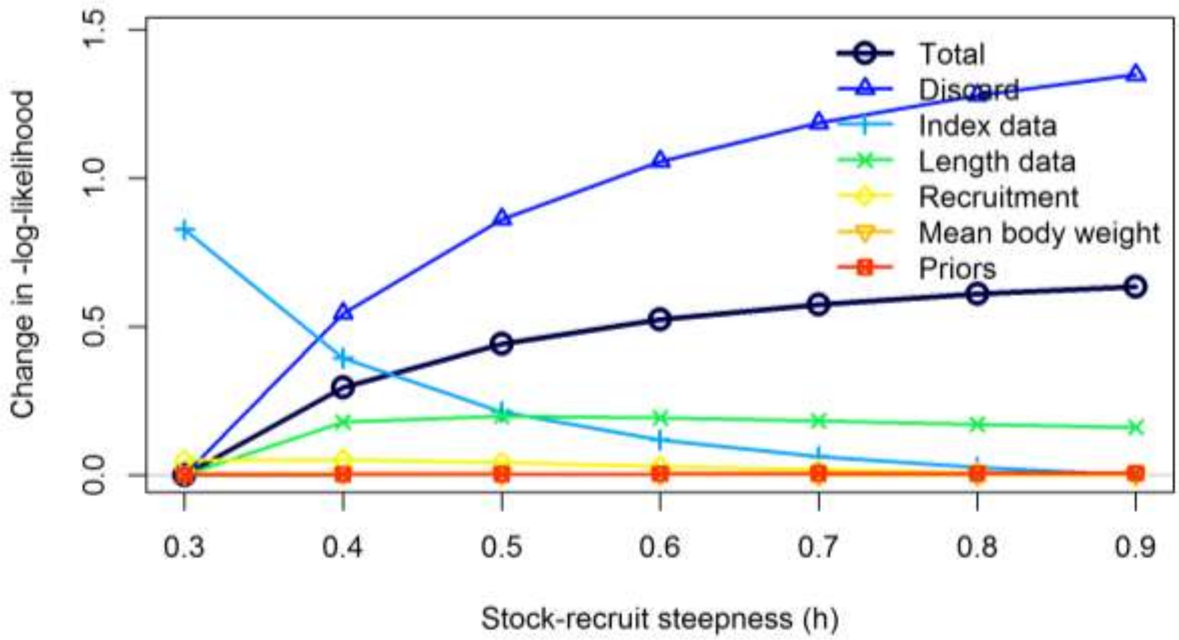


**Figure 52: Likelihood profile over steepness (*h*). The base model has steepness fixed at *h* = 0.6.**

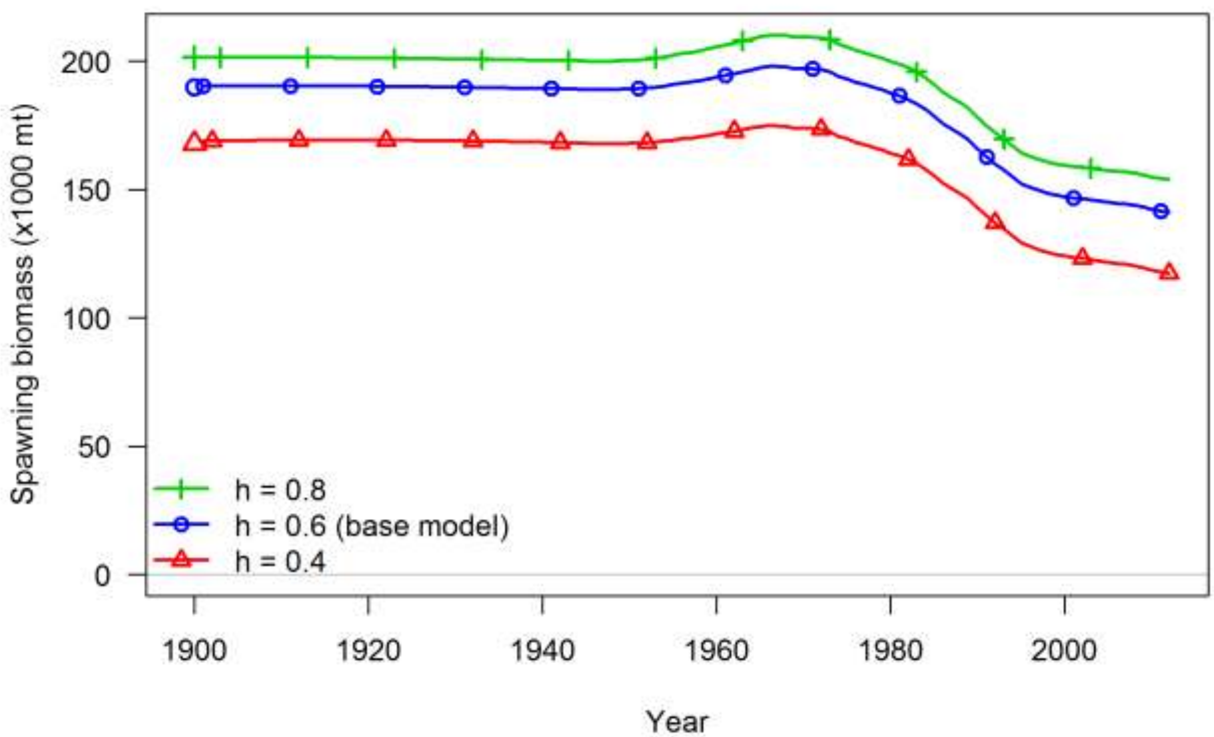


**Figure 53: Time series of spawning biomass associated with lower and higher steepness values from the likelihood profile above.**

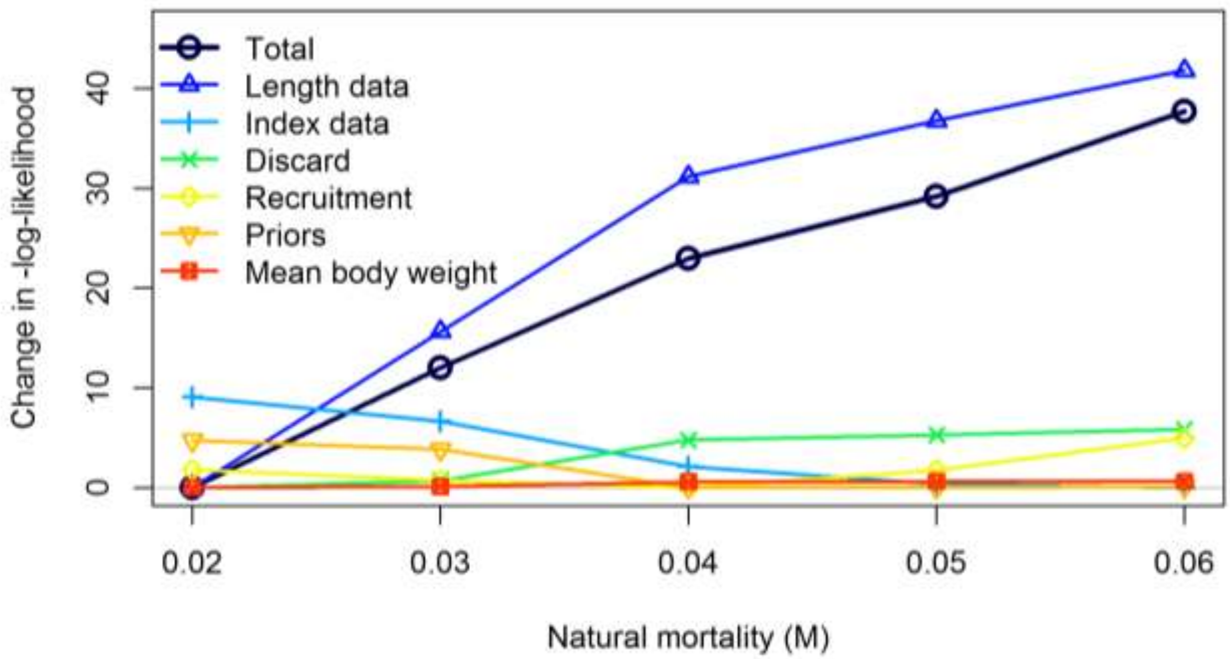


**Figure 54: Likelihood profile over natural mortality (*M*). The base model has mortality fixed at *M* = 0.0505. Models with M = 0.07 and greater did not converge with starting values used for base model.**

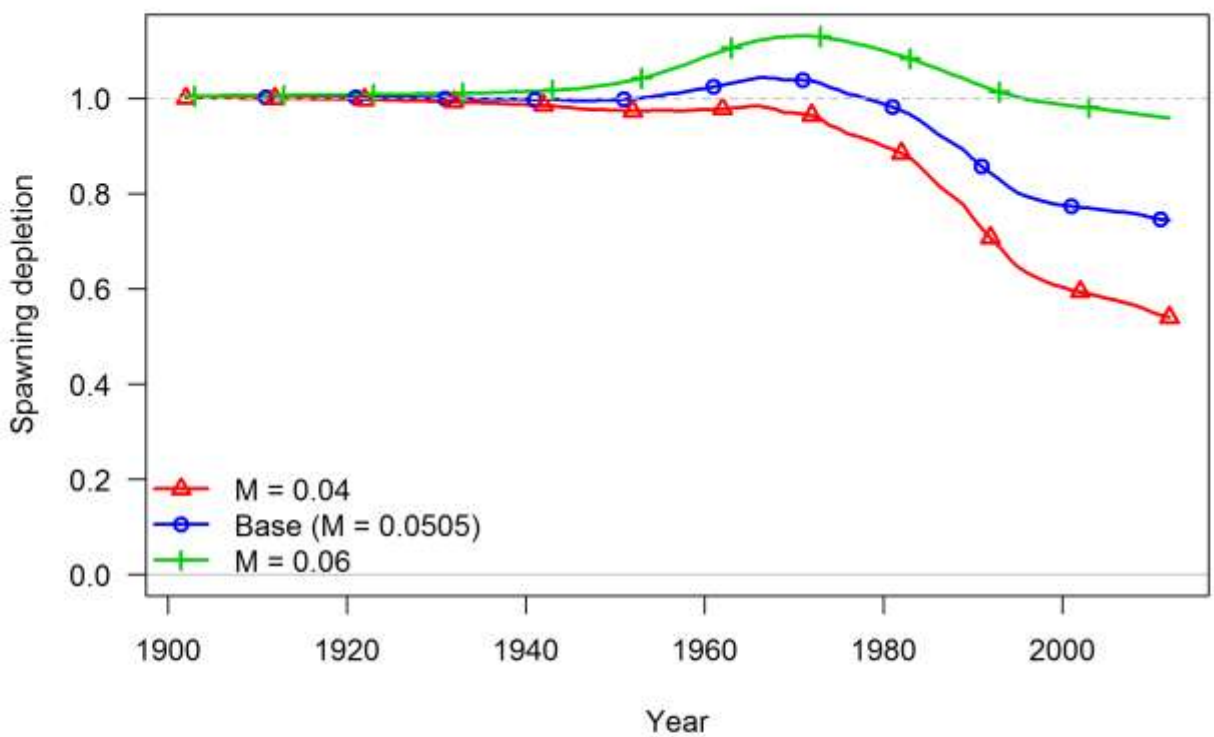


**Figure 55: Time series of spawning depletion associated with two alternative *M* values bracketing the value used in the base model.**

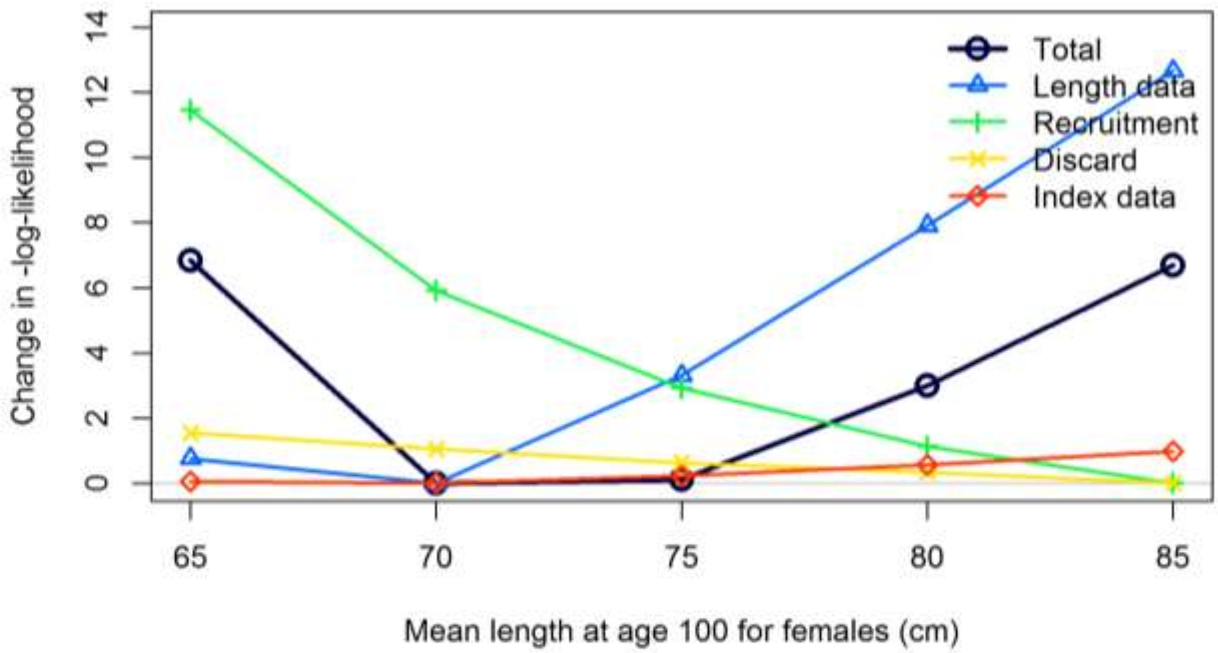


**Figure 56: Likelihood profile over length at age 100 for females. The base model has this value fixed at 75 cm. In all cases the length at age 100 for males is set to 90% of the value for females.**

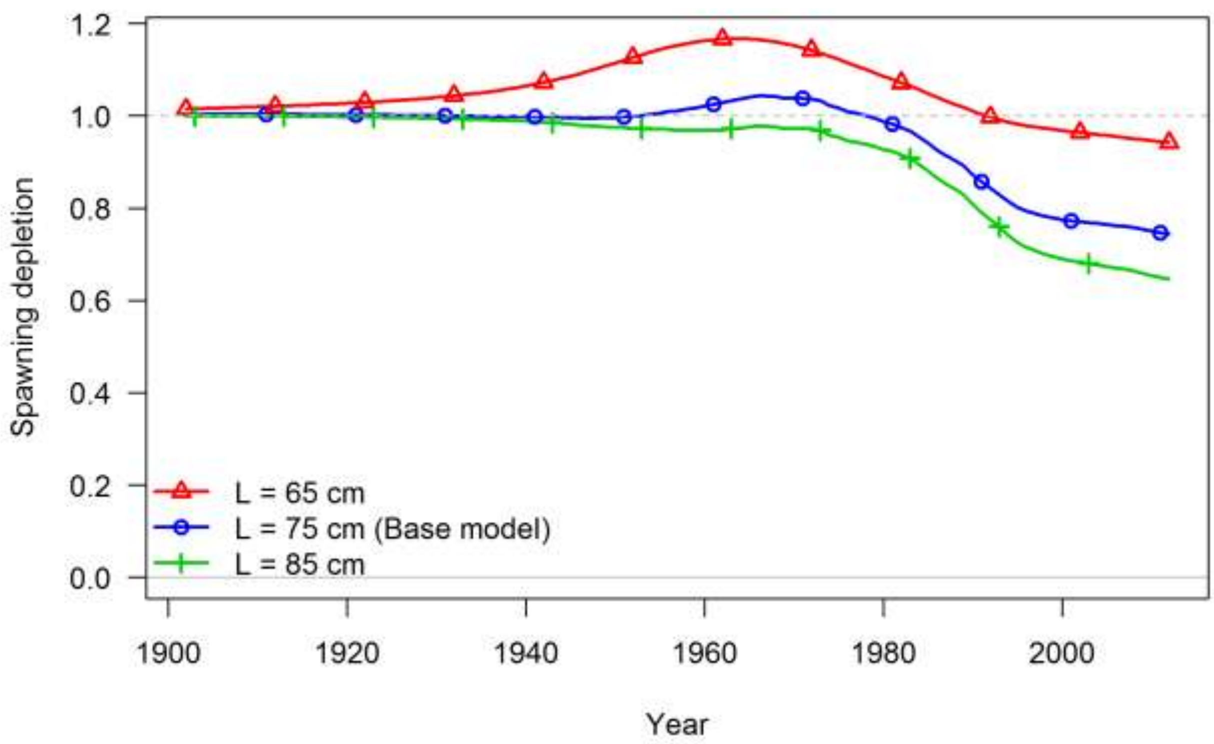


**Figure 57: Time series of spawning depletion for models with alternative values for length at age 100.**

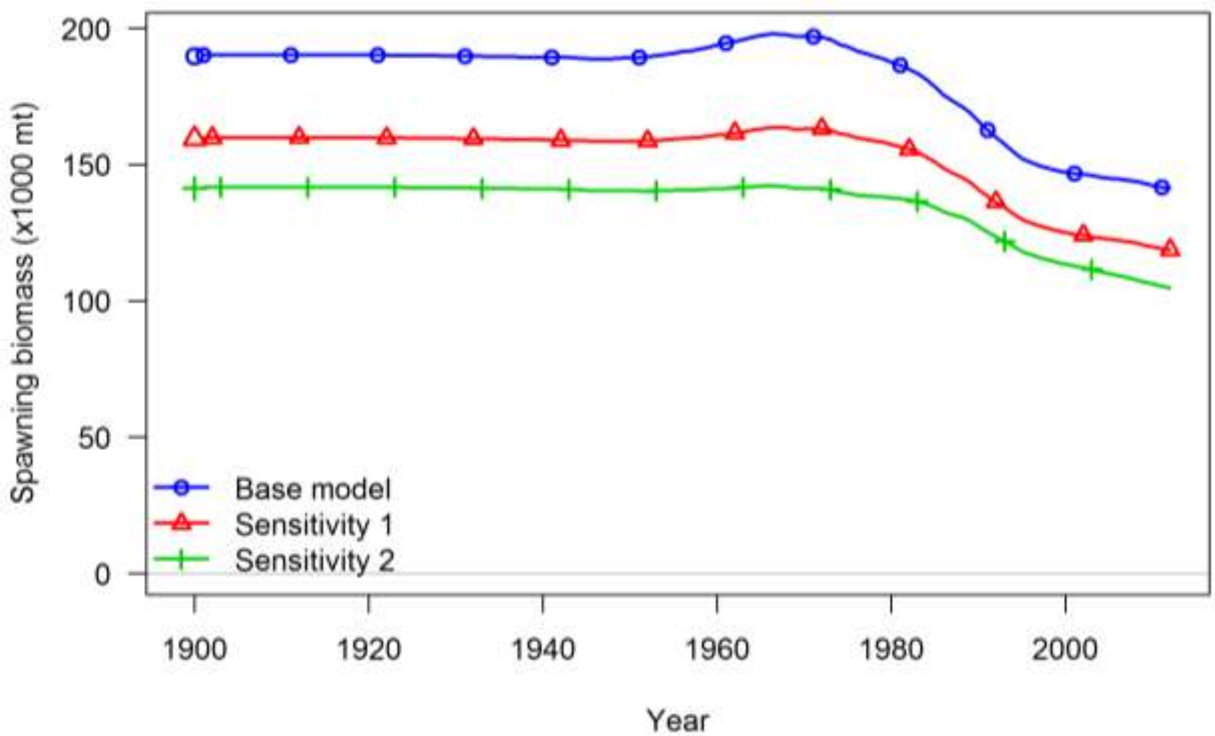


**Figure 58: Time series of spawning biomass associated with alternative assumptions about maturity. Maturity ogives are shown in Figure 12.**

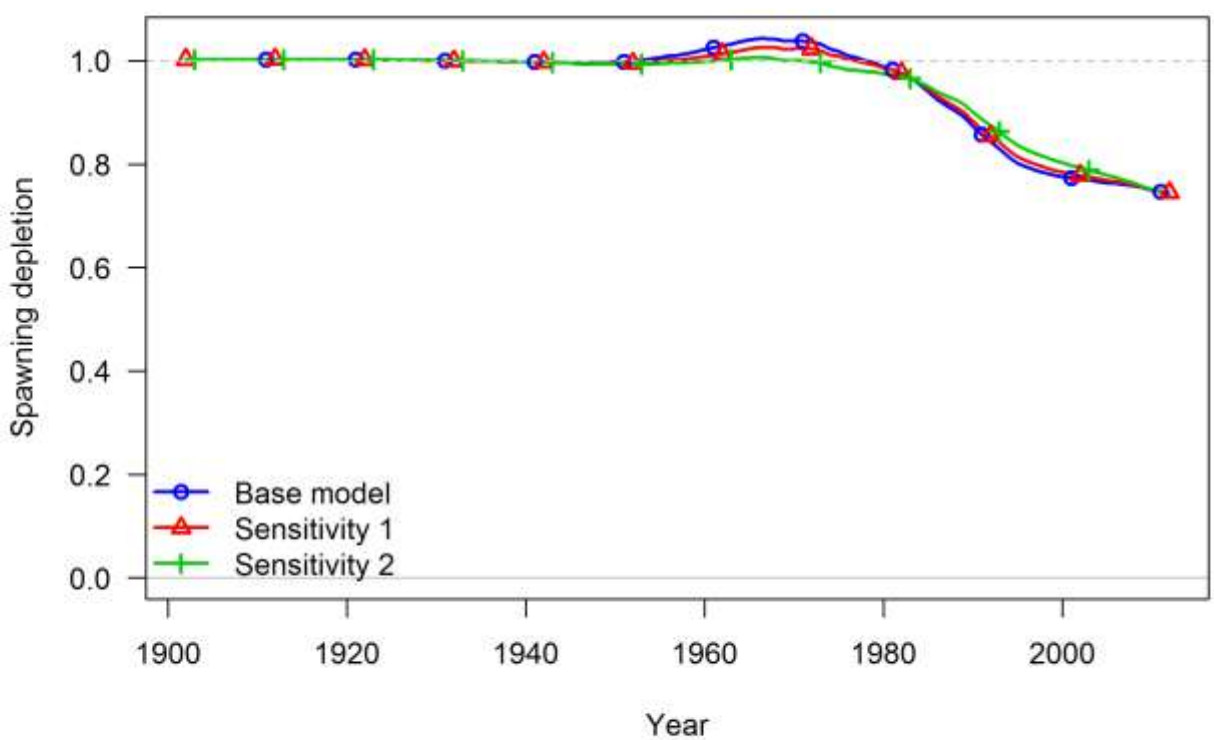


**Figure 59: Time series of depletion associated with alternative assumptions about maturity. Maturity ogives are shown in Figure 12.**

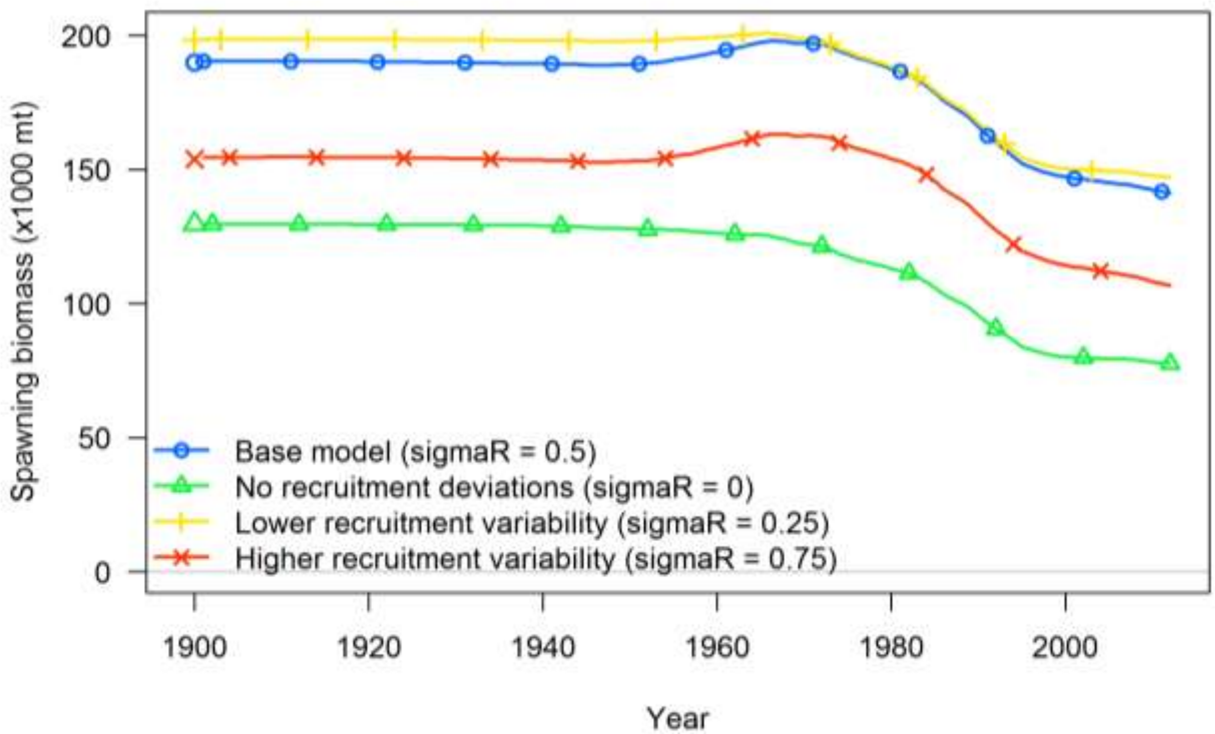


**Figure 60: Time series of spawning biomass associated with alternative values for $\sigma_R$, the parameter controlling variability in recruitment around the stock-recruit curve.**

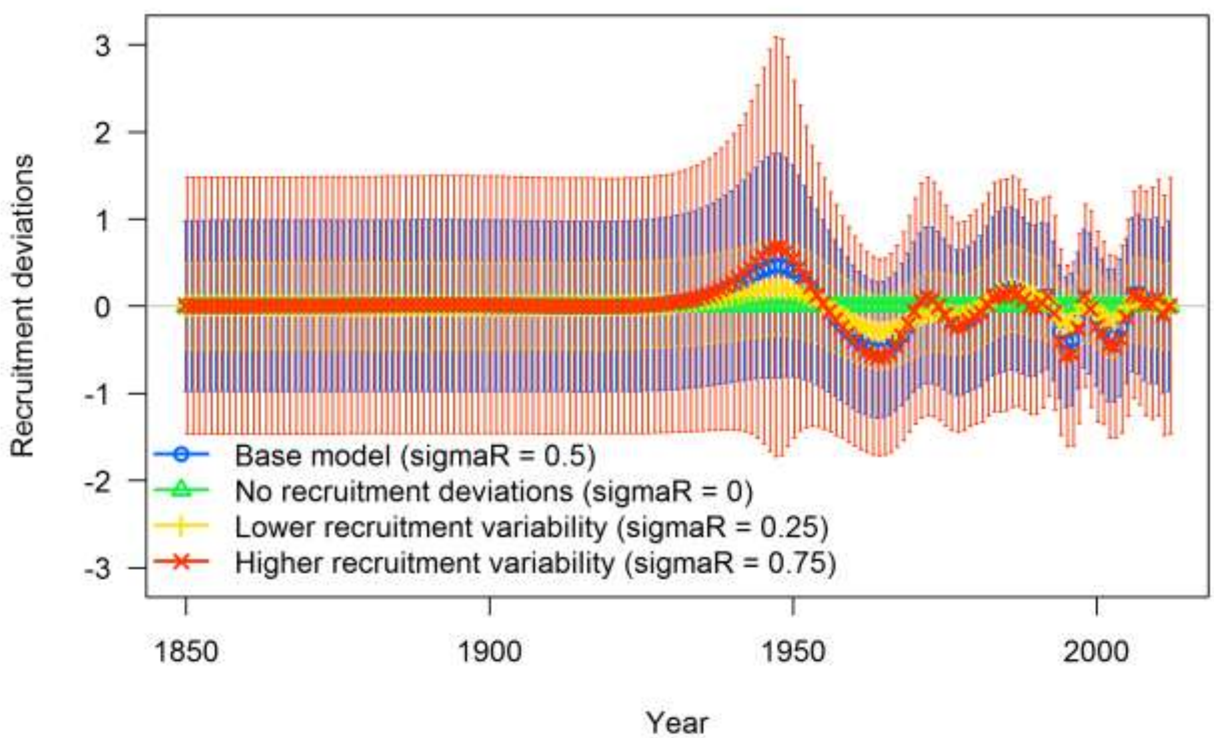


**Figure 61: Time series of estimated recruitment deviations with 95% intervals around the stock-recruit curve associated with alternative values for $\sigma_R$.**

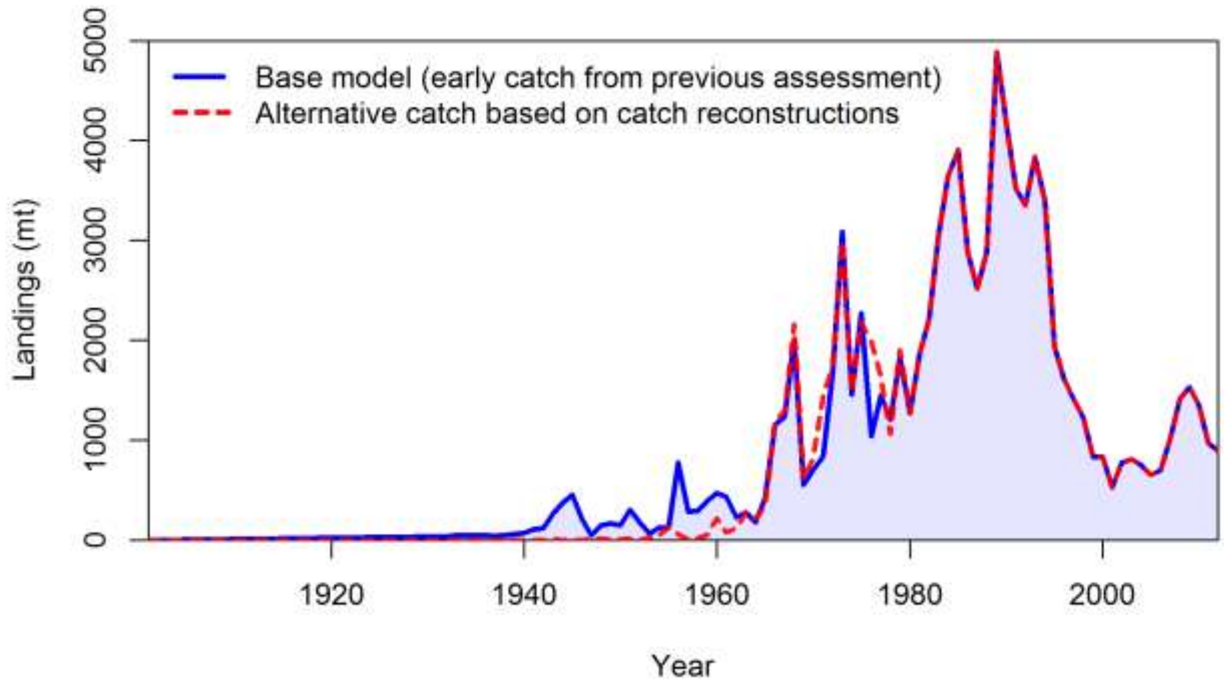


**Figure 62: Time series of catch used in the base model show along with alternative catch assembled from available catch reconstructions. Catch reconstruction estimates may include some longspine thornyheads.**

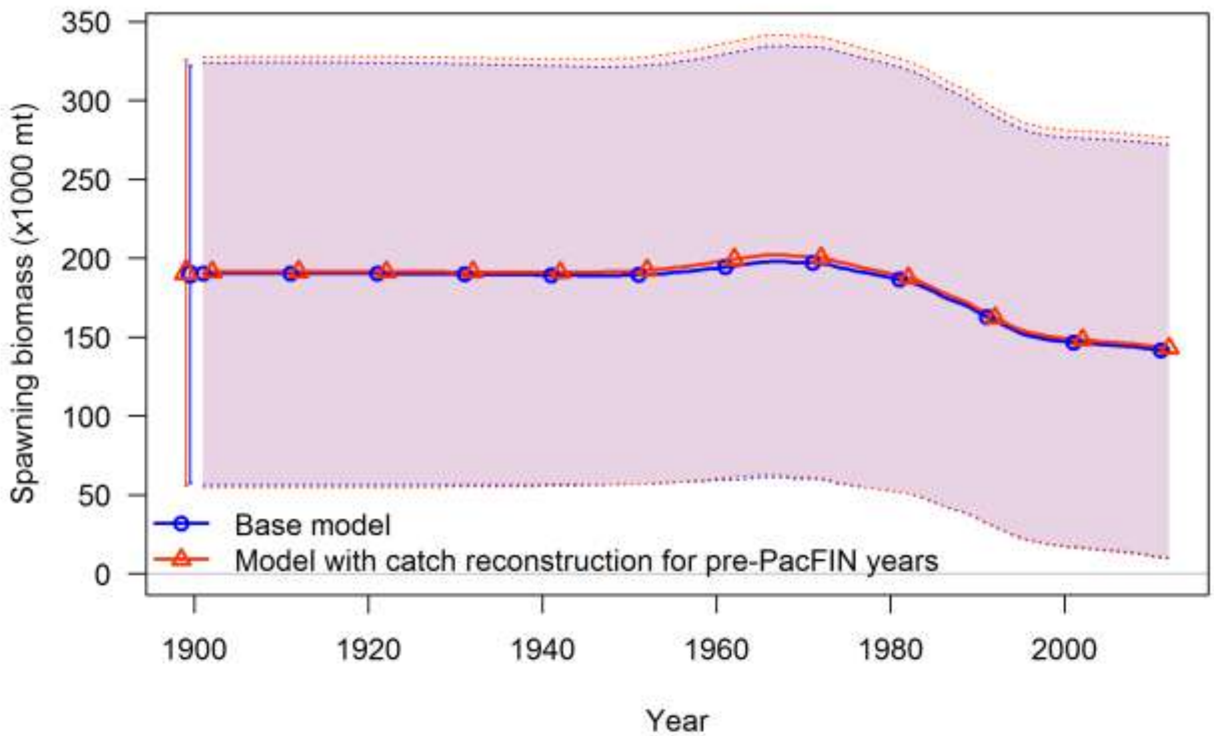


**Figure 63: Time series of spawning biomass and 95% uncertainty intervals associated with alternative catch histories.**

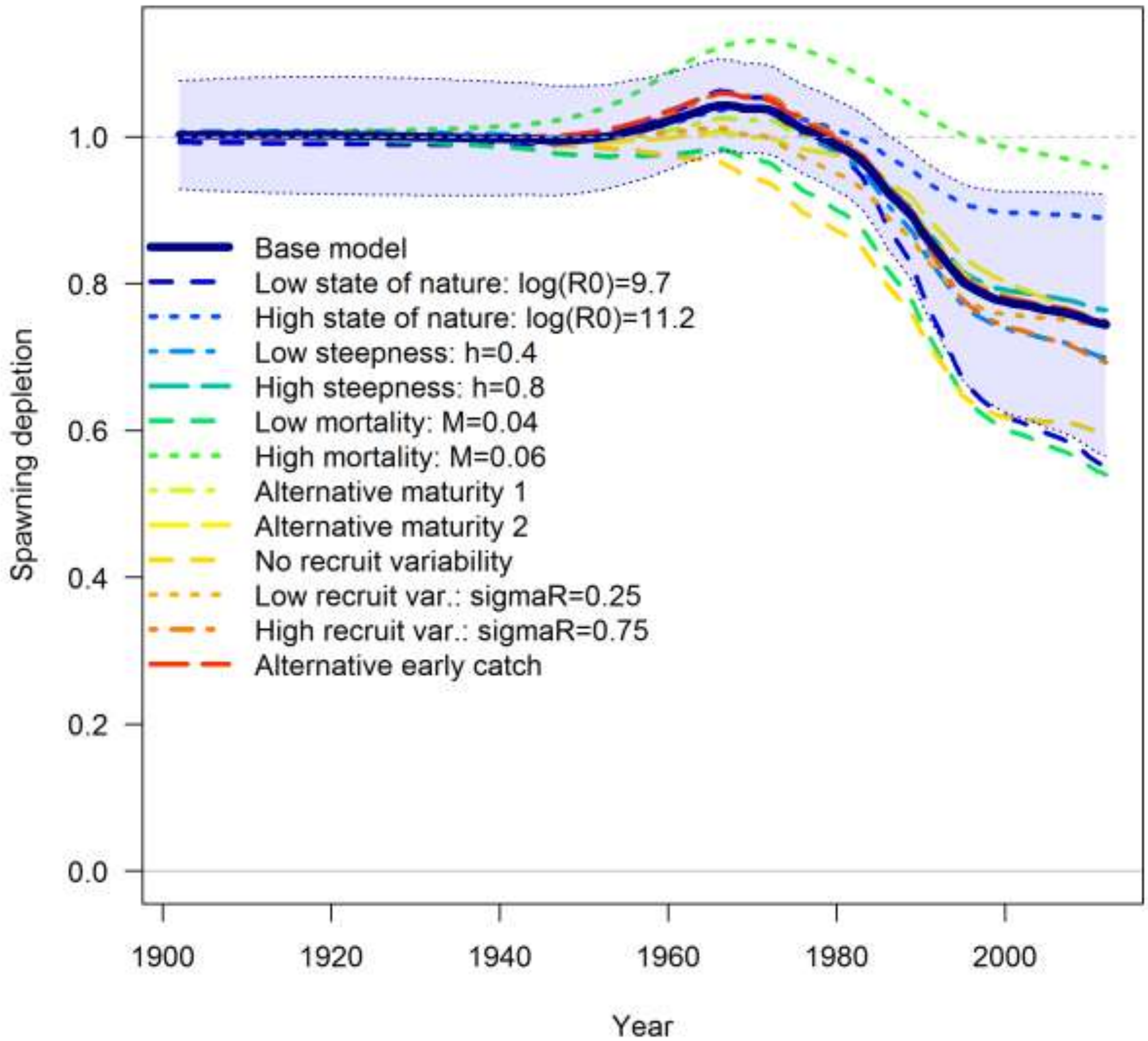


**Figure 64: Summary of spawning depletion estimates for a large set of alternative models compared to the base model with 95% uncertainty intervals (blue shaded region).**

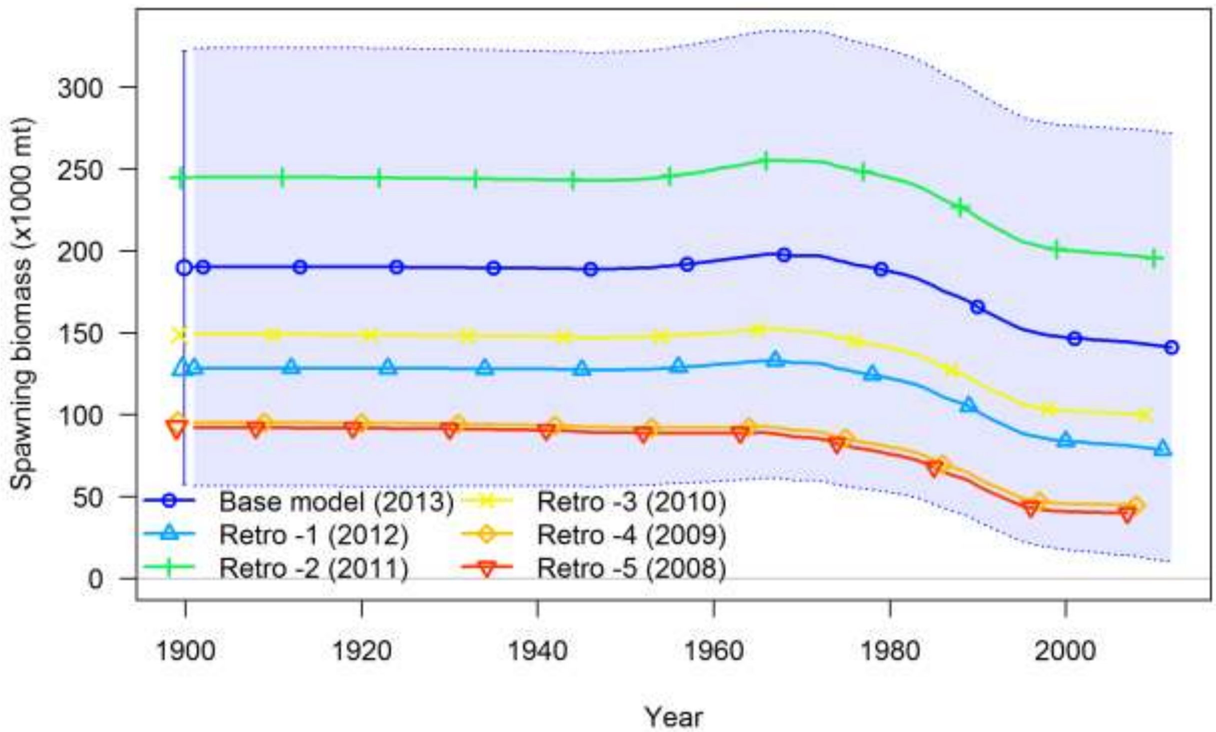


**Figure 65: Time series of spawning biomass in retrospective analysis. The shaded blue region is the 95% interval around the base model, which encompasses the models with 1–5 years of data removed.**

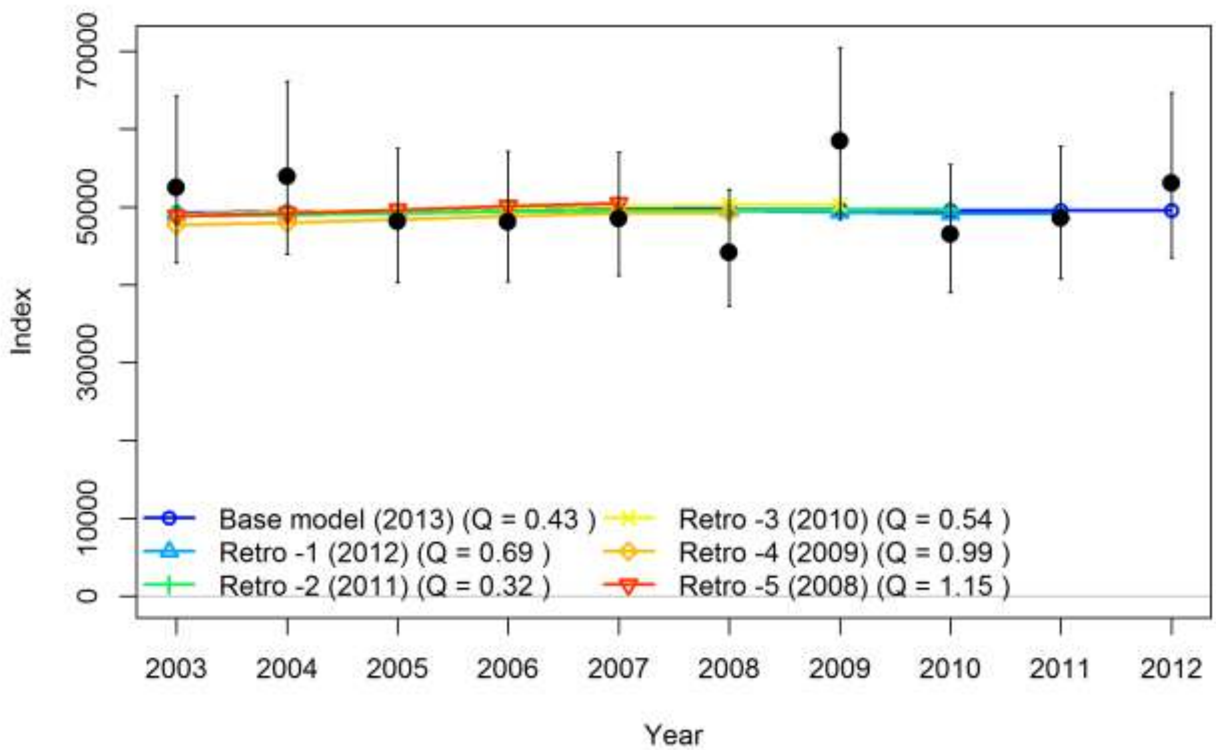


**Figure 66: Fit to NWFSC Combo survey for models in the retrospective analysis. Catchability (Q) values are shown in legend.**

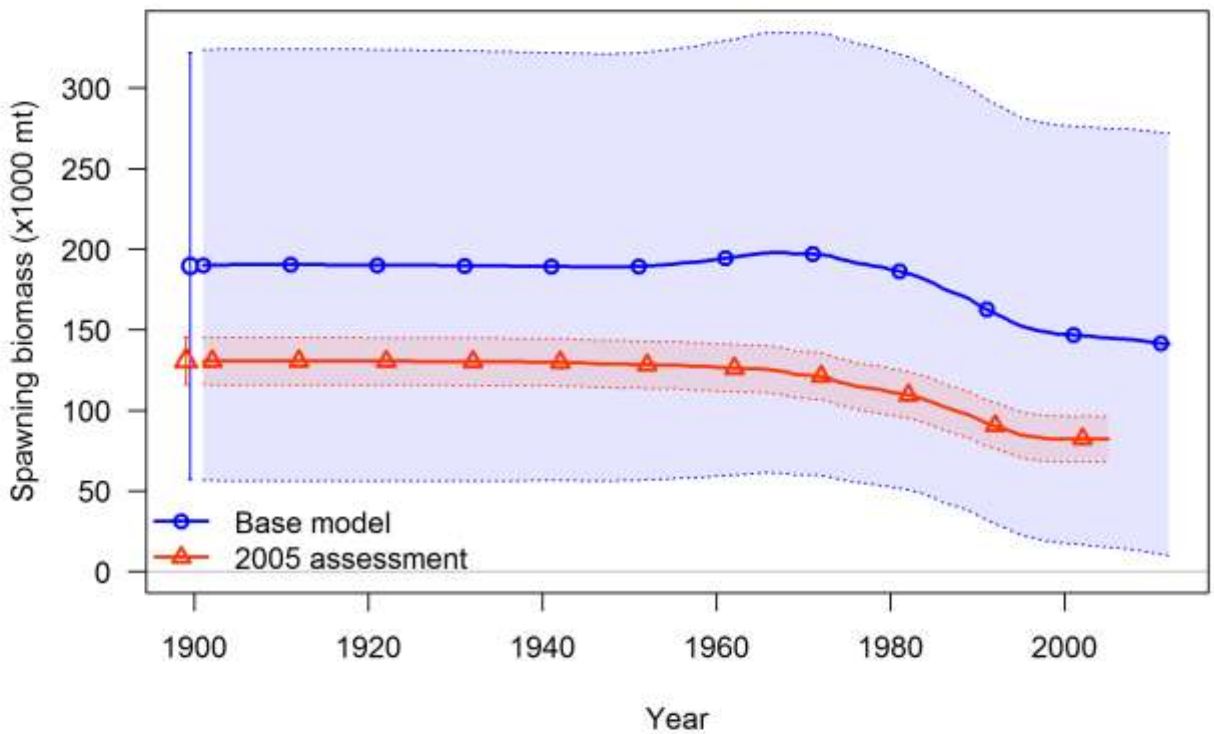


**Figure 67: Comparison of spawning biomass time series and 95% confidence intervals from 2005 assessment and base model.**

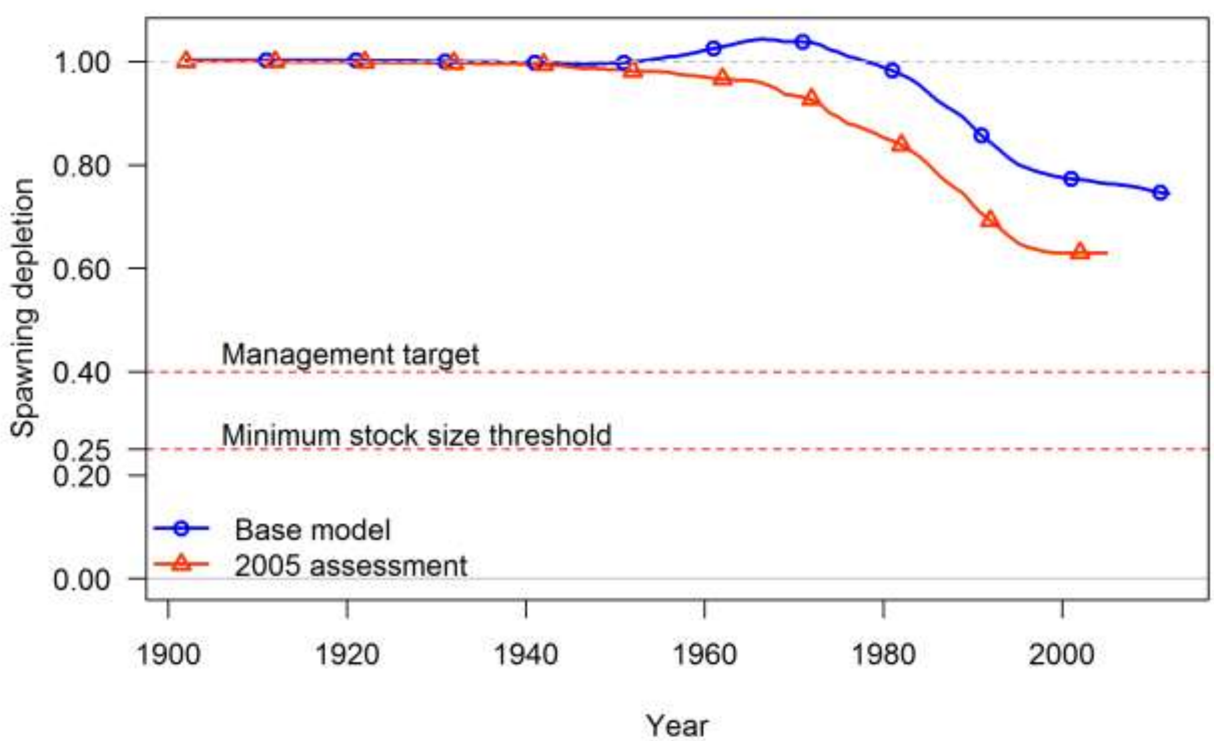


**Figure 68: Comparison of spawning depletion time series from 2005 assessment and base model.**

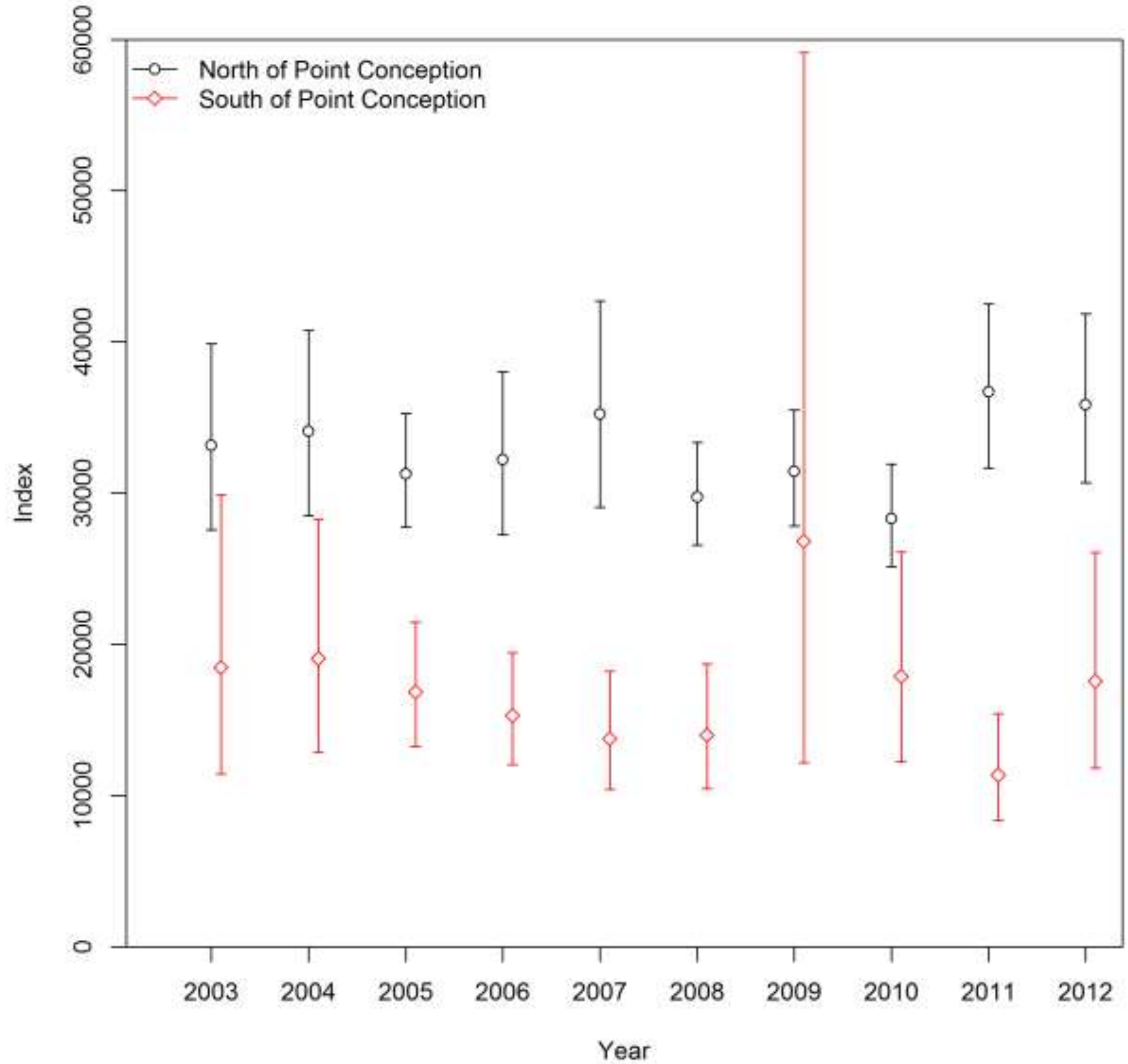


**Figure 69: Subsets of the design-based indices from the NWFSC Combo Survey associated with the strata north and south of Point Conception. The mean value of the southern portion in 34.3% of the total (similar to 34.6% for the GLMM results).**

# Appendix A. Estimated numbers at age

**Table 17: Estimated numbers at age of females**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.9 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1902 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.9 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1903 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1904 | 15.2 | 14.5 | 13.8 | 13.1 | 12.4 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1905 | 15.2 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1906 | 15.2 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1907 | 15.1 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1908 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1909 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1910 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1911 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.1 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1912 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.1 | 9.7 | 74.1 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1913 | 15.1 | 14.4 | 13.7 | 13.0 | 12.3 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 74.0 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1914 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 74.0 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1915 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.9 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1916 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.9 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1917 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.8 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1918 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.8 | 44.8 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1919 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.7 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1920 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.7 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1921 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.6 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1922 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.5 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1923 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.5 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1924 | 15.2 | 14.4 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1925 | 15.2 | 14.4 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1926 | 15.3 | 14.5 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1927 | 15.3 | 14.5 | 13.7 | 13.0 | 12.4 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.3 | 44.5 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1928 | 15.4 | 14.6 | 13.8 | 13.1 | 12.4 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.5 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1929 | 15.5 | 14.6 | 13.9 | 13.1 | 12.4 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.4 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1930 | 15.6 | 14.7 | 13.9 | 13.2 | 12.5 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.4 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1931 | 15.8 | 14.8 | 14.0 | 13.2 | 12.5 | 11.9 | 11.2 | 10.7 | 10.1 | 9.6 | 73.3 | 44.4 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1932 | 15.9 | 15.0 | 14.1 | 13.3 | 12.6 | 11.9 | 11.3 | 10.7 | 10.1 | 9.6 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1933 | 16.1 | 15.1 | 14.2 | 13.4 | 12.7 | 12.0 | 11.3 | 10.7 | 10.2 | 9.6 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1934 | 16.4 | 15.3 | 14.4 | 13.5 | 12.8 | 12.0 | 11.4 | 10.8 | 10.2 | 9.7 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1935 | 16.6 | 15.6 | 14.6 | 13.7 | 12.9 | 12.1 | 11.4 | 10.8 | 10.2 | 9.7 | 73.4 | 44.2 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1936 | 17.0 | 15.8 | 14.8 | 13.9 | 13.0 | 12.2 | 11.5 | 10.9 | 10.3 | 9.7 | 73.5 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1937 | 17.4 | 16.1 | 15.0 | 14.1 | 13.2 | 12.4 | 11.6 | 11.0 | 10.3 | 9.8 | 73.6 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1938 | 17.8 | 16.5 | 15.3 | 14.3 | 13.4 | 12.5 | 11.8 | 11.1 | 10.4 | 9.8 | 73.8 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |

**Table 17: Estimated numbers at age of females (continued)**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1939 | 18.3 | 16.9 | 15.7 | 14.6 | 13.6 | 12.7 | 11.9 | 11.2 | 10.5 | 9.9 | 74.0 | 44.1 | 26.8 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1940 | 18.9 | 17.4 | 16.1 | 14.9 | 13.9 | 12.9 | 12.1 | 11.3 | 10.6 | 10.0 | 74.3 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1941 | 19.6 | 18.0 | 16.6 | 15.3 | 14.2 | 13.2 | 12.3 | 11.5 | 10.8 | 10.1 | 74.7 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1942 | 20.3 | 18.6 | 17.1 | 15.7 | 14.5 | 13.5 | 12.5 | 11.7 | 10.9 | 10.2 | 75.1 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1943 | 21.2 | 19.3 | 17.7 | 16.3 | 15.0 | 13.8 | 12.8 | 11.9 | 11.1 | 10.4 | 75.6 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1944 | 22.0 | 20.1 | 18.4 | 16.8 | 15.5 | 14.2 | 13.1 | 12.2 | 11.3 | 10.6 | 76.2 | 44.1 | 26.6 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1945 | 22.9 | 20.9 | 19.1 | 17.5 | 16.0 | 14.7 | 13.5 | 12.5 | 11.6 | 10.8 | 76.9 | 44.1 | 26.6 | 16.1 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1946 | 23.6 | 21.7 | 19.9 | 18.2 | 16.6 | 15.2 | 14.0 | 12.9 | 11.9 | 11.0 | 77.7 | 44.1 | 26.5 | 16.1 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1947 | 24.0 | 22.4 | 20.7 | 18.9 | 17.3 | 15.8 | 14.5 | 13.3 | 12.2 | 11.3 | 78.8 | 44.1 | 26.5 | 16.1 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1948 | 24.1 | 22.9 | 21.3 | 19.7 | 18.0 | 16.4 | 15.0 | 13.8 | 12.6 | 11.6 | 80.0 | 44.2 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1949 | 23.6 | 22.9 | 21.7 | 20.3 | 18.7 | 17.1 | 15.6 | 14.3 | 13.1 | 12.0 | 81.5 | 44.4 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1950 | 22.6 | 22.4 | 21.8 | 20.7 | 19.3 | 17.8 | 16.3 | 14.9 | 13.6 | 12.4 | 83.2 | 44.5 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1951 | 21.3 | 21.5 | 21.3 | 20.7 | 19.6 | 18.3 | 16.9 | 15.5 | 14.1 | 12.9 | 85.2 | 44.7 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1952 | 19.8 | 20.3 | 20.4 | 20.3 | 19.7 | 18.7 | 17.4 | 16.1 | 14.7 | 13.4 | 87.4 | 44.9 | 26.4 | 15.9 | 9.7 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1953 | 18.3 | 18.9 | 19.3 | 19.4 | 19.3 | 18.7 | 17.8 | 16.6 | 15.3 | 14.0 | 90.0 | 45.2 | 26.4 | 15.9 | 9.7 | 5.9 | 3.6 | 2.1 | 3.3 |
| 1954 | 16.9 | 17.4 | 17.9 | 18.3 | 18.5 | 18.3 | 17.8 | 16.9 | 15.7 | 14.5 | 92.9 | 45.6 | 26.4 | 15.9 | 9.7 | 5.9 | 3.6 | 2.1 | 3.3 |
| 1955 | 15.5 | 16.0 | 16.6 | 17.0 | 17.4 | 17.6 | 17.4 | 16.9 | 16.0 | 15.0 | 96.1 | 46.1 | 26.4 | 15.9 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1956 | 14.3 | 14.8 | 15.3 | 15.8 | 16.2 | 16.5 | 16.7 | 16.6 | 16.1 | 15.3 | 99.4 | 46.6 | 26.4 | 15.9 | 9.6 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1957 | 13.2 | 13.6 | 14.0 | 14.5 | 15.0 | 15.4 | 15.7 | 15.9 | 15.7 | 15.3 | 102.5 | 47.1 | 26.4 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1958 | 12.3 | 12.6 | 12.9 | 13.4 | 13.8 | 14.2 | 14.6 | 15.0 | 15.1 | 15.0 | 105.5 | 47.9 | 26.4 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1959 | 11.4 | 11.7 | 11.9 | 12.3 | 12.7 | 13.1 | 13.5 | 13.9 | 14.2 | 14.3 | 107.8 | 48.7 | 26.5 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1960 | 10.7 | 10.9 | 11.1 | 11.4 | 11.7 | 12.1 | 12.5 | 12.9 | 13.2 | 13.5 | 109.2 | 49.7 | 26.6 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1961 | 10.1 | 10.2 | 10.3 | 10.5 | 10.8 | 11.1 | 11.5 | 11.9 | 12.2 | 12.6 | 109.5 | 50.8 | 26.6 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1962 | 9.7 | 9.6 | 9.7 | 9.8 | 10.0 | 10.3 | 10.6 | 10.9 | 11.3 | 11.6 | 108.6 | 52.1 | 26.8 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1963 | 9.4 | 9.2 | 9.1 | 9.2 | 9.3 | 9.5 | 9.8 | 10.1 | 10.4 | 10.7 | 106.6 | 53.7 | 26.9 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1964 | 9.2 | 8.9 | 8.7 | 8.7 | 8.8 | 8.9 | 9.1 | 9.3 | 9.6 | 9.9 | 103.5 | 55.4 | 27.1 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1965 | 9.3 | 8.8 | 8.5 | 8.3 | 8.3 | 8.3 | 8.4 | 8.6 | 8.8 | 9.1 | 99.5 | 57.3 | 27.4 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1966 | 9.6 | 8.8 | 8.3 | 8.0 | 7.9 | 7.9 | 7.9 | 8.0 | 8.2 | 8.4 | 94.6 | 59.2 | 27.7 | 15.7 | 9.4 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1967 | 10.1 | 9.1 | 8.4 | 7.9 | 7.6 | 7.5 | 7.5 | 7.5 | 7.6 | 7.8 | 88.8 | 60.8 | 27.9 | 15.7 | 9.4 | 5.7 | 3.5 | 2.1 | 3.3 |
| 1968 | 11.0 | 9.6 | 8.6 | 8.0 | 7.5 | 7.3 | 7.1 | 7.1 | 7.1 | 7.2 | 82.8 | 62.3 | 28.2 | 15.6 | 9.4 | 5.7 | 3.5 | 2.1 | 3.3 |
| 1969 | 12.1 | 10.4 | 9.1 | 8.2 | 7.6 | 7.2 | 6.9 | 6.8 | 6.7 | 6.8 | 76.7 | 63.2 | 28.5 | 15.6 | 9.3 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1970 | 13.4 | 11.5 | 9.9 | 8.7 | 7.8 | 7.2 | 6.8 | 6.6 | 6.4 | 6.4 | 71.2 | 63.9 | 29.1 | 15.6 | 9.3 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1971 | 14.6 | 12.7 | 10.9 | 9.4 | 8.3 | 7.4 | 6.8 | 6.5 | 6.2 | 6.1 | 66.1 | 64.0 | 29.7 | 15.6 | 9.3 | 5.6 | 3.5 | 2.1 | 3.2 |
| 1972 | 15.3 | 13.9 | 12.1 | 10.4 | 8.9 | 7.9 | 7.1 | 6.5 | 6.1 | 5.9 | 61.4 | 63.3 | 30.4 | 15.7 | 9.2 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1973 | 15.3 | 14.6 | 13.2 | 11.5 | 9.9 | 8.5 | 7.5 | 6.7 | 6.2 | 5.8 | 57.2 | 61.8 | 31.1 | 15.7 | 9.2 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1974 | 14.8 | 14.6 | 13.8 | 12.5 | 10.9 | 9.4 | 8.1 | 7.1 | 6.4 | 5.9 | 53.5 | 59.2 | 31.7 | 15.6 | 9.1 | 5.5 | 3.4 | 2.1 | 3.2 |
| 1975 | 13.8 | 14.0 | 13.9 | 13.2 | 11.9 | 10.4 | 8.9 | 7.7 | 6.7 | 6.0 | 50.8 | 56.6 | 32.6 | 15.7 | 9.0 | 5.5 | 3.4 | 2.1 | 3.2 |
| 1976 | 13.0 | 13.2 | 13.3 | 13.2 | 12.5 | 11.3 | 9.9 | 8.5 | 7.3 | 6.4 | 48.7 | 53.4 | 33.4 | 15.7 | 9.0 | 5.5 | 3.4 | 2.1 | 3.2 |

**Table 17: Estimated numbers at age of females (continued)**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 12.5 | 12.3 | 12.5 | 12.7 | 12.5 | 11.9 | 10.8 | 9.4 | 8.0 | 6.9 | 47.7 | 50.3 | 34.4 | 15.9 | 9.0 | 5.4 | 3.4 | 2.1 | 3.2 |
| 1978 | 12.6 | 11.9 | 11.7 | 11.9 | 12.1 | 11.9 | 11.3 | 10.2 | 8.9 | 7.6 | 47.5 | 46.9 | 35.2 | 16.0 | 8.9 | 5.4 | 3.3 | 2.1 | 3.2 |
| 1979 | 13.0 | 11.9 | 11.3 | 11.1 | 11.3 | 11.5 | 11.3 | 10.7 | 9.7 | 8.5 | 48.3 | 43.5 | 35.8 | 16.2 | 8.9 | 5.4 | 3.3 | 2.1 | 3.2 |
| 1980 | 13.5 | 12.4 | 11.3 | 10.7 | 10.6 | 10.8 | 10.9 | 10.8 | 10.2 | 9.2 | 50.0 | 40.2 | 36.0 | 16.5 | 8.9 | 5.4 | 3.3 | 2.0 | 3.2 |
| 1981 | 14.3 | 12.9 | 11.8 | 10.8 | 10.2 | 10.1 | 10.2 | 10.4 | 10.2 | 9.7 | 52.7 | 37.3 | 36.0 | 16.8 | 8.9 | 5.3 | 3.3 | 2.0 | 3.2 |
| 1982 | 15.5 | 13.6 | 12.2 | 11.2 | 10.3 | 9.7 | 9.6 | 9.7 | 9.8 | 9.7 | 55.7 | 34.5 | 35.4 | 17.1 | 8.9 | 5.3 | 3.3 | 2.0 | 3.2 |
| 1983 | 16.8 | 14.8 | 12.9 | 11.6 | 10.6 | 9.7 | 9.2 | 9.1 | 9.2 | 9.3 | 58.5 | 32.1 | 34.5 | 17.4 | 8.8 | 5.3 | 3.2 | 2.0 | 3.2 |
| 1984 | 17.5 | 16.0 | 14.1 | 12.3 | 11.1 | 10.1 | 9.3 | 8.8 | 8.6 | 8.7 | 60.5 | 29.8 | 33.0 | 17.8 | 8.8 | 5.2 | 3.2 | 2.0 | 3.2 |
| 1985 | 18.0 | 16.7 | 15.2 | 13.4 | 11.7 | 10.5 | 9.6 | 8.8 | 8.3 | 8.1 | 61.7 | 27.9 | 31.2 | 18.1 | 8.8 | 5.2 | 3.2 | 2.0 | 3.1 |
| 1986 | 18.3 | 17.1 | 15.8 | 14.5 | 12.7 | 11.1 | 10.0 | 9.1 | 8.3 | 7.8 | 62.2 | 26.5 | 29.1 | 18.4 | 8.8 | 5.1 | 3.2 | 2.0 | 3.1 |
| 1987 | 17.8 | 17.4 | 16.3 | 15.1 | 13.7 | 12.1 | 10.5 | 9.5 | 8.6 | 7.9 | 62.6 | 25.6 | 27.1 | 18.7 | 8.8 | 5.1 | 3.1 | 2.0 | 3.1 |
| 1988 | 16.8 | 16.9 | 16.5 | 15.5 | 14.3 | 13.1 | 11.5 | 10.0 | 9.0 | 8.2 | 62.9 | 25.4 | 25.1 | 19.0 | 8.8 | 5.0 | 3.1 | 1.9 | 3.1 |
| 1989 | 15.9 | 16.0 | 16.1 | 15.7 | 14.7 | 13.6 | 12.4 | 10.9 | 9.5 | 8.5 | 62.9 | 25.5 | 23.0 | 19.2 | 8.9 | 5.0 | 3.1 | 1.9 | 3.1 |
| 1990 | 15.7 | 15.1 | 15.2 | 15.3 | 14.9 | 14.0 | 12.9 | 11.8 | 10.3 | 9.0 | 62.3 | 25.9 | 20.9 | 19.0 | 8.8 | 4.9 | 3.0 | 1.9 | 3.1 |
| 1991 | 16.3 | 15.0 | 14.4 | 14.4 | 14.6 | 14.2 | 13.3 | 12.2 | 11.1 | 9.7 | 61.7 | 26.7 | 18.9 | 18.6 | 8.9 | 4.9 | 3.0 | 1.9 | 3.1 |
| 1992 | 16.4 | 15.5 | 14.2 | 13.7 | 13.7 | 13.8 | 13.5 | 12.6 | 11.6 | 10.5 | 61.9 | 27.8 | 17.3 | 18.1 | 9.0 | 4.8 | 3.0 | 1.9 | 3.0 |
| 1993 | 13.8 | 15.6 | 14.7 | 13.5 | 13.0 | 13.0 | 13.1 | 12.8 | 11.9 | 10.9 | 62.9 | 28.9 | 15.9 | 17.5 | 9.1 | 4.8 | 2.9 | 1.8 | 3.0 |
| 1994 | 10.9 | 13.2 | 14.8 | 14.0 | 12.8 | 12.3 | 12.4 | 12.4 | 12.1 | 11.2 | 64.3 | 29.6 | 14.6 | 16.6 | 9.2 | 4.7 | 2.9 | 1.8 | 3.0 |
| 1995 | 9.6 | 10.3 | 12.5 | 14.1 | 13.3 | 12.2 | 11.7 | 11.7 | 11.8 | 11.4 | 66.3 | 30.0 | 13.6 | 15.7 | 9.4 | 4.7 | 2.9 | 1.8 | 3.0 |
| 1996 | 9.9 | 9.1 | 9.8 | 11.9 | 13.4 | 12.6 | 11.6 | 11.1 | 11.1 | 11.1 | 69.3 | 30.4 | 13.0 | 14.7 | 9.6 | 4.7 | 2.8 | 1.8 | 3.0 |
| 1997 | 12.2 | 9.4 | 8.7 | 9.3 | 11.3 | 12.7 | 12.0 | 11.0 | 10.5 | 10.5 | 72.1 | 30.7 | 12.6 | 13.7 | 9.8 | 4.7 | 2.8 | 1.8 | 3.0 |
| 1998 | 15.7 | 11.6 | 8.9 | 8.3 | 8.9 | 10.7 | 12.1 | 11.4 | 10.5 | 10.0 | 74.2 | 30.9 | 12.5 | 12.7 | 10.0 | 4.8 | 2.8 | 1.8 | 2.9 |
| 1999 | 14.9 | 14.9 | 11.1 | 8.5 | 7.9 | 8.4 | 10.2 | 11.5 | 10.8 | 9.9 | 75.5 | 31.1 | 12.6 | 11.8 | 10.1 | 4.8 | 2.8 | 1.8 | 2.9 |
| 2000 | 12.7 | 14.1 | 14.2 | 10.5 | 8.1 | 7.5 | 8.0 | 9.7 | 10.9 | 10.3 | 76.7 | 31.5 | 13.1 | 10.8 | 10.1 | 4.9 | 2.8 | 1.7 | 2.9 |
| 2001 | 11.5 | 12.1 | 13.5 | 13.5 | 10.0 | 7.7 | 7.1 | 7.6 | 9.2 | 10.3 | 77.9 | 31.9 | 13.8 | 10.0 | 10.1 | 4.9 | 2.8 | 1.7 | 2.9 |
| 2002 | 10.3 | 10.9 | 11.5 | 12.8 | 12.8 | 9.5 | 7.3 | 6.7 | 7.2 | 8.8 | 78.6 | 32.7 | 14.6 | 9.3 | 10.0 | 5.0 | 2.8 | 1.7 | 2.9 |
| 2003 | 10.3 | 9.8 | 10.4 | 10.9 | 12.2 | 12.2 | 9.0 | 6.9 | 6.4 | 6.9 | 77.3 | 33.9 | 15.4 | 8.7 | 9.7 | 5.1 | 2.8 | 1.7 | 2.9 |
| 2004 | 11.2 | 9.8 | 9.3 | 9.9 | 10.4 | 11.6 | 11.6 | 8.6 | 6.6 | 6.1 | 74.0 | 35.4 | 16.1 | 8.1 | 9.4 | 5.3 | 2.8 | 1.7 | 2.9 |
| 2005 | 13.6 | 10.7 | 9.3 | 8.9 | 9.4 | 9.9 | 11.0 | 11.0 | 8.2 | 6.3 | 69.8 | 37.2 | 16.7 | 7.7 | 8.9 | 5.4 | 2.8 | 1.7 | 2.9 |
| 2006 | 16.4 | 12.9 | 10.2 | 8.8 | 8.4 | 8.9 | 9.4 | 10.4 | 10.5 | 7.7 | 65.8 | 39.1 | 17.1 | 7.4 | 8.5 | 5.6 | 2.8 | 1.7 | 2.8 |
| 2007 | 16.5 | 15.6 | 12.3 | 9.7 | 8.4 | 8.0 | 8.5 | 8.9 | 9.9 | 9.9 | 63.6 | 41.0 | 17.3 | 7.2 | 7.9 | 5.7 | 2.8 | 1.7 | 2.8 |
| 2008 | 15.5 | 15.7 | 14.8 | 11.7 | 9.2 | 8.0 | 7.6 | 8.0 | 8.5 | 9.4 | 63.8 | 42.2 | 17.5 | 7.2 | 7.4 | 5.8 | 2.8 | 1.7 | 2.8 |
| 2009 | 15.1 | 14.7 | 14.9 | 14.1 | 11.1 | 8.7 | 7.6 | 7.2 | 7.6 | 8.0 | 63.6 | 42.9 | 17.7 | 7.2 | 6.8 | 5.9 | 2.8 | 1.7 | 2.8 |
| 2010 | 15.2 | 14.4 | 14.0 | 14.2 | 13.4 | 10.6 | 8.3 | 7.2 | 6.9 | 7.2 | 62.1 | 43.3 | 17.8 | 7.5 | 6.3 | 5.9 | 2.9 | 1.6 | 2.8 |
| 2011 | 13.7 | 14.5 | 13.6 | 13.3 | 13.5 | 12.7 | 10.0 | 7.9 | 6.8 | 6.5 | 59.9 | 43.7 | 17.9 | 7.8 | 5.8 | 5.9 | 2.9 | 1.6 | 2.8 |
| 2012 | 14.4 | 13.0 | 13.8 | 13.0 | 12.6 | 12.8 | 12.1 | 9.5 | 7.5 | 6.5 | 57.2 | 44.1 | 18.3 | 8.3 | 5.4 | 5.8 | 3.0 | 1.6 | 2.8 |
| 2013 | 14.4 | 13.7 | 12.4 | 13.1 | 12.3 | 12.0 | 12.2 | 11.5 | 9.1 | 7.1 | 55.6 | 43.3 | 19.0 | 8.7 | 5.0 | 5.7 | 3.0 | 1.6 | 2.7 |

**Table 18: Estimated numbers at age of males**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.9 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1902 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.9 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1903 | 15.2 | 14.5 | 13.8 | 13.1 | 12.5 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1904 | 15.2 | 14.5 | 13.8 | 13.1 | 12.4 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1905 | 15.2 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.3 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1906 | 15.2 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.3 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1907 | 15.1 | 14.4 | 13.7 | 13.1 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1908 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.1 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1909 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1910 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.2 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1911 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.7 | 74.1 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1912 | 15.1 | 14.4 | 13.7 | 13.0 | 12.4 | 11.8 | 11.2 | 10.7 | 10.1 | 9.7 | 74.1 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1913 | 15.1 | 14.4 | 13.7 | 13.0 | 12.3 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 74.0 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1914 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 74.0 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1915 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 74.0 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1916 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.9 | 44.8 | 27.0 | 16.3 | 9.9 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1917 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.8 | 44.8 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1918 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.2 | 10.6 | 10.1 | 9.6 | 73.8 | 44.8 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1919 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.7 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1920 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.7 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1921 | 15.1 | 14.3 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.6 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1922 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.5 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1923 | 15.1 | 14.4 | 13.6 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.5 | 44.7 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1924 | 15.2 | 14.4 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1925 | 15.2 | 14.4 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1926 | 15.3 | 14.5 | 13.7 | 13.0 | 12.3 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.4 | 44.6 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1927 | 15.3 | 14.5 | 13.7 | 13.0 | 12.4 | 11.7 | 11.1 | 10.6 | 10.1 | 9.6 | 73.3 | 44.5 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1928 | 15.4 | 14.6 | 13.8 | 13.1 | 12.4 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.5 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1929 | 15.5 | 14.6 | 13.9 | 13.1 | 12.4 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.4 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1930 | 15.6 | 14.7 | 13.9 | 13.2 | 12.5 | 11.8 | 11.2 | 10.6 | 10.1 | 9.6 | 73.3 | 44.4 | 27.0 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1931 | 15.8 | 14.8 | 14.0 | 13.2 | 12.5 | 11.9 | 11.2 | 10.7 | 10.1 | 9.6 | 73.3 | 44.4 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1932 | 15.9 | 15.0 | 14.1 | 13.3 | 12.6 | 11.9 | 11.3 | 10.7 | 10.1 | 9.6 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1933 | 16.1 | 15.1 | 14.2 | 13.4 | 12.7 | 12.0 | 11.3 | 10.7 | 10.2 | 9.6 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1934 | 16.4 | 15.3 | 14.4 | 13.5 | 12.8 | 12.0 | 11.4 | 10.8 | 10.2 | 9.7 | 73.3 | 44.3 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1935 | 16.6 | 15.6 | 14.6 | 13.7 | 12.9 | 12.1 | 11.4 | 10.8 | 10.2 | 9.7 | 73.4 | 44.2 | 26.9 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1936 | 17.0 | 15.8 | 14.8 | 13.9 | 13.0 | 12.2 | 11.5 | 10.9 | 10.3 | 9.7 | 73.5 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1937 | 17.4 | 16.1 | 15.0 | 14.1 | 13.2 | 12.4 | 11.6 | 11.0 | 10.3 | 9.8 | 73.7 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1938 | 17.8 | 16.5 | 15.3 | 14.3 | 13.4 | 12.5 | 11.8 | 11.1 | 10.4 | 9.8 | 73.8 | 44.2 | 26.8 | 16.3 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |

**Table 18: Estimated numbers at age of males (continued)**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1939 | 18.3 | 16.9 | 15.7 | 14.6 | 13.6 | 12.7 | 11.9 | 11.2 | 10.5 | 9.9 | 74.1 | 44.2 | 26.8 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1940 | 18.9 | 17.4 | 16.1 | 14.9 | 13.9 | 12.9 | 12.1 | 11.3 | 10.6 | 10.0 | 74.3 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1941 | 19.6 | 18.0 | 16.6 | 15.3 | 14.2 | 13.2 | 12.3 | 11.5 | 10.8 | 10.1 | 74.7 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1942 | 20.3 | 18.6 | 17.1 | 15.7 | 14.5 | 13.5 | 12.5 | 11.7 | 10.9 | 10.2 | 75.1 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1943 | 21.2 | 19.3 | 17.7 | 16.3 | 15.0 | 13.8 | 12.8 | 11.9 | 11.1 | 10.4 | 75.6 | 44.1 | 26.7 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1944 | 22.0 | 20.1 | 18.4 | 16.8 | 15.5 | 14.2 | 13.1 | 12.2 | 11.3 | 10.6 | 76.2 | 44.1 | 26.6 | 16.2 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1945 | 22.9 | 20.9 | 19.1 | 17.5 | 16.0 | 14.7 | 13.5 | 12.5 | 11.6 | 10.8 | 76.9 | 44.1 | 26.6 | 16.1 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1946 | 23.6 | 21.7 | 19.9 | 18.2 | 16.6 | 15.2 | 14.0 | 12.9 | 11.9 | 11.0 | 77.8 | 44.1 | 26.5 | 16.1 | 9.8 | 5.9 | 3.6 | 2.2 | 3.3 |
| 1947 | 24.0 | 22.4 | 20.7 | 18.9 | 17.3 | 15.8 | 14.5 | 13.3 | 12.2 | 11.3 | 78.8 | 44.1 | 26.5 | 16.1 | 9.7 | 5.9 | 3.6 | 2.1 | 3.3 |
| 1948 | 24.1 | 22.9 | 21.3 | 19.7 | 18.0 | 16.4 | 15.0 | 13.8 | 12.6 | 11.6 | 80.1 | 44.3 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.1 | 3.3 |
| 1949 | 23.6 | 22.9 | 21.7 | 20.3 | 18.7 | 17.1 | 15.6 | 14.3 | 13.1 | 12.0 | 81.5 | 44.4 | 26.4 | 16.0 | 9.7 | 5.9 | 3.6 | 2.1 | 3.3 |
| 1950 | 22.6 | 22.4 | 21.8 | 20.7 | 19.3 | 17.8 | 16.3 | 14.9 | 13.6 | 12.4 | 83.2 | 44.5 | 26.4 | 16.0 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1951 | 21.3 | 21.5 | 21.3 | 20.7 | 19.6 | 18.3 | 16.9 | 15.5 | 14.1 | 12.9 | 85.2 | 44.8 | 26.4 | 16.0 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1952 | 19.8 | 20.3 | 20.4 | 20.3 | 19.7 | 18.7 | 17.4 | 16.1 | 14.7 | 13.4 | 87.5 | 45.0 | 26.4 | 15.9 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1953 | 18.3 | 18.9 | 19.3 | 19.4 | 19.3 | 18.7 | 17.8 | 16.6 | 15.3 | 14.0 | 90.1 | 45.3 | 26.4 | 15.9 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1954 | 16.9 | 17.4 | 17.9 | 18.3 | 18.5 | 18.3 | 17.8 | 16.9 | 15.7 | 14.5 | 93.0 | 45.7 | 26.4 | 15.9 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1955 | 15.5 | 16.0 | 16.6 | 17.0 | 17.4 | 17.6 | 17.4 | 16.9 | 16.0 | 15.0 | 96.1 | 46.1 | 26.4 | 15.9 | 9.7 | 5.9 | 3.5 | 2.1 | 3.3 |
| 1956 | 14.3 | 14.8 | 15.3 | 15.8 | 16.2 | 16.5 | 16.7 | 16.6 | 16.1 | 15.3 | 99.4 | 46.7 | 26.4 | 15.9 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1957 | 13.2 | 13.6 | 14.0 | 14.5 | 15.0 | 15.4 | 15.7 | 15.9 | 15.7 | 15.3 | 102.6 | 47.2 | 26.4 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1958 | 12.3 | 12.6 | 12.9 | 13.4 | 13.8 | 14.2 | 14.6 | 15.0 | 15.1 | 15.0 | 105.6 | 47.9 | 26.4 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1959 | 11.4 | 11.7 | 11.9 | 12.3 | 12.7 | 13.1 | 13.5 | 13.9 | 14.2 | 14.3 | 107.9 | 48.8 | 26.5 | 15.8 | 9.6 | 5.8 | 3.5 | 2.1 | 3.3 |
| 1960 | 10.7 | 10.9 | 11.1 | 11.4 | 11.7 | 12.1 | 12.5 | 12.9 | 13.2 | 13.5 | 109.3 | 49.8 | 26.6 | 15.8 | 9.5 | 5.8 | 3.5 | 2.1 | 3.2 |
| 1961 | 10.1 | 10.2 | 10.3 | 10.5 | 10.8 | 11.1 | 11.5 | 11.9 | 12.2 | 12.6 | 109.6 | 50.9 | 26.7 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.2 |
| 1962 | 9.7 | 9.6 | 9.7 | 9.8 | 10.0 | 10.3 | 10.6 | 10.9 | 11.3 | 11.6 | 108.7 | 52.2 | 26.8 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.2 |
| 1963 | 9.4 | 9.2 | 9.1 | 9.2 | 9.3 | 9.5 | 9.8 | 10.1 | 10.4 | 10.7 | 106.7 | 53.7 | 27.0 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.2 |
| 1964 | 9.2 | 8.9 | 8.7 | 8.7 | 8.8 | 8.9 | 9.1 | 9.3 | 9.6 | 9.9 | 103.6 | 55.5 | 27.2 | 15.7 | 9.5 | 5.8 | 3.5 | 2.1 | 3.2 |
| 1965 | 9.3 | 8.8 | 8.5 | 8.3 | 8.3 | 8.3 | 8.4 | 8.6 | 8.8 | 9.1 | 99.6 | 57.4 | 27.4 | 15.7 | 9.5 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1966 | 9.6 | 8.8 | 8.3 | 8.0 | 7.9 | 7.9 | 7.9 | 8.0 | 8.2 | 8.4 | 94.7 | 59.3 | 27.7 | 15.7 | 9.4 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1967 | 10.1 | 9.1 | 8.4 | 7.9 | 7.6 | 7.5 | 7.5 | 7.5 | 7.6 | 7.8 | 88.9 | 60.9 | 28.0 | 15.7 | 9.4 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1968 | 11.0 | 9.6 | 8.6 | 8.0 | 7.5 | 7.3 | 7.1 | 7.1 | 7.1 | 7.2 | 82.9 | 62.4 | 28.3 | 15.6 | 9.3 | 5.7 | 3.5 | 2.1 | 3.2 |
| 1969 | 12.1 | 10.4 | 9.1 | 8.2 | 7.6 | 7.2 | 6.9 | 6.8 | 6.7 | 6.8 | 76.9 | 63.3 | 28.6 | 15.5 | 9.3 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1970 | 13.4 | 11.5 | 9.9 | 8.7 | 7.8 | 7.2 | 6.8 | 6.6 | 6.4 | 6.4 | 71.4 | 64.1 | 29.1 | 15.6 | 9.2 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1971 | 14.6 | 12.7 | 10.9 | 9.4 | 8.3 | 7.4 | 6.8 | 6.5 | 6.2 | 6.1 | 66.3 | 64.2 | 29.7 | 15.6 | 9.2 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1972 | 15.3 | 13.9 | 12.1 | 10.4 | 8.9 | 7.9 | 7.1 | 6.5 | 6.1 | 5.9 | 61.6 | 63.5 | 30.4 | 15.6 | 9.2 | 5.6 | 3.4 | 2.1 | 3.2 |
| 1973 | 15.3 | 14.6 | 13.2 | 11.5 | 9.9 | 8.5 | 7.5 | 6.7 | 6.2 | 5.8 | 57.4 | 61.9 | 31.1 | 15.6 | 9.1 | 5.5 | 3.4 | 2.1 | 3.2 |
| 1974 | 14.8 | 14.6 | 13.8 | 12.5 | 10.9 | 9.4 | 8.1 | 7.1 | 6.4 | 5.9 | 53.7 | 59.4 | 31.7 | 15.6 | 9.0 | 5.5 | 3.4 | 2.0 | 3.2 |
| 1975 | 13.8 | 14.0 | 13.9 | 13.2 | 11.9 | 10.4 | 8.9 | 7.7 | 6.7 | 6.1 | 51.0 | 56.8 | 32.6 | 15.6 | 9.0 | 5.4 | 3.3 | 2.0 | 3.2 |
| 1976 | 13.0 | 13.2 | 13.3 | 13.2 | 12.5 | 11.3 | 9.9 | 8.5 | 7.3 | 6.4 | 49.0 | 53.7 | 33.4 | 15.7 | 8.9 | 5.4 | 3.3 | 2.0 | 3.1 |

**Table 18: Estimated numbers at age of males (continued)**

| Year | Age(s) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 12.5 | 12.3 | 12.5 | 12.7 | 12.5 | 11.9 | 10.8 | 9.4 | 8.0 | 6.9 | 47.9 | 50.5 | 34.4 | 15.8 | 8.9 | 5.4 | 3.3 | 2.0 | 3.1 |
| 1978 | 12.6 | 11.9 | 11.7 | 11.9 | 12.1 | 11.9 | 11.3 | 10.2 | 8.9 | 7.6 | 47.7 | 47.1 | 35.2 | 16.0 | 8.9 | 5.3 | 3.3 | 2.0 | 3.1 |
| 1979 | 13.0 | 11.9 | 11.3 | 11.1 | 11.3 | 11.5 | 11.3 | 10.8 | 9.7 | 8.5 | 48.5 | 43.8 | 35.8 | 16.2 | 8.9 | 5.3 | 3.3 | 2.0 | 3.1 |
| 1980 | 13.5 | 12.4 | 11.3 | 10.7 | 10.6 | 10.8 | 10.9 | 10.8 | 10.2 | 9.2 | 50.3 | 40.5 | 36.1 | 16.4 | 8.8 | 5.3 | 3.2 | 2.0 | 3.1 |
| 1981 | 14.3 | 12.9 | 11.8 | 10.8 | 10.2 | 10.1 | 10.2 | 10.4 | 10.2 | 9.7 | 52.9 | 37.6 | 36.0 | 16.7 | 8.8 | 5.2 | 3.2 | 2.0 | 3.1 |
| 1982 | 15.5 | 13.6 | 12.2 | 11.2 | 10.3 | 9.7 | 9.6 | 9.7 | 9.8 | 9.7 | 55.9 | 34.8 | 35.5 | 17.0 | 8.8 | 5.2 | 3.2 | 2.0 | 3.1 |
| 1983 | 16.8 | 14.8 | 12.9 | 11.6 | 10.6 | 9.7 | 9.2 | 9.1 | 9.2 | 9.3 | 58.8 | 32.4 | 34.5 | 17.4 | 8.8 | 5.2 | 3.2 | 2.0 | 3.1 |
| 1984 | 17.5 | 16.0 | 14.1 | 12.3 | 11.1 | 10.1 | 9.3 | 8.8 | 8.6 | 8.7 | 60.9 | 30.1 | 33.0 | 17.7 | 8.7 | 5.1 | 3.1 | 1.9 | 3.0 |
| 1985 | 18.0 | 16.7 | 15.2 | 13.4 | 11.7 | 10.5 | 9.6 | 8.8 | 8.3 | 8.2 | 62.2 | 28.2 | 31.2 | 18.0 | 8.7 | 5.0 | 3.1 | 1.9 | 3.0 |
| 1986 | 18.3 | 17.1 | 15.8 | 14.5 | 12.7 | 11.1 | 10.0 | 9.1 | 8.3 | 7.9 | 62.8 | 26.7 | 29.1 | 18.2 | 8.6 | 5.0 | 3.0 | 1.9 | 3.0 |
| 1987 | 17.8 | 17.4 | 16.3 | 15.1 | 13.7 | 12.1 | 10.5 | 9.5 | 8.6 | 7.9 | 63.3 | 25.9 | 27.1 | 18.6 | 8.6 | 4.9 | 3.0 | 1.9 | 3.0 |
| 1988 | 16.8 | 16.9 | 16.5 | 15.5 | 14.3 | 13.1 | 11.5 | 10.0 | 9.0 | 8.2 | 63.5 | 25.6 | 25.1 | 18.9 | 8.7 | 4.9 | 3.0 | 1.9 | 3.0 |
| 1989 | 15.9 | 16.0 | 16.1 | 15.7 | 14.7 | 13.6 | 12.4 | 10.9 | 9.5 | 8.5 | 63.6 | 25.8 | 23.1 | 19.0 | 8.7 | 4.8 | 2.9 | 1.8 | 2.9 |
| 1990 | 15.7 | 15.1 | 15.2 | 15.3 | 14.9 | 14.0 | 12.9 | 11.8 | 10.3 | 9.0 | 63.1 | 26.2 | 20.9 | 18.8 | 8.7 | 4.7 | 2.9 | 1.8 | 2.9 |
| 1991 | 16.3 | 15.0 | 14.4 | 14.4 | 14.6 | 14.2 | 13.3 | 12.3 | 11.2 | 9.8 | 62.6 | 27.1 | 19.0 | 18.4 | 8.7 | 4.7 | 2.8 | 1.8 | 2.9 |
| 1992 | 16.4 | 15.5 | 14.2 | 13.7 | 13.7 | 13.8 | 13.5 | 12.6 | 11.6 | 10.5 | 62.8 | 28.2 | 17.3 | 17.9 | 8.8 | 4.6 | 2.8 | 1.8 | 2.9 |
| 1993 | 13.8 | 15.6 | 14.7 | 13.5 | 13.0 | 13.0 | 13.1 | 12.8 | 11.9 | 11.0 | 63.9 | 29.3 | 15.9 | 17.2 | 8.9 | 4.6 | 2.8 | 1.7 | 2.8 |
| 1994 | 10.9 | 13.2 | 14.8 | 14.0 | 12.8 | 12.3 | 12.4 | 12.5 | 12.1 | 11.3 | 65.3 | 30.0 | 14.6 | 16.4 | 9.0 | 4.5 | 2.7 | 1.7 | 2.8 |
| 1995 | 9.6 | 10.3 | 12.5 | 14.1 | 13.3 | 12.2 | 11.7 | 11.7 | 11.8 | 11.5 | 67.4 | 30.5 | 13.6 | 15.4 | 9.1 | 4.5 | 2.7 | 1.7 | 2.8 |
| 1996 | 9.9 | 9.1 | 9.8 | 11.9 | 13.4 | 12.6 | 11.6 | 11.1 | 11.1 | 11.2 | 70.4 | 31.0 | 13.0 | 14.5 | 9.3 | 4.5 | 2.7 | 1.7 | 2.8 |
| 1997 | 12.2 | 9.4 | 8.7 | 9.3 | 11.3 | 12.7 | 12.0 | 11.0 | 10.6 | 10.6 | 73.2 | 31.3 | 12.6 | 13.5 | 9.5 | 4.5 | 2.6 | 1.6 | 2.7 |
| 1998 | 15.7 | 11.6 | 8.9 | 8.3 | 8.9 | 10.8 | 12.1 | 11.4 | 10.5 | 10.0 | 75.2 | 31.5 | 12.5 | 12.5 | 9.6 | 4.5 | 2.6 | 1.6 | 2.7 |
| 1999 | 14.9 | 14.9 | 11.1 | 8.5 | 7.9 | 8.4 | 10.2 | 11.5 | 10.8 | 9.9 | 76.5 | 31.8 | 12.7 | 11.6 | 9.8 | 4.6 | 2.6 | 1.6 | 2.7 |
| 2000 | 12.7 | 14.1 | 14.2 | 10.5 | 8.1 | 7.5 | 8.0 | 9.7 | 10.9 | 10.3 | 77.6 | 32.2 | 13.1 | 10.7 | 9.8 | 4.6 | 2.6 | 1.6 | 2.7 |
| 2001 | 11.5 | 12.1 | 13.5 | 13.5 | 10.0 | 7.7 | 7.1 | 7.6 | 9.2 | 10.4 | 78.7 | 32.7 | 13.9 | 9.9 | 9.8 | 4.7 | 2.6 | 1.6 | 2.7 |
| 2002 | 10.3 | 10.9 | 11.5 | 12.8 | 12.8 | 9.5 | 7.3 | 6.7 | 7.3 | 8.8 | 79.3 | 33.5 | 14.7 | 9.2 | 9.7 | 4.8 | 2.6 | 1.6 | 2.7 |
| 2003 | 10.3 | 9.8 | 10.4 | 10.9 | 12.2 | 12.2 | 9.0 | 6.9 | 6.4 | 6.9 | 77.9 | 34.7 | 15.6 | 8.6 | 9.4 | 4.9 | 2.6 | 1.6 | 2.6 |
| 2004 | 11.2 | 9.8 | 9.3 | 9.9 | 10.4 | 11.6 | 11.6 | 8.6 | 6.6 | 6.1 | 74.5 | 36.2 | 16.4 | 8.0 | 9.1 | 5.0 | 2.6 | 1.6 | 2.6 |
| 2005 | 13.6 | 10.7 | 9.3 | 8.9 | 9.4 | 9.9 | 11.0 | 11.0 | 8.2 | 6.3 | 70.2 | 38.0 | 16.9 | 7.6 | 8.7 | 5.2 | 2.6 | 1.6 | 2.6 |
| 2006 | 16.4 | 12.9 | 10.2 | 8.8 | 8.4 | 8.9 | 9.4 | 10.4 | 10.5 | 7.8 | 66.2 | 40.0 | 17.4 | 7.3 | 8.2 | 5.3 | 2.6 | 1.6 | 2.6 |
| 2007 | 16.5 | 15.6 | 12.3 | 9.7 | 8.4 | 8.0 | 8.5 | 8.9 | 9.9 | 9.9 | 63.9 | 41.8 | 17.7 | 7.2 | 7.7 | 5.5 | 2.6 | 1.5 | 2.6 |
| 2008 | 15.5 | 15.7 | 14.8 | 11.7 | 9.2 | 8.0 | 7.6 | 8.1 | 8.5 | 9.4 | 64.1 | 43.0 | 17.9 | 7.1 | 7.2 | 5.6 | 2.6 | 1.5 | 2.6 |
| 2009 | 15.1 | 14.7 | 14.9 | 14.1 | 11.1 | 8.7 | 7.6 | 7.2 | 7.6 | 8.0 | 63.9 | 43.6 | 18.0 | 7.2 | 6.6 | 5.7 | 2.7 | 1.5 | 2.6 |
| 2010 | 15.2 | 14.4 | 14.0 | 14.2 | 13.4 | 10.6 | 8.3 | 7.2 | 6.9 | 7.2 | 62.4 | 44.0 | 18.1 | 7.4 | 6.1 | 5.7 | 2.7 | 1.5 | 2.5 |
| 2011 | 13.7 | 14.5 | 13.6 | 13.3 | 13.5 | 12.7 | 10.0 | 7.9 | 6.8 | 6.5 | 60.2 | 44.4 | 18.3 | 7.8 | 5.6 | 5.7 | 2.7 | 1.5 | 2.5 |
| 2012 | 14.4 | 13.0 | 13.8 | 13.0 | 12.6 | 12.8 | 12.1 | 9.5 | 7.5 | 6.5 | 57.6 | 44.6 | 18.7 | 8.3 | 5.2 | 5.6 | 2.8 | 1.5 | 2.5 |
| 2013 | 14.4 | 13.7 | 12.4 | 13.1 | 12.3 | 12.0 | 12.2 | 11.5 | 9.1 | 7.1 | 56.0 | 43.8 | 19.4 | 8.8 | 4.9 | 5.4 | 2.9 | 1.5 | 2.5 |

## Appendix B. SS data file

```
# Shortspine Thornyhead data file
# Ian Taylor and Andi Stephens, 2013
#
#  uses SSv3.24o (April 10, 2013)
#
### Global model specifications ###
#
1901    # Start_year
2012    # End_year
1       # N seasons per year
12      # Months per season
1       # Spawning season - spawning will occur at beginning of this season
4       # N fishing fleets
5       # N surveys
1       # N areas
#
# Fishery/Survey Names
#
Trawl_N%Trawl_S%Non-trawl_N%Non-trawl_S%Triennial1%Triennial2%AFSCslope%NWFSCslope%NWFSCcombo
#
# Further specifications
#
0.5  0.5  0.5  0.5 0.5 0.5 0.5 0.5 0.5 # Timing of each fishery/survey
1    1    1    1   1   1   1   1   1   # Area of each fleet
1    1    1    1             # Units for catch per fleet: 1=Biomass(mt), 2=Numbers(1000s)
0.01 0.01 0.01 0.01          # SE of log(catch) per fleet for equilibrium and continuous options
2                            # Number of genders
100                          # Number of ages
#
### Catch section ###
#
# Initial equilibrium catch (landings + discard) by fishing fleet
0  0  0  0
#
# Nyears Catch
# Nyears Catch
112
#NTrawl STrawl  NOther  SOther  Year Season
0       2       0       0       1901    1
0       2       0       0       1902    1
0       4       0       0       1903    1
0       5       0       0       1904    1
0       6       0       0       1905    1
0       8       0       0       1906    1
0       9       0       0       1907    1
0       10      0       0       1908    1
0       11      0       0       1909    1
0       13      0       0       1910    1
0       14      0       0       1911    1
```

| | | | | | |
|---|---|---|---|---|---|
| 0 | 15 | 0 | 0 | 1912 | 1 |
| 0 | 17 | 0 | 0 | 1913 | 1 |
| 0 | 17 | 0 | 0 | 1914 | 1 |
| 0 | 19 | 0 | 0 | 1915 | 1 |
| 0 | 20 | 0 | 0 | 1916 | 1 |
| 0 | 21 | 0 | 0 | 1917 | 1 |
| 0 | 23 | 0 | 0 | 1918 | 1 |
| 0 | 24 | 0 | 0 | 1919 | 1 |
| 0 | 25 | 0 | 0 | 1920 | 1 |
| 0 | 26 | 0 | 0 | 1921 | 1 |
| 0 | 28 | 0 | 0 | 1922 | 1 |
| 0 | 29 | 0 | 0 | 1923 | 1 |
| 0 | 30 | 0 | 0 | 1924 | 1 |
| 0 | 32 | 0 | 0 | 1925 | 1 |
| 0 | 32 | 0 | 0 | 1926 | 1 |
| 0 | 34 | 0 | 0 | 1927 | 1 |
| 0 | 35 | 0 | 0 | 1928 | 1 |
| 0 | 36 | 0 | 0 | 1929 | 1 |
| 0 | 38 | 0 | 0 | 1930 | 1 |
| 0 | 39 | 0 | 0 | 1931 | 1 |
| 0 | 40 | 0 | 0 | 1932 | 1 |
| 0 | 49 | 0 | 0 | 1933 | 1 |
| 0 | 49 | 0 | 0 | 1934 | 1 |
| 0 | 49 | 0 | 0 | 1935 | 1 |
| 0 | 51 | 0 | 0 | 1936 | 1 |
| 0 | 47 | 0 | 0 | 1937 | 1 |
| 0 | 53 | 0 | 0 | 1938 | 1 |
| 0 | 63 | 0 | 0 | 1939 | 1 |
| 0 | 76 | 0 | 0 | 1940 | 1 |
| 0 | 109 | 0 | 0 | 1941 | 1 |
| 0 | 122 | 0 | 0 | 1942 | 1 |
| 0 | 269 | 0 | 0 | 1943 | 1 |
| 0 | 380 | 0 | 0 | 1944 | 1 |
| 0 | 453 | 0 | 0 | 1945 | 1 |
| 0 | 216 | 0 | 0 | 1946 | 1 |
| 0 | 48 | 0 | 0 | 1947 | 1 |
| 0 | 152 | 0 | 0 | 1948 | 1 |
| 0 | 168 | 0 | 0 | 1949 | 1 |
| 0 | 153 | 0 | 0 | 1950 | 1 |
| 0 | 305 | 0 | 0 | 1951 | 1 |
| 0 | 176 | 0 | 0 | 1952 | 1 |
| 0 | 68 | 0 | 0 | 1953 | 1 |
| 0 | 128 | 0 | 0 | 1954 | 1 |
| 0 | 128 | 0 | 0 | 1955 | 1 |
| 0 | 776 | 0 | 0 | 1956 | 1 |
| 0 | 286 | 0 | 0 | 1957 | 1 |
| 0 | 296 | 0 | 0 | 1958 | 1 |
| 0 | 398 | 0 | 0 | 1959 | 1 |
| 0 | 472 | 0 | 0 | 1960 | 1 |
| 0 | 437 | 0 | 0 | 1961 | 1 |
| 0 | 230 | 0 | 0 | 1962 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 285 | 0 | 0 | 1963 | 1 |
| 12 | 172 | 0 | 0 | 1964 | 1 |
| 20 | 400 | 0 | 0 | 1965 | 1 |
| 612 | 543 | 0 | 0 | 1966 | 1 |
| 369 | 864 | 0 | 0 | 1967 | 1 |
| 168 | 1835 | 0 | 0 | 1968 | 1 |
| 155 | 400 | 0 | 0 | 1969 | 1 |
| 149 | 557 | 0 | 0 | 1970 | 1 |
| 260 | 582 | 0 | 0 | 1971 | 1 |
| 389 | 1297 | 0 | 0 | 1972 | 1 |
| 712 | 2377 | 0 | 0 | 1973 | 1 |
| 215 | 1244 | 0 | 0 | 1974 | 1 |
| 405 | 1867 | 0 | 0 | 1975 | 1 |
| 52 | 992 | 0 | 0 | 1976 | 1 |
| 91 | 1359 | 0 | 0 | 1977 | 1 |
| 76 | 1136 | 0 | 0 | 1978 | 1 |
| 109 | 1720 | 0 | 0 | 1979 | 1 |
| 87 | 1192 | 0 | 0 | 1980 | 1 |
| 242.3 | 1622.8 | 0 | 0.5 | 1981 | 1 |
| 553.7 | 1655.4 | 0 | 0.5 | 1982 | 1 |
| 1492.8 | 1562.1 | 0 | 0.5 | 1983 | 1 |
| 1681.4 | 1961.2 | 0 | 0.5 | 1984 | 1 |
| 1345.9 | 2559.9 | 0 | 1.7 | 1985 | 1 |
| 457.7 | 2422.3 | 0 | 2.6 | 1986 | 1 |
| 558.3 | 1953.0 | 4.2 | 3.2 | 1987 | 1 |
| 696.4 | 2163.1 | 23.1 | 2.1 | 1988 | 1 |
| 1340.4 | 3506.4 | 29.3 | 9.9 | 1989 | 1 |
| 1917.7 | 2227.5 | 27 | 3.3 | 1990 | 1 |
| 2157.0 | 1306.4 | 53.8 | 1.5 | 1991 | 1 |
| 1669.2 | 1625.1 | 51.9 | 9.3 | 1992 | 1 |
| 2037.1 | 1773.9 | 24.4 | 1.1 | 1993 | 1 |
| 1835.3 | 1537.8 | 20.3 | 2.9 | 1994 | 1 |
| 815.0 | 1064.2 | 28.1 | 32.4 | 1995 | 1 |
| 686.2 | 830.9 | 21.2 | 80.6 | 1996 | 1 |
| 579.5 | 771.3 | 23 | 40.2 | 1997 | 1 |
| 504.7 | 668.9 | 17 | 47.3 | 1998 | 1 |
| 318.9 | 398.1 | 17.6 | 99.3 | 1999 | 1 |
| 281.9 | 489.8 | 13.9 | 53.3 | 2000 | 1 |
| 236.2 | 241.2 | 12.6 | 45.6 | 2001 | 1 |
| 231.4 | 428.2 | 10.4 | 104.1 | 2002 | 1 |
| 270.2 | 374.4 | 10.7 | 155.2 | 2003 | 1 |
| 294.6 | 319.4 | 10.5 | 128.8 | 2004 | 1 |
| 254.7 | 252.4 | 10.7 | 138.9 | 2005 | 1 |
| 295.7 | 246.8 | 15.4 | 143.7 | 2006 | 1 |
| 562.4 | 278.9 | 16.2 | 142.5 | 2007 | 1 |
| 902.0 | 325.3 | 19.8 | 175.4 | 2008 | 1 |
| 947.7 | 382.1 | 28.5 | 172.2 | 2009 | 1 |
| 770.3 | 356.7 | 22.2 | 206.1 | 2010 | 1 |
| 424.3 | 286.5 | 24.3 | 237 | 2011 | 1 |
| 380.5 | 322.5 | 35.7 | 155.1 | 2012 | 1 |

#

```
#
### Abundance Indices ###
#
32 # N observations
#
# Units:  0=numbers; 1=biomass; 2=F
# Errtype:  -1=normal; 0=lognormal; >0=T
#_Fleet Units  Errtype
1       1      0    #_NorthTrawl
2       1      0    #_SouthTrawl
3       1      0    #_NorthOther
4       1      0    #_SouthOther
5       1      0    #_Triennial1
6       1      0    #_Triennial2
7       1      0    #_AFSCslope
8       1      0    #_NWFSCslope
9       1      0    #_NWFSCcombo


### AFSC triennial survey
### Shallow/Deep alternative: Shallow triennial for all years
#Year Seas    Fishery Value   sd_log
1980  1       5       2660    0.14397
1983  1       5       3415    0.11794
1986  1       5       1636    0.13302
1989  1       5       2010    0.13880
1992  1       5       2064    0.17697
1995  1       5       3480    0.15198
1998  1       5       3076    0.15184
2001  1       5       3698    0.14188
2004  1       5       4117    0.18055

### Shallow/Deep alternative: Deep triennial only for 1995+
#Year Seas    Fishery Value   sd_log
1995  1       6       3523    0.12239
1998  1       6       2815    0.12634
2001  1       6       3384    0.12357
2004  1       6       3504    0.12889

### AFSC slope survey
#Year   Seas    Fishery Value   sd_log
1997    1       7       27148   0.08413
1999    1       7       25641   0.08243
2000    1       7       31971   0.08342
2001    1       7       31567   0.08090

### NWFSC slope survey
### calculations are in \GLMM_results\NWSurveys_2e5_iter\SSPN_Early\
#Year   Seas    Fishery Value   sd_log
1998    1       8       27416   0.08592
1999    1       8       28311   0.07894
```

```
2000    1       8       30897   0.08111
2001    1       8       26376   0.08015
2002    1       8       32404   0.07977

### NWFSC combo survey
### calculations are in \GLMM_results\NWSurveys_2e5_iter\SSPN_Late\
#Year   Seas    Fishery Value   sd_log
2003    1       9       52474   0.10313
2004    1       9       53885   0.10477
2005    1       9       48155   0.09085
2006    1       9       48076   0.08847
2007    1       9       48499   0.08276
2008    1       9       44137   0.08622
2009    1       9       58430   0.09584
2010    1       9       46489   0.09002
2011    1       9       48556   0.08926
2012    1       9       53045   0.10120
#
#
# N fleets with discard
4
#_Fleet Units Errtype
1       2      30
2       2      30
3       2      30
4       2      30
#
# N observations
48
### Pikitch data from John Wallace
### code is in c:/SS/Thornyheads/Data/Pikitch/Pikitch_discard_rates_code.R, which references stuff from John
#Year   Seas    Fishery Value           CV
1985    1       1       0.3007437       0.875096968
1986    1       1       0.3057904       0.871989114
1987    1       1       0.390653        0.755043223

### Discard rates from ECDP taken from 2005 shortspine assessment
#Year   Seas    Fishery Value           CV
1995    1       1       0.132           0.40
1996    1       1       0.155           0.20
1997    1       1       0.201           0.21
1998    1       1       0.136           0.22
1999    1       1       0.252           0.30

### WCGOP data based on code from Jason Jannot

#Year   Seas    Fishery Value           CV              #_note
2002    1       1       0.335245159     0.086828889     #_Bottom_Trawl_WAOR
2003    1       1       0.432544649     0.077544931     #_Bottom_Trawl_WAOR
2004    1       1       0.241343211     0.104530141     #_Bottom_Trawl_WAOR
2005    1       1       0.199355761     0.168445593     #_Bottom_Trawl_WAOR
```

```
2006	1	1	0.179544612	0.168130911	#_Bottom_Trawl_WAOR
2007	1	1	0.108599973	0.180051291	#_Bottom_Trawl_WAOR
2008	1	1	0.046659398	0.230100051	#_Bottom_Trawl_WAOR
2009	1	1	0.101435957	0.191825142	#_Bottom_Trawl_WAOR
2010	1	1	0.087443339	0.222646136	#_Bottom_Trawl_WAOR
2011	1	1	0.006739797	0.001		#_Bottom_Trawl_WAOR_catch-shares_fully_observed_has_assumed_tiny_CV
2002	1	2	0.279645087	0.151118174	#_Bottom_Trawl_CA
2003	1	2	0.201024932	0.141541966	#_Bottom_Trawl_CA
2004	1	2	0.209662602	0.237090534	#_Bottom_Trawl_CA
2005	1	2	0.151047698	0.205977662	#_Bottom_Trawl_CA
2006	1	2	0.095571796	0.314441499	#_Bottom_Trawl_CA
2007	1	2	0.028857912	0.266351701	#_Bottom_Trawl_CA
2008	1	2	0.025042737	0.244805907	#_Bottom_Trawl_CA
2009	1	2	0.024825575	0.186500398	#_Bottom_Trawl_CA
2010	1	2	0.02119381	0.223866125	#_Bottom_Trawl_CA
2011	1	2	0.008817099	0.001		#_Bottom_Trawl_CA_catch-shares_fully_observed_has_assumed_tiny_CV
2002	1	3	0.04212257	0.363439925	#_H&L_WAOR
2003	1	3	0.115775182	0.378023795	#_H&L_WAOR
2004	1	3	0.137199236	0.562925392	#_H&L_WAOR
2005	1	3	0.086555528	0.24160193	#_H&L_WAOR
2006	1	3	0.145679196	0.739064372	#_H&L_WAOR
2007	1	3	0.229120952	0.320967658	#_H&L_WAOR
2008	1	3	0.111293876	0.426373646	#_H&L_WAOR
2009	1	3	0.063697859	2.135161651	#_H&L_WAOR
2010	1	3	0.100494748	0.306851214	#_H&L_WAOR
2011	1	3	0.098921828	0.419172661	#_H&L_WAOR
2002	1	4	0.209165098	0.286389385	#_H&L_CA
2003	1	4	0.172752926	0.161447006	#_H&L_CA
2004	1	4	0.123425508	0.207194228	#_H&L_CA
2005	1	4	0.063810176	0.232701577	#_H&L_CA
2006	1	4	0.112808086	0.302538535	#_H&L_CA
2007	1	4	0.063235119	0.115288264	#_H&L_CA
2008	1	4	0.051092247	0.167925949	#_H&L_CA
2009	1	4	0.062246542	0.145575545	#_H&L_CA
2010	1	4	0.087162496	0.210516003	#_H&L_CA
2011	1	4	0.04912734	0.101605531	#_H&L_CA_combination_of_catch-shares_and_non-catch-shares
##
### Average weight of discards
# Value is from Wghtd_AVG_W
# CV is ratio of AVG_WEIGHT.SD/AVG_WEIGHT.MEAN
40	#N observations
30	#Degrees of freedom for Student's T distribution used to evaluate mean body weight deviations.
	# (Not conditional, must be here even if no mean body wt observations.)
#Year	Seas	Fleet	Partition	Value	CV		#	Gear		State
2002	1	1	1	0.364642072	2.118749079	#	ALL TRAWL	WA-OR
2003	1	1	1	0.431779002	1.264625597	#	ALL TRAWL	WA-OR
2004	1	1	1	0.372344756	1.025736743	#	ALL TRAWL	WA-OR
2005	1	1	1	0.343027331	0.814245184	#	ALL TRAWL	WA-OR
2006	1	1	1	0.310969633	12.62000381	#	ALL TRAWL	WA-OR
2007	1	1	1	0.256335672	0.743340316	#	ALL TRAWL	WA-OR
2008	1	1	1	0.181144246	1.006699102	#	ALL TRAWL	WA-OR
```

```
2009    1       1       1       0.228195667     0.621404079     #       ALL TRAWL       WA-OR
2010    1       1       1       0.230299418     1.63260079      #       ALL TRAWL       WA-OR
2011    1       1       1       0.132364976     2.519562237     #       ALL TRAWL       WA-OR
2002    1       2       1       1.203992327     0.939911162     #       ALL TRAWL       CA
2003    1       2       1       0.951036879     0.924020709     #       ALL TRAWL       CA
2004    1       2       1       0.866807099     0.931865538     #       ALL TRAWL       CA
2005    1       2       1       0.859717225     1.04266895      #       ALL TRAWL       CA
2006    1       2       1       0.606677363     1.088379327     #       ALL TRAWL       CA
2007    1       2       1       0.233209182     2.866227179     #       ALL TRAWL       CA
2008    1       2       1       0.240984699     1.573568927     #       ALL TRAWL       CA
2009    1       2       1       0.283314819     1.347244662     #       ALL TRAWL       CA
2010    1       2       1       0.289119393     1.843418882     #       ALL TRAWL       CA
2011    1       2       1       0.241109466     1.218321567     #       ALL TRAWL       CA
2002    1       3       1       0.935587086     0.796707154     #       OTHER GEAR      WA-OR
2003    1       3       1       1.362731591     0.794783992     #       OTHER GEAR      WA-OR
2004    1       3       1       1.289451512     0.640189562     #       OTHER GEAR      WA-OR
2005    1       3       1       1.230766218     0.75118062      #       OTHER GEAR      WA-OR
2006    1       3       1       1.70271943      0.485157236     #       OTHER GEAR      WA-OR
2007    1       3       1       1.941936392     0.603611928     #       OTHER GEAR      WA-OR
2008    1       3       1       1.4616857       0.603113256     #       OTHER GEAR      WA-OR
2009    1       3       1       1.538109678     0.581701899     #       OTHER GEAR      WA-OR
2010    1       3       1       1.515242478     0.733887181     #       OTHER GEAR      WA-OR
2011    1       3       1       1.929418253     0.866996647     #       OTHER GEAR      WA-OR
2002    1       4       1       0.773613445     0.866608059     #       OTHER GEAR      CA
2003    1       4       1       0.938616528     0.665412757     #       OTHER GEAR      CA
2004    1       4       1       0.863882591     0.680271218     #       OTHER GEAR      CA
2005    1       4       1       0.940173578     0.956812123     #       OTHER GEAR      CA
2006    1       4       1       0.617362917     0.555537579     #       OTHER GEAR      CA
2007    1       4       1       0.232538998     0.688254613     #       OTHER GEAR      CA
2008    1       4       1       0.411108216     1.06005575      #       OTHER GEAR      CA
2009    1       4       1       0.280832591     0.799593801     #       OTHER GEAR      CA
2010    1       4       1       1.044745397     0.706886658     #       OTHER GEAR      CA
2011    1       4       1       0.927216543     0.547415781     #       OTHER GEAR      CA
#
# Length data
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
# no additional input for option 1
# read binwidth, minsize, lastbin size for option 2
2  # width
4  # minsize
90 # maxsize
# read N poplen bins, then vector of bin lower boundaries, for option 3
-0.001 #_comp_tail_compression
0.001  #_add_to_comp
0 #_combine males into females at or below this bin number
34 #_N_LengthBins
6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72
#
161   # number of observations
### multiplier for inputN = N^p :                               p =     0.6     # this multiplier is applied to column "CC" which is
number of fish
```

```
### PacFIN comps
# created by Andi's excellent code
# Fully expanded combined sexes from "SSPN_Fully_Expanded_Comps.csv"
### Trawl North
#_year  Season  Fleet   gender  partition       inputN  U6      U8      U10     U12     U14     U16     U18     U20     U22     U24
U26     U28     U30     U32     U34     U36     U38     U40     U42     U44     U46     U48     U50     U52     U54     U56     U58
U60     U62     U64     U66     U68     U70     U72     M6      M8      M10     M12     M14     M16     M18     M20     M22     M24
M26     M28     M30     M32     M34     M36     M38     M40     M42     M44     M46     M48     M50     M52     M54     M56     M58
M60     M62     M64     M66     M68     M70     M72
1979    1       1       0       2       38.9    0       0       0       0       0       626.405277      245.2673267     613.1683168
367.9009901     382.1549086     543.2271306     441.1096005     855.4398016     492.7851167     324.285983      485.330046
657.8250564     947.9139122     960.1600227     700.4440979     30.04661492     663.1640505     172.6142808     419.0054398
46.65726309     85.52705684     14.23926427     25.55222486     25.55222486     0       0       64.34140985     1.002304147
25.55222486     0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0
1980    1       1       0       2       28.6    0       0       0       0       0       0       0       21.21710526     0
122.6336634     21.21710526     21.21710526     40.11976048     282.4445531     203.8220521     260.5324311     467.6516855
496.4119063     331.7925783     407.8986385     517.7768373     48.12972771     251.4923642     256.4891968     10.22187005
28.28491771     11.22187005     11.79527632     122.6336634     1       1       10.22187005     0       20.4437401      0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
1981    1       1       0       2       22.6    0       0       0       0       0       0       0       0       0       0
277.971774      0       1348.552644     2062.147007     5650.532506     6084.687444     2394.169716     4559.779356     2785.345084
1810.685872     1573.630928     1295.659154     2844.990843     12.12532049     24.25064097     12.14961973     1307.760175
1283.509534     2579.168689     12.12532049     1283.509534     12.12532049     24.29923945     0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0
1982    1       1       0       2       22.6    0       0       0       0       0       0       0       0       141.0262467
523.7816039     141.0262467     423.07874       10593.11699     9648.898821     11532.73854     9160.438533     5642.774642
5319.226579     2553.118058     4054.820602     465.1924954     334.0209858     2170.362701     5783.838837     416.4581239
4423.16254      82.43713818     2077.45264      334.0209858     223.4633848     1525.550574     82.43713818     141.0262467     0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
1990    1       1       0       2       42.1    0       0       0       0       0       1924.947776     1924.947776     5774.843327
14905.72696     27666.4423      27568.48558     9864.88148      1847.069815     9069.830075     3772.017591     6735.382671
23359.59467     13018.97501     26320.15453     25028.71237     26662.50566     12421.50806     20480.45837     15608.68916
7337.181167     14522.01441     8209.002571     6600.967396     10315.25531     3668.590584     7106.252976     5593.538359
1310.278071     1924.947776     0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0
1991    1       1       0       2       65.3    0       0       0       0       0       0       333.0456247     88.90879198
21413.24098     95250.41859     136595.7272     112333.1227     63427.36283     67626.86423     81490.72307     48402.43843
49514.35549     38630.29679     48288.54562     31287.06857     13839.40397     27694.53994     14511.73812     18100.01391
20159.8324      3823.740062     14620.92732     27283.52312     18611.36944     3510.248662     4349.627476     5017.623552
6831.453701     2482.803179     0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0
1992    1       1       0       2       71.3    0       0       0       0       0       4283.744261     5365.500935     15786.07435
54077.76801     45113.94088     99010.53391     53393.14192     42060.32429     47565.41457     34056.01912     35960.07155
```

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22932.44589	45892.84618	15861.34611	19599.85997	9312.347789	16244.28191	31189.5984	9706.523002
12366.41858	4476.463287	9724.578872	6652.978035	9464.414855	5092.78775	2658.936613	1706.325623
1145.240451	338.6720152	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
1993	1	1	0	2	30.2	0	0	0	0	0	0	5416.211353	39546.82712
52125.0825	52115.5363	57267.77154	63774.80354	14586.66515	37637.42123	49721.20008	16917.67653
14122.83002	8063.225695	12965.58343	6993.775095	27168.29731	23347.55616	10045.06738	9457.51208
2973.246148	11090.42812	9460.622373	2973.246148	26305.33322	1971.631769	13184.11758	3329.746643
1971.631769	8485.702754	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
# next two values turned off after investigation of outliers
1994	1	-1	0	2	9.1	0	0	12713.39147	38140.1744	0	76280.34879	63566.95733
88993.74026	25426.78293	12713.39147	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1995	1	-1	0	2	6.7	0	0	0	0	0	0	0	0	0	0	0
0	0	622.5845188	0	622.5845188	622.5845188	622.5845188	1245.169038	622.5845188	2490.338075
622.5845188	0	1245.169038	0	0	622.5845188	11422.21299	0	5711.106497	5711.106497
5711.106497	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
1996	1	1	0	2	41.5	0	0	0	0	0	0	1654.26599	2424.662486
27660.50029	23466.08213	32985.46835	28967.09679	22002.39485	48447.13798	15307.46481	26874.7827
44070.24734	22224.84517	7997.711487	8774.533502	7183.915352	6620.098545	1305.839118	626.1648094
3929.045226	1612.34413	2042.524985	2150.031018	0	1198.299426	0	0	1198.299426	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	1	1	0	2	104.6	0	0	0	0	635.1738665	640.5539514	5445.218045
7073.243147	15270.90073	14909.45973	21221.76311	15992.63334	9975.498658	10462.8571	10228.1183
7864.847433	9055.687749	6689.867269	5458.986106	7636.338759	4152.832393	5469.863328	6534.989123
4186.716302	5239.854646	3614.080987	3242.603434	3246.350192	2414.441641	556.5159002	733.1062255
88.80798926	734.472811	88.80798926	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
1998	1	1	0	2	53.4	0	0	0	0	0	0	6695.932686	21202.13222
43547.93777	30340.33423	39605.16146	40890.86669	35235.81211	15335.56476	18521.83533	15062.30927
20943.48222	15149.56165	8689.484335	7862.757955	8115.447606	4713.698503	8927.532915	4263.478204
4517.327663	4988.636735	4295.649537	5138.374729	735.1896078	1535.326124	794.5993269	968.8591766
1605.980917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0
1999	1	1	0	2	56	0	0	0	0	0	0	284.2626852	568.5253705
6696.922718	13356.3953	10408.70391	16148.00183	16960.76337	12954.29842	11622.35575	15145.2801
13471.35841	12133.86768	7330.49254	7065.859455	6246.046354	3751.049233	4582.173221	3657.343824
2418.061644	2243.937905	3873.707222	5021.455746	1872.267058	521.7329404	773.2022583	702.0059588
997.6469031	67.41086536	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
```

2000 1 1 0 2 49.2 0 0 0 0 0 0 0 1638.429484 2102.196242
6162.208956 9181.985259 14403.85118 6281.298891 8778.052288 9300.03407 11527.23672 10165.13913
11958.56879 6209.975413 3528.248 5128.884231 6909.749538 4897.094214 3221.659307 3451.945944
2437.368143 2381.868326 1670.981282 2820.286896 1674.2899 839.3506021 111.4432515 80.08084897
272.5284633 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
2001 1 1 0 2 84.7 0 0 0 0 0 15.11692596 232.9897173 3597.255614
3942.158152 3952.050931 5540.840173 7142.354854 5057.200388 4614.118306 7306.099677 4497.135176
4729.396794 3887.309812 4160.380501 4500.160838 5048.766867 4384.068209 2444.298217 3277.014306
3774.857303 2917.975266 2851.207554 2287.438972 2053.979954 958.7921025 420.343676 88.69178368
447.5078842 31.88475175 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2002 1 1 0 2 104.4 0 0 0 0 0 120.4216394 356.2034501 1444.796666
4629.748049 5591.501051 10542.64296 8305.624839 8042.06163 6685.555972 5170.757884 6467.521198
4650.582875 4833.777764 4504.360034 4307.13274 3977.628303 2224.562619 2465.407951 3012.686677
2939.352487 3157.73827 4014.815091 2318.104067 1588.342782 2015.095195 494.1096029 437.3030948
561.5000384 202.1618673 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2003 1 1 0 2 108.3 0 0 0 0 0 26.00615009 106.1969125 879.0673461
7241.16543 14402.38266 10085.09096 8576.775295 9525.500191 6332.217275 5696.1953 5413.446741
5445.437504 5066.963855 5579.154612 3850.481684 3023.184481 3255.901097 1850.689566 3259.15061
2885.984191 2681.099285 3031.984828 2124.090631 2129.611021 1540.925673 828.0948394 206.8154171
215.3130931 174.2923358 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2004 1 1 0 2 80.8 0 0 0 0 0 44.72459162 44.72459162 2442.066316
4696.770148 13206.45432 35544.37189 17921.0061 15882.22489 10568.6648 9779.82033 6509.929639
4955.240031 8062.953975 4015.46027 6205.379543 2911.104475 2956.875875 1426.584331 2059.922552
2560.00969 2817.440252 3239.432611 1905.5808 1214.247748 665.5772482 2268.84844 403.3372719
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2005 1 1 0 2 85.2 0 0 0 0 0 0 361.7306212 5567.6808
11864.25195 23431.729 24682.18201 24800.55441 19870.7376 13681.46981 8541.964174 8525.631951
6424.794651 8121.55857 4937.129422 6606.852918 4345.915421 2666.012003 4014.389674 2730.644437
4088.028014 3103.858716 1957.711343 705.0552482 540.4111413 385.1897696 228.9609973 296.7184702
217.9086997 217.9086997 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0
2006 1 1 0 2 82.8 0 0 0 0 0 417.0722112 722.8554348 2779.754551
19949.43444 12956.98218 19992.40135 27629.94469 24102.57829 15661.84764 10472.68587 11547.54747
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2463.040935 6114.920761 1525.33405 2982.386843 1771.138248 1450.003411 736.8622521 474.3013382
267.8045569 345.0098562 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2007 1 1 0 2 107.5 0 0 0 0 0 1010.553717 855.1458853 10812.76067
33093.84511 61277.51499 71419.89007 57227.8135 49767.86627 47827.35553 30746.57294 22494.95902

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15911.95285	12850.15214	10770.70153	5272.643638	3868.164363	6611.333375	4611.186164	4963.221993
2664.407333	4193.280581	2561.392392	2030.053814	1985.950206	1549.609198	1419.712486	381.1498601
799.5635423	43.65259447	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2008	1	1	0	2	112.7	0	0	0	0	0	2822.675361	6806.953086	32787.88889
54884.036	75205.03903	74054.31005	62013.93597	59699.26549	44773.19126	31428.73642	29471.82858
31410.31836	12527.87184	15786.70307	10558.85931	12780.05099	6413.571433	7289.542705	7611.141593
7869.938415	8418.737788	12742.94786	6695.436041	3825.08436	3412.175507	2243.121159	255.1146995
388.9583397	1296.949036	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2009	1	1	0	2	118.4	0	0	0	0	1400.678782	1890.520785	5985.91883
15832.00962	35448.64763	76738.83823	89311.32958	77999.04987	51893.68149	62442.2377	45705.31733
23144.40299	14276.02441	16915.76381	18021.09038	10082.53389	7379.78673	8310.292534	6086.549522
7219.197722	8333.988661	7930.084971	7303.262041	3997.579795	6075.500971	3979.356778	2143.374211
1660.86691	2168.673576	695.2491494	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2010	1	1	0	2	121.5	0	1224.614098	0	421.0423793	0	343.6613544	7502.097021
15142.15131	27265.27503	46564.40952	59370.12095	56992.89354	51224.33344	36234.50581	29840.83268
22890.75901	15268.87761	16092.87463	18005.10015	8624.615266	10398.48301	5548.743737	6827.859089
5593.928672	6170.500383	8755.267901	9020.80915	5686.015271	3883.693465	3791.299976	2891.158491
900.4421385	1456.237206	310.3441406	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2011	1	1	0	2	106.2	0	0	0	0	29.58870069	1549.342467	7094.992452
6580.115029	15553.78583	32332.15638	45614.79276	33375.86619	29712.39783	18346.75466	16075.69976
15852.44029	6722.53307	8220.895806	3488.351502	3022.64833	5676.401642	4465.919701	3523.768886
2428.929543	2977.771665	2916.687313	1132.425754	2279.353763	1121.807348	1788.962384	455.0349641
782.1807648	1223.174395	479.8141142	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2012	1	1	0	2	103	0	0	0	101.6627008	298.4610652	1614.624706	5402.386866
6556.107868	18404.02171	26479.75381	38529.81258	24178.10021	24556.81338	19413.08991	16107.16338
9530.474869	9807.949217	5800.608162	5812.669596	6041.480794	4768.641256	3671.403154	3171.190949
2502.780242	4287.013191	1705.043626	2416.527054	2644.553641	1266.201081	154.3935112	610.4114642
220.0680214	217.8908102	146.4815835	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2013	1	1	0	2	38.2	0	0	0	28.10654121	49.8528637	166.1263083	270.1858285
326.258699	604.4893471	1223.891687	1494.058926	802.3087505	845.2864681	635.2751607	468.2287912
278.2953003	261.3512914	404.2793402	67.78783308	294.8580716	352.1774391	181.8060228	116.7693402
290.6166281	240.5802721	50.39676975	16.3847937	79.11460085	56.38579775	92.65095425	11.33732535
5.047468354	5.047468354	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0
### Trawl South
#_year	Season	Fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
```

M26 M28 M30 M32 M34 M36 M38 M40 M42 M44 M46 M48 M50 M52 M54 M56 M58
M60 M62 M64 M66 M68 M70 M72
1978 1 2 0 2 70 0 0 0 0 0 2.653061224 74.89361702 149.787234
415.266745 750.2559864 1596.723185 1146.187746 1152.170794 1497.752536 1701.891325 1511.512383
1775.748642 2138.145439 3400.89629 1604.914076 1795.025143 1315.726296 861.5114278 957.9346999
590.0853863 754.7092559 427.6076328 441.9237861 316.7417898 315.9829595 131.6872827 34.46327684
61.39516129 73.02586207 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
1979 1 2 0 2 48.7 0 0 0 0 0 0 0 0 30.42553191
68.57142857 400.9721065 1104.111577 1102.825377 673.3393267 865.8765705 707.5491286 1258.794053
1573.310434 1577.759227 1642.538269 1314.992865 1625.95247 1521.10635 623.3254729 543.0711951
711.7250716 429.5737057 512.353877 89.04903448 452.5417667 110.647171 413.6618597 0 122.6336634
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1980 1 2 0 2 30.5 0 0 0 0 0 0 3.809108911 55.83333333
55.83333333 167.5 182.2761056 248.6780664 635.2327714 490.9139223 498.4393745 727.7940023 481.5778368
378.2163434 564.890827 138.2378517 439.1309098 297.8135841 241.6325568 74.04440303 50.24592157
210.2475965 219.9313501 108.1052632 160.4576634 3.809108911 3.809108911 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1981 1 2 0 2 14.7 0 0 0 0 0 0 0 0 12713.39147
14880.08758 11175.59047 32040.9079 21380.17591 2166.696112 2166.696112 6263.721488 17160.82033
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0 0 0 0 0 0 0 0 0 0 0 0 0
1982 1 2 0 2 36.7 0 0 0 0 0 0 0 1533.056215 8195.217329
14129.67695 40163.1434 50055.84707 61264.57 34761.71615 47438.75694 56366.94117 70860.85684
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486.0979963 565.849313 0 0 0 0 0 0 0 0 0 0 0 0 0

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1987 1 2 0 2 33.2 0 0 0 0 0 0 1324.007327 1324.007327
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0 12713.39147 0 0 12713.39147 0 0 0 0 0 0 0 0 0 0
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1995	1	2	0	2	102.6	0	0	0	0	0	6853.700267	8632.540553	19222.26099
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239.7588426	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0
1996	1	2	0	2	97.4	0	0	0	0	0	1529.979353	5092.635853	15679.76176
39236.14182	49475.94409	57937.97252	37461.08346	33339.9367	36317.60361	21345.01374	17580.47634
20785.9256	17585.35858	18110.70781	22217.57441	24140.136	16661.61064	14443.55131	12959.59873
9860.08808	8931.682088	8021.814338	2337.619206	4054.461098	1690.517985	1426.119691	757.8744077
60.6456159	66.20574521	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
1997	1	2	0	2	87.4	0	0	0	0	0	0	0	5330.169113	10088.31325
47997.9711	22719.60402	47302.36341	33020.73708	31160.95693	13333.852	8394.580382	9330.718121
14719.84695	16244.8935	15024.9123	17619.96352	13490.52874	16239.42605	15132.28022	11083.92103
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128.5384342	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1998	1	2	0	2	67.9	0	0	0	0	0	42.95146387	0	15293.81364
21688.73567	37491.13419	34890.06962	55441.4935	51190.5926	38561.84154	21471.77822	23404.31028
16454.27393	10803.34095	11820.28861	17350.80927	16332.2216	15504.72458	15590.89129	15291.11495
8665.262374	8056.59976	5774.216722	4239.643443	1602.861102	1370.364328	66.99036597	347.5464255
435.8233742	910.0001224	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
1999	1	2	0	2	56.1	0	0	0	0	0	2962.626135	5830.704647	2326.931623
5925.25227	16323.00321	18996.84864	19341.62151	17391.76407	23539.1687	19730.89875	15288.80174
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5611.916001	5526.823849	3984.441032	3067.654955	2403.562747	1496.518407	849.2041875	331.6494891
211.0302338	395.562368	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2000	1	2	0	2	64.1	0	0	0	0	0	0	0	262.9155924	262.9155924
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11929.69732	7149.669515	6446.97514	8359.198911	9174.408649	8728.636149	6080.319121	9399.940418
9678.515083	4741.762094	2618.984782	1435.682657	2144.082234	597.3504839	1373.986576	1695.421336
375.9755127	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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103.4319488	108.7991307	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2002	1	2	0	2	104.5	0	0	0	0	253.5533988	0	507.1067976	3146.494025
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0	0	0	0
2003	1	2	0	2	93	0	0	0	0	0	0	131.1140143	317.7897971
3327.568233	5469.940266	10398.10871	14203.93946	14791.25551	12449.91879	11832.3569	10259.81243
6843.76691	7440.37762	6868.293398	9150.739115	9988.617808	11616.71124	9258.463199	6733.455524
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323.9692658	323.9692658	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2004	1	2	0	2	65.8	0	0	0	0	0	0	0	157.3265332	938.9623961
1095.13939	8649.57993	14331.60756	13779.26779	13759.03407	11972.19738	7374.321698	5619.874724
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2005	1	2	0	2	77	0	0	0	0	0	142.0233735	51.19084231	2809.304713
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0	0	0	0
2006	1	2	0	2	124.6	0	0	0	0	0	7.886967802	178.5083713	1369.222581
4198.976638	5386.652503	9252.79752	8861.514931	7290.875234	7575.059876	6368.429611	4668.663001
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26.42495917	42.45758146	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2007	1	2	0	2	92.5	0	0	0	0	637.570685	0	1324.757149	2648.423251
8098.808883	10015.2781	20487.70861	14860.12927	11818.55994	12124.27555	10068.12626	5780.543482
4246.081469	3515.434484	3625.573271	4164.855303	5054.740693	5493.856469	3854.064365	3921.721165
2342.322634	4104.898875	3101.909761	2228.008584	1505.604651	272.4055664	476.9050913	400.5081921
10.72723172	10.72723172	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0
2008	1	2	0	2	101.6	0	0	0	0	8.953503828	238.4367672	438.2205802
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0	0	0	0	0	0
2009	1	2	0	2	99.5	0	0	0	20.35186895	20.35186895	61.05560685	372.4593859
2554.401604	6719.55579	9084.111088	9463.190967	11407.36577	15622.12003	15125.83551	24686.53986
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31550.20218	22391.03665	33633.68605	13869.27366	10201.22933	9898.073162	7262.383101	5617.396085
5264.715428	1546.322414	1142.024947	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2010	1	2	0	2	87.4	0	0	0	0	0	0	0	1967.341464	3382.55936
6144.485129	8096.879354	10124.35393	5780.602361	6300.795773	2948.010593	3201.989097	3322.032697
3630.376602	4304.228068	5514.710048	7714.568106	6774.69409	6155.883352	6145.94948	3719.729147
6419.53172	8021.226768	3806.618584	1878.621242	1712.790108	1070.898377	1306.81912	704.4629649
140.7500403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0
2011	1	2	0	2	120.8	0	0	14.33483846	59.98426112	469.9359486	801.4190182
2023.409813	7856.665729	13463.28852	16021.24899	12261.50645	7939.114201	8543.103021	6196.311159
9416.077463	7804.777114	5557.039706	7153.762281	2884.648248	3032.816205	3695.412465	2688.393483
3440.466219	4241.691429	3912.194818	2802.542355	3389.194192	2354.03108	1336.18046	1237.781666
780.1451139	916.8431474	307.8718339	137.1454959	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
2012	1	2	0	2	107.3	0	0	0	43.34520692	2912.346741	564.3254348	263.1977886
1510.004876	5581.841191	8063.626372	7980.082369	8107.599647	11231.81357	7543.212005	7549.876634
8273.83138	9446.255969	6288.452158	4737.82415	7410.658047	3524.185868	5082.864709	6146.621751
6952.091656	6019.671594	5265.980935	3754.646031	1926.75136	1029.244567	1013.450407	340.2804811
545.3626	401.247972	87.06448892	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
### Non-trawl North
#_year	Season	Fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
2000	1	3	0	2	1.9	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	103.6696704	0	103.6696704	103.6696704	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
2001	1	3	0	2	7.7	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	213.5257156	213.5257156	213.5257156	213.5257156	640.5771467	427.0514311
213.5257156	427.0514311	427.0514311	427.0514311	213.5257156	427.0514311	427.0514311	213.5257156	0
213.5257156	0	0	213.5257156	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2002	1	3	0	2	4	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	103.6696704	0	0	0	0	103.6696704	207.3393409	103.6696704
```

```
207.3393409 0 0 103.6696704 0 0 103.6696704 103.6696704 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2004 1 3 0 2 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 2716.026494 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2006 1 3 0 2 1.5 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 103.6696704 103.6696704 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
2007 1 3 0 2 17.2 0 0 0 0 0 0 0 0 0 230.5538952
161.2787921 338.07309 338.07309 729.9057773 284.3134926 584.142491 499.351882 284.3134926
353.5885958 584.142491 637.9020884 353.5885958 353.5885958 284.3134926 0 53.75959736 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2008 1 3 0 2 27.5 0 0 0 0 0 0 0 0 115.0193601
115.0193601 43.57729975 185.4075621 473.9385626 195.34715 804.3940823 330.9070987 1040.05841
671.5968928 516.6606404 150.8209089 314.1407012 167.5873063 43.57729975 124.958948 160.6042867
97.19910431 43.57729975 43.57729975 90.21608471 115.0193601 46.63878496 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2009 1 3 0 2 18.6 0 0 0 0 0 0 0 0 0 103.6696704
311.0090113 207.3393409 311.0090113 207.3393409 518.3483522 725.6876931 622.0180226 414.6786817
829.3573635 311.0090113 311.0090113 207.3393409 207.3393409 414.6786817 207.3393409 207.3393409
207.3393409 207.3393409 103.6696704 103.6696704 103.6696704 207.3393409 0 103.6696704 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2010 1 3 0 2 24.7 0 0 0 0 0 0 0 0 0 83.45187317
54.4280004 54.4280004 850.228351 790.1436854 518.8758764 921.3435601 558.6355896 475.1837164
500.1517476 90.5679685 584.0397172 253.8519697 139.4806971 311.8997152 163.2840012 181.135937 0
137.8798736 221.3317467 54.4280004 137.8798736 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2011 1 3 0 2 42.4 0 0 0 0 0 0 59.62168154 0 23.94272424
31.53973549 228.8542166 304.1401787 462.3179131 477.5119356 676.6507408 721.9591564 584.9186974
878.9295959 699.6360057 499.9107101 526.5436483 275.1061997 308.1844586 92.74165307 155.3925785
190.0510735 23.94272424 161.5405819 31.53973549 137.5978577 44.85620459 23.94272424 23.94272424
23.94272424 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
2012 1 3 0 2 43.5 0 0 0 0 0 0 0 0 0 0
66.6053925 242.0613033 253.19343 2310.573692 307.4200782 371.3589588 819.1632006 1144.496253
629.9911686 507.9286046 663.935428 341.3634289 259.0017509 379.1448574 359.9801523 105.9051111
254.1739052 301.1672901 75.81914983 16.65134812 0 16.65134812 0 19.50874616 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
### Non-trawl South
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```
#_year	Season	Fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
1985	1	4	0	2	1.9	0	0	0	0	0	0	0	0	0	0	0
0	0	3099.723146	0	0	3674.175085	4448.737314	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1986	1	4	0	2	3.7	0	0	0	0	0	0	0	0	0	0	0
0	348.82136	0	1058.092517	0	2083.096071	121.8639723	0	576.1313754	2964.655448	0
4915.75031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1987	1	4	0	2	11	0	0	0	0	0	0	0	0	0	366.9858758
183.4929379	91.74646896	458.7323448	1986.217815	2065.864433	1451.015389	223.2311591	60.76606204
3600.597026	1754.425278	2120.255993	1846.171747	0	0	1846.171747	0	0	0	0
91.74646896	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
1988	1	4	0	2	3.5	0	0	0	0	0	0	0	0	0	0	0
0	0	10048.23795	0	4289.812566	592.9905149	7861.969293	1024.734819	4126.628826	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
1989	1	4	0	2	5.7	0	0	0	0	0	0	0	0	0	0	0
0	0	0	415.5931108	293.2583695	4381.882177	4270.183994	1107.912869	2535.944344	5164.385854
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
1990	1	4	0	2	6.7	0	0	0	0	0	0	0	0	0	0
1658.714727	0	0	0	1969.723738	9686.894006	3656.987498	3172.723872	0	2653.943563
7737.664964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	1	4	0	2	13.3	0	0	0	0	0	0	0	0	0	0
404.2118419	1269.306432	2643.01733	202.105921	2425.06793	953.6555768	1285.149911	2456.754888
1600.800767	735.7061766	2020.856088	2020.856088	735.7061766	1067.200511	533.6002557	1802.906688
533.6002557	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1993	1	4	0	2	1.9	0	0	0	0	0	0	0	0	0	0	0
0	0	0	323.1405685	0	4928.628915	940.3572126	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1994	1	4	0	2	9.9	0	0	0	0	0	0	0	0	0	0
6672.044768	7882.050117	608.0624901	1186.686866	868.361794	2516.423086	2928.076934	1744.42747
2055.04866	5210.170764	868.361794	1736.723588	4278.029279	1736.723588	1736.723588	0	0
868.361794	868.361794	0	0	0	0	0	0	0	0	0	0	0	0	0
```

0 0 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
1995 1 4 0 2 8.6 0 0 0 0 0 0 0 0 0 0 0
0 2467.788894 106.7797605 106.7797605 3199.135743 427.1190422 985.8985658 320.3392816 106.7797605
213.5595211 106.7797605 106.7797605 213.5595211 213.5595211 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
1996 1 4 0 2 7.1 0 0 0 0 0 0 0 0 0 0 0
0 0 1353.686658 676.8433291 1353.686658 0 0 676.8433291 0 676.8433291 1353.686658
2030.529987 1353.686658 0 1353.686658 0 0 676.8433291 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1997 1 4 0 2 8.6 0 0 0 0 0 0 0 0 0 0 0
0 0 0 528.1530582 0 528.1530582 1409.737056 4229.211169 3347.627171 528.1530582
3347.627171 3347.627171 1937.890114 1056.306116 1409.737056 2819.474113 1409.737056 0 2819.474113
0 0 0 528.1530582 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
1998 1 4 0 2 18.6 0 0 0 0 0 0 0 0 0 0 0
0 369.9370345 2071.210889 2115.952537 1565.957653 279.9081102 1004.395418 1021.855573 2458.717205
266.2673641 506.4455382 2108.697681 792.880998 896.5506684 103.6696704 0 0 679.612284 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
1999 1 4 0 2 91.3 0 0 0 0 0 66.00327334 300.8065709 597.9896766
999.3725875 2550.521239 3739.433633 5268.98741 7770.93427 6163.155051 5660.254566 6936.781818
6899.225902 3926.463022 3250.327501 4070.749745 1506.297769 1458.558869 1137.923876 1082.463814
721.1689054 1093.776556 396.3646392 360.3738148 75.87100837 52.28216275 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2000 1 4 0 2 38.8 0 0 0 0 0 0 0 49.06515175 225.2536512
1375.641477 2303.603233 1969.82795 2115.312636 3562.591645 3685.25519 1561.083382 942.2735005
2355.796909 987.3705256 610.7549346 740.4545638 604.1169988 952.9913985 643.8164378 1082.642157
643.8164378 528.7020433 885.1353376 0 0 0 528.7020433 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
2001 1 4 0 2 16 0 0 0 0 0 0 0 0 0 103.6696704
311.0090113 311.0090113 5547.536848 9272.215324 6112.363769 127.0789509 1909.327795 254.1579017
127.0789509 1655.169893 2036.406746 127.0789509 230.7486213 254.1579017 0 127.0789509 0 0
127.0789509 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2002 1 4 0 2 64.1 0 0 0 0 0 0 0 51.66615963 440.5251727
4492.036889 8022.58685 13150.87951 11771.51885 9128.403533 11992.2681 6098.141662 3995.1944
1874.090342 3401.935321 1936.626017 3471.698543 1616.285664 477.334686 569.2460648 573.2956559
747.0864248 345.7313852 450.0760487 51.66615963 51.66615963 256.765157 256.765157 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2003 1 4 0 2 56.6 0 0 0 0 0 0 0 0 386.7527581
1205.020065 5118.212322 8756.975176 10609.31929 16973.24082 13892.56287 9710.540675 10202.13242

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490.5663932 0 1163.292616 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2004 1 4 0 2 18.7 0 0 0 0 0 0 0 0 0 0
518.3483522 890.2069527 1036.696704 311.0090113 944.8363616 737.4970207 719.4675128 408.4585015
475.5282709 164.5192596 2371.331027 207.3393409 207.3393409 408.4585015 207.3393409 0 469.3080907
164.5192596 207.3393409 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2005 1 4 0 2 47.4 0 0 0 0 0 0 0 414.6786817 2253.472943
5125.853818 7740.402906 5404.685358 9245.380828 23241.34456 16163.11486 10870.76333 10553.26754
7304.726034 3174.788386 1598.827119 487.5892192 1801.260524 669.8655628 280.2498783 1126.695649
311.0090113 103.6696704 0 176.5802079 0 0 176.5802079 0 176.5802079 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0
2006 1 4 0 2 46.2 0 0 0 0 0 0 0 93.1990681 0
1355.312845 8062.489559 9960.385132 15233.22707 22512.44341 15032.85005 10226.43485 7880.794878
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376.5242351 93.1990681 93.1990681 93.1990681 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0
2007 1 4 0 2 29.3 0 0 0 0 0 0 0 1479.286451 338.9200764
792.8337411 5605.40579 6640.042391 7324.203145 9878.464333 9080.532761 8443.280318 4177.645527
3945.75774 1732.14741 539.9462002 815.8803063 1399.540551 103.6696704 0 1700.950519 0 0
103.6696704 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
2008 1 4 0 2 89.4 0 0 0 0 0 0 0 302.2391429 2298.591023
5787.895625 8250.199021 24276.18557 35691.60444 25183.38891 17716.4917 5322.618301 9250.617463
4154.533399 3446.12426 2895.377164 1514.775272 1244.84228 1072.556029 129.8414064 648.0169862
376.5301691 272.4511504 47.44727518 47.44727518 271.7430472 141.9016409 82.41891433 129.8661895
82.41891433 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0
2009 1 4 0 2 69.3 0 0 0 0 0 0 0 291.8866994 1438.377936
3402.817112 15987.13201 31657.98309 21196.2792 22748.48287 23043.08058 17686.70045 14461.75028
6141.960412 11259.26827 8356.059523 4388.694946 3548.094685 4399.859585 1928.053683 1883.798666
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0 0 0 0 0 0 0 0 0 0 0 0 0 0
2010 1 4 0 2 68.1 0 0 0 0 0 0 0 103.6696704 1240.025016
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890.9112303 311.0090113 103.6696704 207.3393409 103.6696704 0 258.680511 103.6696704 258.680511
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2011 1 4 0 2 116.1 0 0 0 0 0 0 84.02163747 133.9433737
2336.444158 4829.976904 9371.501661 8688.910435 8154.603331 8974.57535 10455.69793 10098.81277
7436.426222 5874.132332 8478.76696 7295.513461 8310.057857 5712.798535 5019.107548 3528.883557
2993.673204 1591.195461 1061.357427 157.0272121 199.5732241 37.22329439 284.2237138 68.5709177

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43.48445872	66.2906176	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
2012	1	4	0	2	92.2	0	0	0	0	0	15.6118345	15.6118345	385.3000756
1920.151565	3633.498363	6925.513865	5583.112419	3333.589209	5017.222926	5771.82751	8071.548645
7702.683417	9655.809044	5005.616069	4423.135415	4180.134399	2394.401436	3260.085873	1498.662284
1142.115479	1100.514776	458.7929234	228.6587279	41.13117937	23.41775176	701.2038859	280.8326764	0
15.6118345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0
### Length comps from Pikitch discard study, produced by John Wallace and process by code in file
c:/SS/Thornyheads/comps/WCGOP_discard_comps_calcs.R
# discards (partition 1)
#_year	season	fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
1985	1	1	0	1	24.6	0	0	0	0.037037037	0	0	0.111111111	0.228148148
0.268148148	0.234074074	0.308148148	0.274074074	0.157037037	0.302222222	0.04	0	0.04	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	1	0	1	110.7	0	0.011196934	0.016371154	0.027992336	0.122199232	0.138701595
0.209066732	0.321333718	0.358829277	0.395181773	0.223827751	0.109103203	0.044104469	0.013699636
0.002797396	0	0	0.002797396	0	0	0	0.002797396	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
1987	1	1	0	1	38.3	0	0	0	0	0.022995126	0.07301728	0.184997785
0.385963669	0.551998228	0.686973859	0.067027027	0.027027027	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# utilized (partition 2) Setting these to have negative fleet number because they are less complete than the PacFIN comps from the
same years
1986	1	-1	0	2	84.5	0	0	0	0	0	0	0	0	0	0.022733002
0.294802768	0.541127103	0.24573112	0.324863838	0.199027435	0.124678584	0.079245034	2.49E-05
0.022732078	0.122252459	1.91E-06	8.08E-06	1.52E-05	0.022735008	6.34E-06	0	2.22E-06
4.43E-06	4.43E-06	1.91E-06	0	0	2.22E-06	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
1987	1	-1	0	2	43.1	0	0	0	0	0	0	0	0	0	0.139704291
0.344175983	0.488207717	0.27847097	0.156653444	0.137468446	0.12917418	0.112225027	0.072124053
0.055174901	0.033898305	0.016949153	0.03577353	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0
```

```
### Length comps from WCGOP discard observations, calculated by Andi and processed by code in file
c:/SS/Thornyheads/comps/WCGOP_discard_comps_calcs.R
# zero values in columns for males
#_year  season  fleet   gender  partition       inputN  U6      U8      U10     U12     U14     U16     U18     U20     U22     U24
U26     U28     U30     U32     U34     U36     U38     U40     U42     U44     U46     U48     U50     U52     U54     U56     U58
U60     U62     U64     U66     U68     U70     U72     M6      M8      M10     M12     M14     M16     M18     M20     M22     M24
M26     M28     M30     M32     M34     M36     M38     M40     M42     M44     M46     M48     M50     M52     M54     M56     M58
M60     M62     M64     M66     M68     M70     M72
2006    1       1       0       1       51.3    0.000933932     0.015161679     0.012005045     0.050769397     0.053931026
0.084047756     0.090596621     0.166508506     0.255341033     0.127799546     0.075849983     0.029087037     0.017532184
0.012596764     0.005744453     0       0       0.000361794     0       0.001085381     0.000361794     0       0       0       0
0       0       0       0.000286069     0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0
2007    1       1       0       1       67.7    0.001067326     0.001643666     0.031115581     0.036043099     0.073717228
0.124285788     0.159795053     0.17702998      0.195964989     0.101012841     0.061427015     0.017096874     0.006741339
0.001754351     0.004698943     0.004763693     0.001754351     0       8.79E-05        0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0
2008    1       1       0       1       87.1    0.001107168     0.002338281     0.016359105     0.043666045     0.128098353
0.202661027     0.172928682     0.204723937     0.107396943     0.063723615     0.018383228     0.011955122     0.008811853
0.010135815     0.005653147     0       0.000252333     0       0.000252333     0       0.001528746     0       0       0       0
0       0       2.43E-05        0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0
2009    1       1       0       1       107.3   0.000252304     0.001369352     0.022276413     0.030028139     0.094250058
0.145231947     0.16748135      0.190248263     0.170985004     0.100076117     0.042795192     0.008788839     0.011225837
0.000156292     0.004916114     0.004019242     0.005237976     0.000229954     0.000186802     0.000131301     0       0.000101375
1.21E-05        0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0
2010    1       1       0       1       73.2    0       0.000183245     0.003243669     0.028111525     0.051682189     0.084699148
0.177316396     0.273746854     0.20759716      0.079217725     0.035267762     0.010088923     0.026121325     0.017156476
0.001565449     0.001646141     0       0       0       0.000471203     0       0       0.000471203     0.000471203     0.000471203
0       0       0       0       0.000471203     0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0
2011    1       1       0       1       78.7    0.032543195     0.017293142     0.054742982     0.143047386     0.145733482
0.171153188     0.153781032     0.157166783     0.08188635      0.024466363     0.009600741     0.001082426     0.000830115
0.000987164     0.004217882     0.000874986     0       0       0.000112178     0.000112178     0       0       0       0       0
0       0.000368427     0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0
2006    1       2       0       1       27.3    0.0010017       0.049248688     0.13325481      0.080501719     0.037463569
0.043558037     0.082139376     0.031319811     0.17167437      0.109452562     0.078227243     0.049113088     0.029717846
0.032080361     0.035953599     0.010718187     0       0.012487856     0.003205439     0.008881737     0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0
0       0       0       0       0       0       0       0       0       0
```

2007 1 2 0 1 32.9 0 0 0.000268938 0.037493764 0.137677474 0.12373167
0.261339775 0.167770291 0.106131305 0.112209982 0.020747518 0.028057342 0.001774989 0.000268938
0.002259077 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0.000268938 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
2008 1 2 0 1 32.2 0 0 0 0.007054186 0.018218684 0.061902752 0.111101608
0.35467914 0.282040172 0.05439221 0.046347912 0.030936476 0.023550982 0.008942708 0.000277724 0
0 0 0 0.000277724 0 0 0 0 0.000277724 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0
2009 1 2 0 1 41.4 0 0 0 0.005429989 0.020108646 0.087175105 0.133371075
0.29582215 0.192799489 0.14750025 0.082574819 0.019992076 0.014994351 0.000232051 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2010 1 2 0 1 24.1 0 0 0.007894996 0.02166063 0.005870638 0.071851023
0.064066248 0.187822418 0.302850225 0.188602769 0.108525731 0.030011383 0.006073074 0.001012179 0
0 0 0 0 0 0 0 0.003758688 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0
2011 1 2 0 1 38.6 0.001946921 0.005690998 0.006346212 0.093801736 0.20062451
0.132293785 0.088690075 0.120623316 0.182580318 0.117206525 0.04420508 0.002620855 0.000374408
0.001198105 0.001797157 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2005 1 3 0 1 3.2 0 0 0 0 0 0 0 0 0 0
0.285714286 0 0.285714286 0.285714286 0 0 0.142857143 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2006 1 3 0 1 17 0 0 0 0 0 0 0.005870703 0.005870703
0.02348281 0.0686499 0.106977248 0.099560788 0.110443123 0.095105382 0.186179519 0.04520441
0.018786248 0.051324622 0.037572497 0.02714008 0.043053879 0 0.010063452 0.010063452 0.015656237
0.038994948 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
2007 1 3 0 1 27.1 0 0 0.001424816 0 0 0.001424816 0.001424816
0.005414302 0.014533127 0.014755754 0.047321713 0.076022858 0.092076017 0.093121124 0.108515493
0.072277857 0.008833861 0.08403406 0.088477041 0.072195206 0.05172105 0.010258678 0.048319631
0.006596185 0.015925632 0.014289895 0.014927202 0.034276007 0.021832857 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2008 1 3 0 1 12.5 0 0 0 0 0.0117638 0 0.0117638 0 0
0.070582798 0.0176457 0.14436388 0.168222336 0.214358488 0.122992977 0.075545651 0.035291399
0.080413974 0.023527599 0 0.0117638 0 0 0.0117638 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
2009 1 3 0 1 10.5 0 0 0 0 0 0 0 0 0 0.01754386
0.076023392 0.111111111 0.111111111 0.052631579 0.14619883 0.111111111 0.052631579 0.087719298
0.070175439 0.055555556 0.038011696 0.01754386 0.01754386 0 0 0 0 0.01754386
0.01754386 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2010 1 3 0 1 13.1 0 0 0 0.009515395 0.038061578 0.028546184 0.019030789
0.10466934 0 0.019030789 0.20933868 0.10466934 0.174457962 0.063508462 0.009515395 0.05233467
0.05551553 0.038061578 0.042819275 0.019030789 0 0 0 0 0 0 0.011894243 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
2011 1 3 0 1 26.5 0 0 0 0 0 0.00942247 0.024498423 0.018844941
0.027040994 0.045856022 0.057288218 0.059182087 0.096265306 0.089704161 0.059675645 0.070318853
0.068941074 0.060146769 0.056534822 0.056277725 0.027639246 0.027011082 0.035496796 0.035502287
0.007490268 0.02256622 0 0.013982155 0 0.011469496 0.0106788 0.008166141 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2006 1 4 0 1 24 0 0 0 0 0 0 0.00152866 0.006216551
0.040237733 0.137142051 0.251804304 0.128980704 0.244229672 0.084687775 0.039962453 0.008050944
0.001974519 0.00076433 0.020827995 0.002687894 0.011872594 0 0.007477696 0.005299355 0.000955413
0 0 0.005299355 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
2007 1 4 0 1 29 0 0 0 0 0 0 0.008079789 0.036199841
0.126470582 0.148515314 0.111406714 0.186143627 0.29681398 0.063523855 0.014487897 0.002786134
0.004179201 0 0 0 0 0 0.001393067 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0
2008 1 4 0 1 22.3 0 0 0 0 0 0.004679868 0.003509901 0.008336015
0.071046243 0.136886133 0.290517418 0.116777326 0.100909649 0.053050689 0.028042645 0.026762994
0.013162128 0.009323174 0.032576267 0.006581064 0.03115037 0.017988242 0.032466583 0 0.009652227
0 0.002193688 0 0.004387376 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2009 1 4 0 1 16.6 0 0 0 0 0 0.011622839 0 0.036466657
0.063925614 0.133662647 0.096469563 0.086009008 0.039517652 0.058114194 0.039517652 0.037193084
0.094144995 0.058114194 0.09879413 0.032543949 0.023245678 0.023245678 0.005811419 0.047653639
0.013947407 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2010 1 4 0 1 24 0 0 0 0 0 0 0.013968052 0.002971926
0.054980629 0.041904155 0.036851881 0.023973536 0.027957332 0.024228272 0.014336005 0.061179218
0.016076704 0.086369828 0.078211184 0.059084718 0.055957119 0.066613597 0.080737321 0.03930372
0.073364114 0.045937483 0.030016452 0.020209096 0.037743459 0.0080242 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

```
2011	1	4	0	1	22.8	0	0	0	0	0.002472025	0.002472025	0	0.004944049
0.028675486	0.083554434	0.097438973	0.075643955	0.069711096	0.085367252	0.082236021	0.05504375
0.062295022	0.002472025	0.064272642	0.028869952	0.052489324	0.024225842	0.04210682	0.05384409
0.025255852	0.013843338	0.006798068	0.012360123	0.021135811	0	0	0.002472025	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

### Length comps from AK triennial survey, calculated in file c:/SS/Thornyheads/comps/AK_survey_comps.R
###      note: combining males and females due to lack of trust is sex determination from this survey
# zero values in columns for males
### Shallow/Deep alternative: Shallow triennial for all years
# zero values in columns for males
#_year	season	fleet	gender	partition	Nsamp	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
## 1980	1	5	0	0	20.5	0	0.326797386	0.326797386	1.307189542	0.980392157	2.287581699
3.094033312	7.397744044	12.00716846	5.840185537	17.52055661	8.760278305	10.95034788	3.65011596
8.760278305	3.65011596	5.110162345	3.65011596	2.190069576	0.730023192	0.730023192	0.730023192	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
## 1983	1	5	0	0	13.7	0	0	0	0	6.41025641	7.692307692	12.82051282
14.1025641	26.92307692	12.82051282	6.41025641	7.692307692	5.128205128	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1	5	0	0	27.2	0	0	0.423988083	0.408995349	2.467453146	1.950485296
3.315429313	5.633143805	12.90542178	16.07820742	22.18746142	13.38474179	8.760379785	4.735650502
3.497593867	1.946658371	1.151891483	0	0.765301949	0.387196642	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1989	1	5	0	0	92.1	0.063954122	0.075106871	0.568128067	0.9662749	2.441352775
5.12658233	6.823767936	12.23061743	17.77825092	18.21727841	15.96489334	10.52257638	4.21251583
2.287042298	1.340242924	0.579139866	0.379572853	0.111159013	0.155771865	0.084279017	0	0.071492848
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
1992	1	5	0	0	72.3	0.031460261	0.200534546	1.282114112	1.662539687	3.88444415
5.985344078	12.3496482	14.0402569	13.99088707	16.32364135	12.06371113	8.59909058	4.696272698
2.115173891	1.725629577	0.318560247	0.427862322	0.302829202	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1995	1	5	0	0	145.5	0.024249528	0.496147078	1.05235154	2.243802985	4.201711386
8.217641106	14.7316106	16.45438075	18.17738699	13.38830499	8.842614359	5.896153768	3.050810693
1.587813445	0.810092011	0.389292621	0.227485565	0.097510714	0.110639874	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
```

```
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1998	1	5	0	0	155.9	0.029825636	0.237628709	0.81746814	1.908443599	2.883653155
9.744713983	16.02256648	20.04595434	17.33504234	13.13747015	8.668105015	4.861663393	1.995817097
1.095531826	0.651459098	0.251197523	0.115247028	0.031430524	0.030049216	0.031430524	0.029138748
0.061370941	0	0	0	0	0.014792535	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	1	5	0	0	150.4	0	0.299922432	0.848457183	2.582640027	4.299389123	10.29481135
19.67591978	12.7337098	18.47485517	10.53804784	6.550858741	6.93012039	2.823139297	1.244046789
0.850581015	0.734826875	0.310988803	0.149836032	0.453424995	0.038064379	0.092918161	0.073441819	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
2004	1	5	0	0	131.5	0.02798798	0.422514571	0.870510673	1.865749358	2.505487415
3.83377209	3.303566033	12.1258476	15.26888313	19.16243968	13.98166069	10.152021	7.228956775
3.961467949	2.413689575	0.968993244	1.026974482	0.220497045	0.108327345	0.127345173	0.135003546
0.085980724	0	0	0.019044475	0.183279447	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
### Shallow/Deep alternative: Deep triennial only for 1995+
# zero values in columns for males
#_year	season	fleet	gender	partition	Nsamp	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
1995	1	6	0	0	206.9	0.112455446	0.668440799	2.200681798	4.401920823	6.085164281
10.87135676	14.18583461	17.21083961	15.11888439	11.05643533	7.370611555	4.103138889	2.064308079
1.457264992	0.712303265	0.803455616	0.514197789	0.377112836	0.108918348	0.120844056	0.060999759
0.161000176	0.033897284	0.044966264	0.051035572	0	0.025582417	0.059515293	0	0.018833974	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0
1998	1	6	0	0	186.9	0.147521512	0.784045777	1.920244293	4.181413576	7.9362766
10.98733643	13.39728466	15.53374365	15.97249594	12.3419091	5.798747269	3.412499618	2.782394868
1.566631139	1.02947579	0.774626021	0.310723034	0.306440521	0.193947301	0.212340267	0.113026457
0.05699428	0.045868576	0.080436962	0.009980623	0.05232957	0.023478717	0.009262482	0	0
0.009262482	0	0.009262482	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0
2001	1	6	0	0	188.9	0.091979539	0.349738679	1.210957508	3.110440774	7.239928032
10.36352239	14.50642672	13.93855775	13.65358246	11.28004613	8.294121614	4.533425082	2.491260158
1.538303615	1.217463152	1.796825067	1.238299904	0.861412357	0.632679885	0.43587965	0.357098887
0.292038303	0.234692992	0.13879367	0.017166563	0.054105974	0.043296339	0.077956807	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0
2004	1	6	0	0	167.9	0.519770778	1.323687489	1.655067394	2.690494248	2.941535981
3.13513326	5.167696633	13.69057991	19.26990873	20.75598261	12.39785584	7.313428525	3.44528155
1.835766926	1.159000169	0.501843501	0.65503411	0.339819809	0.234305995	0.143474215	0.172657297
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0.161031251	0.19555598	0.020653615	0.041334214	0.154250483	0	0.011616667	0.046579196	0	0
0	0	0.020653615	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0
### Length comps from AK slope survey, calculated in file c:/SS/Thornyheads/comps/AK_survey_comps.R
###	note: combining males and females due to lack of trust is sex determination from this survey
# zero values in columns for males
#_year	season	fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
1997	1	7	0	0	210.6	0.030386654	0.369562218	1.804653004	2.757247317	4.942339502
11.89074365	16.48339926	18.9390944	15.88222381	12.16100635	6.225180361	3.646951966	1.443751181
1.166680808	0.845981201	0.478373068	0.218968131	0.185644309	0.054925958	0.074103429	0.02070116
0.097120933	0.109658155	0.030501764	0.015537486	0.044561245	0.044464033	0.015537486	0	0
0.02070116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0
1999	1	7	0	0	198.5	0.019095526	0.195653984	1.281515857	3.118860815	6.504941305
10.98437758	14.67758907	18.0146668	17.65895756	10.39036528	6.724947841	3.669172649	2.325368094
1.169345388	0.824962954	0.734027803	0.301482516	0.390871841	0.341922216	0.206555462	0.101443027
0.155621262	0.074859406	0.048615552	0	0.024986015	0.036850548	0	0	0	0.022943661	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0
2000	1	7	0	0	203.1	0.123295768	0.43611988	0.355917511	2.021318246	6.217659489
10.37440467	15.10487062	17.25871678	17.64141568	13.3953186	6.563098983	3.97764435	2.256182198
1.386027972	0.772824157	0.690743879	0.304106406	0.383496035	0.200152614	0.115567782	0.212498183
0.061517877	0.020728465	0.019651226	0.05570012	0	0.041407781	0.009614732	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0
2001	1	7	0	0	186.2	0.05596268	0.355900227	1.172479391	1.56290144	4.491634356
10.83139185	13.50069213	16.27651529	17.12002454	12.97070003	8.743981154	5.231906564	2.772091448
1.395948164	0.954810176	0.825242662	0.760772963	0.348527414	0.247568579	0.021965721	0.118374294
0.115576025	0.035173305	0.063087587	0.010542592	0	0.016229422	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0
### Length comps from NWFSC surveys, calculated in file c:/SS/Thornyheads/comps/NWFSC_survey_comps.R
### sex determination seems to have been sorted out in 2005, so combining earlier years. Note that only one 2000 from early survey had
length measurements
#_year	Season	Fleet	gender	partition	inputN	U6	U8	U10	U12	U14	U16	U18	U20	U22	U24
U26	U28	U30	U32	U34	U36	U38	U40	U42	U44	U46	U48	U50	U52	U54	U56	U58
U60	U62	U64	U66	U68	U70	U72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
1998	1	8	0	0	216.8	0.077385619	0.562559509	1.452053501	2.942848139	4.93316692
8.47024576	12.5792311	14.24343412	12.69464717	10.06514512	6.881429906	4.344328936	3.726125238
3.087467881	2.131982052	1.505967871	1.195737446	1.078422416	1.061613175	1.205601824	0.978878903
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0.814347047 0.823087113 0.660923277 0.834741009 0.543072387 0.537254678 0.349862766 0.075708391
0.070804629 0.021934738 0.024332606 0.014952919 0.010705835 0.06709767 0.562559509 1.452053501
2.942848139 4.93316692 8.47024576 12.5792311 14.24343412 12.69464717 10.06514512 6.881429906
4.344328936 3.726125238 3.087467881 2.131982052 1.505967871 1.195737446 1.078422416 1.061613175
1.205601824 0.978878903 0.814347047 0.823087113 0.660923277 0.834741009 0.543072387 0.537254678
0.349862766 0.075708391 0.070804629 0.021934738 0.024332606 0.014952919 0.010705835
1999 1 8 0 0 251.8 0.081420433 0.327487784 2.04159955 4.251857901 6.950471531
8.190062058 9.924976613 12.01655931 12.19940723 9.32009787 6.355568216 4.772094952 3.969518824
2.925607606 2.481167198 1.702473341 1.483334535 1.279911178 1.240803927 1.249845675 1.229726221
1.005106678 1.058876913 0.940778584 0.717090165 0.559183367 0.673730904 0.380593842 0.186203292
0.2062691 0.161785847 0.081125386 0.035263966 0 0.066641218 0.327487784 2.04159955 4.251857901
6.950471531 8.190062058 9.924976613 12.01655931 12.19940723 9.32009787 6.355568216 4.772094952
3.969518824 2.925607606 2.481167198 1.702473341 1.483334535 1.279911178 1.240803927 1.249845675
1.229726221 1.005106678 1.058876913 0.940778584 0.717090165 0.559183367 0.673730904 0.380593842
0.186203292 0.2062691 0.161785847 0.081125386 0.035263966 0
2000 1 8 0 0 218.6 0.164528453 0.539098982 1.120001142 3.591558761 6.450336041
9.189806561 10.84458331 13.15235178 11.96461731 9.531239623 6.65871878 4.173857393 3.17118773
2.555598714 1.773805477 1.578028903 1.342395365 1.378107143 1.419331512 1.182996578 1.305916474
1.214968844 1.184044248 0.825487023 0.6627089 0.878333075 0.688085519 0.522117626 0.475394568
0.235418696 0.117982324 0.061125047 0.046268098 0 0.158357435 0.539098982 1.120001142 3.591558761
6.450336041 9.189806561 10.84458331 13.15235178 11.96461731 9.531239623 6.65871878 4.173857393
3.17118773 2.555598714 1.773805477 1.578028903 1.342395365 1.378107143 1.419331512 1.182996578
1.305916474 1.214968844 1.184044248 0.825487023 0.6627089 0.878333075 0.688085519 0.522117626
0.475394568 0.235418696 0.117982324 0.061125047 0.046268098 0
2001 1 8 0 0 221 0.08340262 0.252148515 0.773731016 0.926781316 1.733228858
2.867890298 4.333804124 5.254866118 5.179084321 7.185020564 8.958302658 8.408198152 7.738211704
12.49244624 7.107492284 5.399626842 3.436326789 2.906515555 0.673467244 1.542634205 4.811830371
2.614923301 2.541119193 1.485460042 0.302648374 0.238328498 0.170395556 0.174763086 0.249157643
0.06398497 0.046427554 0.024225372 0.010447152 0.013109467 0.05564037 0.252148515 0.773731016
0.926781316 1.733228858 2.867890298 4.333804124 5.254866118 5.179084321 7.185020564 8.958302658
8.408198152 7.738211704 12.49244624 7.107492284 5.399626842 3.436326789 2.906515555 0.673467244
1.542634205 4.811830371 2.614923301 2.541119193 1.485460042 0.302648374 0.238328498 0.170395556
0.174763086 0.249157643 0.06398497 0.046427554 0.024225372 0.010447152 0.013109467
2002 1 8 0 0 276.9 0.214600951 0.228894555 0.754943583 0.569936498 1.346196334
3.336462522 6.741876127 10.53227114 13.07223084 10.63398096 8.02123752 7.581790263 6.248759351
5.327210713 4.16801842 3.999473079 2.862267755 2.539138826 2.606058483 2.238744703 1.40861612
1.563226584 1.075733187 1.024466677 0.670017433 0.368746938 0.34996398 0.170734514 0.149206763
0.080530276 0.054164959 0.024651136 0.022898394 0.01295042 0.196543627 0.228894555 0.754943583
0.569936498 1.346196334 3.336462522 6.741876127 10.53227114 13.07223084 10.63398096 8.02123752
7.581790263 6.248759351 5.327210713 4.16801842 3.999473079 2.862267755 2.539138826 2.606058483
2.238744703 1.40861612 1.563226584 1.075733187 1.024466677 0.670017433 0.368746938 0.34996398
0.170734514 0.149206763 0.080530276 0.054164959 0.024651136 0.022898394 0.01295042
# first two years of combo survey have sexes combined
2003 1 9 0 0 214.5 0.143799623 0.303030821 1.00886991 1.552529703 2.733674168
2.711281081 4.653827445 8.573039547 9.114363609 9.799368709 8.99916528 6.765106372 5.44838546
5.255839708 4.753114027 4.788233596 4.284893607 4.133505529 2.806905142 3.052344575 1.972814648
1.519303603 1.734155933 1.02344612 0.900260813 0.601089829 0.474600672 0.502784002 0.211589304
0.051274318 0.056983885 0.05682642 0.00679627 0.00679627 0.143799623 0.303030821 1.00886991
1.552529703 2.733674168 2.711281081 4.653827445 8.573039547 9.114363609 9.799368709 8.99916528
6.765106372 5.44838546 5.255839708 4.753114027 4.788233596 4.284893607 4.133505529 2.806905142

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3.052344575	1.972814648	1.519303603	1.734155933	1.02344612	0.900260813	0.601089829	0.474600672
0.502784002	0.211589304	0.051274318	0.056983885	0.05682642	0.00679627	0.00679627
2004	1	9	0	0	197.4	0.284421675	1.275670187	2.330140848	2.62799238	3.27603371
2.865826962	4.779280901	8.13971663	10.18595315	11.3923255	8.916513857	6.994560536	6.370330491
5.37858658	4.61821747	3.211580902	2.917892446	2.779435509	2.289229678	1.760643759	1.689574398
1.579577814	1.61326729	0.69856653	0.68253191	0.534697668	0.263024676	0.202657342	0.0602913
0.085490799	0.066784004	0.081580911	0.008344963	0.039257227	0.232610946	1.275670187	2.330140848
2.62799238	3.27603371	2.865826962	4.779280901	8.13971663	10.18595315	11.3923255	8.916513857
6.994560536	6.370330491	5.37858658	4.61821747	3.211580902	2.917892446	2.779435509	2.289229678
1.760643759	1.689574398	1.579577814	1.61326729	0.69856653	0.68253191	0.534697668	0.263024676
0.202657342	0.0602913	0.085490799	0.066784004	0.081580911	0.008344963	0.039257227
# later years with split sexes
#_year	Season	Fleet	gender	partition	inputN	F6	F8	F10	F12	F14	F16	F18	F20	F22	F24
F26	F28	F30	F32	F34	F36	F38	F40	F42	F44	F46	F48	F50	F52	F54	F56	F58
F60	F62	F64	F66	F68	F70	F72	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24
M26	M28	M30	M32	M34	M36	M38	M40	M42	M44	M46	M48	M50	M52	M54	M56	M58
M60	M62	M64	M66	M68	M70	M72
2005	1	9	3	0	220.5	0.165219888	0.391179319	1.045602577	1.744514078	2.854431141
2.030474945	2.501615491	5.023090253	5.140685657	5.530326293	4.077813649	3.088587305	2.269765555
2.055897311	1.697043966	1.450142513	1.277907727	0.831412667	0.839880087	0.659158495	0.671067308
0.614036973	0.58218919	0.291063721	0.277940045	0.274412491	0.17445629	0.126233709	0.099647459
0.09690612	0.044320947	0	0.021195476	0	0.16521917	0.391180037	1.045601141	1.756255597
3.02607501	2.043752274	3.066169786	5.465771995	6.595070856	5.808356088	4.393535061	3.252502579
2.478873434	2.474638647	1.799214491	1.527226699	1.380543519	1.395905213	0.775420565	0.80424627
0.814236576	0.540910425	0.339159933	0.286172678	0.098164781	0.16385568	0.070062825	0.044982229
0.033917788	0.014760007	0	0	0	0
2006	1	9	3	0	188.5	0.088609235	0.273637597	0.489992025	1.290087237	2.202994339
2.565415979	2.514004341	3.755947566	5.54876593	5.376022352	5.381263848	3.253156349	2.435983711
2.424403619	1.648649453	1.375443411	1.487668968	1.137113304	0.97521508	0.864114847	0.721238783
0.802528861	0.590241441	0.608088203	0.632146096	0.416302435	0.360057185	0.287146035	0.230613992
0.070501172	0.073279885	0.11400732	0.023089168	0.016024939	0.088607414	0.273635776	0.489994756
1.298819422	2.159271503	2.170494696	2.323006117	3.683894977	4.545772833	5.221575302	4.933452347
3.969249234	2.910494339	2.548114581	2.271120131	1.824018786	1.822109559	1.251030488	1.337271627
0.896340442	1.272152161	0.910861308	0.619316859	0.333616628	0.424711408	0.196342601	0.038352055
0.059611206	0.084640556	0.008366182	0	0	0	0
2007	1	9	3	0	175.5	0.041957756	0.346588527	0.798602057	1.157670402	2.029950746
3.369944316	3.631248056	4.055623468	7.529969295	5.838477674	5.745110462	3.395262057	3.114022184
1.904980062	1.725892945	1.768435993	1.375584731	1.061050198	1.072485731	0.634821874	0.739621538
0.63156734	0.614996638	0.48410911	0.30246134	0.313108268	0.245315249	0.220483454	0.254688397
0.065265481	0.053218471	0.04496893	0.01908977	0.090175058	0.041957756	0.299378544	0.812375679
1.09340993	1.958280166	3.029341172	3.393736447	3.798788742	5.40020388	5.61558605	4.044513696
2.101054517	2.278060766	1.531974829	1.885222597	1.158286499	1.221089131	1.011862542	1.15271082
0.813507757	0.560827837	0.409468942	0.64368058	0.381011415	0.297846772	0.206243139	0.051149925
0.061828429	0.069853864	0	0	0	0	0
2008	1	9	3	0	159.9	0.16817772	0.377076712	0.407486527	1.195803317	2.179333577
3.005851658	2.487498475	3.573173933	4.556520695	5.3178613	3.638676135	3.082198519	2.459638423
1.952533404	2.445583023	1.444066077	1.135501517	1.042168085	0.972965172	0.957052691	0.903123377
0.707727369	0.552016011	0.533422148	0.586905685	0.375845063	0.281304961	0.266801862	0.194342093
0.157348432	0.091370672	0.021832466	0.010043415	0.013277214	0.168176759	0.377075751	0.407487488
1.215891107	2.164854497	2.880805668	2.707755153	4.204490073	4.809726383	6.047223225	5.640221864
3.794570031	3.312789711	3.433272259	1.937004252	1.492888179	1.725571829	1.339579593	1.021240621
```

```
0.952736155     0.86362895      0.773110441     0.574349976     0.46134859      0.242501295     0.159261235     0.096229056
0.035091426     0.022833541     0       0.021878581     0.021878581     0       0
2009    1       9       3       0       149.2   0.295651499     0.915246111     0.674950614     0.915792304     1.737411529
2.538219786     2.33402868      2.684946293     3.31468548      3.277824645     3.389802723     3.53407631      2.958254892
2.989421448     2.349559777     2.310315344     1.574624492     2.520985358     1.354723272     1.434656465     1.192884646
0.826152556     0.506570614     0.344472223     0.325176428     0.338157097     0.338464093     0.205611057     0.125503417
0.043037317     0.067196293     0       0       0.00955039      0.295650738     0.915246111     0.669151972     0.925724344
1.718016703     2.408323967     3.295179434     4.046206368     4.378415515     5.140702265     3.546911479     4.774173569
2.629668753     2.314746597     3.428446114     3.003521928     2.224738149     1.280536158     1.144481376     0.807227746
1.235870924     1.102947044     0.647991348     0.397715058     0.112110627     0.089399026     0.009945752     0.005573156
0.012415431     0.011009192     0       0       0       0
2010    1       9       3       0       141.5   0.240348547     1.267577937     1.445387287     1.748523674     1.967413409
2.445875264     2.633988443     2.978043129     4.34737625      4.839500733     3.694144767     2.236770008     3.029775272
2.149194257     2.4515024       1.684387393     1.614424552     1.312413422     0.839804434     0.878415361     0.541959981
0.610335921     0.438275906     0.740612054     0.308956158     0.40227785      0.28606489      0.220006506     0.247641506
0.026519926     0.029297428     0       0.00724289      0       0.300092421     1.281319486     1.445388136     1.748522826
2.019727698     2.314395802     3.376993578     4.580924033     5.340219094     6.951017534     4.175171123     2.685942921
2.071178102     2.032887101     2.042058883     1.899526269     1.453974377     1.494840911     1.02419985      1.073259718
0.97024944      0.786532063     0.338304502     0.34704519      0.244956502     0.114920526     0.135629167     0.062796326
0.01658694      0       0.007281926     0       0       0
2011    1       9       3       0       159.6   0.198108409     0.453811688     1.03588376      1.274100315     1.492426204
1.884473196     2.690469983     3.32425248      4.253313616     4.701386415     4.317007143     3.505980932     3.21026105
2.446197796     2.012238326     1.478631447     1.378161973     1.204883027     1.160268172     1.20043033      1.200103518
0.664024953     0.408783971     0.456026136     0.59207874      0.540211774     0.54119221      0.336394685     0.292211918
0.055236698     0.046648961     0.008898986     0       0.013098107     0.198105663     0.453812604     1.035882844     1.286054123
1.439100028     2.09283178      3.136656061     4.476446477     5.612590075     5.512855699     5.536084973     3.307778232
2.372318175     2.19354293      2.548681236     1.935508942     1.901164402     1.206895163     1.172171631     1.032336432
0.890587049     0.801416844     0.415662582     0.333862579     0.299231507     0.146385168     0.164804724     0.051389106
0.008287473     0.049943627     0.010414954     0       0       0
2012    1       9       3       0       159.2   0.098347569     0.570364482     1.331728727     1.318142849     1.433770593
2.126543885     2.72031459      4.7871209       5.14118312      4.672895712     3.708811807     3.68297547      2.541007705
1.506799288     2.231835456     0.967251732     1.097629646     1.168723583     1.234449654     1.024781899     0.751340843
0.999591572     0.721824127     0.904709863     0.553748331     0.359322009     0.255536159     0.238382894     0.10889826
0.044187466     0.029868788     0.042497521     0.010169143     0.025246003     0.098347569     0.577009632     1.23584566
1.328596925     1.526092003     1.960653391     2.742030051     4.28628077      4.582783347     5.495255165     4.351691614
3.951748709     2.141049243     2.571467646     2.555355039     2.494803605     1.898484063     1.558431025     1.457356128
0.934350214     1.136587617     0.964565342     0.797529386     0.41285084      0.203349295     0.206903582     0.068011263
0.029217046     0.015428932     0       0       0.007923253     0       0
#
0  #  N age' bins
0  #  number of ageerr matrices to generate
0  #  N age observations
2  #  Length bins range method
0  #  Combine males into females below this age bin number.
0  #  N size@age observations; values on row1; N on row2
0  #  environmental data  N variables
0  #  environmental data  N observations
0  #  No WtFrequency methods
0  #  No Tagging data
0  #  No Morph data
999  # end  of  file
```

## Appendix C. SS control file

```
# Shortspine Thornyhead control file
# Ian Taylor and Andi Stephens, 2013
#
#  uses SSv3.24o (April 10, 2013)
#
1  # N growthmorphs
1  # N submorphs within growth patterns
#
3 # Block designs
2 2 1 # Blocks in each design
# design 1 (trawl north)
2007 2010 # design 1, block 1
2011 2012 # design 1, block 2
# design 2 (trawl south)
2007 2010 # design 2, block 1
2011 2012 # design 2, block 2
# design 3 (non-trawl south)
2007 2012 # design 3, block 1
#
# Natural mortality and growth parameters for each morph
0.5  #_fracfemale
1    #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
2    #_N_breakpoints
20 40 # age(real) at M breakpoints
1    # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_speciific_K; 4=not implemented
2    #_Growth_Age_for_L1
100  #_Growth_Age_for_L2 (999 to use as Linf)
0.1  #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0    #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
1    #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity by GP; 4=read age-fecundity by GP; 5=read fec and wt
from wtatage.ss; 6=read length-maturity by GP
#_two alternative empirical age- or length- maturity by growth patterns (use option 6 above)
#0 0 0 0 0 0.001 0.060 0.863 0.998 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
#0 0 0 0 0 0     0.027 0.414 0.499 0.520 0.540 0.560 0.580 0.600 0.620 0.640 0.660 0.680 0.700 0.720 0.740 0.760 0.780 0.800 0.820
0.840 0.860 0.880 0.900 0.920 0.940 0.960 0.980 1 1 1 1 1 1 1 1 1 1 1
1    #_First_Mature_Age
1    #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W
0    #_hermaphroditism option:  0=none; 1=age-specific fxn
3    #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
1    #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)
#
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
0.01    0.15    0.05050 -3.129   3      0.5361  -3      0       0       0       0       0       0       0       #F_natM_young (Owen
prior)
-3      3       0       0       -1      0.2     -3      0       0       0       0       0       0       0
#F_natM_old_as_exponential_offset(rel_young)
3       10      7       9       -1      2       -2      0       0       0       0       0       0       0       #F_Lmin
55      95      75      70      -1      5       -2      0       0       0       0       0       0       0       #F_Lmax
```

```
0.01    0.03    0.018   0.017   -1      0.8     -3      0       0       0       0       0       0       0       #F_VBK
0.05    0.25    0.125   0.1     -1      0.8     -3      0       0       0       0       0       0       0       #F_CV-young
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0       #F_CV-
old_as_exponential_offset(rel_young)
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0
#M_natM_young_as_exponential_offset(rel_morph_1)
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0
#M_natM_old_as_exponential_offset(rel_young)
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0
#M_Lmin_as_exponential_offset
-3      3       -0.1053605 -0.1 -1      0.8     -2      0       0       0       0       0       0       0
#M_Lmax_as_exponential_offset
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0
#M_VBK_as_exponential_offset
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0       #M_CV-
young_as_exponential_offset(rel_CV-young_for_morph_1)
-3      3       0       0       -1      0.8     -3      0       0       0       0       0       0       0       #M_CV-
old_as_exponential_offset(rel_CV-young)

#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
0       100     4.770654e-06 0  -1      0.8     -3      0       0       0       0       0       0       0       #Female_wt-len-1
0       100     3.262977     0  -1      0.8     -3      0       0       0       0       0       0       0       #Female_wt-len-2
0       100     18.2    22      -1      0.8     -3      0       0       0       0       0       0       0       #Female_mat-len-1
-3      100     -2.3    -0.4    -1      0.8     -3      0       0       0       0       0       0       0       #Female_mat-len-2
0       100     1       1       -1      0.8     -3      0       0       0       0       0       0       0
#Female_eggs/gm_intercept
0       100     0       0       -1      0.8     -3      0       0       0       0       0       0       0       #Female_eggs/gm_slope
0       100     4.770654e-06 0  -1      0.8     -3      0       0       0       0       0       0       0       #Male_wt-len-1
0       100     3.262977     0  -1      0.8     -3      0       0       0       0       0       0       0       #Male_wt-len-2

#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
0       0       0       0       -1      0       -4      0       0       0       0       0       0       0       #RecrDist_GP_1
0       0       0       0       -1      0       -4      0       0       0       0       0       0       0       #RecrDist_Area_1
0       0       0       0       -1      0       -4      0       0       0       0       0       0       0       #RecrDist_Seas_1
0       0       0       0       -1      0       -4      0       0       0       0       0       0       0       #CohortGrowDev
#
# Seasonal effects on biology parameters (0=none)
 0 0 0 0 0 0 0 0 0 0
#
#
#_Spawner-Recruitment
3 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm
#
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
7       13      10.3    10      -1      10      4       #_SR_LN(R0)
#0.2    1       0.6     0.6     -1      0.2     -4      #_SR_BH_steep (old model)
0.2     1       0.6     0.779   -2      0.152   -2      #_SR_BH_steep (Thorson prior turned off)
0       2       0.5     0.5     -1      0.8     -4      #_SR_sigmaR
-5      5       0       0       -1      1       -3      #_SR_envlink
-5      5       0       0       -1      1       -4      #_SR_R1_offset
-1      1       0       0       -1      100     -1      #_SR_autocorr
```

```
#
0     #_SR_env_link
0     #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1     #_do_recdev:  0=none; 1=devvector; 2=simple deviations
1850  # first year of main recr_devs; early devs can preceed this era
2012  # last year of main recr_devs; forecast devs start in following year
6     #_recdev phase
1     # (0/1) to read 13 advanced options
 0    #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 -4   #_recdev_early_phase
 5   #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1    #_lambda for Fcast_recr_like occurring before endyr+1
 1859.5  #_last_early_yr_nobias_adj_in_MPD
 1918.4  #_first_yr_fullbias_adj_in_MPD
 2010.7  #_last_yr_fullbias_adj_in_MPD
 2012.1  #_first_recent_yr_nobias_adj_in_MPD
 0.072   #_max_bias_adj_in_MPD (1.0 to mimic pre-2009 models)
 0    #_period of cycles in recruitment (N parms read below)
 -5   #min rec_dev
 5    #max rec_dev
 0    #_read_recdevs
#_end of advanced SR options
#
#Fishing Mortality info
0.06 # F ballpark for annual F (=Z-M) for specified year
1999 # F ballpark year (neg value to disable)
1    # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
0.9  # max F or harvest rate, depends on F_Method
#
# init F setupforeachfleet
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
0       1       0.00    0.01    -1       99      -1
0       1       0.00    0.01    -1       99      -1
0       1       0.00    0.01    -1       99      -1
0       1       0.00    0.01    -1       99      -1
#
#_Q_setup
 # Q_type options:  <0=mirror, 0=float_nobiasadj, 1=float_biasadj, 2=parm_nobiasadj, 3=parm_w_random_dev, 4=parm_w_randwalk,
5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked
#_Den-dep  env-var  extra_se  Q_type
 0 0 0 0 # 1 NorthTrawl
 0 0 0 0 # 2 SouthTrawl
 0 0 0 0 # 3 NorthOther
 0 0 0 0 # 4 SouthOther
 0 0 1 0 # 5 Triennial1
 0 0 0 0 # 6 Triennial2
 0 0 0 0 # 7 AFSCslope
 0 0 0 0 # 8 NWFSCslope
 0 0 0 0 # 9 NWFSCcombo
#
```

```
#LO  HI      INIT    PRIOR   PR_type SD      PHASE
0.01 0.5     0.05    0.05    -1      0.1     4 # additive value for triennial survey

## #LO  HI      INIT    PRIOR   PR_type SD      PHASE
## -3   3       -0.5    -0.5    -1      2       2       #_Q_for_triennial_early
## -3   3       -0.5    -0.5    -1      2       2       #_Q_for_triennial_late
## -3   3       0       0.01    -1      2       2       #_Q_for_AFSC_slope_survey
## -3   3       0       0.01    -1      2       2       #_Q_for_NWFSC_slope_survey
## -3   3       0       0.01    -1      2       -2      #_Q_for_NWFSC_combo_survey
#### -3   3       -0.2231 0.01    -1      2       -2      #_Q_for_NWFSC_combo_survey
#
# SELEX & RETENTION PARAMETERS
#Pattern  Retention(0/1)  Male(0/1)  Special
# Size selex
24  1  0  0  # North Trawl
24  1  0  0  # South Trawl
24  1  0  0  # North Other
24  1  0  0  # South Other
24  0  0  0  # Triennial1
24  0  0  0  # Triennial2
24  0  0  0  # AFSC Slope survey
24  0  0  0  # NWFSC Slope survey
24  0  0  0  # NWFSC combo survey
# Age selex
10  0  0  0  # North Trawl
10  0  0  0  # South Trawl
10  0  0  0  # North Other
10  0  0  0  # South Other
10  0  0  0  # Triennial1
10  0  0  0  # Triennial2
10  0  0  0  # AFSC Slope survey
10  0  0  0  # NWFSC Slope survey
10  0  0  0  # NWFSC combo survey
#
#LO  HI  INIT  PRIOR  PR type  SD  PHASE  env-variable  use dev  dev minyr  dev maxyr  dev stddev  Block Pattern
#Size-Selectivity for North Trawl (double normal)
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       1       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal

#Retention for North Trawl
```

```
5       70      23      27      -1      99      3       0       0       0       0       0       1       3       # infl_for_logistic
0.1     40      2       15      -1      99      3       0       0       0       0       0       0       0       #
95%width_for_logistic
0.0001  1       0.9     0.9     -1      99      3       0       0       0       0       0       1       3       # final
-3      3       0       0       -1      3       -4      0       0       0       0       0       0       0       # male_offset

#Size-Selectivity for South Trawl (double normal)
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       1       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal

#Retention for South Trawl
5       70      23      27      -1      99      3       0       0       0       0       0       2       3       # infl_for_logistic
0.1     40      2       15      -1      99      3       0       0       0       0       0       0       0       #
95%width_for_logistic
0.0001  1       0.9     0.9     -1      99      3       0       0       0       0       0       2       3       # final
-3      3       0       0       -1      3       -4      0       0       0       0       0       0       0       # male_offset

#Size-Selectivity for North non-trawl (double normal)
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal

#Retention for North non-trawl
5       70      23      27      -1      99      3       0       0       0       0       0       0       0       # infl_for_logistic
0.1     40      2       15      -1      99      3       0       0       0       0       0       0       0       #
95%width_for_logistic
0.0001  1       0.9     0.9     -1      99      3       0       0       0       0       0       0       0       # final
-3      3       0       0       -1      3       -4      0       0       0       0       0       0       0       # male_offset

#Size-Selectivity for South non-trawl (double normal)
```

```
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal
#Retention for South non-trawl
5       70      23      27      -1      99      3       0       0       0       0       0       3       3       # infl_for_logistic
0.1     40      2       15      -1      99      3       0       0       0       0       0       0       0       #
95%width_for_logistic
0.0001  1       0.9     0.9     -1      99      3       0       0       0       0       0       3       3       # final
-3      3       0       0       -1      3       -4      0       0       0       0       0       0       0       # male_offset

#Size-Selectivity for Triennial1
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       -7      -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal

#Size-Selectivity for Triennial2
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal
#Size-Selectivity for AK slope
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
```

```
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       -7      -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal
#Size-Selectivity for NW slope
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal
#Size-Selectivity for NW combo
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE   env-var use_dev dev_min dev_max dev_SD  Block   Block_Fxn
10      60      30      30      -1      5       2       0       0       0       0       0       0       0       #
SizeSel_3P_1_Type24_size_double-normal
-7      7       0       -0.5    -1      2       3       0       0       0       0       0       0       0       #
SizeSel_3P_2_Type24_size_double-normal
-5      10      3       1.75    -1      5       3       0       0       0       0       0       0       0       #
SizeSel_3P_3_Type24_size_double-normal
-5      10      5       0.1     -1      2       4       0       0       0       0       0       0       0       #
SizeSel_3P_4_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_5_Type24_size_double-normal
-999    15      -999    0       -1      5       -99     0       0       0       0       0       0       0       #
SizeSel_3P_6_Type24_size_double-normal
#
1 #_custom_sel-blk_setup (0/1)
#### BLOCK PARAMETERS FOR EACH FLEET
#_LO    HI      INIT    PRIOR   PR_type SD      PHASE
-10     10      0       0       0       5       4       #       Retain_1P_1_Trawl_N_BLK1delta_2007
-10     10      0       0       0       5       4       #       Retain_1P_1_Trawl_N_BLK1delta_2011
-0.5    0.5     0       0       0       0.2     4       #       Retain_1P_3_Trawl_N_BLK1delta_2007
-0.5    0.5     0       0       0       0.2     4       #       Retain_1P_3_Trawl_N_BLK1delta_2011
#
-10     10      0       0       0       5       4       #       Retain_2P_1_Trawl_S_BLK2delta_2007
-10     10      0       0       0       5       4       #       Retain_2P_1_Trawl_S_BLK2delta_2011
```

```
-0.5    0.5     0       0       0       0.2     4       #       Retain_2P_3_Trawl_S_BLK2delta_2007
-0.5    0.5     0       0       0       0.2     4       #       Retain_2P_3_Trawl_S_BLK2delta_2011
#
-10     10      0       0       0       5       4       #       Retain_4P_1_Non-trawl_S_BLK3delta_2007
-0.5    0.5     0       0       0       0.2     4       #       Retain_4P_3_Non-trawl_S_BLK3delta_2007
#
2 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)
#
0  # TG_custom
1 #_Variance_adjustments_to_input_values
#_fleet:
#1      2       3       4       5       6       7       8       9
0       0       0       0       0       0       0       0       0       #_add_to_survey_CV
0       0       0       0       0       0       0       0       0       #_add_to_discard_stddev
0       0       0       0       0       0       0       0       0       #_add_to_bodywt_CV
0.5595  0.9773  0.5422  0.4024  0.6812  0.6494  1       0.5126  1       #_mult_by_lencomp_N
1       1       1       1       1       1       1       1       1       #_mult_by_agecomp_N
1       1       1       1       1       1       1       1       1       #_mult_by_size-at-age_N
#
5  # max lambda phases: read this Number of values for each componentxtype below
1  # include (1) or not (0) the constant offset For Log(s) in the Log(like) calculation
#
3 # number of changes to make to default Lambdas (default value is 1.0)
# lambdas below are to mimic the old ballpark F approach of phasing out that component
#
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch; 9=init_equ_catch;
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin; 17=F_ballpark
#like_comp fleet/survey  phase  value  sizefreq_method
17          999           2     0.1      999
17          999           3     0.01     999
17          999           5     0        999
#
0 # extra SD pointer
#
999  # end-of-file
```

# Appendix D. SS starter file

```
# Shortspine Thornyhead starter file
# Ian Taylor and Andi Stephens, 2013
#
#  uses SSv3.24o (April 10, 2013)
#
SST_data.SS
SST_control.SS
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
1 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed info from first call to echoinput.sso (0,1)
0 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
0 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
1 # Include prior_like for non-estimated parameters (0,1)
0 # Use Soft Boundaries to aid convergence (0,1) (recommended)
3 # Number of datafiles to produce: 1st is input, 2nd is estimates, 3rd and higher are bootstrap
25 # Turn off estimation for parameters entering after this phase
0 # MCeval burn interval
1 # MCeval thin interval
0 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-2 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
0.0001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
1 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
1 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
1 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates); 4=true F for range of ages
0 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file
```

## Appendix E. SS forecast file

```
# Shortspine Thornyhead forecast file
# Ian Taylor and Andi Stephens, 2013
#
#  uses SSv3.24o (April 10, 2013)
#
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.5 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
# Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel.
endyr)
 0 0 0 0 0 0
#  2010 2010 2010 2010 2010 2010 # after processing
1 # Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
12 # N forecast years
0.20 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0
#  1180659524 1667592815 7631713 0 # after processing
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.40 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0.10 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
#
# NOTE: 0.942 target below based on qlnorm(0.45, 0, sigma=0.4751487)
#       which is based on estimated SD of 2013 spawning biomass in base model
# UPDATE: better calculation provides new sigma 0.451 which leads to 0.945 below.
0.945 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
#-65534 #_Forecast loop control #5 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2013  #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
2001 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2011 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
-1 -1 -1 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
-1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
```

```
0 0 0 0
#_Conditional on >1 allocation group
# allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
2 # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in
SSV3.20)
# Input fixed catch values
#Year Seas Fleet Catch(or_F)
2013  1    1     405.2 # average of 2011 and 2012
2013  1    2     307.2
2013  1    3      32.6
2013  1    4     207.5
2014  1    1     405.2 # average of 2011 and 2012
2014  1    2     307.2
2014  1    3      32.6
2014  1    4     207.5
999 # verify end of input
```

# Shortspine Thornyhead

# Stock Assessment Review (STAR) Panel Report

**NOAA Fisheries**
**Northwest Fisheries Science Center**
**2725 Montlake Blvd.**
**July 22-26, 2013**

**STAR Panel Members**

| | |
|---|---|
| Meisha Key (Chair) | California Department of Fish and Wildlife, PFMC Scientific and Statistical Committee (SSC) |
| Ray Conser | Fish Stock Assessment Consulting, LLC |
| Yan Jiao | Center for Independent Experts (CIE) |
| Jean Jacques Maguire | Center for Independent Experts (CIE) |

**Pacific Fishery Management Council (PFMC) Advisors**

| | |
|---|---|
| Corey Niles | Washington Department of Fish and Wildlife, PFMC Groundfish Management Team (GMT) |
| Pete Leipzig | Fishermen’s Marketing Association, PFMC Groundfish Advisory Subpanel (GAP) |
| John DeVore | PFMC Staff |

**Stock Assessment Team (STAT)**

| | |
|---|---|
| Ian Taylor | NMFS, Northwest Fisheries Science Center |
| Andi Stephens | NMFS, Northwest Fisheries Science Center |

## Overview

A draft assessment of the shortspine thornyhead (*Sebastolobus alascanus*) off the U.S. west coast was reviewed by the STAR panel during July 22-26, 2013. This assessment was presented to the STAR Panel by Dr. Ian Taylor (lead STAT author) and used the Stock Synthesis platform (version 3.24o). Previous stock assessments of shortspine thornyhead were carried out by Jacobsen (1990, 1991), Ianelli et al (1994), Rogers et al (1997, 1998), Piner and Methot (2001), and Hamel (2005). This Panel also reviewed the longspine thornyhead assessment during the same week (see separate Longspine Thornyhead STAR Panel Report) and to the extent possible, strove to ensure a consistent treatment of the catch data, influence of fishery regulations, and population vital rates.

Shortspine thornyhead are found in the waters off of the West Coast of the United States from northern Baja California to the Bering Sea. The majority of the spawning biomass occurs in the oxygen minimum zone between 600 and 1,400 meters, where longspine thornyheads are most abundant. Shortspine thornyhead are believed to have ontogenetic migration down the slope, although large individuals are found across the depth range. Additionally, they do not appear to be distributed evenly across the West Coast, with higher densities in shallower depths (under 500 meters) off of Oregon and Washington, and higher densities in deeper depths off of California. They are associated with Dover sole, sablefish and longspine thornyhead.

Dr. Taylor reviewed the fisheries, the data used in the analysis, and the Stock Synthesis (SS3) modeling approach. Following the initial presentation and discussion of the assessment, the Panel made written requests to the STAT for additional analyses. Upon completion, the STAT presented the results to the Panel which in turn, made additional requests related to the questions and issues arising from the new material. This process was repeated five times during the week until a base case was achieved and the uncertainty was fully characterized, to the extent possible given the time available.

Stock depletion in 2013 ($SSB_{2013}/SSB_0$) is estimated to be 0.742 with a slightly declining trend in SSB during recent years. The stock status appears to be healthy and robust to the data and modeling scenarios explored by the Panel. Recent fishing mortality rates are less than the $F_{MSY}$ proxy and recent SSB are well above the target and limit reference points. However, important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are particularly lacking for shortspine thornyhead, making the stock assessment only marginally sufficient to estimate the status of the resource. In particular although the SSB trend is fairly robust, the data and modeling are not informative as to the scale of SSB. $R_0$ is used as a proxy to bracket the uncertainty in the decision table.

The Panel commends the high quality of the draft assessment document, and greatly appreciated the STAT's patience and efficiency in responding to the Panel's many requests for additional analyses. The Panel also valued the many contributions from the GMT and GAP advisors. The STAR panel concluded that the shortspine thornyhead assessment was based on the best available data, and that this new assessment constitutes the best available information on shortspine thornyhead off the U.S. west coast.

## Discussion and Additional Analyses Requested by the STAR Panel

1. Determine why Slide 15 of the presentation (comparing GLMM lognormal, GLMM gamma and design based) and slide 19 of the presentation (NWFSC Combo survey) do not match. *Rationale: They are supposed to show the same data, but the trends are different.*
   **Response: Slide 15 mistakenly showed LST GLMM results rather than the intended SST results. A corrected figure was presented.**

2. Remove the Pikitch discard data for the south. *Rationale: The study did not cover the southern area and information from the fishery suggested that there was no reason to discard (i.e., Eureka fisheries had a market for all its fish).*
   **Response: These data were removed and the estimated discard fraction for the southern trawl fishery decreased slightly (from ~16% to 14%). Little or no effects were found in the results or model diagnostics.**

3. For the AFSC triennial shelf survey, only include 1995 LF and index onwards without the extra variance. *Rationale: This will provide consistent sampling over depth and area to have a more consistent index.*
   **Response: The SSB trend was not affected but the absolute SSB level was reduced approximately 20%. [It was decided to use this as a sensitivity case while leaving the complete time series in the base case.]**

4. Provide a graph of the trends (year effect) by stratum for the NWFSC Combo survey to verify that there is no regional difference in stock trends. *Rationale: To consider if there is a need for the management line at 34$^{o}$27' and if there is any biological justification for the line.*
   **Response: There was no apparent trend with respect to year, suggesting there is no scientific evidence to maintain this management line.**

5. Begin estimating recruitment deviations in 1930 rather than 1850. *Rationale: There are no size data until 1978. The initial population structure is actually pretty close to equilibrium. This should affect the uncertainties more than the population size estimates.*
   **Response: Beginning the process of estimating recruitment deviations later had no effect on model results. [It was decided to maintain the full time series in the base case.]**

6. With the Pikitch data being removed for the south, estimate discards in 2 blocks: up until 2004 and 2005 onwards. *Rationale: This is when the WGCOP survey began and the first discard information available.*
   **Response: It was discovered that discard length compositions for the south do not begin until 2006; thus blocking has little or no effect. The discard fraction here was around 2%. The STAT came up with an alternative run with blocking beginning in 2007 and an additional block beginning in 2011 when catch shares began and had 100%**

**observer coverage. This blocking increased the discard fraction from approximately 2% to 3% in the south.**

7. With the entire time series of the AFSC triennial shelf survey included in the base case, exclude the size compositions for 1980 and 1983. *Rationale: These years had low sample sizes with only 1 haul per year.*
   **Response: This made no difference in results. [Include in new base.]**

8. Use the old maturity function from the previous assessment until the new data are more thoroughly analyzed. *Rationale: The maturity ogive developed from the work of Pearson and Gunderson (2003) that was used in the last assessment appeared to be more realistic and samples from this study were collected during the shortspine thornyhead spawning season. The new information was collected outside of their peak spawning season and should be evaluated further.*
   **Response: This increased SSB but did not change depletion. [Include in new base.]**

9. Provide a sensitivity using the old versus the new maturity curve.
   **Response: same as #8 above.**

10. Remove the trawl north LF for 1994-1995. *Rationale: Because of poor fit and low sample sizes for these years (outliers).*
    **Response: Improved fits and there were no changes in management results such as depletion. [Include in new base.]**

11. Block on fishery selectivity beginning in 1992. *Rationale: There was a concern that the fishery appears to be selecting the same or smaller sizes than the survey which uses much smaller mesh size. Minimum mesh size changed in 1992 from 3 to 4.5".*
    **Response: Trawl-North selectivity showed that smaller fish were more selected after moving to larger mesh which is counterintuitive. Alternative retention blocking (2007-10 and 2011-12) did not rectify this anomaly.**

12. Explore asymptotic selectivity for NWFSC Combo survey. *Rationale: The fishery trawl has higher selectivity for larger fish than the survey has. (Could be that fishery fishes closer to rocky areas where the survey may not go.)*
    **Response: The ascending limb did not change and did not affect overall selectivity. The trend in SSB was similar but the scale was reduced by ~50%. Depletion was still above management target. Total likelihood increased 54 units (poorer fit) and was therefore not recommended for the base model.**

13. When looking at sensitivities also include yield estimates and other parameters, not only SSB. *Rationale: More diagnostics are needed to determine influences and model stability.*
    **Response: This additional information was presented to the Panel for the remainder of the review.**

14. Use the reconstructed catches by California and Oregon. Make a graph of the two series of catch estimates as well. *Rationale: Since efforts have been made to improve historical catches and these reconstructed estimates have been used for other assessments this year, this request could not be ignored.*
**Response: The reconstructed SST catch prior to the 1970s are quite small relative to the catch history used in the 2005 assessment. This difference in catch history does not have significant effects on the results. [For consistency with LST, do not use the reconstructed catch as part of the base case.]**

15. Implement Second Round of conclusions, i.e., 1) Remove the Pikitch discard data for the south, 2) Include entire time series from the AFSC triennial shelf, excluding the size compositions for 1980 and 1983, 3) Use the maturity ogive from the previous assessment until the new data are more thoroughly analyzed, and 4) Remove the trawl north LF for 1994-1995 because of poor fit and small sample sizes. Further, steepness should be fixed at 0.6. Also use the reconstructed catch series with the addition of the estimated foreign fleet catches from the 2005 assessment, which was not included in the previous request. *Rationale: To evaluate these changes in full.*
**Response: Model responded as anticipated. Adding the foreign catches caused the reconstructed catch series and that used in the last assessment to be quite similar.**

16. Blocks for retention curve:
- Trawl north: 1901-2006, 2007-2010, from 2011 onward
- Trawl south: 1901 to 2006, 2007-2010, from 2011 onward
- Non-trawl north: no blocks
  - This fleet is minimal with no reason to treat with blocking scheme
- Non-trawl south: 1901 to 2006, from 2007

*Rationale: The draft assessment initially had 7 retention time blocks, with no supporting evidence for the blocks presented. This was an attempt to reduce parameters being estimated in the model. The splits from 2007 on were based on available length data. For the trawl fleets, the additional blocking represents the beginning of the catch shares program and 100% observer coverage in those years. (A decrease in discards during these years has been observed.) For the non-trawl north fleet, there was no evident reason to treat this fleet with a blocking scheme.*
**Response: The new retention functions were reasonable. This blocking better reflects the fishery practices and regulations. SSB trend was not affected but the SSB scaling was reduced approximately 50%. Subject to several additional requests (see below), consider this run as the candidate base case. [This new blocking also seemed to fix the scaling problem that arose when "ballpark F" was turned off.]**

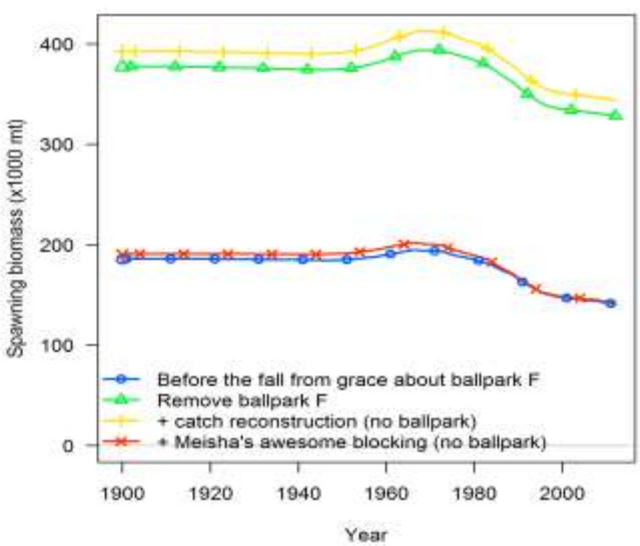
17. If blocks for retention produce SSB in the 400,000 mt range, constrain the catchability for the NWFSC Combo survey between 0.50 and 2.0. *Rationale: to evaluate the scaling problem.*
**Response: This run was not needed based on the results of #16 request above.**

18. Add an additional retention time block for the trawl north fleet: 1901-1991, 1992-2006, 2007-2010, from 2011 as a sensitivity. *Rationale: To see if the mesh size had an effect beginning in 1992. [This time block was deemed appropriate in the longspine thornyhead assessment.]*
**Response: This run may not have converged. Results were difficult to interpret. The additional block did not improve the model fit and therefore concluded not necessary to include in the base model.**

19. Mimic the 2005 assessment's implementation of the ballpark F. *Rationale: The 2005 assessment employed the Ballpark F option in SS, i.e., F was fixed at an input value for all phases of the optimization through the penultimate phase and then F was freely estimated in the last phase. The STAT intended to use Ballpark F in the same way for this assessment but unbeknownst to the STAT, the new version of SS3 continues to fix F in the last phase.*
**Response: SSB trend was not affected but the SSB scaling was affected - SSB approximately doubled.**

20. Redo the profiling on log($R_0$) (figure 48 of original document) and jitter. *Rationale: To update and evaluate changes to new base model.*
**Response: Profiling on log($R_0$) showed a fairly flat total likelihood. The base case estimated log($R_0$) = 10.3 (was 9.8 in draft base case). A 2 likelihood unit change from the minimum gives a range of log($R_0$) from approximately 9.8 to a value greater than 12 (12 was the largest value used in the profile). This is a wide range of estimates for $R_0$ across a small range of likelihoods, suggesting that there is little data informing the scale of the population. This further explains why the ballpark F treatment had such large scaling effects. Jittering showed all runs returning to the same place.**

21. Modify the phasing and see if we get the same results (red line in figure below). *Rationale: To check the influence of alternative phasing.*
**Response: Using the original phasing produced nearly identical results.**



22. Check to see if you get yellow (catch reconstruction, no ballpark F) or green lines (removing ballpark f) if ballpark F is phased out instead of simply turned off. *Rationale: To check the effect of correcting the Ballpark F in conjuction with the new blocking.*
**Response: Phasing out the ballpark F parameter had no effect on results. This request and the above (#21) illustrated that the new retention blocking solved the scaling issues and better fit the available data.**

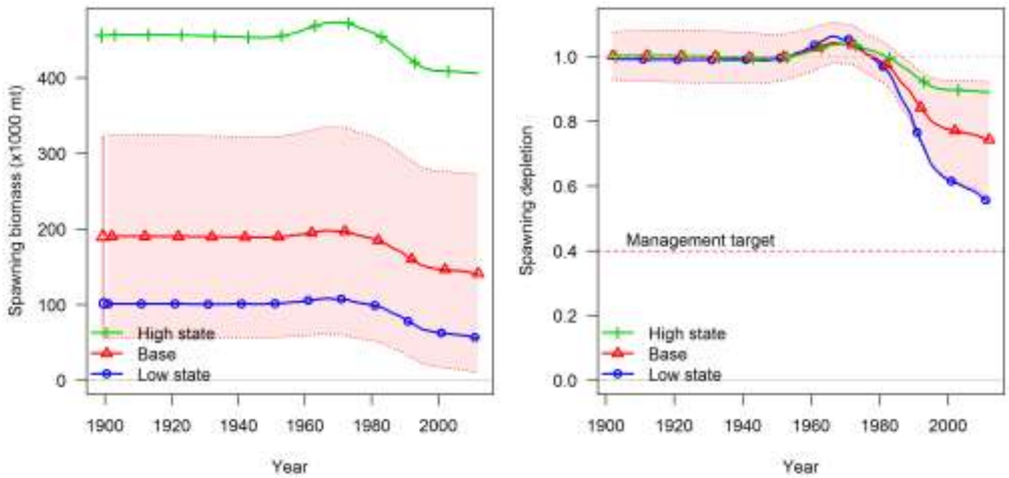
23. Show fits to indices and length frequencies. *Rationale: To evaluate based on changes for a new base model.*
**Response: This was done and presented to the Panel. Satisfactory results.**

24. Remove historical reconstructed catches and replace with 2005 assessment catches. *Rationale: After noticing a discrepancy in the early reconstructed catches in the longspine thornyhead review, for consistency, go back to the 2005 assessment estimates.*
**Response: This was done and had no effect on the results.**

25. Remove 1994 and 1995 Trawl north LF. *Rationale: There was no effect in an earlier sensitivity, but these had been overlooked and still had not been removed at this point.*
**Response: This was done and had no effect on the results.**

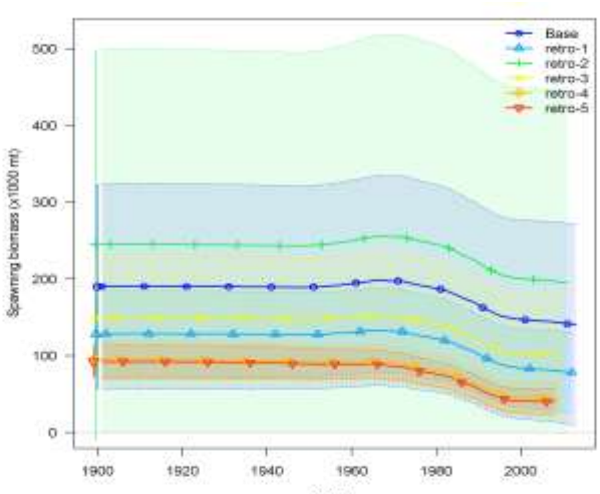
26. Uncertainty boundaries (low and high states of nature):
    a. Take the 12.5% quantile in 2013 spawning biomass estimate from the base model as the low state of nature (from the Delta Method normal approximation of variance).
    b. Calculate the approximate R0 value associated with it from the likelihood profile on $R_0$.
    c. Determine the change in likelihood at the alternative $R_0$ value.
    d. Add the change in the likelihood to the base model to determine the upper $R_0$ value from the likelihood profile to get the high state of nature. If the upper state of nature is over 600,000 mt (largest reasonable value from sensitivity runs) then instead choose an $R_0$ value That represents a change in likelihood of 1.2 units from the low state of nature (the distance in log likelihood space from the 12.5% to 87.5% quantiles).

    *Rationale: The 12.5% quantile in 2013 spawning biomass estimate from the base case model appears to provide a reasonable low state of nature (given the suite of sensitivity runs examined by the Panel). Due to the normality assumption of the delta method and the consequent symmetric confidence interval, however, the 87.5% quartile does not adequately represent a high state of nature. Using the likelihood profile on log($R_0$) to better characterize the asymmetric confidence interval should provide a more appropriate high state of nature.*
    **Response: The base case estimate of SSB in 2013 was 141,000 mt (depletion=0.74). The low state of nature SSB in 2013 was 56,000 mt (depletion=0.55), and the high state of nature SSB in 2013 was 405,000 mt (depletion=0.89). These runs appear to adequately capture the uncertainty in the assessment.**




27. Plot actual biomass (SSB) estimates from previous assessments and from this one. *Rationale: To compare results from the two assessments.*
    **Response: The plot showed a similar trend, with the SSB time series from the 2005 assessment scaled at a lower biomass.**

28. Do the retrospective with the new base case. *Rationale: To evaluate the effects of removing data, one year at a time.*
    **Response: A 5-step retrospective analysis was presented, i.e. successively dropping the years 2012, 2011, 2010, 2009, 2008. SSB trends were similar among the five retrospective runs and the base case but the scale of the SSB varied greatly among the runs. Despite the wide range of SSB estimates from the retrospective runs, a clear retrospective pattern did not emerge, e.g. no tendency to successively underestimate or overestimate SSB. Although all of the retrospective runs fell within the range of uncertainty identified in Request 3, above, the runs clearly demonstrate the difficulties in establishing SSB scale in the assessment and the tendency for small changes in model configuration to lead to important changes in model results.**



## Description of Base Model and Alternative Models Used to Bracket Uncertainty

Data used in the base model:

- Full catch history (with discard estimates) from 1901-2012 and fishery length frequency data (as available).
- Five surveys along with their respective length frequency data:
    - AFSC Triennial Shelf (100-366 m): 1980-2004
    - AFSC Triennial Shelf (366-500 m): 1995-2004
    - AFSC Slope: 1997, 1999-2001
    - NWFSC Slope: 1998-2002
    - NWFSC Shelf/Slope Combo: 2003-2012

Model structure:

- Single stock in USA waters – Canadian border to Mexican border
- Four fisheries: trawl-north, trawl-south, non-trawl-north, non-trawl-south
- Begin model in 1901
- Recruitment deviations estimated from 1850+
- Beverton-Holt stock recruit relationship
- M = 0.0505 fixed
- h = 0.6 fixed
- sigma-R = 0.5 fixed
- All von Bertalanffy growth parameters fixed
- Selectivities estimated for all fisheries and surveys

Starting with the model configuration described in the draft assessment document, the following changes were made to create a new base case:

- Errors were corrected (selectivity parameters and ballpark F fixed) – the former had little effect but the latter was important.
- Pikitch discard data for Trawl South was removed (few samples & not representative) – little effect.
- Remove 1980 and 1983 size comps from the Triennial Shelf Survey (small sample size) – little effect.
- Remove the trawl north LF for 1994-1995 because of poor fit– little effect.
- Change steepness to h=0.6 (consistent with 2005 assessment).
- Use old maturity ogive.
- Use three selectivity blocks for the trawl fishery– important effect.

Uncertainty was characterized by identifying two scenarios that represented low and high states of nature using the following algorithm:

a. Take the 12.5% quantile in 2013 spawning biomass estimate from the base model as the low state of nature (from the Delta Method normal approximation of variance).

b. Calculate the approximate $R_0$ value associated with it from the likelihood profile on $R_0$.
c. Determine the change in likelihood at the alternative $R_0$ value.
d. Add the change in the likelihood to the base model to determine the upper $R_0$ value from the likelihood profile to get the high state of nature. If the upper state of nature is over the largest reasonable value from sensitivity runs, then instead choose an $R_0$ value that represents a change in likelihood of 1.2 units from the low state of nature (the distance in log likelihood space from the 12.5% to 87.5% quantiles).

## Comments on the Technical Merits of the Assessment

The STAR panel agreed that this stock assessment is based on the best available data and best available science. Important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are particularly lacking for shortspine thornyhead, making the stock assessment only marginally sufficient to estimate the status of the resource.

This Panel suggests not conducting another full stock assessment on this stock until pertinent information is available for improvement. In the meantime, using an index of abundance (i.e., NWFSC Combo survey) to detect trends should be sufficient.

## Areas of Disagreement

There were no areas of disagreement among the Panel members nor between the Panel and the STAT.

## Unsolved Problems and Major Uncertainties

- Scaling issues. The ballpark F and the retrospective analysis had the biggest effect on the scale of the biomass.
- Sensitivity of results to small changes in model specifications.
- Lack of age data in the model.
- The need to fix all growth parameters outside the model. The current model has no information to provide a means of estimating important parameters. Uncertainty is likely underestimated due to fixing growth, M, *h*, and sigmaR.

## Concerns Raised by the GMT and GAP Advisors During the Meeting

### GAP Advisor Comments

The stability of the model was a cause for concern. Small adjustments to the model caused large changes in SSB which could have potential management implications. The concerns are particularly related to selectivity. Some examples are as follows: 1) there should have been greater separation between survey and the fishery, 2) estimated selectivity went in the opposite direction of what was expected when mesh size changed in the fishery in 1992, and 3) selectivity of 20 cm shortspine and longspine thornyheads should have been similar.

**GMT Advisor Comments**

The GMT Advisor shared many of the GAP Advisor's concerns about the sensitivity of the model to assumptions about selectivity and retention. There is not much if any information available on how selectivity and retention may have changed over time or how it varied between areas, ports, and even buyers. Market conditions are thought to have determined largely whether fish were discarded or kept in the past yet such past conditions are not documented. The GMT Advisor supported the STAR Panel and STAT recommendation to reduce the number of retention curve blocks in the trawl fisheries.

The GMT representative also had questions about the advantage of estimating discards over simpler approaches that have been used in many assessments (e.g. using the estimates of discard in years where data is available and assuming a constant discard proportion where it is not). In this assessment, the discard percentage ("fraction") jumped substantially between runs, especially for the Trawl South fishery. The model fit to the observer-based discards estimates was also poor in many years. Despite these concerns, the GMT Advisor was satisfied that the states of nature recommended by the Panel would cover the uncertainty added by uncertainty in historical discard and total catch.

Likewise, the GMT supported the use of the STAT's catch history given the time constraints yet hopes the catch reconstruction can be better resolved for the next assessment.

## Research Recommendations

1. Ageing to help estimate pertinent parameters in the model (e.g. M, growth), perhaps including new methods such as tagging. Tagging studies would also further investigate the assumption of an ontogenetic movement pattern seen for this species.
2. Maturity ogive to evaluate the pattern seen in the most recent data collected.
3. More efforts to reconstruct historical catches for thornyheads.
4. Investigate alternative, simpler methods that may be more robust.

## References

Pearson, K. E. and D. R. Gunderson. 2003. Reproductive biology and ecology of shortspine thornyhead rockfish, *Sebastolobus alascanus*, and longspine thornyhead rockfish, *S. altivelis*, from the northeastern Pacific Ocean. Environmental Biology of Fishes 67: 117-136.

Ralston, S., D.E. Pearson, J.C. Field, and M. Key. 2010. Documentation of the California catch reconstruction project. NOAA Technical Memorandum. NMFS, NOAA-TM-NMFS-SWFSC-461.

Agenda Item G.3.a
Attachment 7 (Full Version, Electronic Only)
September 2013



# Stock Assessment and Status of Longspine Thornyhead (*Sebastolobus altivelis*) off California, Oregon and Washington in 2013

Andi Stephens
Ian G. Taylor

Northwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

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# Table of Contents

# Executive Summary

## Stock

This assessment pertains to the longspine thornyhead (*Sebastolobus altivelis*) population located off the west coast of the continental USA, from the US/Canadian border in the north to the southern end of the Conception INPFC area (32.5° latitude). Longspine thornyheads have been reported from 200 meters (m) to as deep as 1,755 m, however survey and fishery data are only available down to 1,280 m. This resource is modeled as a single stock because genetic analyses do not indicate significant stock structure within this range. This is the same stock assumption made in the most recent assessment of longspine thornyhead in 2005 (Fay, 2005).

## Landings and Catch

Landings of longspine were modeled as a single coast-wide fishery. Very small amounts of longspine thornyhead are caught using gears other than trawl; this catch was combined with the trawl catch. Recreational fishery landings of thornyheads were negligible, so only commercial landings were included in the model.

The fishery for thornyheads increased gradually during the 1960s and 1970s, but did not expand significantly until the late 1980s with the development of a market for smaller thornyheads. At their peak in the early 1990s, annual landings were over 6,000 mt. Landings have declined in recent years in response to increased management restrictions. Landings in this assessment were estimated for the period 1964-2012.

Discard rates (landings divided by total catch) for longspine have been estimated as high as 46% per year, but are more frequently below 20%. Discard rates in the trawl fisheries observed by the West Coast Groundfish Observer Program (WCGOP) from 2003–2011 were less than 20%, except in 2009 when they were 28%. Discard rates have since dropped to less than 5% in 2011, the only estimate available under the catch shares program that began that year.

**Table a: Recent Catches**

| Year | Catch (mt) |
|---|---|
| 2003 | 1,886 |
| 2004 | 837 |
| 2005 | 792 |
| 2006 | 911 |
| 2007 | 956 |
| 2008 | 1,463 |
| 2009 | 1,375 |
| 2010 | 1,588 |
| 2011 | 972 |
| 2012 | 912 |

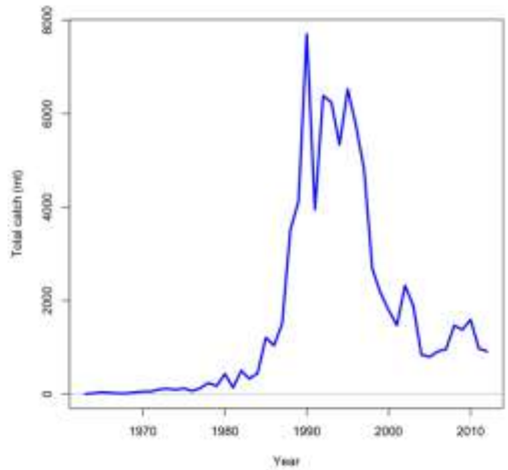


**Figure a: Catch History**

## Data and assessment

This is the fifth stock assessment of West Coast longspine thornyhead. The previous stock assessments were conducted in 1990, 1992, 1994, 1997, and 2005. The most recent assessment, conducted by Gavin Fay in 2005, was the first to assess longspine thornyhead separately from shortspine thornyhead. Data sources included in the current assessment are:

1. Commercial landings and length composition information from California, Oregon and Washington obtained from the PACFIN database;
2. Commercial landings and mean body weights from the California Department of Fish and Wildlife (CDFW);
3. Discard rates and length compositions from an Oregon State University observer study (Pikitch);
4. Discard rates from the Enhanced Data Collection Project (EDCP);
5. Discard rates, length compositions, and mean body weights from the West Coast Groundfish Observer Program (WGCOP);
6. Biomass indices and length-composition information from the Alaska Fisheries Science Center (AFSC) and Northwest Fisheries Science Center (NWFSC) FRAM slope surveys.
7. Biomass indices and length-composition information from the Northwest Fisheries Science Center (NWFSC) combined shelf-slope survey.

These data were used to fit an age-structured population dynamics model using the length-age-structured model Stock Synthesis 3, version 24o (Methot 2005). Parameters chosen for this assessment included a natural mortality rate (M) of 0.11, and Beverton-Holt steepness (*h*) of 0.6. Fishery and survey selectivities were estimated as asymptotic, with the exception of the AFSC slope survey, which is dome shaped.

Most of the data used in the previous assessment has been newly extracted and processed, including length compositions from each fishing fleet and survey, indices of abundance derived from new GLMM analyses of survey data, discard rates from both the 1980s Pikitch study and the current West Coast Groundfish Observer Program (WCGOP), and the time-series of landings from 1981-2012. Data retained from the previous assessment without reanalysis are the estimated historic catch for the years up to 1980 and the discard rates from the EDCP study in the 1990s. As in the previous assessment, no age data is used in this analysis.

## Stock biomass

Total and spawning biomass of longspine thornyhead has shown a decline since the late 1980s; with the rate of this decline slowing since the mid-1990s due to reduced catches. The stock, however, is only lightly exploited, and the current spawning biomass is estimated to be over 29,000 mt, 75% of the unfished equilibrium level.

**Table b: Recent trend in beginning of the year biomass and depletion**

| Year | Spawning biomass (1000 mt) | ~95% confidence interval | Estimated depletion | ~95% confidence interval |
|---|---|---|---|---|
| 2001 | 18.5 | 8.2 - 28.8 | 47.20% | 34.5% - 59.9% |
| 2002 | 19.1 | 8.3 - 29.8 | 48.70% | 35.3% - 62.1% |
| 2003 | 19.4 | 8.1 - 30.1 | 49.50% | 35.0% - 64.0% |
| 2004 | 20.0 | 8.1 - 31.8 | 51.00% | 35.5% - 66.5% |
| 2005 | 21.1 | 86 - 33.5 | 53.80% | 37.6% - 70.0% |
| 2006 | 22.2 | 9.2 - 35.3 | 56.80% | 40.0% - 73.7% |
| 2007 | 23.4 | 9.8 - 37.1 | 59.90% | 42.5% - 77.3% |
| 2008 | 24.7 | 10.4 - 38.9 | 63.10% | 45.0% - 81.1% |
| 2009 | 25.7 | 10.9 - 40.5 | 65.70% | 46.8% - 84.5% |
| 2010 | 26.8 | 11.3 - 42.2 | 68.40% | 48.8% - 88.0% |
| 2011 | 27.7 | 11.7 - 43.7 | 70.80% | 50.3% - 91.2% |
| 2012 | 28.7 | 12.1 - 45.2 | 73.30% | 52.2% - 94.5% |
| 2013 | 29.4 | 12.5 - 46.4 | 75.20% | 53.5% - 96.9% |

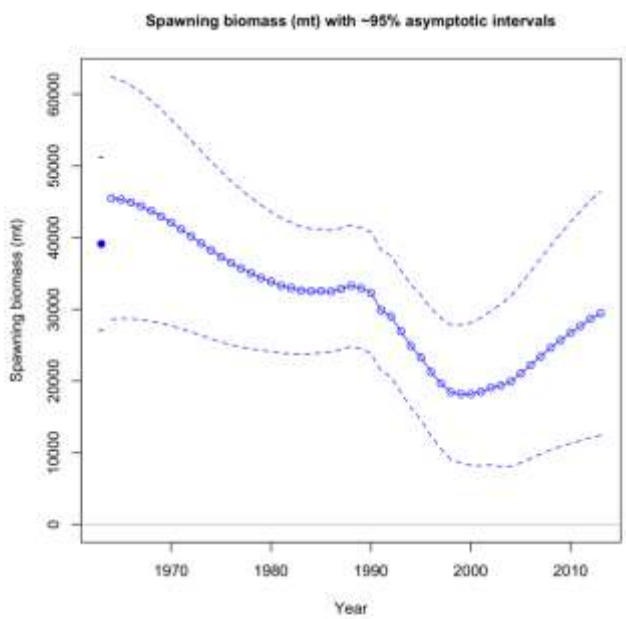


**Figure b: Biomass trajectory**

## Recruitment

Expected annual recruitment was described by a Beverton-Holt function of spawning biomass. Annual deviations about this stock-recruitment curve were estimated for the years 1944 through 2012. The impact of recruitment variability on the biomass for longspine thornyhead is low due to the long-lived nature of the species. The bulk of the biomass for this stock is contained in a large number of old age-classes. In addition, no age data are available for this species (other than that used to estimate growth). Estimation of recruitment events is therefore difficult, and information is only available to estimate recruitment for recent years when size-composition data from the slope surveys are available (since 1997).

**Table c: Recent recruitment**

| Year | Estimated recruitment (millions) | 95% confidence interval |
|---|---|---|
| 2001 | 196.4 | 95.1 - 405.7 |
| 2002 | 110.9 | 47.2 - 260.0 |
| 2003 | 256.3 | 13.4 - 490.6 |
| 2004 | 93.2 | 39.2 - 221.1 |
| 2005 | 118.0 | 54.7- 254.2 |
| 2006 | 101.1 | 47.4 - 216.0 |
| 2007 | 65.2 | 27.5 - 154.8 |
| 2008 | 72.4 | 31.2 - 167.7 |
| 2009 | 67.2 | 27.8 - 162.1 |
| 2010 | 68.5 | 27.5 - 170.5 |
| 2011 | 92.7 | 35.5 - 242.1 |
| 2012 | 132.6 | 41.6 - 422.6 |
| 2013 | 129.4 | 40.8 - 410.0 |

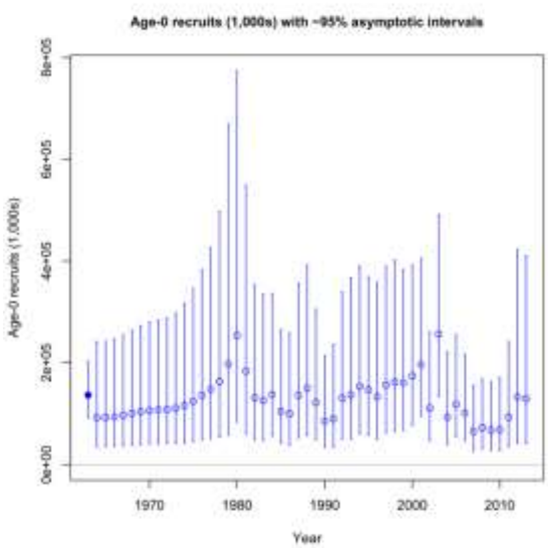


**Figure c: Recruitment**

## Exploitation status

The 2013 spawning biomass of longspine thornyhead is estimated to be 75% of the unexploited equilibrium level. The stock is therefore well above the management target of $SB_{40\%}$. The current fishing mortality rate is also well below the $F_{msy}$ proxy ($F_{50\%}$).

**Table d. Recent trend in spawning potential ratio (entered as (1-SPR)/(1-$SPR_{50\%}$) and summary exploitation rate (catch divided by biomass of age-2 and older fish)**

| Year | Estimated (1-SPR) / (1-$SPR_{50\%}$) | ~95% confidence interval | Harvest rate (proportion) | ~95% confidence interval |
|---|---|---|---|---|
| 2003 | 74.9% | 46.6% - 103.2% | 3.6% | 1.5% - 5.7% |
| 2004 | 41.4% | 21.3% - 61.5% | 1.6% | 0.6% - 2.5% |
| 2005 | 38.0% | 19.3% - 56.8% | 1.4% | 0.6% - 2.2% |
| 2006 | 40.7% | 21.2% - 60.3% | 1.5% | 0.6% - 2.4% |
| 2007 | 40.6% | 21.2% - 60.0% | 1.5% | 0.6% - 2.4% |
| 2008 | 54.0% | 30.6% - 77.5% | 2.3% | 1.0% - 3.6% |
| 2009 | 50.2% | 27.8% - 72.5% | 2.1% | 0.9% - 3.3% |
| 2010 | 54.2% | 30.6% - 77.7% | 2.4% | 1.0% - 3.8% |
| 2011 | 36.2% | 18.5% - 53.8% | 1.4% | 0.6% - 2.3% |
| 2012 | 33.2% | 16.8% - 49.6% | 1.3% | 0.6% - 2.1% |

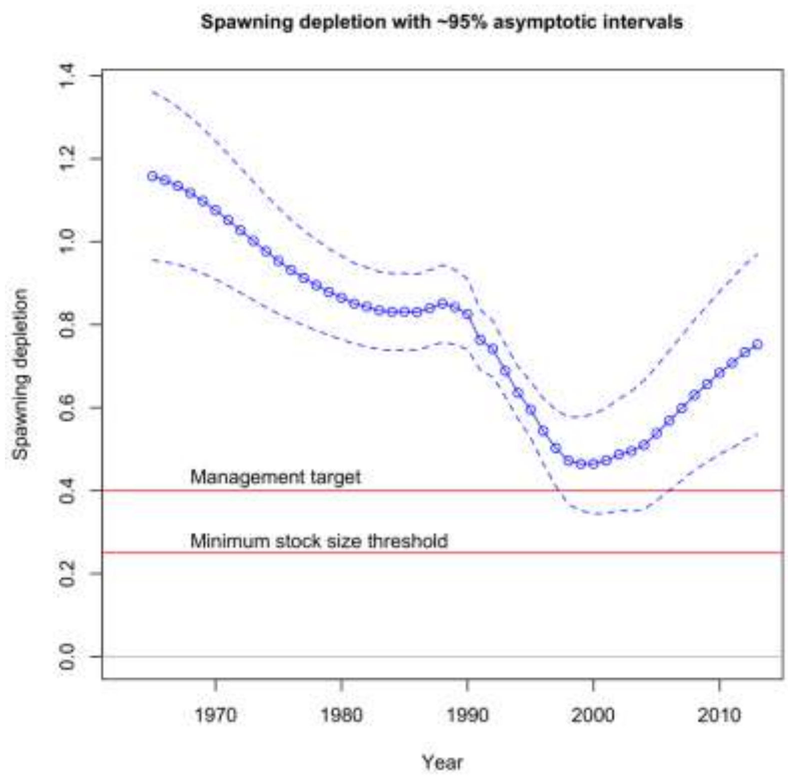


**Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.**

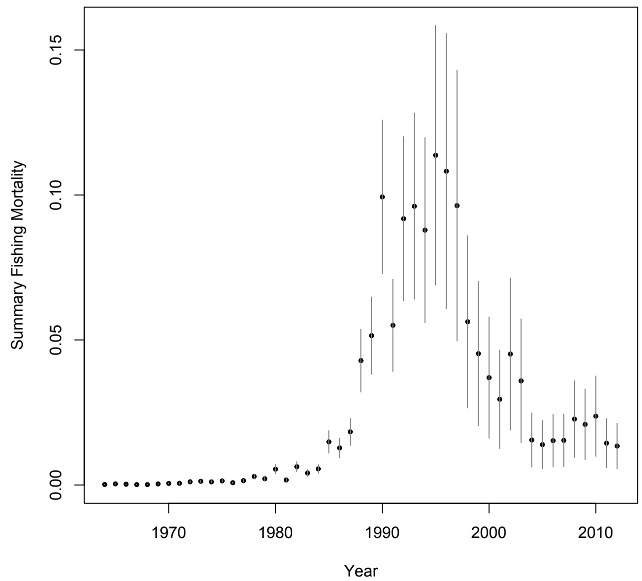


**Figure e. Time-series of estimated summary harvest rate (total catch divided by age-2 and older biomass) for the base case model (round points) with approximate 95% asymptotic confidence intervals (grey lines).**

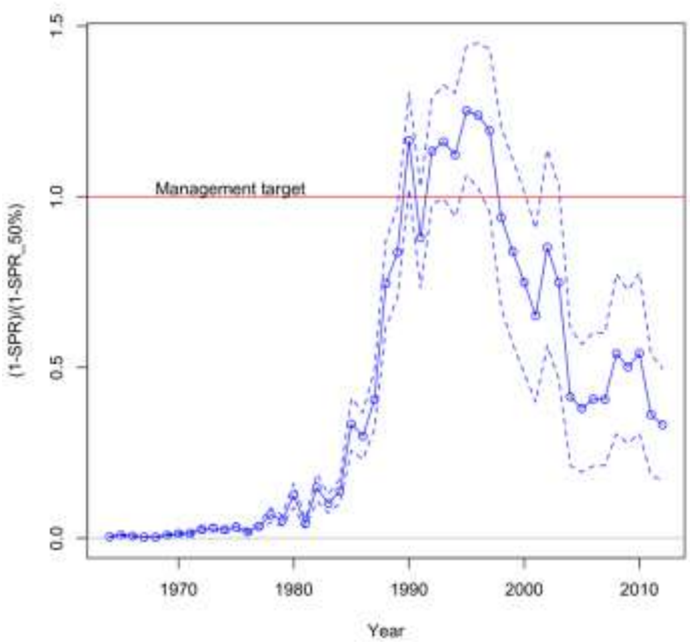


**Figure f. Estimated spawning potential ratio (SPR) for the base case model with approximate 95% asymptotic confidence intervals. The ratio shown in the figure is (1-SPR)/(1-$SPR_{50\%}$), which is twice (1-SPR). This ratio is chosen so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.**

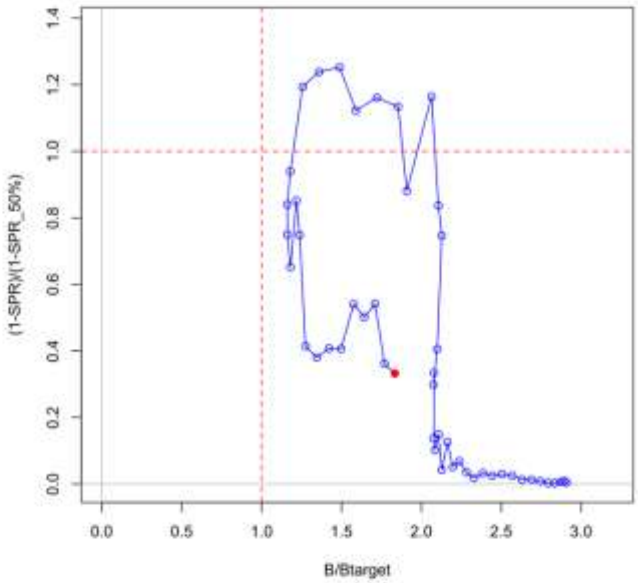


**Figure g. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 1-$SPR_{50\%}$ (the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2012.**

## Ecosystem considerations

Shortspine and longspine thornyheads have historically been caught with each other and with Dover sole and sablefish, making up a "DTS" fishery. Other groundfishes that frequently co-occur in these deep waters include a complex of slope rockfishes, rex sole, longnose skate, roughtail skate, Pacific grenadier, giant grenadier, Pacific flatnose as well as non-groundfish species such as Pacific hagfish and a diverse complex of eelpouts. Shortspine thornyheads typically occur in shallower water than the shallowest longspine thornyheads, and migrate to deeper water as they age. When shortspines have reached a depth where they overlap with longspines, they are typically larger than the largest longspines. Longspine thornyheads have been found in stomachs of shortspine thornyheads and sablefish, leading to the hypothesis that changes in abundance of these species could be linked through predation mortality. Because juvenile longspine thornyheads settle directly into adult habitat, there may be significant cannibalism, as well.

Thornyheads spawn gelatinous masses of eggs, which float to the surface. This may represent a significant portion of the upward movement of organic carbon from the deep ocean (Wakefield, 1990). Thornyheads have been observed in towed cameras beyond the 1280-meter limit of the current fishery and survey, but their distribution, abundance, and ecosystem interactions in these deep waters are relatively unknown. Longspine thornyheads are estimated to occur to a maximum depth of 1700 meters.

## Reference points (groundfish)/Harvest control rules (CPS)

Reference points were calculated using the estimated selectivity in the last year of the model (2012), and the estimated values are dependent on these assumptions. Sustainable total yield (landings plus discards) was estimated at 3,781 mt when using an $SPR_{50\%}$ reference harvest rate and ranged from 2,121-5,441 mt based on estimates of uncertainty. The spawning biomass equivalent to 40% of the unfished spawning output ($B_{40\%}$) was 2,487 mt. The most recent catches (landings plus discards) have been lower than the lower confidence bound of potential long-term yields calculated using an $SPR_{50\%}$ reference point.

**Table e. Summary of reference points and management outputs for the base case model.**

| Quantity | Estimate | ~95% confidence interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 39,134 | (27,093 - 51175) |
| Unfished age 1+ biomass (mt) | 91,049 | (61,393 - 120,705) |
| Unfished recruitment (R0, millions) | 136,529 | (81,731 - 191,327) |
| Spawning biomass (2013) | 29.4 | (12.5 – 46.4) |
| SD of log Spawning Biomass (2013) | 0.29 | – |
| Depletion (2013) | 75.2% | (53.5% - 96.9%) |
| ***Reference points based on $B_{40\%}$*** | | |
| Proxy spawning biomass ($B_{40\%}$) | 15,654 | (10,837 – 20,471) |
| SPR resulting in $B_{40\%}$ ($SPR_{SB40\%}$) | 50% | – |
| Exploitation rate resulting in $B_{40\%}$ | 0.06 | (0.057 - 0.063) |
| Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt) | 2,487 | (1,718 – 3,256) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 15,654 | (10,837 – 20,471) |
| $SPR_{proxy}$ | 50% | – |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.06 | (0.057 - 0.063) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 2,487 | (1,718 – 3,256) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 13,108 | (9,110 – 17,106) |
| $SPR_{MSY}$ | 44.6% | (44.4% - 44.8%) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.071 | (0.068 – 0.074) |
| *MSY* (mt) | 2,529 | (1,746 – 3,312) |

## Management performance

Catches for longspine thornyheads have not approached the catch limits in recent years. ACLs increased in 2007, however catch remained low. The fishery for longspine thornyhead may be limited by the ACLs on sablefish, with which they co-occur, and by the challenging economics of deep-sea fishing.

**Table f. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.**

| Year | OFL (mt) | ABC (mt) | Commercial Landings (mt) | Estimated Total Catch (mt) |
|---|---|---|---|---|
| 2003 | 2,851 | 2,656 | 1,556 | 1,886 |
| 2004 | 2,851 | 2,656 | 689 | 837 |
| 2005 | 2,461 | 2,461 | 652 | 792 |
| 2006 | 2,461 | 2,461 | 750 | 911 |
| 2007 | 3,907 | 2696 | 810 | 956 |
| 2008 | 3,907 | 2696 | 1,243 | 1,463 |
| 2009 | 3,766 | 2626 | 1,171 | 1,375 |
| 2010 | 3,671 | 2560 | 1,359 | 1,588 |
| 2011 | 3,571 | 2495 | 926 | 972 |
| 2012 | 3,483 | 2430 | 871 | 912 |

**Table g. Projection of potential OFL, landings, and catch, summary biomass (age-2 and older), spawning biomass, and depletion for the base case model projected with status quo catches in 2011 and 2012, and catches at the OFL from 2013 onward. The 2011 and 2012 OFL's are values specified by the PFMC and not predicted by this assessment. The OFL in years later than 2012 is the calculated total catch determined by $F_{SPR}$.**

| Year | Predicted OFL (mt) | ACL Catch (mt) | Landings (mt) | Age 2+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 4,788 | 4,788 | 68,131 | 29,436 | 0.75 | 75% |
| 2014 | 4,606 | 4,606 | 64,499 | 28,098 | 0.72 | 72% |
| 2015 | 4,405 | 4,405 | 60,954 | 26,550 | 0.68 | 68% |
| 2016 | 4,190 | 4,190 | 57,688 | 24,866 | 0.64 | 64% |
| 2017 | 3,966 | 3,966 | 54,795 | 23,146 | 0.59 | 59% |
| 2018 | 3,743 | 3,743 | 52,330 | 21,511 | 0.55 | 55% |
| 2019 | 3,531 | 3,531 | 50,309 | 20,097 | 0.51 | 51% |
| 2020 | 3,338 | 3,338 | 48,712 | 18,999 | 0.49 | 49% |
| 2021 | 3,173 | 3,173 | 47,495 | 18,228 | 0.47 | 47% |
| 2022 | 3,037 | 3,037 | 46,598 | 17,730 | 0.45 | 45% |
| 2023 | 2,931 | 2,931 | 45,955 | 17,430 | 0.45 | 45% |
| 2024 | 2,852 | 2,852 | 45,500 | 17,261 | 0.44 | 44% |

## Unresolved problems and major uncertainties

The absence of a reliable ageing method provides a significant hindrance to estimating growth and natural mortality of longspine thornyhead. Uncertainty persists as to both the maximum age and asymptotic length of longspines, since various values of each have been reported in the literature. Additionally, the indices of abundance are all relatively flat, providing little information about the scale of the population. The Fay (2005) model estimated a much larger spawning biomass and a less-depleted stock (Figure 68), however that model did not provide estimates of uncertainty. The current NWFSC index has the largest number of data points of any available index on the west coast, and each additional year of this index will be valuable for understanding any changes in size composition or abundance. However, in the absence of large changes in longspine catch, the current state of the population is likely to persist.

## Harvest Projections and Decision table

Axes of uncertainty for this assessment are the size of initial recruitment and the size of future catch. Initial recruitment is here represented by the log of the initial recruitment, LN($R_0$). Table h displays the projected percent depletion and spawning biomass (in metric tonnes) for the base model using three values of LN($R_0$), to represent three states of nature, and three catch streams.

The states of nature were derived by finding round values of LN($R_0$) in the profile analysis that provided a difference in likelihood outcomes near 1.5 units. This value was taken as the change in likelihood associated with a model that had spawning biomass in 2013 closest to the 12.5% quantile of the estimated distribution of this quantity in the base model, which is expected to be the center of the lowest 25% range of values. The profile over LN($R_0$) was used to derive the "high" state of nature based on the belief that the low- and high-states were unlikely to be symmetrically distributed around the base model. These bracketing values were 11.5 and 12.3, the low and high around the base estimate of 11.8243.

The "high catch" stream was derived by running the base model with a 4.4% buffer applied to the control rule target of 40% virgin biomass. This is the buffer required when the value of the standard deviation of the log of spawning biomass is less than 0.36; in this case, σ=0.29.

The "medium" catch was derived by projecting the model for 50 years with an SPR of 0.665, which is midway between 0.83 (SPR for 2024 when the base model was run with the low catch) and 0.5, which is defined as the high catch SPR. This population stabilized at 59% depletion, within the 50-60% range requested. The catch associated with years 2015-2024 from this model was used as the medium catch for this analysis.

Finally, The "low" catch stream consists of the mean of the 2011-2012 catches repeated for 12 years.

The table reports values from 2015 through 2024, omitting 2013-2014, because there is no difference between the results for those years in any cell in the table.

The only scenario in this table in which the stock in 2024 is depleted below the 40% target level is the "Low State", "High Catch" scenario, however even in this case the stock is still above the 25% minimum stock size threshold in 2024.

**Table h. Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis of catch uncertainty. Columns range over low, mid, and high state of nature, and rows range over differing assumptions of catch levels. Depletion is the percentage of virgin spawning biomass represented by current spawning biomass. Spawning biomass is in metric tonnes.**

| | | | Low State $LN(R_0) = 11.5$ | | Medium State $LN(R_0) = 11.8243$ | | High State $LN(R_0) = 12.3$ | |
|---|---|---|---|---|---|---|---|---|
| | Year | Catch | Depletion (%) | Spawning Biomass | Depletion (%) | Spawning Biomass | Depletion (%) | Spawning Biomass |
| Low Catch | 2015 | 942 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 942 | 60.4 % | 18,734 | 75.6 % | 29,572 | 96.2 % | 54,924 |
| | 2017 | 942 | 59.2 % | 18,378 | 74.3 % | 29,090 | 94.7 % | 54,063 |
| | 2018 | 942 | 57.9 % | 17,974 | 72.8 % | 28,506 | 92.8 % | 52,982 |
| | 2019 | 942 | 56.8 % | 17,635 | 71.4 % | 27,960 | 90.8 % | 51,880 |
| | 2020 | 942 | 56.2 % | 17,437 | 70.4 % | 27,561 | 89.2 % | 50,932 |
| | 2021 | 942 | 56.0 % | 17,394 | 69.9 % | 27,343 | 87.9 % | 50,223 |
| | 2022 | 942 | 56.3 % | 17,472 | 69.7 % | 27,282 | 87.1 % | 49,745 |
| | 2023 | 942 | 56.8 % | 17,634 | 69.8 % | 27,333 | 86.6 % | 49,445 |
| | 2024 | 942 | 57.5 % | 17,845 | 70.2 % | 27,457 | 86.3 % | 49,272 |
| Medium Catch | 2015 | 2,510 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 2,473 | 58.1 % | 18,025 | 73.8 % | 28,868 | 94.9 % | 54,223 |
| | 2017 | 2,422 | 54.8 % | 17,004 | 70.9 % | 27,726 | 92.3 % | 52,710 |
| | 2018 | 2,361 | 51.5 % | 15,994 | 67.8 % | 26,543 | 89.4 % | 51,035 |
| | 2019 | 2,295 | 48.7 % | 15,114 | 65.1 % | 25,463 | 86.5 % | 49,406 |
| | 2020 | 2,229 | 46.5 % | 14,443 | 62.9 % | 24,598 | 84.0 % | 47,999 |
| | 2021 | 2,167 | 45.1 % | 13,990 | 61.3 % | 23,979 | 82.1 % | 46,896 |
| | 2022 | 2,113 | 44.2 % | 13,715 | 60.2 % | 23,575 | 80.7 % | 46,082 |
| | 2023 | 2,068 | 43.7 % | 13,571 | 59.6 % | 23,334 | 79.7 % | 45,501 |
| | 2024 | 2,033 | 43.5 % | 13,512 | 59.3 % | 23,207 | 78.9 % | 45,089 |
| High Catch | 2015 | 4,787 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 4,537 | 54.8 % | 16,996 | 71.2 % | 27,845 | 93.2 % | 53,206 |
| | 2017 | 4,278 | 48.6 % | 15,083 | 66.0 % | 25,820 | 89.0 % | 50,816 |
| | 2018 | 4,021 | 42.9 % | 13,324 | 61.1 % | 23,896 | 84.8 % | 48,409 |
| | 2019 | 3,776 | 38.1 % | 11,832 | 56.8 % | 22,212 | 80.9 % | 46,183 |
| | 2020 | 3,552 | 34.4 % | 10,674 | 53.3 % | 20,867 | 77.6 % | 44,305 |
| | 2021 | 3,356 | 31.7 % | 9,837 | 50.8 % | 19,876 | 75.0 % | 42,840 |
| | 2022 | 3,192 | 29.8 % | 9,263 | 49.0 % | 19,189 | 73.1 % | 41,756 |
| | 2023 | 3,060 | 28.6 % | 8,878 | 47.9 % | 18,735 | 71.7 % | 40,977 |
| | 2024 | 2,959 | 27.8 % | 8,613 | 47.1 % | 18,444 | 70.8 % | 40,424 |

## Research and data needs

Research and data needs for future assessments include the following:

1) Age and growth information are needed for future stock assessments. Otoliths have been collected in good quantities from the NWFSC survey, but at this time the ageing methods are not believed to be reliable. Additional research on ageing methods for thornyheads would be valuable.

   This could involve investigation of biochemical aging methods, for example an analysis of telomere length in relation to body length.

2) A survey using a towed camera to assess the abundance in deeper water. The proportion of the stock and its size range in deeper water is unknown. Further exploration of perceived differences in catchability between towed cameras and trawl nets should also be explored.
3) More tows or visual surveys south of 34.5 deg. N. latitude. Because the southern Conception Area is a large potential habitat for thornyheads, more effort should be directed to describing their distribution in this area, for inclusion in future assessments.
4) An investigation of the possible discontinuity in the reconstructed thornyhead historical catches would be useful for future assessments.

**Table i. Summary table of the results.**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 1,556 | 689 | 652 | 750 | 810 | 1,243 | 1,171 | 1,359 | 926 | 871 | NA |
| Estimated Total catch (mt) | 1,886 | 837 | 792 | 911 | 956 | 1,463 | 1,375 | 1,588 | 972 | 912 | 4,788 |
| OFL (mt) | 2,851 | 2,851 | 2,461 | 2,461 | 3,907 | 3,907 | 3,766 | 3,671 | 3,571 | 3,483 | 3,391 |
| ACL (mt) | 2,656 | 2,656 | 2,461 | 2,461 | 2,696 | 2,696 | 2,626 | 2,560 | 2,495 | 2,430 | 2,365 |
| 1-SPR | 37.43 | 20.70 | 19.01 | 20.37 | 20.31 | 27.02 | 25.08 | 27.08 | 18.08 | 16.61 | 37.43 |
| Exploitation rate (catch/ age 2+ biomass) | 0.036 | 0.015 | 0.014 | 0.015 | 0.015 | 0.023 | 0.021 | 0.024 | 0.014 | 0.013 | 0.070 |
| Age 2+ biomass (mt) | 52.53 | 54.00 | 56.97 | 59.54 | 62.13 | 64.41 | 65.83 | 66.96 | 67.40 | 67.94 | 68.13 |
| Spawning Biomass | 19.4 | 20 | 21.1 | 22.2 | 23.4 | 24.7 | 25.7 | 26.8 | 27.7 | 28.7 | 29.4 |
| ~95% Confidence Interval | 8.1 - 30.1 | 8.1 - 31.8 | 86 - 33.5 | 9.2 - 35.3 | 9.8 - 37.1 | 10.4 - 38.9 | 10.9 - 40.5 | 11.3 - 42.2 | 11.7 - 43.7 | 12.1 - 45.2 | 12.5 - 46.4 |
| Recruitment | 256.3 | 93.2 | 118.0 | 101.1 | 65.2 | 72.4 | 67.2 | 68.5 | 92.7 | 132.6 | 129.4 |
| ~95% Confidence Interval | 13.4 - 490.6 | 39.2 - 221.1 | 54.7- 254.2 | 47.4 - 216.0 | 27.5 - 154.8 | 31.2 - 167.7 | 27.8 - 162.1 | 27.5 - 170.5 | 35.5 - 242.1 | 41.6 - 422.6 | 40.8 - 410.0 |
| Depletion (%) | 0.495 | 0.51 | 0.538 | 0.568 | 0.599 | 0.631 | 0.657 | 0.684 | 0.708 | 0.733 | 0.752 |
| ~95% Confidence Interval | 35.0% - 64.0% | 35.5% - 66.5% | 37.6% - 70.0% | 40.0% - 73.7% | 42.5% - 77.3% | 45.0% - 81.1% | 46.8% - 84.5% | 48.8% - 88.0% | 50.3% - 91.2% | 52.2% - 94.5% | 53.5% - 96.9% |

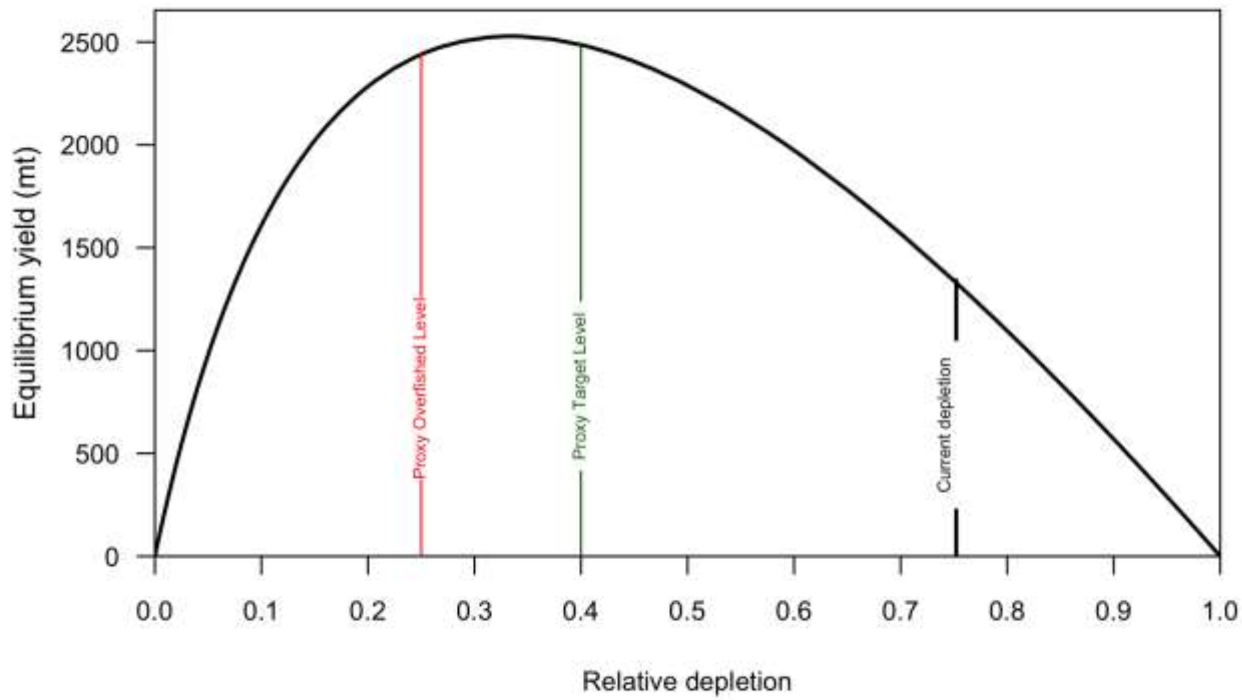


**Figure h. Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2010 fishery selectivity and distribution with steepness fixed at 0.6. The depletion is relative to unfished spawning biomass.**

# 1 Introduction

This is an assessment of the longspine thornyhead (*Sebastolobus altivelis*) stock along the west coast of the continental USA. The analyses presented here follow the previous assessment (Fay 2005) by considering longspine thornyheads separate from shortspine thornyhead (*S.alascanus*), although the two species made up a single market category in the historical fishery, they are often difficult to separate in early landings data, and are similar in many respects (Jacobson and Vetter 1996).

Longspine thornyhead (*Sebastolobus altivelis*) is a rockfish species belonging to the genus *Sebastolobus* in the Scorpaenidae family. Its scientific name '*altivelis*' means "high sail", which describes the tall dorsal fin that distinguishes it from the shortspine thornyhead (*Sebastolobus alascanus*). Longspine thornyhead is a slow growing fish that lives in deep benthic waters, concentrating in the oxygen minimum zone (OMZ) and where water pressure is high. This species ranges from Cabo San Lucas, Baja California, to the Aleutian Islands.

## 1.1 Basic Information

Longspine thornyhead occur from the southern tip of Baja, California, to the Aleutian Islands (Jacobson and Vetter 1996, Orr et al. 1998). There appears to be no distinct geographic breaks in stock abundance along the west coast (Rogers *et al*. 1997, Fay 2005). Adult longspine thornyhead are bottom dwellers, and inhabit the deep waters of the continental slope throughout their range (see map, Figure 1 and 2.).

Bottom trawl surveys and camera sled observations show that longspine occur at depths greater than 600 m, with a distribution to about 1700 m depth (e.g., Love et al. 2005), and a peak in abundance and spawning biomass in the oxygen minimum zone (OMZ) at about 1000 m depth (Wakefield 1990; Jacobson and Vetter 1996). Longspine are better adapted to deep water than shortspine (Siebenaller 1978; Siebenaller and Somero 1982). Wakefield (1990) estimated that in Central California, 83% of the longspine population resides within an area of the continental slope bounded by 600 and 1,000 m depth.

Unlike shortspine thornyhead, the mean size of longspines is similar throughout the depth range of the species (Jacobson and Vetter 1996). Camera sled observations indicate that longspines do not school or aggregate, and are distributed relatively evenly over soft sediments (Wakefield 1990). Differences in density of individuals at depth do occur with latitude however, with higher densities of longspine in deep water (1000-1400 m) off Oregon than off central California (Jacobson and Vetter 1996).

The strong relationship between depth and size found in shortspine thornyhead (Jacobson and Vetter 1996) is not observed for longspines, with the distribution of longspines being relatively uniform with depth (Rogers et al. 1997). Unlike shortspines, longspine do not undergo an ontogenetic migration to deeper waters (Wakefield 1990.

## 1.2 Life History

Longspine thornyheads prefer muddy or soft sand bottoms in deep-water environments characterized by high pressure and low oxygen concentrations. These are low productivity (Vetter and Lynn 1997) and low diversity (Haigh and Schnute 2003) habitats where food availability is limited. Longspines have adapted to this environment with an extremely slow metabolism that allows it to wait up to 180 days between feedings (Vetter and Lynn 1997). They are not territorial, and do not school. They have no swim bladders; instead oil in the bones and spines provides floatation. Video observations from submersibles and ROVs indicate that thornyhead are sit-and-wait predators that rest on the bottom and remain motionless for extended periods (John Butler, NOAA Fisheries, Southwest Fisheries Science Center, CA, as cited in Jacobson and Vetter 1996).

### 1.2.1 Spawning and early life history

The spawning season for longspine thornyheads appears to be extended, and occurs over several months during February, March and April (Pearcy 1962; Best 1964; Moser 1974; Best 1964; Wakefield and Smith 1990). Both thornyhead species produce a bi- lobed jellied egg mass that is fertilized at depth and which then floats to the surface where final development and hatching occur (Pearcy 1962). An extended larval and pelagic juvenile phase follows, which is thought to be 18-20 months long (Moser 1974; Wakefield 1990). Juvenile longspine settle on the continental slope at depths between 600 and 1200 m (Wakefield 1990). Moser (1974) reports a mean length at settlement of 4.2-6.0 cm, although pelagic juveniles up to 69 mm in length have been collected in midwater trawls off Oregon (J. Siebenaller unpubl. data, as cited in Wakefield and Smith 1990).

Following settlement, longspine thornyhead are strictly benthic (Jacobson and Vetter 1996). No apparent pulse in recruitment during the year was observed by Wakefield and Smith (1990), perhaps due to long (4-5 months) spawning season, variation in growth rates, and variation in the duration of the pelagic period (Wakefield and Smith 1990). There is potential for cannibalism because juveniles settle directly on to the adult habitat (Jacobson and Vetter 1996).

### 1.2.2 Fecundity and maturity

Estimates for reproductive parameters of longspine thornyheads are difficult to obtain, due to difficulties in assessing maturity stage without histological examination (Pearson and Gunderson 2003). Estimates of the length at 50% maturity based on histological examinations are provided by Jacobson (1991, N=120) and Pearson and Gunderson (2003, N=239). Ianelli *et al.* (1994) used visual estimates of maturity stage to model maturity at length (N=3,738). Table 7 lists the parameter values provided by these studies. The length at which 50% of females are mature ranges from 18-20 cm, which corresponds to ages of approximately 12-15 years.

Adult females release between 20,000 and 450,000 eggs over a 4-5 month period (Best 1964; Moser 1974). Wakefield (1990) and Cooper *et al.* (2005) both found linear relationships between fecundity and somatic weight. The data analysed by Cooper *et al.* (2005) indicated that fecundity of longspine between 20 and 30 cm in length ranged from 20,000 to 50,000 eggs.

This assessment used the parameter values obtained by Pearson and Gunderson (2003) to determine the maturity at length, as these values were determined from histological samples, used individuals collected from locations throughout the west coast, and were based on a larger sample size than the histology estimates provided by Jacobson (1991).

### 1.2.3 Age and growth

There is considerable uncertainty regarding age and growth of thornyheads (Jacobson and Vetter 1996), although data indicate that longspine thornyhead are long lived. Age estimates of over 40 years have been obtained from otoliths using thin-section and break- and-burn techniques (Ianelli et al. 1994). High frequencies of large longspine thornyheads may be due to a strongly asymptotic growth pattern, with accumulation of many age groups in the largest size-classes (Jacobson and Vetter 1996).

Size-at-age data (Ianelli et al. 1994) indicate that longspine grow to a maximum size of about 30cm TL at ages of about 25-45 years, with little or no sexual dimorphism in length at age – longspines in British Columbia, Canada also display no sexual dimorphism (Starr and Haigh 2000). Orr et al. (1998) report a maximum length for longspines of 38 cm, although individuals of this size are rare in both trawl surveys and commercial landings. Growth increments on otoliths suggest that juveniles reach 80 mm after 1 year of life as demersal juveniles (Wakefield unpubl. data, as cited in Wakefield and Smith 1990), which would correspond to an age of 2.5 - 3 years old.

Estimates of mean length at age for longspine, based on the Von Bertalanffy growth curve, have been published by Jacobson (1991, N=192) and Kline (1996, N=478). The data used by Jacobson (1991) originated from fish in port samples of commercial landings in Oregon, and ages were obtained from sectioned otoliths (Jacobson 1991). Length and age data used by Kline came from California during 1990-1991. The length and age observation pairs for these two curves were analyzed together with additional data (Donna Kline, Moss Landing Marine Laboratory, pers. comm.) for the 2005 assessment to obtain a third growth curve based on a larger sample size (N=815). The parameter values and associated estimates of variability of length at age used for this assessment were those obtained from the analysis of the larger dataset, conducted for the 2005 (Fay) assessment (Table 7).

### 1.2.4 Natural mortality

The longevity of longspine thornyheads is uncertain. The species appears to be long- lived, although not as much so as shortspine. The maximum age reported by Jacobson et al. (1990) was 45 years, which, according to the authors, corresponds to a rate of natural mortality, *M* of 0.1 per year. In their 1994 assessment, Ianelli et al. used a range for *M* of 0.08 – 0.12 per year. Recently, Pearson and Gunderson (2003) obtained a much lower estimate of 0.015 per year for *M* from a prediction model based on a gonadal somatic index (GSI). This value for *M* would suggest that longevity of longspines is much greater than the maximum ages previously measured, and given the growth information presented above, that a large proportion of the population would be near the asymptotic length. Food habits data indicate that predation mortality on adult longspine thornyheads is lower than that on juveniles, and the low mortality rate calculated by Pearson and Gunderson (2003) for adults could reflect an age-dependent mortality determined by predation risk.

## 1.3 Ecosystem Considerations

Longspine and shortspine thornyheads have different but overlapping depth ranges (Jacobson and Vetter 1996), and, due to the bathymetric demography of shortspines, it is frequently larger specimens of this species that are found with longspines. As such, the two species do not tend to be the same size at the same depth. However, there is some overlap in size at the shallower end of the longspine bathymetric distribution.

Settled longspine thornyheads are prey for both sablefish (*Anoplopoma fimbria*), and large shortspine, and longspine are common in stomach samples of both species (Laidig et al. 1997; Buckley et al. 1999). Size distribution data for longspines found in sablefish and shortspine stomachs indicate a high incidence of predation by these species on settled juvenile longspine, with longspine above 20cm rare in stomach data (Laidig et al. 1997, Buckley et al. 1999). These two species are predators of longspine thornyheads on the continental slope, suggesting that the rate of predation mortality could be lower for adult longspine than for juveniles. There may also be cannibalism, because juveniles settle directly on to the adult habitat (Jacobson and Vetter 1996).

Thornyheads are captured with Dover sole (*Microstomus pacificus*) and sablefish. The peak spawning biomass for these two species also occurs in the OMZ.

## 1.4 Fishery Information

Longspine thornyhead are exploited in the limited entry deep-water trawl fishery operating on the continental slope that also targets shortspine thornyhead, Dover sole and sablefish. A very small proportion of longspine landings are due to non-trawl gears (gillnet, hook and line), primarily in California. Longspine and shortspine thornyhead make up a single market category. The thornyhead fishery developed in Northern California during the 1960s, with early landings being primarily from the Eureka INPFC area. The fishery then expanded north and south, and the majority of the landings of longspine thornyhead have since been in the Monterey, Eureka, and Columbia INPFC areas, with some increase in landings from the Conception and Vancouver INPFC areas in recent years.

Landings of longspine thornyhead averaged about 100 mt in the 1970s, rose steadily in the 80s, and peaked at 5,870 mt in 1990. Landings have decreased since, to annual landings of around 2,000-2,500 mt (Figure 4). Average landings over the last ten years have been just over 1,000 mt (Figure 4,Table 3).

The markets for longspine thornyheads along the west coast developed at different rates than for shortspine (Rogers *et al.* 1997). A primarily domestic market for thornyheads developed in the Eureka INPFC area in California during the early 1960s. Initially, thornyheads were sold with other rockfish under a variety of names. Large thornyheads (minimum size 12-14 inches) were trimmed and sold as ocean catfish, and also later sold filleted as Skin-on Perch. Due to size restrictions, there was little market for the smaller longspines, and these early fish were primarily shortspine. Smaller fish began to be taken by processors in Eureka during the late 1970s, and by the early 1980s, the minimum marketable size was 10 inches. This decrease in the minimum marketable size for thornyheads probably facilitated the development of the fishery for longspines.

An export market for thornyheads developed during the late 1980s because a similar species, *S. macrochir*, was depleted off Japan. As the Japanese market developed, processors began accepting fish as small as 7-8 inches, and landings of the smaller longspine thornyhead increased. As the market for smaller longspine developed, the trawl fishery moved into deeper water where longspine thornyheads are more common.

Trends toward deep-water fishing, higher prices, and increased landings for thornyheads occurred later in Oregon and Washington than in California (Rogers *et al.* 1997). A coastwide minimum marketable size of 10 inches was apparently in effect during 1990. However, this was replaced by a two-tiered price structure in 1991 (Pete Leipzig, Fishermen's Marketing Association, as cited by Jacobson, 1991). Marketing of thornyheads in Oregon as Skin-on Perch with a 10-inch minimum limit continued until about 1992 (Whitey Forsman, Pacific Coast, Warrenton OR, as cited by Rogers *et al*. 1997).

Exvessel prices for thornyheads increased substantially in 1994 and in 1995, although these have decreased since. The 1994 increase was likely a result of increased management restrictions on catches, and changes in the relative value of the Japanese yen and US dollar (Whitey Forsman, Pacific Coast, Warrenton OR, as cited by Rogers *et al.* 1997).

In 1997, processors coastwide imposed an 8-inch minimum size limit for thornyheads (Jay Bornstein, Bornstein Seafoods, Bellingham, WA; Whitey Forsman, Pacific Coast, Warrenton OR; Jerry Thomas, Eureka Fisheries, CA, all as cited by Rogers *et al.* 1997). Up to seven size categories had different prices, and longspines had lower prices than shortspines of the same size, due to both a lower condition factor (lower weight at length) and coloration differences in skin and flesh.

Management measures contributed to a decline in coastwide landings from an estimated peak of 4,815 in 1989 to between 1,000 and 2,000 mt per year from 1995 through 1998. Landings fell below 1,000 mt per year from 1999 through 2006, then rose to 1,531 in 2009 and have declined since that time (Table 1).

## 1.5 Summary of Management History

Beginning in 1989, both thornyhead species were managed as part of the deepwater complex with sablefish and Dover sole (DTS). In 1991, the Pacific Fishery Management Council (PFMC) first adopted separate ABC levels for thornyheads and catch limits were imposed on the thornyhead group. Harvest guidelines (HG) were instituted in 1992, coincident with a change in mesh size from 3 to 4.5 inches. In

1995, separate landing limits were placed on shortspine and longspine thornyheads and trip limits became more restrictive. Trip limits (generally, limits on 20-month cumulative landings) have often been adjusted during the year since 1995 in order to not exceed the HG or OY for that year.

Although the depth range for longspine extends well beyond the depths at which shortspine are most abundant, no management options have been available for specifying higher longspine limits only in the zone where they could be caught with minimal coincident catch of shortspines. Since early 2011, trawl harvest of each thornyhead species has been managed under the PFMC's catch share, or individual quota, program. Whereas the trip limits previously used to limit harvest restricted only the amount of fish each vessel could land, individual vessels fishing under the catch-share program are now held accountable for all of the quota-share species they catch.

### 1.6 Management Performance

Landings of longspine thornyhead have been below the catch limits since 1999. Estimated total catch, including discards, has likewise remained below the limit during this period (Table 3).

### 1.7 Fisheries off Canada, and Alaska

The Alaska Fishery Science Center conducts assessments of thornyheads as a mixed-stock complex, including shortspine and longspine thornyheads. Broadfin thornyheads (*S. macrochir)* were formerly believed to have been caught with shortspines in the Gulf of Alaska, but this is now thought to have been misidentification of shortspines. The 2011 assessment reports that "It is unlikely that thornyheads are overfished or approaching overfished condition", however noting that fishing in the Western Gulf of Alaska approaches the ABC for the complex (Murphy and Ianelli, 2011).

Fisheries and Oceans Canada lists longspine thornyhead as a species of special concern under the Species at Risk Act (SARA), noting that the primary threat to the species is commercial fishing. The fishery is managed by Total Allowable Catches (TACs), Individual Vessel Quotas (IVQs) and 100% at-sea and dockside monitoring (Fisheries and Oceans Canada, 2012).

## 2 Assessment

### 2.1 Data

An overview of all data time-series used in this assessment is given in Figure 3.

#### 2.1.1 Biology

***Natural mortality and longevity***

Lifespan for longspine thornyheads is believed to be in the range of 35-45 years (Jacobson and Vetter 1996, Ianelli et al., 1994). Previous assessments investigated M in the range 0.015-0.12 (Fay, 2005, Ianlli et al., 1994). For this assessment, a prior on natural mortality was developed based on a maximum age of 45 years, with a mean of 0.11131 and standard deviation on a log scale of 0.5208 (Hamel, pers. comm.). For the base case, natural mortality was fixed at the mean of this prior distribution.

***Length-weight relationship***

The length-weight relationship for shortspine thornyheads was retained from the previous assessment (Fay, 2005). Longspines are not believed to have dimorphic growth; therefore a single relationship was used for both males and females. The mean weight at length is given by: $W(L) = 4.30E\text{-}06\ L^{3.352}$ (Table

7, Figure 11).

***Length at age***
No new age data or information on growth or length at age has been developed since the previous assessment. The Von Bertalanffy K was previously set to 0.064; this is estimated to be 0.109 in the present model. The length at age 3 is set to 11 cm, and the average length at age 40 is estimated to provide the best fit to the data at 27.8 cm. Values are given in Table 6 and Table 7.

***Maturation and fecundity***
Pearson and Gunderson (2003) estimated length at 50% maturity for longspines to be 17.83 cm on the West coast, with most females maturing between 17 and 19 cm (Figure 11). This was represented in the previous assessment by the logistic function: $mat(L) = (1+e^{-1.79(L-17.826)})^{-1}$, where *L* is the length in cm (Table 7, Figure 12).

### 2.1.2 Catch History
PacFIN data from 1981-present for all gears was used to estimate landings in the fishery. All landings reported for the longspine and nominal longspine categories were considered longspine, whereas landings placed in the thornyheads category were divided between longspine and shortspine by the ratio of categorized longspine and shortspine landings for the entire coast. The values of this ratio from 1981-2012 are shown in Figure 5.

Catches prior to 1981 were set equal to those used in the Fay (2005) model, rather than to the reconstructed history provided by CDFW and ODFW for most West Coast assessments. The 2013 shortspine and longspine thornyhead assessments were prepared together. In the previous shortspine assessment, the numbers reported as domestic catch were much, much higher in the late 60s through the mid-70s than the total of the reconstructed catch, differing by hundreds of metric tons/year. Those higher landings had been in all previous assessments. In the longspine reconstructed catch, there was a distinct jump from very low levels to much higher levels that seemed unlikely (Figure 6).

In order to provide realistic catch streams, and consistency with previous peer-reviewed assessments, catches prior to 1981 were set equal to those used in the previous model. A sensitivity (Figure 58) using the historical catch reconstructed estimates (Ralston et al., 2010) was conducted during the STAR panel, and the recommendation from the panel (for both species) was to use past assessment estimates (see STAR panel report).

### 2.1.3 Discards/Retention
Discard rates (defined as the weight discarded divided by the total caught weight (i.e. discarded plus retained weight)) for longspine thornyhead likely changed with changes in market price-at-size and acceptable minimum size over the course of the fishery. Management restrictions in place from the mid-late 1990s may have also affected the discarding of longspine.

Discard data for longspine thornyhead came from four sources. Data from the Pikitch study (Pikitch et al., 1988), conducted in Oregon, were provided for the years 1985-1987 (John Wallace, pers. comm.). These provide the single highest discard rate, 45% in 1987.

No longspine thornyhead length measurements were available to associate with the 1985-1987 discard rates estimate in the Pikitch discard study. However, an associated mesh size study that took place in the production fishery in 1988-1990 included length measurements for longspines. To make the data from the two studies more comparable, length-compositions from the mesh size study were created by weighting the longspine thornyhead length observations by using the ratio of mesh sizes by-tow seen in the production fishery based discard database to those seen in the mesh database (J. Wallace, pers. comm.). That is, samples from the mesh size study that were collected with mesh sizes less commonly seen in the fishery were given lower weight than the more common mesh sizes.

The discard estimates from the EDCP program were assumed to be equal to those in the previous assessment because the data necessary for recalculating these rates and the associated length compositions was not available in time to be included in the document. Helser *et al.* (2002) analyzed data from the Enhanced Data Collection Project (EDCP) to produce discard estimates for longspine by INPFC area for the years 1995-1999. Values during these years are in the range 10-20%.

Discard rates were also available from the West Coast Groundfish Observer Program (WCGOP) for the years 2002-2011. These ranged from 29% to 5%, though the average over this period was 17%. The lowest value in the range occurred in 2011, when the catch shares program (i.e., 100% observer coverage) was implemented.

Discard data are summarized in Table 2.

### 2.1.4 Mean body weights

Information from the WCGOP was compiled to obtain estimates of mean body weight. No estimates of variance were associated with these data.

### 2.1.5 Length Compositions

Fishery length-composition data were obtained from PacFIN for 1978-2012. The number of fish sampled by port samplers from different trips has not been proportional to the amount of landed catch in these trips. Sampling effort has also varied among the states. In order to account for non-proportional sampling and generate more representative length-frequency distributions, the observed length data were expanded using the following algorithm:

1. Length data were acquired at the trip level by sex, year and state.
2. The raw numbers in each trip were scaled by a per-trip expansion factor calculated by dividing the total weight of trip landings by the total weight of the species sampled.
3. A per-year, per-state expansion factor was computed by dividing the total weight of state landings by the total weight of the species sampled for length in the state.
4. The per-trip expanded numbers were multiplied by the per-state expansion factor and summed to provide the coastwide length-frequency distributions by year.

PacFIN length data for males, females and unsexed fish were combined, since the majority of the sampled fish were not sexed. Only randomly collected samples from PacFIN were used.

Length compositions from the Pikitch study were available for 1988-1990. Length compositions from the WCGOP covered the years 2005-2011, however there was only one sample lengthed in 2005, so that sample was disregarded. There were length compositions for each year of the AFSC and NWFSC surveys, however fish appear to have been reliably sexed only from 2005 onward. The NWFSC lengths for 2005-2012 are the only lengths entered by-sex in the model. Length composition sampling effort is summarized in Table 5; note that the ratio of females to males is .51 overall with little variation, so gender is not explicitly reported.

In camera-tows, thornyheads are seen to be spaced randomly across the sea floor (Wakefield 1990), indicating a lack both of schooling and territoriality. This likelihood contributes to the conclusion in a bootstrapping analysis by Stewart and Hamel (2013), that "thornyheads had the highest average effective sample size per haul…and also the greatest independence among fish within tows". This can be seen in the spatial distribution of WCGOP catch in Figure 9. Based on these findings, the input samples sizes for both fishery and survey length compositions were calculated from the number of fish sampled in each year, independent of the number of hauls from which these fish were collected. The input sample sizes were set to $N_{input} = N_{sampled}^{\,0.6}$, which is an approximation to the pattern found by Stewart and Hamel (2013, their Figure 4D).

### 2.1.6 Age Compositions

No age composition data was used for this assessment, because thornyheads have proven very difficult to age (P. MacDonald, pers. comm.). Even in directed studies such as those done by Kline (1996) and Butler et al. (1995) there are large inter-reader differences, and a second reading by the same ager can produce a markedly different result. No production ageing of thornyheads is undertaken at this time for the West Coast, although longspine thornyhead otoliths are routinely collected in the NWFSC trawl survey. The Alaska Fisheries Science Center does not attempt ageing thornyheads.

### 2.1.7 NMFS Surveys

Four trawl surveys have been conducted on the U.S. west coast over the past four decades. The Alaska Fisheries Science Center (AFSC) conducted a triennial groundfish trawl survey on the continental shelf, from 1977 to 2001. In 2004, the Northwest Fisheries Science Center (NWFSC) conducted the triennial survey. This survey contributes to many of the West Coast stock assessments, however it did not extend into longspine habitat and is not included here.

The AFSC began a slope survey in the 1980s, however the annual geographic coverage was very limited until 1996, and that data is not used in the current assessment. Starting in the late 1990s, two slope surveys that do inform this assessment were conducted on the West Coast, one using the research vessel Millar Freeman, the "AFSC Slope Survey", which ended in 2001, and the other a cooperative survey using commercial fishing vessels, conducted by NWFSC, the "NWFSC Slope Survey" which covered the years 1998–2002.

In 2003, the design of the NWFSC Slope Survey was modified and the survey was expanded to cover the shelf and slope between 50 m and 1280 m. This combination shelf-slope survey, "NWFSC Combo Survey", has been conducted every year from 2003 to the present with consistent design. Ninety-seven percent (97%) of all tows deeper than 500 m from this survey have longspine thornyheads in the catch (Figure 8). Data for the years 2003–2012 were available for this assessment. The NWFSC Combo Survey now represents the largest number of survey observations, the largest depth and latitudinal range, and the most consistent groundfish sampling program in the history of west coast scientific data collection. Continuing this time series in a consistent manner is vital for improving estimates of current stock status and detecting any future changes in size distribution or abundance of west coast groundfish.

The results from these three fishery-independent surveys are used in this assessment (Table 4). Indices of abundance for all of the surveys were derived using a delta-generalized linear mixed model (GLMM) following the methods of Thorson and Ward (2013). The surveys were stratified by latitude and depth, and vessel-specific differences in catchability (via inclusion of random effects for the NWFSC surveys and fixed effects for the AFSC survey) were estimated for each survey time series. The Delta-GLMM approach explicitly models both the zero and non-zero catches and allows for skewness in the distribution of catch rates. Gamma error structures were considered for the positive tows. Model convergence was evaluated using the effective sample size of all estimated parameters (typically >500 of more than 1000 kept samples indicates convergence).

### 2.1.8 Changes in data from the 2005 assessment

Most of the data used in the previous assessment has been newly extracted and processed, including length compositions from each fishing fleet and survey, indices of abundance derived from new GLMM analyses of survey data, discard rates from both the 1980s Pikitch study and the current West Coast Groundfish Observer Program (WCGOP), and the time-series of landings from 1981-2012.

Catch (1981-2012) and length-composition data 1978-2012) were updated from PacFIN. This data was extracted on May 23, 2013. Catches prior to 1981 were set equal to those used in the previous model

Biomass indices and length compositions for the AFSC slope survey (1997, 1999-2001) were used in this assessment. Biomass indices and length compositions for the NWFSC slope survey (1998-2004) were used in the assessment. The entire time series of each slope survey index was re-calculated using GLMM modeling software produced by Thorson and Ward (2013). The NWFSC length composition data were extracted on March 28, 2005.

### 2.1.9 Environmental and Ecological Data

No ecological or environmental information was used in this assessment.

## 2.2 History of Modeling Approaches Used for this Stock

This is the 5th stock assessment of west coast longspine thornyhead, but only the second in which it was assessed individually. Most assessments of thornyheads have treated longspine and shortspine thornyheads as a single stock. Previous assessments were conducted by Jacobson (1990, 1991), Ianelli *et al.* (1994), Rogers *et al.* (1997), and Fay (2005). The 1990 and 1991 assessments were very similar. Important features included reviews of available biological data, and analyses of trends in mean lengths from port samples and catch rates calculated from logbook data. Swept-area and video biomass estimates were used to estimate average biomass levels and exploitation rates in the Monterey to US-Vancouver management areas. The available data were used to conduct per-recruit analyses of yield, revenue, and spawning biomass, and to develop estimates of the then target level of $F_{35\%}$.

The 1994 assessment used coast-wide abundance estimates based on slope survey data, an updated analysis of the logbook data, and fishery length-composition data to estimate the parameters of length-based Stock Synthesis models, under different assumptions regarding discarding practices.

The 1997 assessment by Rogers *et al.* used a length-based version of Stock Synthesis 1 to fit an age-structured model to data for the Monterey, Eureka, Columbia and Vancouver INPFC areas. Models were fitted to biomass estimates and length data from the AFSC slope surveys (1988-1996), a logbook CPUE index, discarded proportions by year, and length composition data from California and Oregon. Sensitivity to discard rates based on changes in prices and minimum size were explored.

The 2005 assessment fit an age-structured model to longspine thornyheads using Stock Synthesis 2, and identified the catchability of the slope surveys (Fay combined the then-brief NWFSC survey with the AFSC survey) as the primary source of uncertainty in the model. Sensitivity analyses involved the use of different combinations (inclusions and exclusions) of landings data sources and survey biomass estimates, as well as estimations of natural mortality and steepness. Model outcomes from this analysis were significantly more optimistic than those from 1997, likely due to assumptions regarding selectivity of the slope survey and to the inclusion of data from the INPFC Conception area.

It is worth noting that the use of the pre-1996 data was only feasible through combining data from multiple years into ‘super-years’, in order to achieve reasonable spatial coverage. This practice was used consistently whenever the AFSC slope survey was included in assessments up until 2005 or 2007. Given inter-annual changes in ocean conditions, that practice (and the inclusion of those early years) has been abandoned, now that longer, more-reliable survey time-series are available.

### 2.2.1 2005 STAR Panel recommendations

Many of the STAR Panel suggestions from 2005 are outside the scope of this assessment, as they involve investigations into otolith annuli signals, or using towed cameras to investigate habitat.

Including the length compositions of discards was among the recommendations that could be addressed; they are in the current model. Some analysis of Q values has been part of model selection for the base case. Q was found to be quite sensitive to changes in initial recruitment; see Figure 62.

The star panel suggested investigating the implications of having two natural mortality rates, blocked in the region above and below 15 or 20 cm. Initial investigation of this in a model with fixed early M (0.11131) and allowing M for older fish to be estimated as an offset resulted in an improved total likelihood (128.591 vs. 135.264 in the base model), but a seeming lack of convergence. Mortality of older fish was estimated at 81% of early M, or 0.09.

## 2.3 Software

This assessment uses the Stock Synthesis modeling framework developed by Dr. Richard Methot (NMFS, NWFSC). The most recent version (SSv3.24o, distributed on April 10, 2013) was used, since it included improvements in the output statistics for producing assessment results and several corrections to older versions.

## 2.4 General Model Specifications

This assessment focuses on the population of longspine thornyhead that occurs in coastal waters of the western United States, off Washington, Oregon and California. The population within this area is treated as a single coast-wide stock, given the lack of data suggesting the presence of multiple stocks. The modeling period begins in 1944, assuming that in 1943 the stock was in an unfished equilibrium condition.

Fishery removals are considered to occur within one commercial deepwater trawl fishery. Very little catch of longspine thornyhead occurs via other methods, so all commercial landings were treated as one fishery.

Historical landings for the domestic fishery was reconstructed by state, and then combined into the coast-wide fleet. Selectivity and retention parameters are estimated for this fishery. The AFSC slope and NWFSC surveys are treated as separate fleets with independently estimated selectivity and catchability parameters reflecting differences in depth and latitudinal coverage, design and methods. Given the difference in latitudinal range, catchability was estimated independently for the NWFSC slope and NWFSC shelf-slope surveys.

No seasons are used to structure removals or biological predictions; data collection is assumed to be relatively continuous throughout the year. Fishery removals in the model occur instantaneously at the mid-point of each year and recruitment on the 1st of January.

The base model is a sex-specific model and the sex ratio at birth is assumed to be 1:1. Growth is monomorphic; natural and fishing mortality are assumed to be the same for males and females at all ages.

Expected annual recruitment was described by a Beverton-Holt function of spawning biomass. Steepness (the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass) was fixed to 0.6. The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$).

Annual deviations about this stock-recruitment curve were estimated for the years 1944 through 2012. Recruitment deviations were modeled as recommended by Methot and Taylor (2011). This involved estimating the uncertainty associated with the recruitment deviates and using this uncertainty to adjust the lognormal recruitment distributions to account for differences between the median and mean. The values used in this bias adjustment (Figure 13) were estimated by a function in the R4SS software package (Taylor et al., 2013). These values were determined in a model prior to the base model, but the differences that would result from a further iteration of the estimation process are expected to be small.

The length composition data are summarized into 1-cm bins, ranging between 5 cm (representing fish under 6 cm) and 35+ cm.

Iterative re-weighting was used in the assessment to achieve consistency between the input sample sizes and the effective sample sizes for length composition samples based on model fit. This reduces the potential for particular data sources to have a disproportionate effect on total model fit.

Retention in the fishery was estimated separately for the periods 1964-1991, 1992-2006, 2007-2010, and 2011-12.

Likelihood components for the model were:

1. Indices (log-normal)
2. Length frequencies (multinomial)
3. Discard fraction (normal)
4. Mean body weight of discards (T-distribution with d.f. = 30)
5. Recruitment deviations (normal)
6. Priors (parameter-dependent)

### 2.4.1 Estimated and Fixed Parameters

In the assessment, there are parameters of three types, including life history parameters, stock-recruitment parameters and selectivity and retention parameters. These parameters were either fixed or estimated within the model. Reasonable bounds were specified for all estimated parameters. A full list of all biological parameters used in the assessment is provided in Table 6. Selectivity parameters are given in Table 9.

### 2.4.2 Life history and recruitment

The Von Bertalanffy rate parameter, K is estimated to be 0.109 in the present model, and the average length at age 40 is estimated to provide the best fit to the data at 27.8 cm. The length at age 3 is set to 11 cm, as in the Fay (2005) model. Previous and current values are given in Table 6 and Table 7.

For this assessment, a prior on natural mortality was developed based on a maximum age of 45 years, which had a mean of 0.11131 and a standard deviation on a log scale of 0.5208 (Hamel, pers. comm.). For the base case, natural mortality was fixed at the mean of this prior distribution.

This assessment assumed a Beverton-Holt stock recruitment relationship with a steepness of 0.6. Steepness is the fraction of expected equilibrium recruitment associated with 20% of equilibrium spawning biomass. The previous value was 0.75; however, no scientific justification was given for that value (Fay, 2005).

Most recent rockfish assessments use a steepness prior of 0.779, estimated from a meta-analysis of rockfish assessment results (Thorson, 2013). This value might be expected in the present assessment. However, rockfish ecology and reproduction are quite different from those of thornyheads, which (for example) do not give birth to live young but rather spawn floating egg masses.

Steepness in the shortspine thornyhead assessment was fixed at 0.6 both in the 2005 and 2013 models (Hamel, 2005, and Taylor and Stephens, in preparation). This value was justified based on consistency between the modeling approach and management targets, in addition to being within a range of biologically reasonable values. For consistency, therefore, steepness for the longspine model was also fixed at 0.6.

The scale of the population is estimated through the log of the initial recruitment parameter ($R_0$). Recruitment deviations were estimated for the years 1944 through 2012. Estimated recruitments do not show high variability, and the uncertainty in each estimate is greater than the variability between estimates.

### 2.4.3 Selectivity and retention

Gear selectivity parameters used in this assessment were specified as a function of size with the additional assumption that age 0 fish were not selected, regardless of their size. Separate size-based selectivity curves were fit to the fishery and survey.

The AFSC slope survey was allowed to be dome-shaped, and was modeled with double-normal selectivity. The double-normal selectivity curve was used in a configuration that has four parameters, including: 1) peak, which is the length at which selectivity is first fully selected, 2) width of the plateau on the top, 3) width of the ascending part of the curve, 4) width of the descending part of the curve. The double-normal has an additional pair of parameters, which scale the initial and final selectivity values, but these were not used in the estimations.

For the fishery and NWFSC surveys, the peak selectivity was estimated to occur near the maximum size, indicating logistic selectivity. This was modeled using a 2-parameter function, in which the first parameter is the length at the inflection point at 50% selectivity, and the second parameter describes the width between that point and the 95% selectivity, controlling the steepness of the curve.

Retention curves are defined as a logistic function of size. These controlled by four parameters: (1) inflection, (2) slope, (3) asymptotic retention, and (4) male offset to inflection. Male offset to retention was fixed at 0 (i.e. no male offset was applied). The parameters for inflection and asymptotic retention were modeled as time-varying quantities via use of time blocks defining the following four periods: 1964-1991, 1992-2006, 2007-10, and 2011-12. Blocks roughly correspond to changes in discarding which may have been driven by processor-imposed size-limits (Table 11), or to differences in management regimes. The changes between blocks are represented as random walks.

### 2.4.4 Key assumptions and structural choices

The structure of the base model was selected to balance model realism and parsimony. While the model was able to estimate natural mortality, uncertainty about the historical selectivity of the fishery led to concern about the estimated natural mortality rates. The *a priori* information about natural mortality from Hoenig's (1983) method led to the natural mortality rate being set at 0.11131.

The fishery selectivity curve is estimated to be asymptotic even when given the opportunity to be a dome-shaped (i.e. a double-normal form). We have, therefore, chosen to specify that fishery selectivity is asymptotic.

## 2.5 Base Model Results

A converged base model was found with appropriate gradient, covariance and Hessian properties. Additional exploration to conclude the base model was not settling on a local likelihood minimum was conducted by jittering staring values for all parameters at a jitter values of 0.1 50 times. These jitter runs confirm the base case likelihood minimum over a moderate exploration of likelihood space.

### 2.5.1 Life History Parameters

The list of the all the parameters used in the assessment model and their values (either fixed or estimated) is provided in Table 6. Only the Von Bertalanffy K and Lmax, the length at the maximum age (40) were estimated in this model. K was estimated at 0.109, and Lmax at 27.8282. Both values are reasonable and consistent with what we know about the species.

### 2.5.2 Discards

The base model balances the information in the discard fraction or amount data with the length and mean weight data to estimate the shape of the retention curve and, in the case of the trawl fleet, a time-varying asymptote for retention reflecting changes in management measures (Figure 17).

The model does a reasonable job of fitting the length composition data for trawl discard, including balancing those data and the discard ratio data for 2006 and 2007, and matching the decline in average length of discards following the implementation of the catch shares fishery in 2011 (Figure 26 to Figure 28).

### 2.5.3 Abundance Indices

The base model did not indicate contradictions between the survey biomass indices and the estimated trends in selected biomass (Figure 20 to Figure 22). The fits to the all surveys were generally flat. This is not unexpected for the short time-series of the AFSC and NWFSC slope surveys. The NWFSC survey index shows shallow upward trend.

### 2.5.4 Length compositions

The model fit to length-frequency distributions, by year and aggregated across all years, Pearson residuals for the fits by fishery/survey, year and sex, and associated sample size comparisons are shown in Figure 23 to Figure 42. The quality of fit varies among years and fleets, which reflects the differences in quantity and quality of data. The Pearson residuals, which reflect the noise in the data both within and among years, did not exhibit any strong trends. Effective samples sizes varied from input sample sizes, but through iterative reweighting the difference between these were minimized.

Plots of observed and expected length compositions for the trawl and non-trawl landings aggregated across all years show acceptably good fits.

The survey length composition generally exhibits slightly smaller average length than the fishery.

### 2.5.5 Selectivities

Estimated selectivity curves for the fishery and surveys are shown in Figure 43. Estimated parameter values are given in Table 9. Full selectivity for longspine thornyhead in the NWFSC surveys and the fishery includes the asymptotic length (Figure 46). The time-varying retention is shown in Figure 44. Figure 45 compares the selectivity, retention and mortality curves for the fishery; it is worth noting that this figure is for year 2012, after the implementation of catch-shares, and shows that the small fish are being retained.

The NWFSC surveys both reach full selection by the maximum age of the fish (Figure 48 and Figure 49), which the model estimated to be 27.86 years (Table 6) (the large range of age bins in the model for plus-group fish allows for better growth modeling).

The AFSC slope survey selectivity is domed (Figure 43 and Figure 47) as it was in the previous assessment.

### 2.5.6 Derived outputs

The deviations from the estimated stock-recruitment function have a very large uncertainty, which is fairly consistent throughout the time-series (Figure 50 and Figure 51). Figure 52 shows the spawner-recruit time-series.

The estimated time series of spawning biomass, spawning depletion (relative to $B_0$) and fishing mortality are presented in Table 10 and Figure 53 to Figure 55. Trends in spawning biomass and spawning depletion track one another very closely. Exploitation never exceeded the management target except during peak fishing in the 1990s.

Figure 56 is a quadrant plot showing stock status over time relative to biomass and spawning potential ratio. The biomass has never been depleted below the management level of 0.4, and the exploitation has fallen since the 1990s so that the stock is currently neither depleted nor overfished.

The yield curve, Figure 57, shows the current stock status well above both the target and overfished levels. Longspine thornyhead appears to be well-recovered from the overfishing in the 1990s.

## 2.6 Profiles and sensitivity and retrospective analyses

Parameter uncertainty in the assessment is explicitly captured in the asymptotic confidence intervals estimated within the model and reported throughout this assessment for key parameters and management quantities. These intervals reflect the uncertainty in the model fits to the data sources in the assessment, but do not include the uncertainty associated with alternative model configurations and fixed parameters. To explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in model assumptions, a variety of sensitivity runs were performed.

### 2.6.1 Sensitivity to Historical Catch Reconstruction and Recruitment Deviations

The states of California and Oregon conducted reconstructions of the historical catch in the groundfish fishery, and those reconstructions have been used for many recent assessments for the pre-PacFIN era (prior to 1981). When compared with the catches used in the 2005 models, the reconstructed thornyhead catches were found to provide inconsistent or unrealistic values in some years. This impacted longspine thornyhead catches for the years 1969-1977 (Figure 58). Figure 59 and 68, and Table 12 demonstrate the relative insensitivity of the model to the alternate catch streams. The 2005 model values were used in this assessment.

The model was run without the estimation of recruitment deviations in order to investigate their impact on outcomes. This resulted in a generally higher scale for the biomass estimates, but a similar endpoint for depletion (Figure 61, Table 12).

### 2.6.2 Profiles

Profiles were conducted across values of initial recruitment, ln(R0), natural mortality, *M*, and steepness *h*, in order to evaluate the sensitivity of the model to assumptions about these parameters.

The catchability (Q values) for the three surveys are shown for a range of values of ln(R0). Figure 62 shows that Q for the indices, which are all relatively flat, were best fit by large populations. However, the likelihood profile for ln(R0) (Figure 63) shows that values of initial recruitment much different from that estimated (ln(R0) = 11.82) are highly unlikely.

The likelihood profile over natural mortality, M (Figure 64), shows that the length data fit a lower mortality rate, near 0.5, than that fixed in the base case (0.11131). Other likelihood components are insensitive to changes in M over a range from 0.05 to 0.15.

Steepness (*h*) from the Beverton-Holt spawner-recruit relationship was fixed at 0.6 in the base case model. The likelihood profile over *h* (Figure 65) shows that while the length data in the model are fit best with a low value for *h*, the discard, the indices and the estimated recruitment are relatively insensitive to changes in *h*.

### 2.6.3 Retrospective analyses

The retrospective analyses are shown in Figure 66 and Figure 67. No strong patterns are obvious in these figures, indicating that the model is not strongly influenced by recent data. The base case model may be slightly more optimistic than the retrospectives.

# 3 Reference Points

A summary of reference points for the base model is provided in Table 8. Unfished spawning biomass (as a proxy of egg production) is estimated to be 39,134 mt (95% CI: 27,093 – 51,175), with spawning biomass at the beginning of 2013 estimated to be 15,654 mt (95% CI: 10,837 – 20,471). The stock's status (depletion) is estimated to be at 75.2% of the unfished level in 2013.

The stock is declared overfished if the current spawning output is estimated to be below 25% of unfished level. The management target for longspine thornyhead is defined as 40% of the unfished spawning output ($SB_{40\%}$), which is estimated by the model to be 15,654 mt (95% confidence interval: 10,837 – 20,471 mt), which corresponds to an exploitation rate of 0.06. This harvest rate provides an equilibrium yield of 2,487 mt (95% confidence interval: 1,718 – 3,256 mt).

Note that the reference points based on $B_{40\%}$ and those based on the SPR proxy for MSY are the same when h=0.6, as in this model, therefore the exploitation rate corresponding to an SPR of 50% (the proxy Fmsy), is 0.06, resulting in an equilibrium yield of 2,487 mt at $SB_{40\%}$ (95% confidence interval: 1,718 – 3,256 mt) at a biomass of 15,654 mt (95% confidence interval: 10,837 – 20,471 mt).

This assessment estimates that the 2012 SPR is 83%, while the SPR-based management fishing mortality target is 50%. Since 1964, the SPR has been above 50%, which means that overfishing of longspine thornyhead has not been occurring.

# 4 Harvest Projections and Decision Tables

Axes of uncertainty for this assessment are the size of initial recruitment and the size of future catch. Initial recruitment is here represented by the log of the initial recruitment, $LN(R_0)$. Table 13 displays the projected percent depletion and spawning biomass (in metric tonnes) for the base model using three values of $LN(R_0)$, to represent three states of nature, and three catch streams.

The states of nature were derived by finding round values of $LN(R_0)$ in the profile analysis that provided a difference in likelihood outcomes near 1.5 units. This value was taken as the change in likelihood associated with a model that had spawning biomass in 2013 closest to the 12.5% quantile of the estimated distribution of this quantity in the base model, which is expected to be the center of the lowest 25% range of values. The profile over $LN(R_0)$ was used to derive the "high" state of nature based on the belief that the low- and high-states were unlikely to be symmetrically distributed around the base model. These bracketing values were 11.5 and 12.3, the low and high around the base estimate of 11.8243.

The "high catch" stream was derived by running the base model with a 4.4% buffer applied to the control rule target of 40% virgin biomass. This is the buffer required when the value of the standard deviation of the log of spawning biomass is less than 0.36; in this case, $\sigma$=0.29.

The "medium" catch was derived by projecting the model for 50 years with an SPR of 0.665, which is midway between 0.83 (SPR for 2024 when the base model was run with the low catch) and 0.5, which is defined as the high catch SPR. This population stabilized at 59% depletion, within the 50-60% range requested. The catch associated with years 2015-2024 from this model was used as the medium catch for this analysis.

Finally, The "low" catch stream consists of the mean of the 2011-2012 catches repeated for 12 years.

The table reports values from 2015 through 2024, omitting 2013-2014, because there is no difference between the results for those years in any cell in the table.

The only scenario in Table 13 in which the stock in 2024 is depleted below the 40% target level is the “Low State”, “High Catch” scenario, however even in this case the stock is still above the 25% minimum stock size threshold in 2024.

# 5 Regional Management Considerations

Currently both shortspine and longspine thornyheads have a management boundary at Pt. Conception, CA at 34º27’ N latitude. There is no evidence of stock structure associated with this line and the amount of data associated with the fishery to the south of this boundary is unlikely to justify any effort to develop a spatial model with explicit accounting for this boundary. Therefore, the best method for apportioning the quotas between areas is the fraction of the population observed in the trawl survey (Figure 7). The fraction of the total estimated biomass south of 34º27’ N in the NWFSC Combo Survey is 23.9% based on the median GLMM results. This is very similar to 23.8% the raw, swept area biomass.

These estimates include extrapolation of observed densities south of 34º27’ N into the large, unobserved, Cowcod Conservation Area (indicated by the absence of tows centered around 33º N, 119º W in Figure 2). The uncertainty associated with that extrapolation is difficult to quantify at this point. Due to the smaller size of the southern area with fewer survey stations, the uncertainty in the south is higher, with a mean CV of 16.6% compared to a 5.3% CV in the north.

# 6 Research Needs

Research and data needs for future assessments include the following:

1. Age and growth information are needed for future stock assessments. Otoliths have been collected in good quantities from the NWFSC survey, but at this time the ageing methods are not believed to be reliable. Additional research on ageing methods for thornyheads would be valuable.
   This could involve investigation of biochemical aging methods, for example an analysis of telomere length in relation to body length.

2. A survey using a towed camera to assess the abundance in deeper water. The proportion of the stock and its size range in deeper water is unknown. Further exploration of perceived differences in catchability between towed cameras and trawl nets should also be explored.
3. More tows or visual surveys south of 34.5 deg. N. latitude. Because the southern Conception Area is a large potential habitat for thornyheads, more effort should be directed to describing their distribution in this area, for inclusion in future assessments.
4. An investigation of the possible discontinuity in the reconstructed thornyhead historical catches would be useful for future assessments.

# 7 Acknowledgments

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# 9 Tables

**Table 1: Trawl and Non-Trawl catch in metric tonnes. Unspecified thornyheads were divided between shortspine and longspines according to the ratio of identified catch, and these numbers represent the total. Values in bold (1964-1976 catch) were taken from the 2005 assessment, as the original sources for these numbers were no longer available.**

| Year | Trawl | | | | Non-Trawl | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | WA | OR | CA | NA | WA | OR | CA | NA | |
| 1964 | 0 | 0 | 0 | **13** | 0 | 0 | 0 | 0 | **13** |
| 1965 | 0 | 0 | 0 | **30** | 0 | 0 | 0 | 0 | **30** |
| 1966 | 0 | 0 | 0 | **21** | 0 | 0 | 0 | 0 | **21** |
| 1967 | 0 | 0 | 0 | **10** | 0 | 0 | 0 | 0 | **10** |
| 1968 | 0 | 0 | 0 | **10** | 0 | 0 | 0 | 0 | **10** |
| 1969 | 0 | 0 | 0 | **29** | 0 | 0 | 0 | 0 | **29** |
| 1970 | 0 | 0 | 0 | **42** | 0 | 0 | 0 | 0 | **42** |
| 1971 | 0 | 0 | 0 | **44** | 0 | 0 | 0 | 0 | **44** |
| 1972 | 0 | 0 | 0 | **82** | 0 | 0 | 0 | 0 | **82** |
| 1973 | 0 | 0 | 0 | **93** | 0 | 0 | 0 | 0 | **93** |
| 1974 | 0 | 0 | 0 | **77** | 0 | 0 | 0 | 0 | **77** |
| 1975 | 0 | 0 | 0 | **99** | 0 | 0 | 0 | 0 | **99** |
| 1976 | 0 | 0 | 0 | **54** | 0 | 0 | 0 | 0 | **54** |
| 1977 | 0 | 0 | 0 | **102** | 0 | 0 | 0 | 0 | **102** |
| 1978 | 0 | 0 | 197 | 0 | 0 | 0 | 0 | 0 | 197 |
| 1979 | 0 | 0 | 143 | 0 | 0 | 0 | 0 | 0 | 143 |
| 1980 | 0 | 0 | 357 | 0 | 0 | 0 | 0 | 0 | 357 |
| 1981 | 0 | 1 | 110 | 0 | 0 | 0 | 1 | 0 | 112 |
| 1982 | 0 | 26 | 382 | 0 | 0 | 0 | 1 | 0 | 408 |
| 1983 | 3 | 52 | 210 | 0 | 0 | 0 | 1 | 0 | 266 |
| 1984 | 4 | 68 | 288 | 0 | 0 | 0 | 0 | 0 | 360 |
| 1985 | 13 | 387 | 569 | 0 | 0 | 0 | 0 | 0 | 969 |
| 1986 | 12 | 194 | 619 | 0 | 0 | 0 | 1 | 0 | 827 |
| 1987 | 2 | 72 | 1,108 | 0 | 0 | 0 | 0 | 0 | 1,182 |
| 1988 | 11 | 86 | 2,639 | 0 | 0 | 0 | 0 | 0 | 2,736 |
| 1989 | 25 | 617 | 2,529 | 0 | 0 | 0 | 0 | 0 | 3,171 |
| 1990 | 36 | 1,748 | 4,083 | 4 | 0 | 0 | 0 | 0 | 5,870 |
| 1991 | 37 | 949 | 1,986 | 0 | 0 | 0 | 0 | 0 | 2,972 |
| 1992 | 238 | 1,968 | 3,274 | 0 | 0 | 0 | 0 | 0 | 5,481 |
| 1993 | 344 | 2,181 | 2,829 | 0 | 0 | 0 | 0 | 0 | 5,354 |
| 1994 | 423 | 1,752 | 2,388 | 0 | 0 | 0 | 0 | 0 | 4,563 |
| 1995 | 732 | 1,587 | 3,124 | 0 | 2 | 3 | 119 | 0 | 5,567 |
| 1996 | 419 | 1,516 | 2,803 | 1 | 0 | 0 | 141 | 0 | 4,881 |
| 1997 | 408 | 1,164 | 2,348 | 1 | 0 | 0 | 132 | 0 | 4,053 |
| 1998 | 196 | 629 | 1,401 | 0 | 0 | 1 | 26 | 0 | 2,252 |
| 1999 | 106 | 499 | 1,172 | 0 | 0 | 0 | 32 | 0 | 1,810 |

**Table 1. Continued. Trawl and Non-Trawl Landings.**

| Year | Trawl | | | | Non-Trawl | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | WA | OR | CA | NA | WA | OR | CA | NA | |
| 2000 | 64 | 510 | 853 | 0 | 0 | 0 | 69 | 0 | 1,496 |
| 2001 | 83 | 393 | 673 | 17 | 0 | 0 | 55 | 0 | 1,221 |
| 2002 | 124 | 465 | 1,316 | 4 | 0 | 0 | 15 | 0 | 1,924 |
| 2003 | 104 | 384 | 1,049 | 1 | 0 | 0 | 18 | 0 | 1,556 |
| 2004 | 26 | 117 | 536 | 0 | 0 | 0 | 10 | 0 | 689 |
| 2005 | 4 | 78 | 551 | 3 | 0 | 0 | 16 | 0 | 652 |
| 2006 | 9 | 128 | 594 | 1 | 0 | 0 | 18 | 0 | 750 |
| 2007 | 43 | 177 | 570 | 1 | 0 | 0 | 20 | 0 | 810 |
| 2008 | 89 | 371 | 769 | 1 | 0 | 0 | 14 | 0 | 1,243 |
| 2009 | 61 | 449 | 634 | 4 | 0 | 0 | 22 | 0 | 1,171 |
| 2010 | 44 | 643 | 642 | 1 | 1 | 1 | 26 | 0 | 1,359 |
| 2011 | 26 | 354 | 519 | 0 | 0 | 1 | 25 | 0 | 926 |
| 2012 | 14 | 256 | 584 | 0 | 0 | 0 | 16 | 0 | 871 |

**Table 2: Discard rates.**

| Source | Year | Value | CV |
|---|---|---|---|
| Pikitch | 1985 | 0.221 | 0.946 |
| | 1986 | 0.222 | 0.943 |
| | 1987 | 0.458 | 0.421 |
| EDCP | 1995 | 0.100 | 0.200 |
| | 1996 | 0.120 | 0.200 |
| | 1997 | 0.130 | 0.200 |
| | 1998 | 0.170 | 0.200 |
| | 1999 | 0.200 | 0.200 |
| WCGOP | 2002 | 0.198 | 0.078 |
| | 2003 | 0.193 | 0.085 |
| | 2004 | 0.177 | 0.155 |
| | 2005 | 0.158 | 0.155 |
| | 2006 | 0.121 | 0.186 |
| | 2007 | 0.150 | 0.168 |
| | 2008 | 0.134 | 0.106 |
| | 2009 | 0.285 | 0.117 |
| | 2010 | 0.227 | 0.112 |
| | 2011 | 0.047 | 0.001 |

**Table 3: Recent trend in commercial landings (mt) relative to the management guidelines. Estimated total catch reflects the commercial landings plus the model estimated discarded biomass.**

| Year | OFL (mt) | ABC (mt) | Commercial Landings (mt) | Estimated Total Catch (mt) |
|---|---|---|---|---|
| 2003 | 2,851 | 2,656 | 1,556 | 1,886 |
| 2004 | 2,851 | 2,656 | 689 | 837 |
| 2005 | 2,461 | 2,461 | 652 | 792 |
| 2006 | 2,461 | 2,461 | 750 | 911 |
| 2007 | 3,907 | 2,696 | 810 | 956 |
| 2008 | 3,907 | 2,696 | 1,243 | 1,463 |
| 2009 | 3,766 | 2,626 | 1,171 | 1,375 |
| 2010 | 3,671 | 2,560 | 1,359 | 1,588 |
| 2011 | 3,571 | 2,495 | 926 | 972 |
| 2012 | 3,483 | 2,430 | 871 | 912 |

**Table 4: Final design and model (GLMM)-based abundance indices for longspine thornyhead.**

| | AFSC slope | | | NWFSC slope | | | NWFSC shelf-slope | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Design | Model | log_SD | Design | Model | log_SD | Design | Model | log_SD |
| 1995 | | | | | | | | | |
| 1996 | | | | | | | | | |
| 1997 | 103,403 | 103,712 | 0.07 | | | | | | |
| 1998 | | | | 72,692 | 72,770 | 0.09 | | | |
| 1999 | 100,313 | 100,499 | 0.07 | 84,620 | 84,076 | 0.09 | | | |
| 2000 | 99,337 | 99,184 | 0.07 | 87,038 | 87,669 | 0.09 | | | |
| 2001 | 100,571 | 100,456 | 0.07 | 85,590 | 85,285 | 0.08 | | | |
| 2002 | | | | 88,957 | 89,069 | 0.09 | | | |
| 2003 | | | | | | | 139,366 | 140,537 | 0.08 |
| 2004 | | | | | | | 148,931 | 150,353 | 0.09 |
| 2005 | | | | | | | 132,760 | 134,201 | 0.09 |
| 2006 | | | | | | | 138,480 | 139,453 | 0.08 |
| 2007 | | | | | | | 138,959 | 139,599 | 0.08 |
| 2008 | | | | | | | 166,411 | 166,747 | 0.09 |
| 2009 | | | | | | | 172,436 | 173,041 | 0.09 |
| 2010 | | | | | | | 175,257 | 175,702 | 0.08 |
| 2011 | | | | | | | 160,828 | 161,373 | 0.09 |
| 2012 | | | | | | | 189,656 | 190,780 | 0.08 |

**Table 5: Summary of sampling effort (number of hauls and fish sampled) used to create length compositions. The only sexed fish were sampled in the 2005-2012 NWFSC Combo Survey, where the ratio of females to males was .51 overall with little between-year variation, so gender is not explicitly reported.**

| Year | Commercial Trawl | | Pikitch Study | WCGOP | AFSC Slope Survey | | NWFSC Slope Survey | | NW Shelf/Slope Survey | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hauls | Samples | Samples | Samples | Hauls | Samples | Hauls | Samples | Hauls | Samples |
| 1978 | 246 | 449 | | | | | | | | |
| 1979 | 212 | 398 | | | | | | | | |
| 1980 | 74 | 138 | | | | | | | | |
| 1981 | 15 | 23 | | | | | | | | |
| 1982 | 77 | 120 | | | | | | | | |
| 1983 | 200 | 297 | | | | | | | | |
| 1984 | 377 | 809 | | | | | | | | |
| 1985 | 623 | 1443 | | | | | | | | |
| 1986 | 352 | 723 | | | | | | | | |
| 1987 | 241 | 592 | | | | | | | | |
| 1988 | 18 | 55 | | | | | | | | |
| 1989 | 288 | 1234 | | | | | | | | |
| 1990 | 1363 | 5381 | | | | | | | | |
| 1991 | 1248 | 4631 | | | | | | | | |
| 1992 | 1771 | 6839 | | | | | | | | |
| 1993 | 888 | 4050 | | | | | | | | |
| 1994 | 758 | 4025 | | | | | | | | |
| 1995 | 1329 | 7931 | | | | | | | | |
| 1996 | 1479 | 8770 | | | | | | | | |
| 1997 | 1760 | 12158 | | | 134 | 33655 | | | | |
| 1998 | 1120 | 5149 | | | | | 160 | 23879 | | |
| 1999 | 1142 | 4558 | 524 | | 146 | 23883 | 206 | 27118 | | |
| 2000 | 982 | 4147 | 5777 | | 159 | 20993 | 196 | 22652 | | |
| 2001 | 1310 | 4832 | 705 | | 160 | 27061 | 208 | 24399 | | |
| 2002 | 1789 | 6833 | | | | | 276 | 34042 | | |
| 2003 | 1466 | 5268 | | | | | | | 194 | 15432 |
| 2004 | 1099 | 3765 | | | | | | | 150 | 11171 |
| 2005 | 1069 | 3478 | | | | | | | 228 | 13530 |
| 2006 | 2018 | 5878 | | 1154 | | | | | 236 | 9069 |
| 2007 | 1931 | 5130 | | 2023 | | | | | 248 | 6196 |
| 2008 | 2356 | 7184 | | 2547 | | | | | 258 | 3622 |
| 2009 | 2341 | 6522 | | 3714 | | | | | 239 | 3098 |
| 2010 | 2386 | 7211 | | 2312 | | | | | 258 | 3044 |
| 2011 | 2429 | 7226 | | 4291 | | | | | 247 | 5012 |
| 2012 | 2310 | 6968 | | | | | | | 247 | 4798 |

**Table 6: Biological parameterizations used in the longspine thornyhead model. Two of the growth parameters, K and the size-at-age for reference age 2 (40 years), were estimated, as was ln($R_0$) (bold values).**

| Parameter | Value | Bounds | Prior Type | Prior Mean | Prior SD |
|---|---|---|---|---|---|
| Females and Males | | | | | |
| Natural mortality (M) | 0.111313 | 0.01 - 03 | | | |
| Length at Age 3 | 8.573 | 5 - 25 | | | |
| **Length at Age 40** | **27.8282** | 5 - 40 | Full Beta | 30 | NA |
| **VBGF K** | **0.108505** | 0.05 - 0.2 | LogNormal | 0.1 | NA |
| Length CV at Amin | 0.131 | 0.015 - 0.25 | | | |
| Length CV at Amax | -0.892 | -3 - 5 | | | |
| Weight-Length a | 4.30E-06 | -3 - 3 | | | |
| Weight-Length b | 3.352 | -3 - 8 | | | |
| Length at 50% maturity | 17.826 | 0.001 - 40 | | | |
| Maturity slope | -1.79 | -3 - 3 | | | |
| Eggs/kg | 1 | -3 - 3 | | | |
| Eggs/kg slope | 0 | -3 - 3 | | | |
| Stock-recruit | | | | | |
| **ln($R_0$)** | **11.8243** | 3-31 | LogNormal | 9.3 | NA |
| Steepness (h) | 0.6 | 0.2 - 1 | | | |
| $\sigma_R$ | 0.6 | 0 - 2 | | | |

**Table 7: Biological parameterizations estimated in studies and used in the 2005 assessment.**

| Biological parameter | Source: Jacobson (1991) | Ianelli et al. (1994) | Kline (1996) | Pearson & Gunderson (2003) | 2005 Assessment |
|---|---|---|---|---|---|
| Length-weight relationship | | | | | |
| a | 4.30 e-06 | | | | |
| b | 3.352 | | | | |
| Von Bertalanffy growth curve | | | | | |
| $L_\infty$ (cm) | 33.86 | | 30.06 | | 31.2 |
| K | 0.0585 | | 0.072 | | 0.064 |
| t0 | -0.38 | | -1.9 | | -2.02 |
| | (N = 192) | | (N = 478) | | (N = 815) |
| Maturity at length | | | | | |
| L50 (cm) | 18.8 | 22.1 | | 17.8 | |
| slope | -0.593 | -0.766 | | -1.79 | |
| | (N=120) | (N=3738) | | (N = 239) | |

**Table 8: Summary of reference points and management outputs for the base case model.**

| Quantity | Estimate | ~95% confidence interval |
|---|---|---|
| Unfished Spawning biomass (mt) | 39,134 | (27,093 - 51175) |
| Unfished age 1+ biomass (mt) | 91,049 | (61,393 - 120,705) |
| Unfished recruitment (R0, millions) | 136,529 | (81,731 - 191,327) |
| Spawning biomass (2013) | 29.4 | (12.5 – 46.4) |
| SD of log Spawning Biomass (2013) | 0.29 | – |
| Depletion (2013) | 75.2% | (53.5% - 96.9%) |
| ***Reference points based on $B_{40\%}$*** | | |
| Proxy spawning biomass ($B_{40\%}$) | 15,654 | (10,837 – 20,471) |
| SPR resulting in $B_{40\%}$ ($SPR_{SB40\%}$) | 50% | – |
| Exploitation rate resulting in $B_{40\%}$ | 0.06 | (0.057 - 0.063) |
| Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt) | 2,487 | (1,718 – 3,256) |
| ***Reference points based on SPR proxy for MSY*** | | |
| Spawning biomass | 15,654 | (10,837 – 20,471) |
| $SPR_{proxy}$ | 50% | – |
| Exploitation rate corresponding to $SPR_{proxy}$ | 0.06 | (0.057 - 0.063) |
| Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt) | 2,487 | (1,718 – 3,256) |
| ***Reference points based on estimated MSY values*** | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 13,108 | (9,110 – 17,106) |
| $SPR_{MSY}$ | 44.6% | (44.4% - 44.8%) |
| Exploitation rate corresponding to $SPR_{MSY}$ | 0.071 | (0.068 – 0.074) |
| *MSY* (mt) | 2,529 | (1,746 – 3,312) |

**Table 9: Selectivity parameterizations used in the longspine thornyhead model.**

| | | | | | Prior | | |
|---|---|---|---|---|---|---|---|
| Fishery/Survey | Parameter | Value | Min | Max | Type | Mean | SD |
| Fishery | Logistic 1 | 23.5035 | 6.5 | 25 | Normal | 20 | 1 |
| | Logistic 2 | 9.03702 | 0.01 | 25 | No prior | | |
| Fishery Retention | Retention curve 1 | 9.03702 | 2 | 40 | No prior | | |
| | Retention curve 2 | 21.8443 | 1.00E-05 | 30 | No prior | | |
| | Retention curve 3 | 1.77623 | 1.00E-04 | 1 | No prior | | |
| | Retention curve 4 | 0 | -10 | 5 | No prior | | |
| Retention Blocks | Retention 1992 | 0 | -10 | 10 | Normal | 0 | 5 |
| | Retention 2007 | -0.103126 | -10 | 10 | Normal | 0 | 5 |
| | Retention 2011 | -0.0295415 | -10 | 10 | Normal | 0 | 5 |
| | Retention 1992 | -0.198137 | -10 | 10 | Normal | 0 | 5 |
| | Retention 2007 | -0.0758172 | -10 | 10 | Normal | 0 | 5 |
| | Retention 2011 | -0.164209 | -10 | 10 | Normal | 0 | 5 |
| AFSC Slope | Double-normal 1 | 19.705 | 6.5 | 34.5 | No prior | | |
| | Double-normal 2 | -19.6327 | -20 | 7 | No prior | | |
| | Double-normal 3 | 2.95146 | -5 | 10 | No prior | | |
| | Double-normal 4 | 3.71387 | -5 | 20 | No prior | | |
| | Double-normal 5 | -999 | -999 | 15 | No prior | | |
| | Double-normal 6 | -999 | -999 | 15 | No prior | | |
| NWFSC Slope | Logistic 1 | 20.0197 | 6.5 | 25 | Normal | 20 | 1 |
| | Logistic 2 | 11.5486 | -7 | 25 | No prior | | |
| NW Shelf/Slope | Logistic 1 | 20.5822 | 6.5 | 25 | Normal | 20 | 1 |
| | Logistic 2 | 12.1119 | 0.01 | 25 | No prior | | |

**Table 10: Time-series of total biomass, summary (age2+) spawning biomass, spawning output, depletion (stock status), recruitment, and exploitation rate estimated in the model.**

| Year | Total biomass (mt) | Summary biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Exploitation rate |
|---|---|---|---|---|---|---|
| 1964 | 103,038 | 102,727 | 45,523 | 1.16% | 91,951 | 0 |
| 1965 | 101,936 | 101,627 | 45,311 | 1.16% | 92,226 | 0 |
| 1966 | 100,568 | 100,256 | 44,925 | 1.15% | 93,824 | 0 |
| 1967 | 99,004 | 98,686 | 44,394 | 1.13% | 96,575 | 0 |
| 1968 | 97,292 | 96,963 | 43,737 | 1.12% | 100,060 | 0 |
| 1969 | 95,467 | 95,127 | 42,969 | 1.10% | 103,521 | 0 |
| 1970 | 93,558 | 93,207 | 42,103 | 1.08% | 106,054 | 0 |
| 1971 | 91,622 | 91,264 | 41,170 | 1.05% | 107,320 | 0 |
| 1972 | 89,718 | 89,356 | 40,203 | 1.03% | 108,223 | 0 |
| 1973 | 87,849 | 87,483 | 39,212 | 1.00% | 110,524 | 0 |
| 1974 | 86,084 | 85,706 | 38,240 | 0.98% | 115,486 | 0 |
| 1975 | 84,482 | 84,083 | 37,326 | 0.95% | 124,280 | 0 |
| 1976 | 83,025 | 82,592 | 36,470 | 0.93% | 135,917 | 0 |
| 1977 | 81,809 | 81,336 | 35,723 | 0.91% | 147,919 | 0 |
| 1978 | 80,758 | 80,240 | 35,038 | 0.90% | 163,136 | 0 |
| 1979 | 79,883 | 79,288 | 34,391 | 0.88% | 197,156 | 0 |
| 1980 | 79,439 | 78,698 | 33,861 | 0.87% | 253,856 | 0.01 |
| 1981 | 79,019 | 78,266 | 33,304 | 0.85% | 183,459 | 0 |
| 1982 | 79,200 | 78,658 | 32,989 | 0.84% | 131,160 | 0.01 |
| 1983 | 79,436 | 79,004 | 32,635 | 0.83% | 125,812 | 0 |
| 1984 | 80,315 | 79,876 | 32,521 | 0.83% | 137,379 | 0.01 |
| 1985 | 81,326 | 80,911 | 32,549 | 0.83% | 104,401 | 0.01 |
| 1986 | 81,717 | 81,373 | 32,495 | 0.83% | 99,695 | 0.01 |
| 1987 | 82,306 | 81,920 | 32,855 | 0.84% | 136,067 | 0.02 |
| 1988 | 82,422 | 81,947 | 33,304 | 0.85% | 149,910 | 0.04 |
| 1989 | 80,518 | 80,054 | 32,970 | 0.84% | 121,979 | 0.05 |
| 1990 | 77,930 | 77,572 | 32,302 | 0.83% | 85,500 | 0.1 |
| 1991 | 72,044 | 71,751 | 29,882 | 0.76% | 89,848 | 0.06 |
| 1992 | 69,848 | 69,489 | 29,028 | 0.74% | 130,450 | 0.09 |
| 1993 | 65,421 | 64,974 | 26,944 | 0.69% | 136,737 | 0.1 |
| 1994 | 61,201 | 60,719 | 24,887 | 0.64% | 153,347 | 0.09 |
| 1995 | 57,889 | 57,384 | 23,302 | 0.60% | 146,754 | 0.11 |
| 1996 | 53,615 | 53,141 | 21,285 | 0.54% | 133,141 | 0.11 |
| 1997 | 50,328 | 49,849 | 19,673 | 0.50% | 156,349 | 0.1 |
| 1998 | 48,200 | 47,667 | 18,465 | 0.47% | 162,173 | 0.06 |
| 1999 | 48,276 | 47,734 | 18,184 | 0.46% | 160,700 | 0.05 |
| 2000 | 49,010 | 48,452 | 18,189 | 0.46% | 173,860 | 0.04 |

**Table 10. Continued.**

| Year | Total biomass (mt) | Summary biomass (mt) | Spawning biomass (mt) | Depletion | Age-0 recruits | Exploitation rate |
|---|---|---|---|---|---|---|
| 2001 | 50,289 | 49,674 | 18,484 | 0.47 | 196,411 | 0.03 |
| 2002 | 51,927 | 51,388 | 19,064 | 0.49 | 110,856 | 0.05 |
| 2003 | 53,102 | 52,527 | 19,378 | 0.50 | 256,257 | 0.04 |
| 2004 | 54,632 | 54,001 | 19,958 | 0.51 | 93,155 | 0.02 |
| 2005 | 57,314 | 56,966 | 21,060 | 0.54 | 117,956 | 0.01 |
| 2006 | 59,908 | 59,536 | 22,244 | 0.57 | 101,145 | 0.02 |
| 2007 | 62,419 | 62,130 | 23,440 | 0.60 | 65,197 | 0.02 |
| 2008 | 64,637 | 64,408 | 24,674 | 0.63 | 72,369 | 0.02 |
| 2009 | 66,062 | 65,827 | 25,705 | 0.66 | 67,170 | 0.02 |
| 2010 | 67,184 | 66,957 | 26,771 | 0.68 | 68,454 | 0.02 |
| 2011 | 67,662 | 67,398 | 27,689 | 0.71 | 92,717 | 0.01 |
| 2012 | 68,304 | 67,937 | 28,698 | 0.73 | 132,555 | 0.01 |

**Table 11: Summary of the history of fishery processor size-limits, spatial extent of the fishery, and management regime.**

| Era | Size Limit (in.) | Extent | Management |
|---|---|---|---|
| 1960s | 12 - 14 | Eureka INPFC | |
| Late 70s - Early 80s | 10 | | |
| Late 80s | 8 | OR, WA fishery | Deepwater complex (DTS) |
| 1990 (peak landings) | 10 | Coastwide | |
| 1991 | 10 | | Separate ABC, Trip limits |
| 1992 | | | Harvest Guidelines, mesh size change (3 – 4.5 in.) |
| 1995 | | | Landing and trip limits |
| 1997 | 8 | | Post-1995 yearly adjustments |
| 2011 | | | Catch-shares |

**Table 12: Sensitivity results comparing the base model (Base), historical catch reconstruction (H C), and the model without recruitment deviations (No Rec Devs).**

| | | Base | H C | No Rec Devs |
|---|---|---|---|---|
| Parameters | LN($R_0$) | 11.82 | 11.82 | 12.52 |
| | AFSC Slope Q | 3.18 | 3.18 | 1.44 |
| | NWFSC Slope Q | 3.01 | 3.03 | 1.78 |
| | NWFSC Combo Q | 4.58 | 4.6 | 2.8 |
| Derived Quantities | $SB_0$ | 39,134 | 38,955 | 55,881 |
| | 2013 Depletion | 0.752 | 0.753 | 0.756 |
| Reference Points based on B40% | SSB | 15,654 | 15,582 | 22,352 |
| | Yield | 2,486 | 2,475 | 3,552 |
| Perfomance | Likelihood | 318.26 | 318.147 | 422.429 |
| | Gradient | 0.000616 | 0.00051795 | 0.00195 |

**Table 13: Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis of catch uncertainty. Columns range over low, mid, and high state of nature, and rows range over differing assumptions of catch levels. Depletion is the percentage of virgin spawning biomass represented by current spawning biomass. Spawning biomass is in metric tonnes.**

| | | | Low State $LN(R_0) = 11.5$ | | Medium State $LN(R_0) = 11.8243$ | | High State $LN(R_0) = 12.3$ | |
|---|---|---|---|---|---|---|---|---|
| | Year | Catch | Depletion (%) | Spawning Biomass | Depletion (%) | Spawning Biomass | Depletion (%) | Spawning Biomass |
| Low Catch | 2015 | 942 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 942 | 60.4 % | 18,734 | 75.6 % | 29,572 | 96.2 % | 54,924 |
| | 2017 | 942 | 59.2 % | 18,378 | 74.3 % | 29,090 | 94.7 % | 54,063 |
| | 2018 | 942 | 57.9 % | 17,974 | 72.8 % | 28,506 | 92.8 % | 52,982 |
| | 2019 | 942 | 56.8 % | 17,635 | 71.4 % | 27,960 | 90.8 % | 51,880 |
| | 2020 | 942 | 56.2 % | 17,437 | 70.4 % | 27,561 | 89.2 % | 50,932 |
| | 2021 | 942 | 56.0 % | 17,394 | 69.9 % | 27,343 | 87.9 % | 50,223 |
| | 2022 | 942 | 56.3 % | 17,472 | 69.7 % | 27,282 | 87.1 % | 49,745 |
| | 2023 | 942 | 56.8 % | 17,634 | 69.8 % | 27,333 | 86.6 % | 49,445 |
| | 2024 | 942 | 57.5 % | 17,845 | 70.2 % | 27,457 | 86.3 % | 49,272 |
| Medium Catch | 2015 | 2,510 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 2,473 | 58.1 % | 18,025 | 73.8 % | 28,868 | 94.9 % | 54,223 |
| | 2017 | 2,422 | 54.8 % | 17,004 | 70.9 % | 27,726 | 92.3 % | 52,710 |
| | 2018 | 2,361 | 51.5 % | 15,994 | 67.8 % | 26,543 | 89.4 % | 51,035 |
| | 2019 | 2,295 | 48.7 % | 15,114 | 65.1 % | 25,463 | 86.5 % | 49,406 |
| | 2020 | 2,229 | 46.5 % | 14,443 | 62.9 % | 24,598 | 84.0 % | 47,999 |
| | 2021 | 2,167 | 45.1 % | 13,990 | 61.3 % | 23,979 | 82.1 % | 46,896 |
| | 2022 | 2,113 | 44.2 % | 13,715 | 60.2 % | 23,575 | 80.7 % | 46,082 |
| | 2023 | 2,068 | 43.7 % | 13,571 | 59.6 % | 23,334 | 79.7 % | 45,501 |
| | 2024 | 2,033 | 43.5 % | 13,512 | 59.3 % | 23,207 | 78.9 % | 45,089 |
| High Catch | 2015 | 4,787 | 61.1 % | 18,953 | 76.3 % | 29,841 | 97.0 % | 55,396 |
| | 2016 | 4,537 | 54.8 % | 16,996 | 71.2 % | 27,845 | 93.2 % | 53,206 |
| | 2017 | 4,278 | 48.6 % | 15,083 | 66.0 % | 25,820 | 89.0 % | 50,816 |
| | 2018 | 4,021 | 42.9 % | 13,324 | 61.1 % | 23,896 | 84.8 % | 48,409 |
| | 2019 | 3,776 | 38.1 % | 11,832 | 56.8 % | 22,212 | 80.9 % | 46,183 |
| | 2020 | 3,552 | 34.4 % | 10,674 | 53.3 % | 20,867 | 77.6 % | 44,305 |
| | 2021 | 3,356 | 31.7 % | 9,837 | 50.8 % | 19,876 | 75.0 % | 42,840 |
| | 2022 | 3,192 | 29.8 % | 9,263 | 49.0 % | 19,189 | 73.1 % | 41,756 |
| | 2023 | 3,060 | 28.6 % | 8,878 | 47.9 % | 18,735 | 71.7 % | 40,977 |
| | 2024 | 2,959 | 27.8 % | 8,613 | 47.1 % | 18,444 | 70.8 % | 40,424 |

# Figures

## 9.1 Ecology

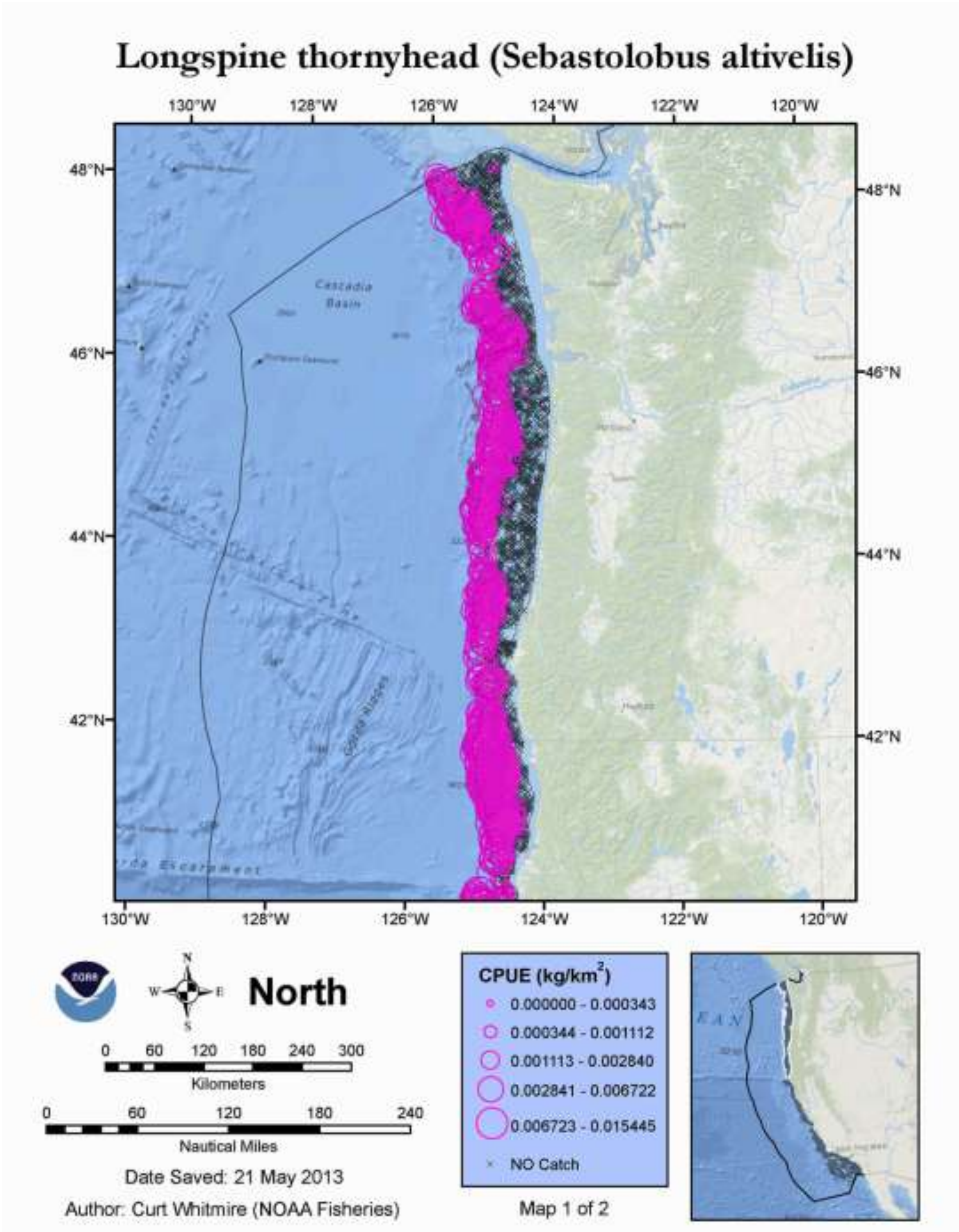



**Figure 1: Occurrence and abundance of longspine thornyhead found in the NWFSC annual survey (2003-2012) north of 40º10' N latitude.**

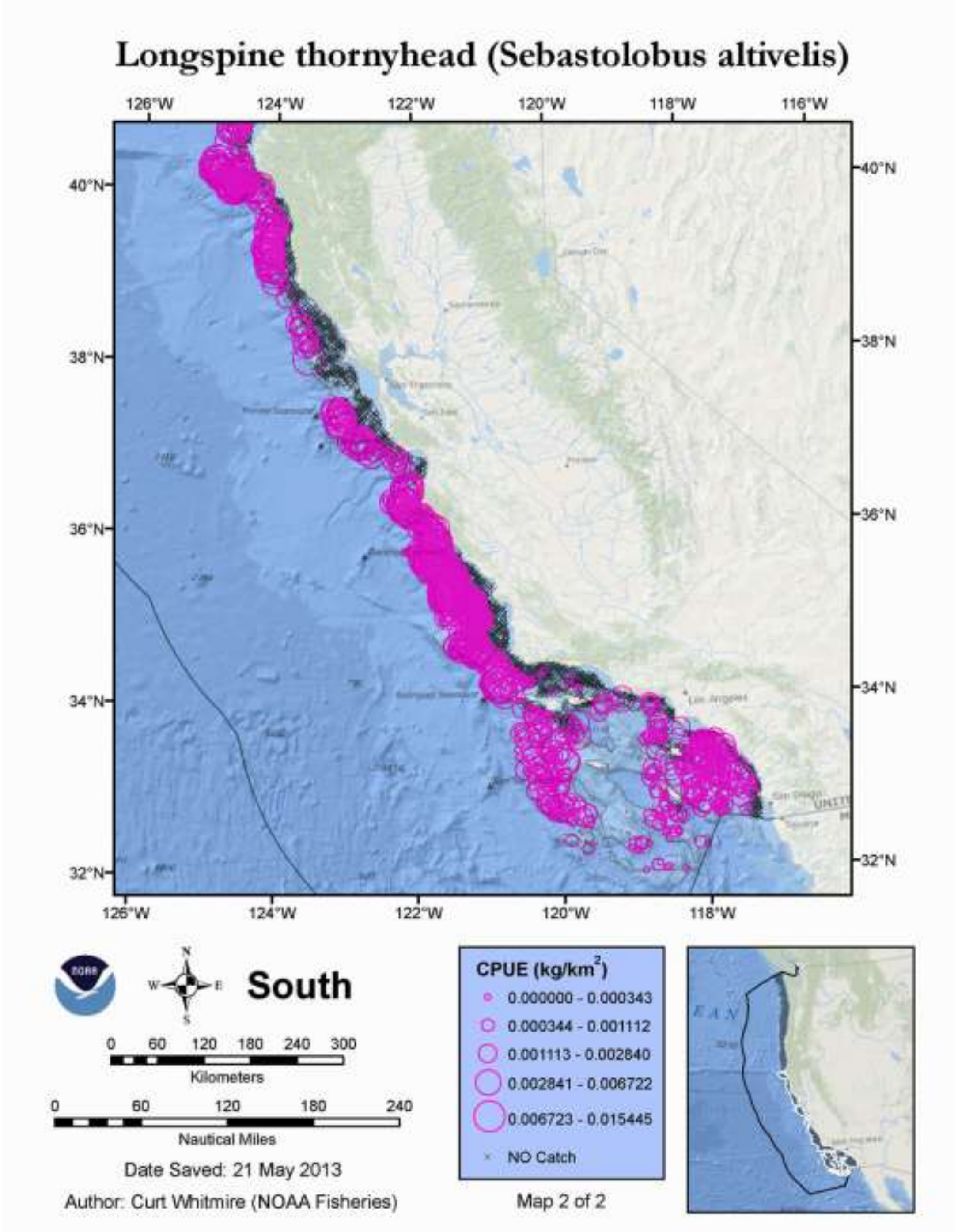



**Figure 2: Occurrence and abundance of longspine thornyhead found in the NWFSC annual survey (2003-2012) south of 40º10' N latitude.**

## 9.2 Data

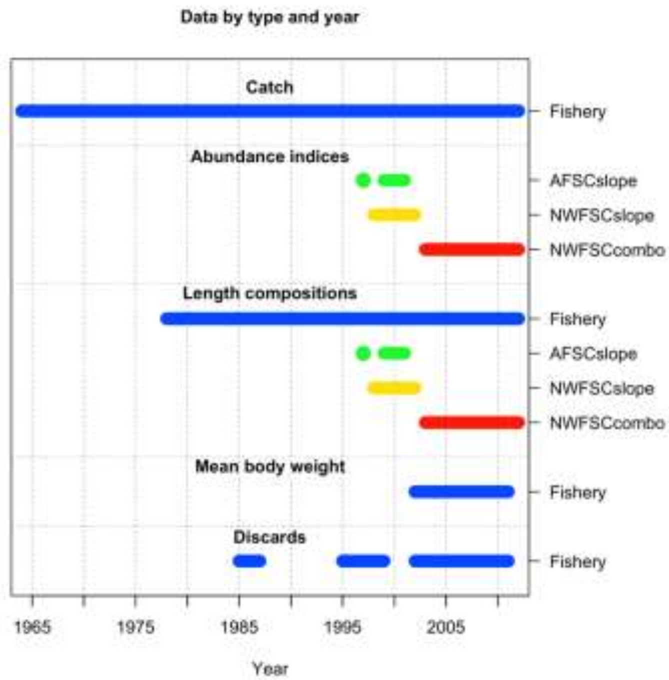



**Figure 3: Data type and coverage in the base case model.**

## 9.3 Landings

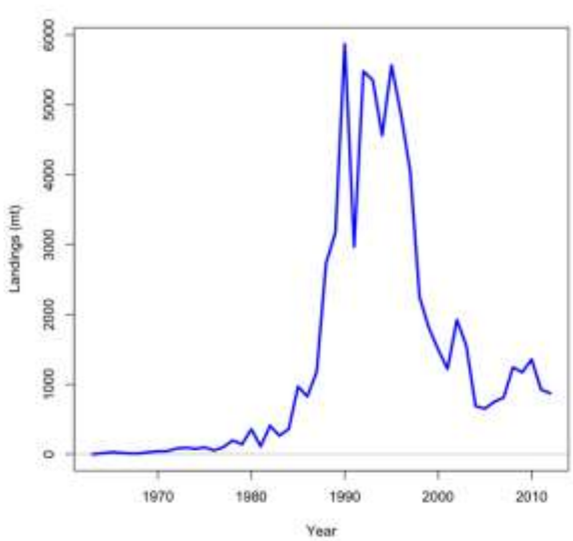



**Figure 4: Total landings of longspine thornyheads, 1964-2012.**

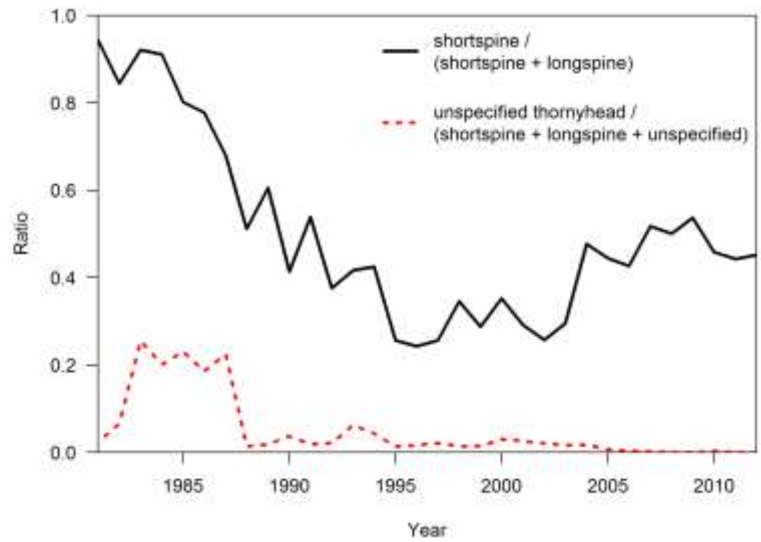



**Figure 5: Ratio of shortspine to combined thornyheads in the subset of the landings for which the species was identified (solid black line), and the ratio of unspecified landings to total landings of both thornyhead species (dotted red line). The ratio of specified thornyheads was used to apportion the unspecified landings into estimates of the landings for each species. Longspine ratio is (1 – shortspine ratio).**

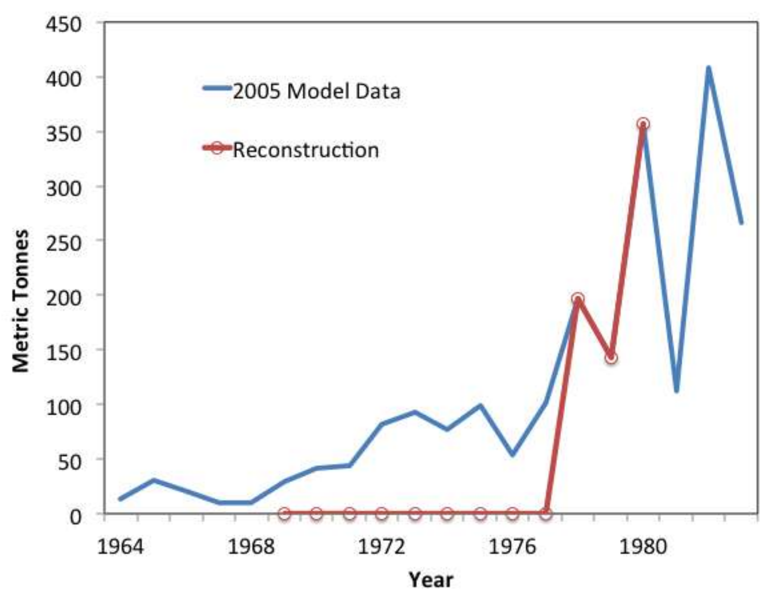



**Figure 6: 2005 Model data (blue) and data compiled from California and Oregon data reconstructions (red, with open circles).**

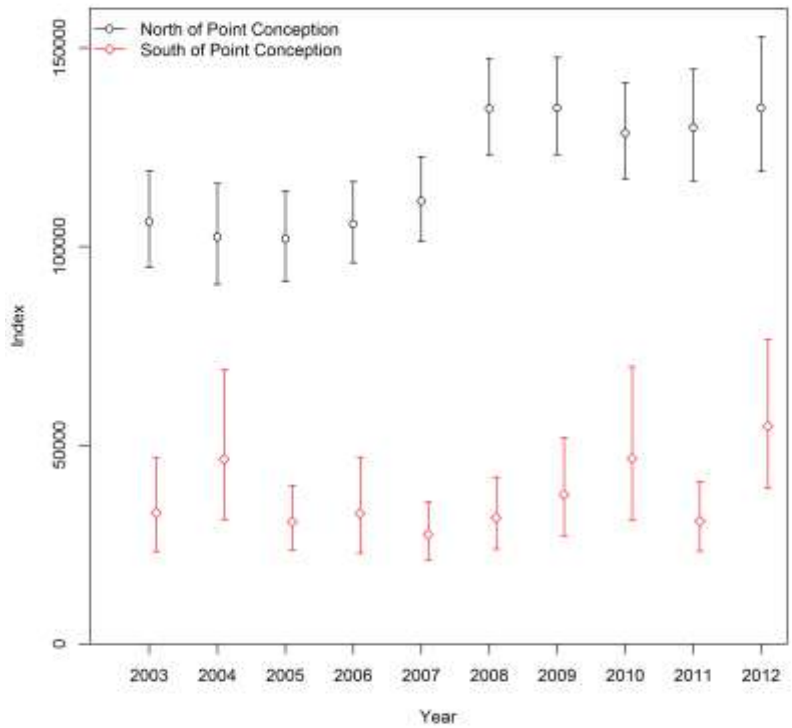



**Figure 7: Subsets of the design-based indices from the NWFSC Combo Survey associated with the strata north and south of Point Conception. The mean value of the southern portion is 23.8% of the total (similar to 23.9% for the GLMM results). Due to the smaller size of the southern area with fewer survey stations, the uncertainty in the south is higher, with a mean CV of 16.6% compared to a 5.3% CV in the north.**

## 9.4 Surveys

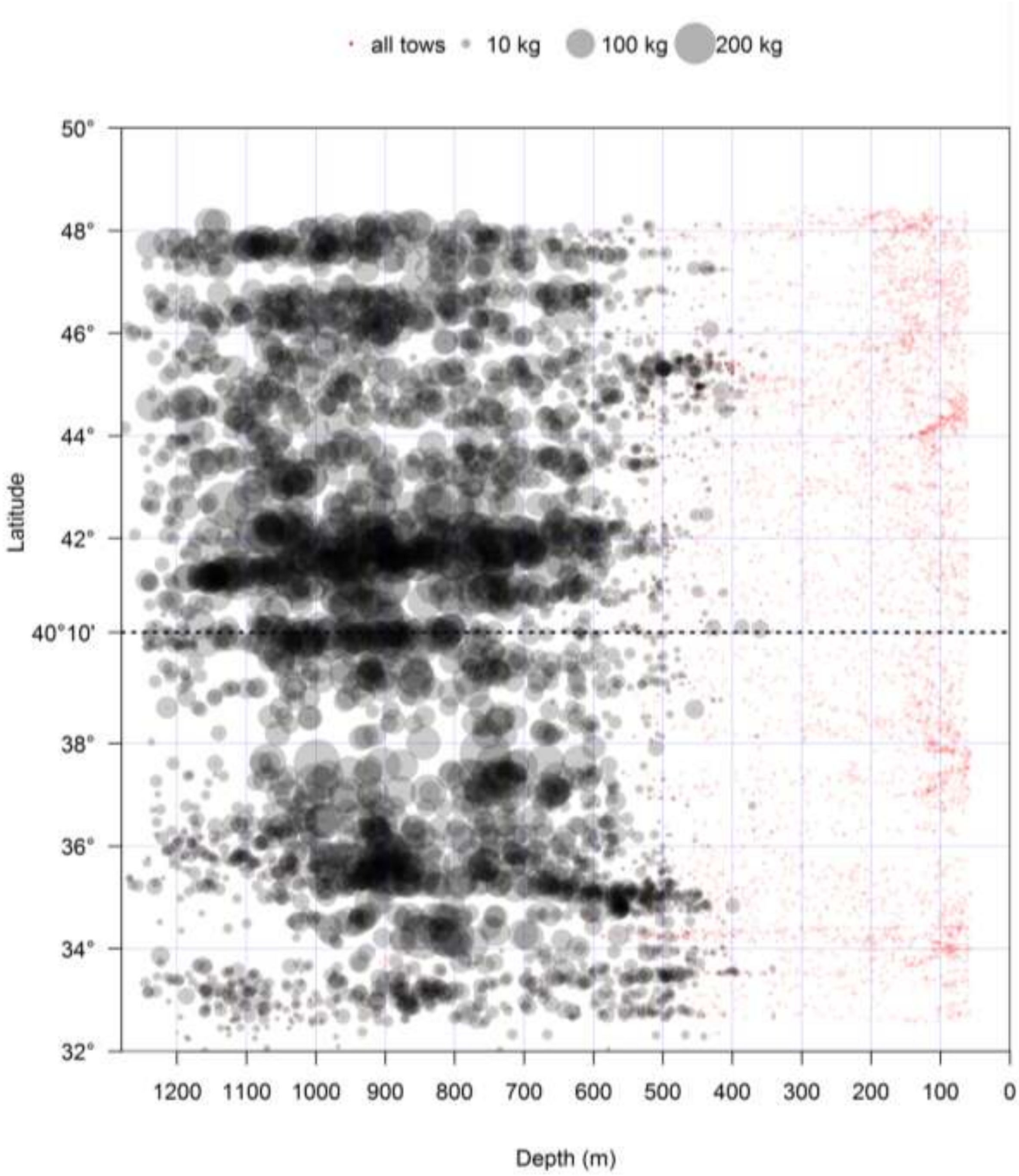



**Figure 8: Spatial distribution of longspine thornyhead in NWFSC shelf-slope combo survey data (2003 – 2012). Red points indicate location of all tows. Grey points indicate location of longspine thornyheads with area of circle proportional to biomass of catch with scale indicated in the key at the top. Swept area is not accounted for in this figure, but tows typically cover similar area.**

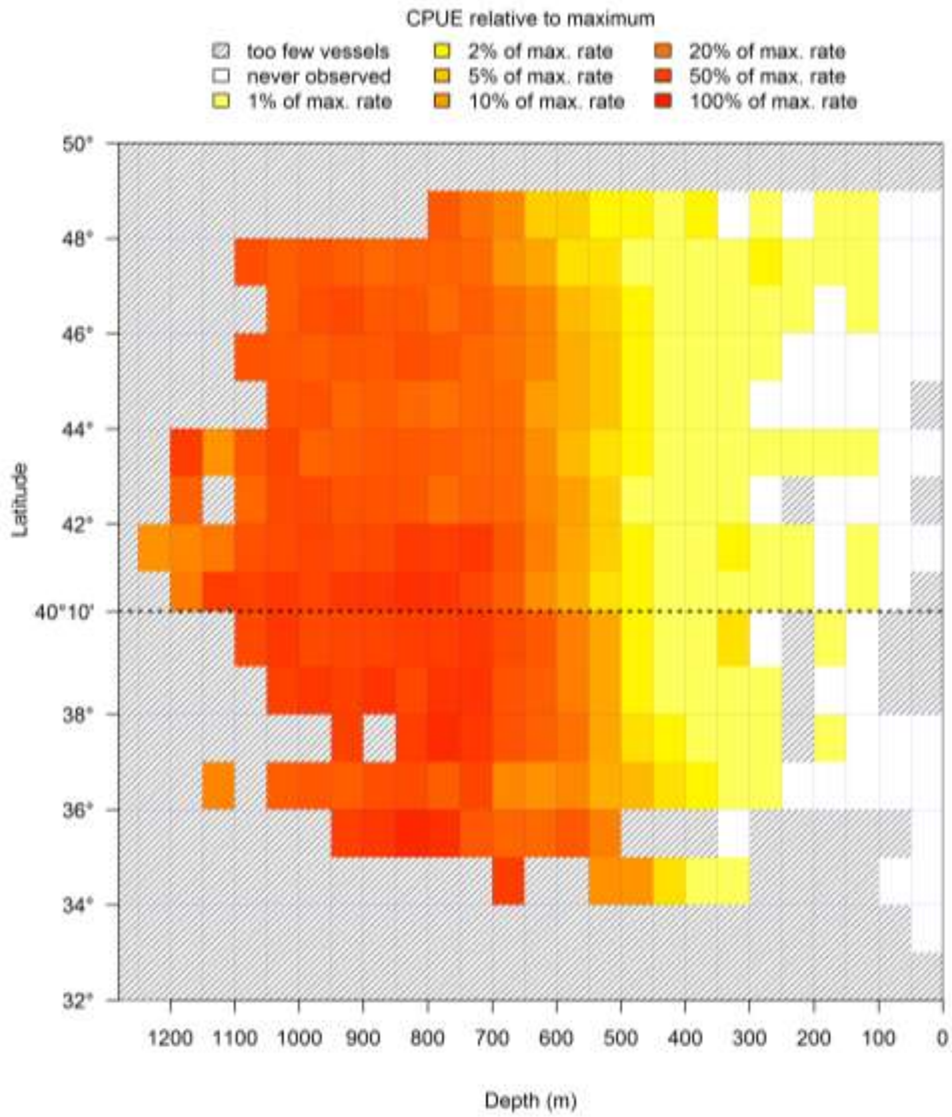



**Figure 9: Spatial distribution of longspine thornyhead in WCGOP trawl data (2002 – 2011). Colors represent CPUE relative to the maximum. Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught. CPUE represented here is the sum of the observed catch across all years divided by the sum of the trawl durations during observed hauls within each cell.**

## 9.5 Biology

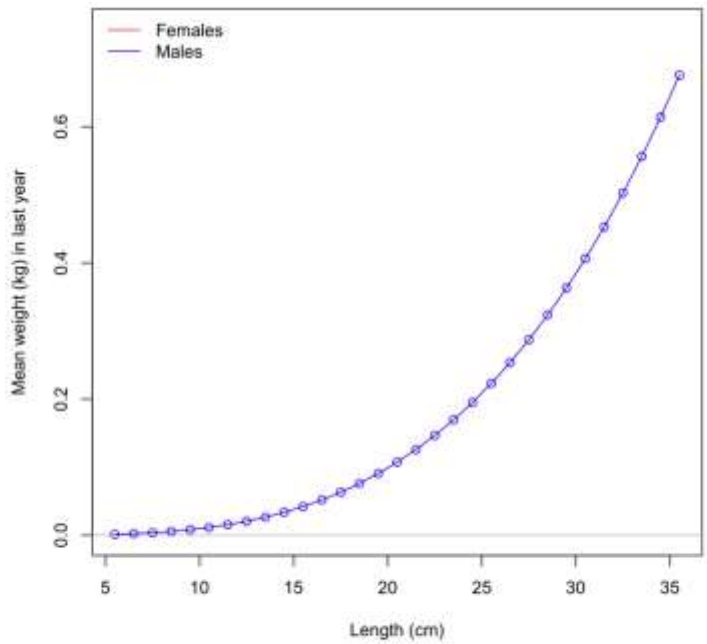



**Figure 10: Length-weight relationship for female and male longspines assumed in the base case model.**

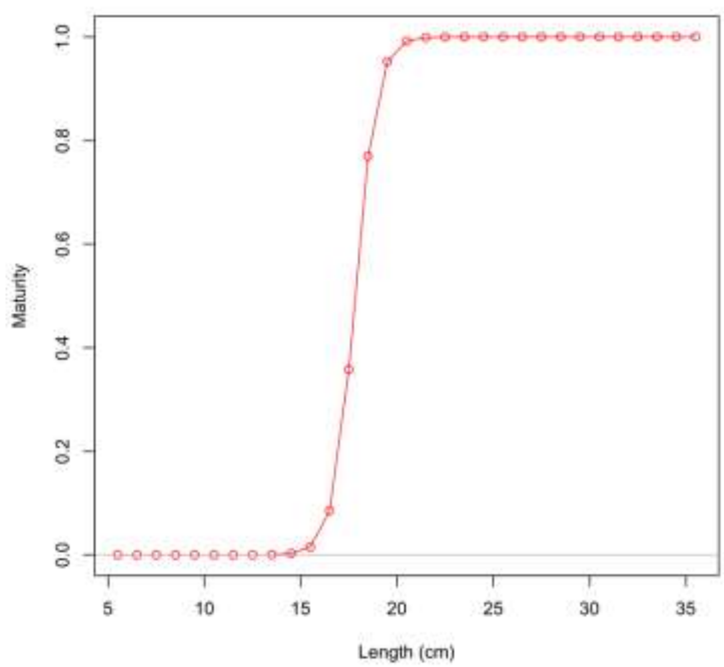



**Figure 11: Female maturity ogive used in the longspine thornyhead base case model. Length at 50% maturity = 17.83.**

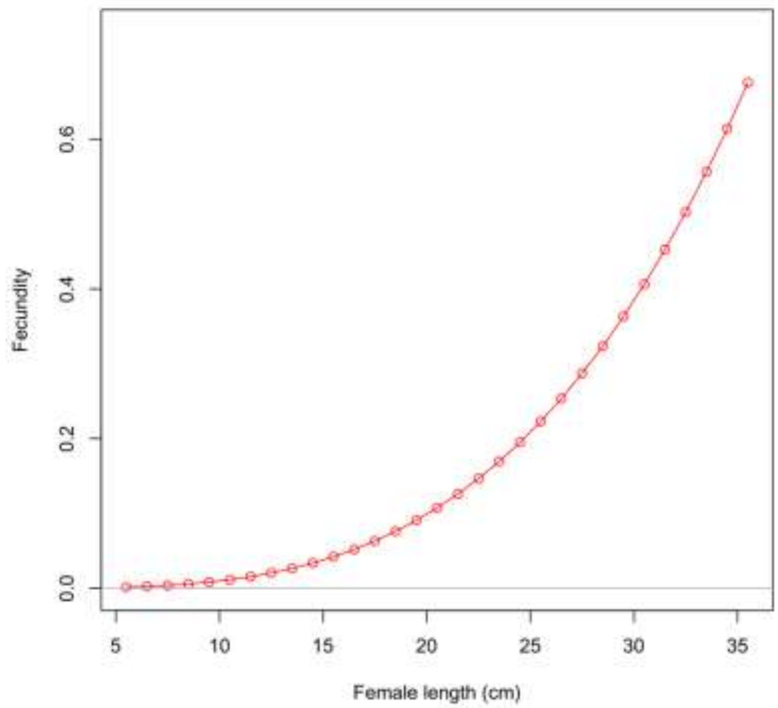



**Figure 12: Fecundity at length relationship assumed in the longspine thornyhead base case model.**

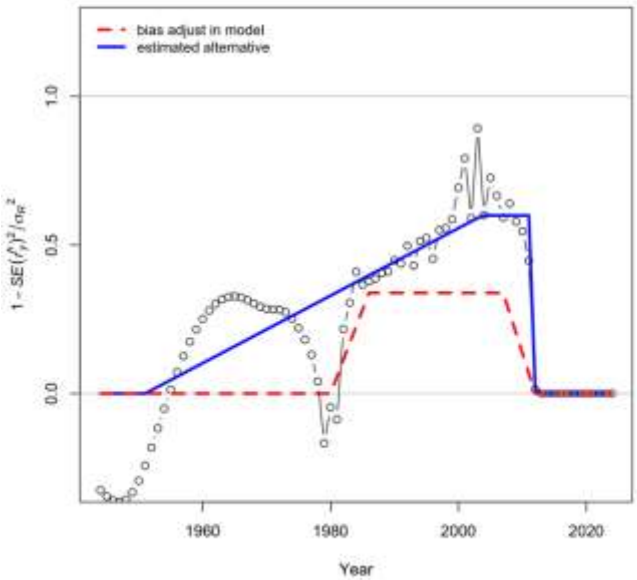



**Figure 13: Time series of the applied bias0 adjustment in the base case model.**

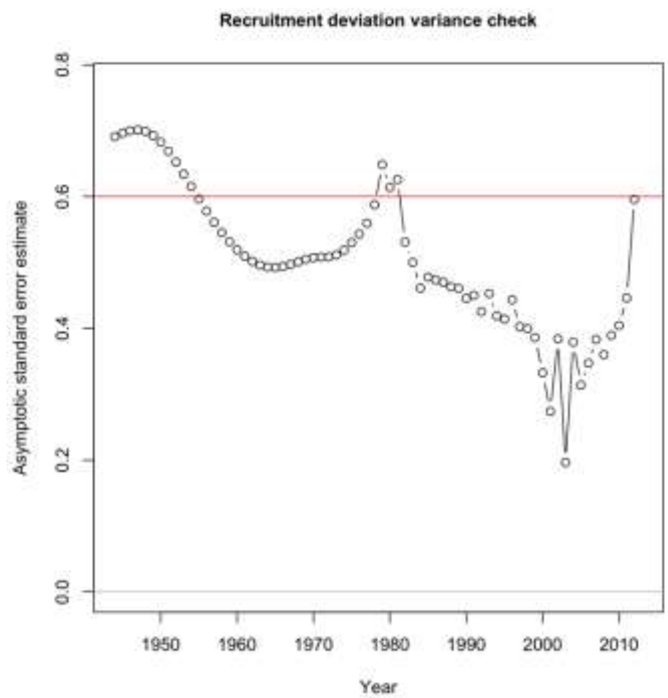



**Figure 14: Time series of the estimated asymptotic recruitment error for years with estimated recruitment deviations from the base case assessment. Assumed model values are indicated by the red line.**

## 9.6 Model results
### 9.6.1 Base model

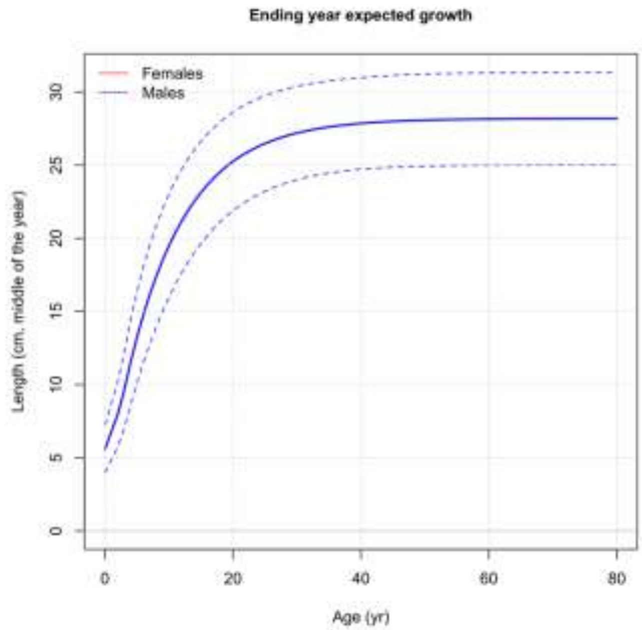



**Figure 15: Estimated age and growth relationship for females and males in the base case model.**

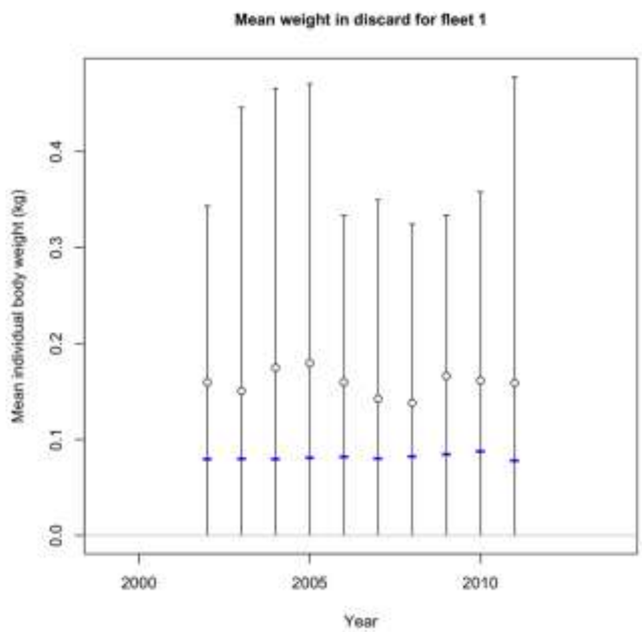



**Figure 16: Base case model fit to longspine thornyhead mean individual body weight in the trawl fishery. Blue lines are model fit; error bars are observation error.**

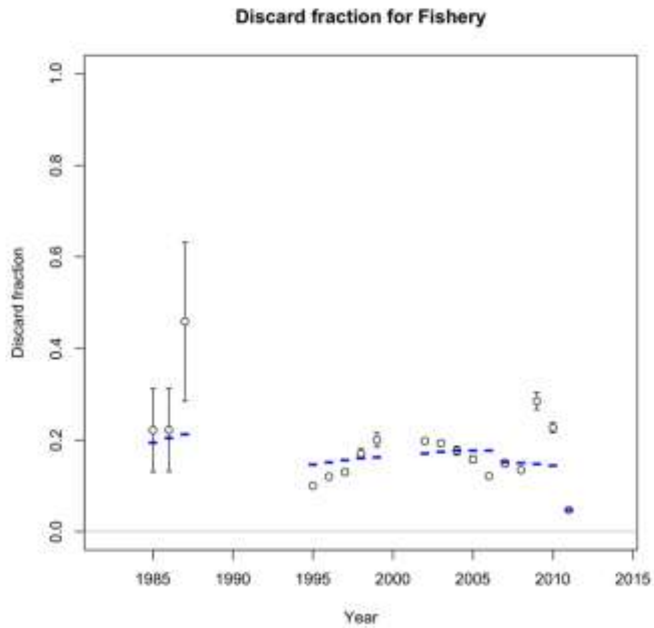



**Figure 17: Base case model fits to discard fraction in the fishery.**

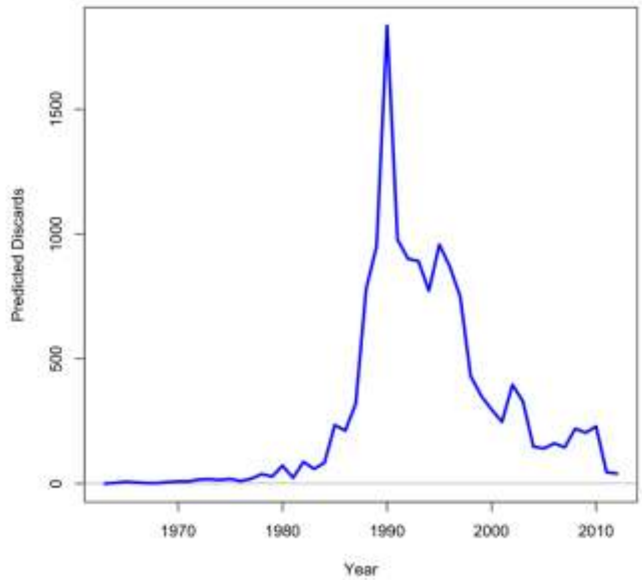



**Figure 18: Base case model predicted discards of longspine thornyheads.**

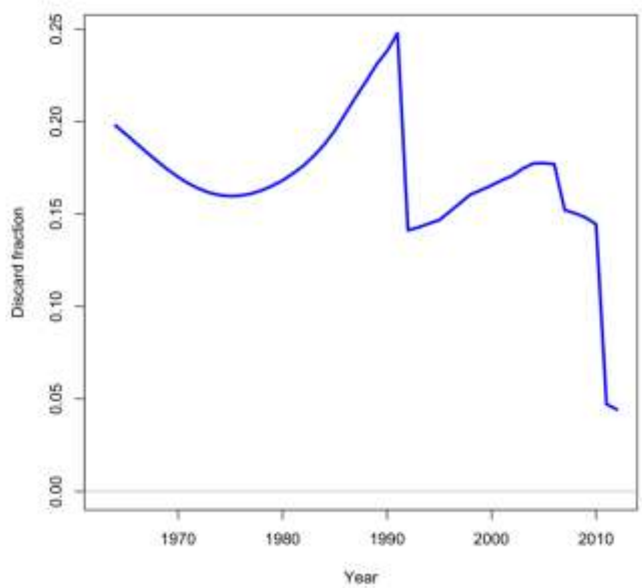
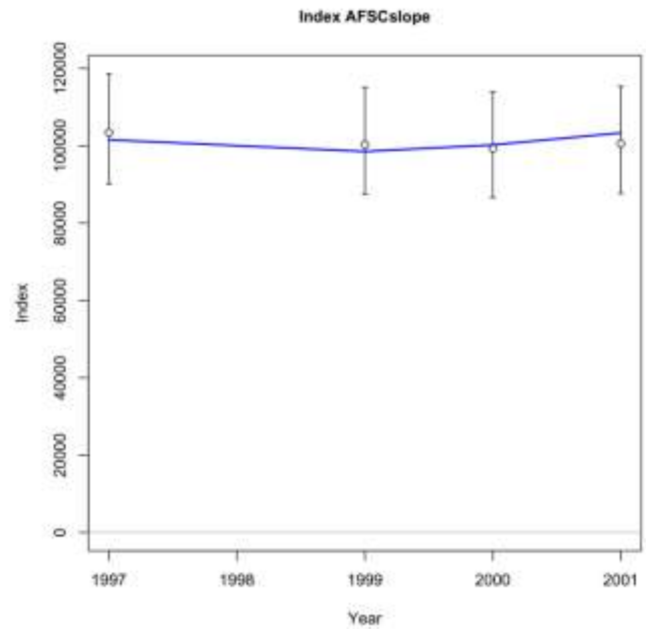



**Figure 19: Discard fraction of longspine thornyheads used in the base case model.**

## 9.6.2 Indices



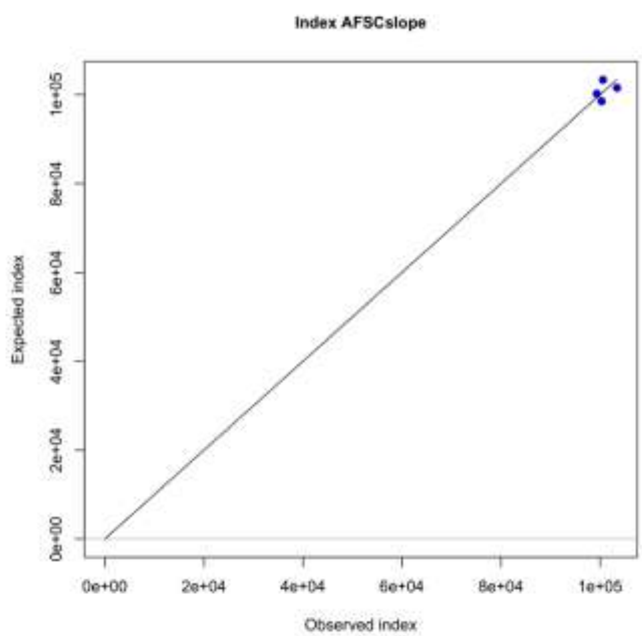




**Figure 20: Top panel: Base case model fit (solid blue line) to the AFSC slope survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of survey values.**

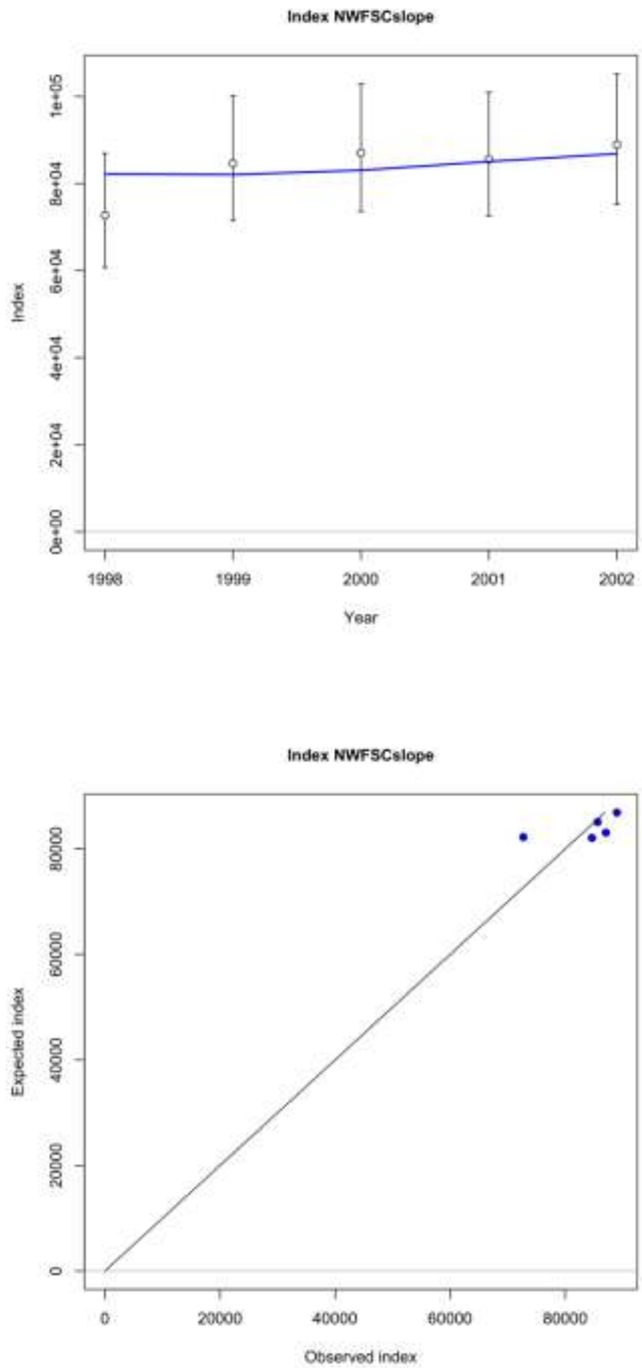



Figure 21: Top panel: Base case model fit (solid blue line) to the NWFSC slope survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of survey values.

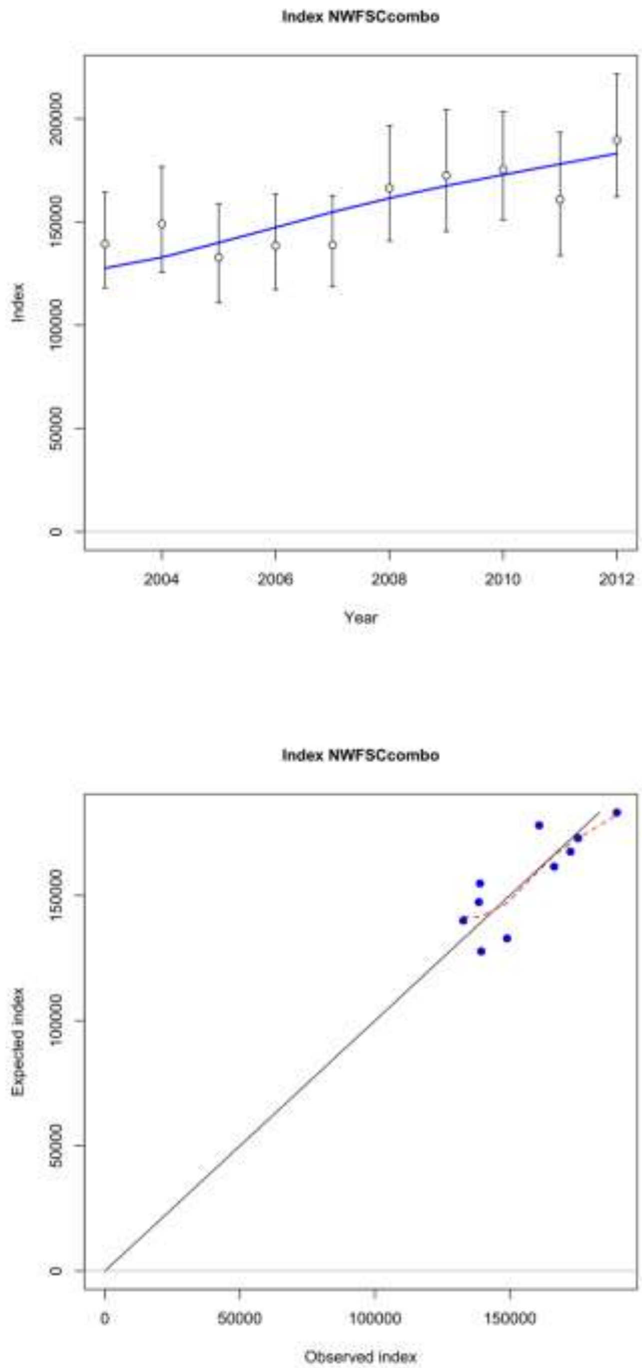



Figure 22: Top panel: Base case model fit (solid blue line) to the NWFSC combo survey data (points with vertical lines indicating 95% CIs). Bottom panel: 1:1 observed to model expectations of survey values

## 9.6.3 Length compositions

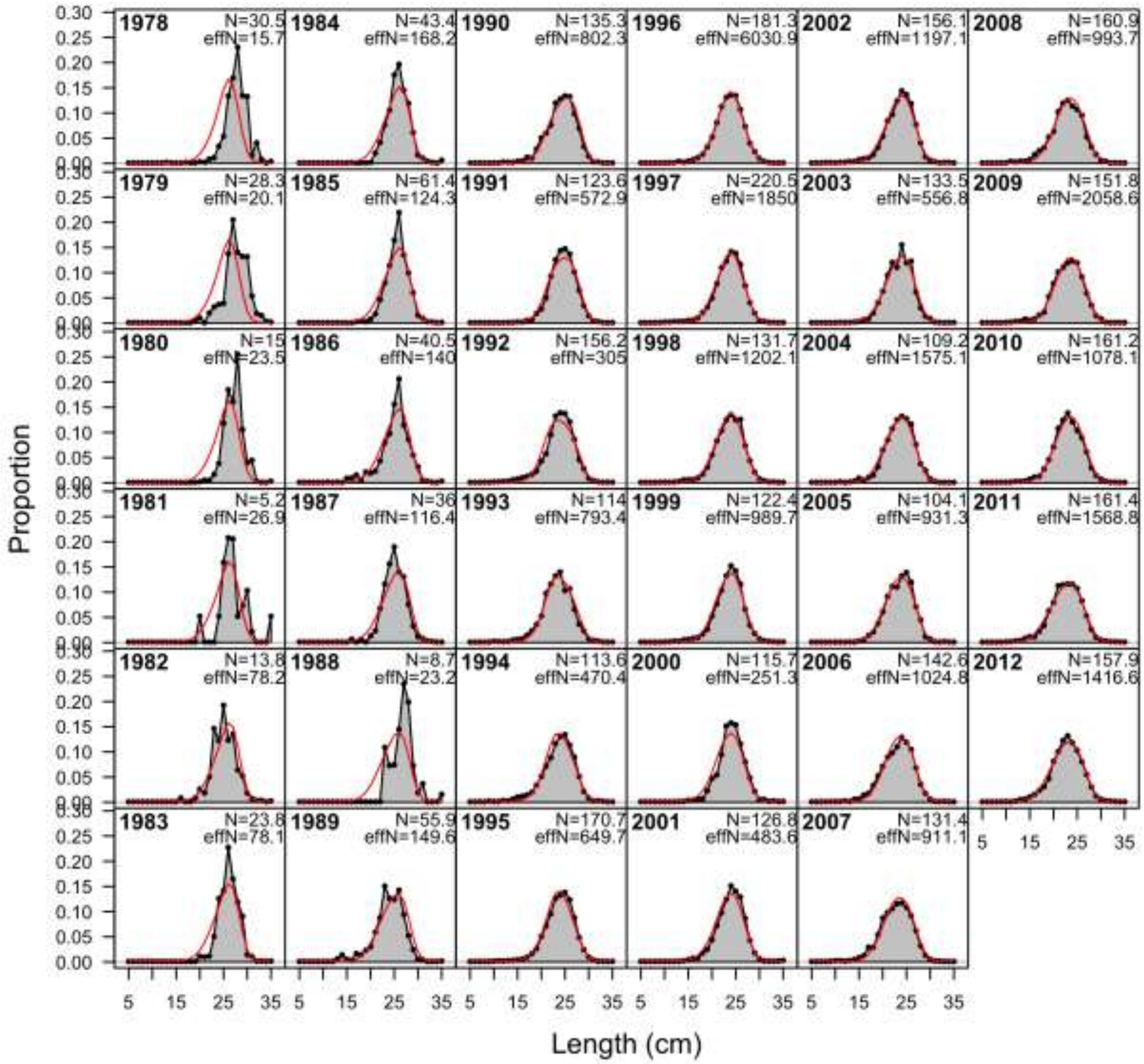



**Figure 23: Base case fits to the fishery combined-sex length composition data.**

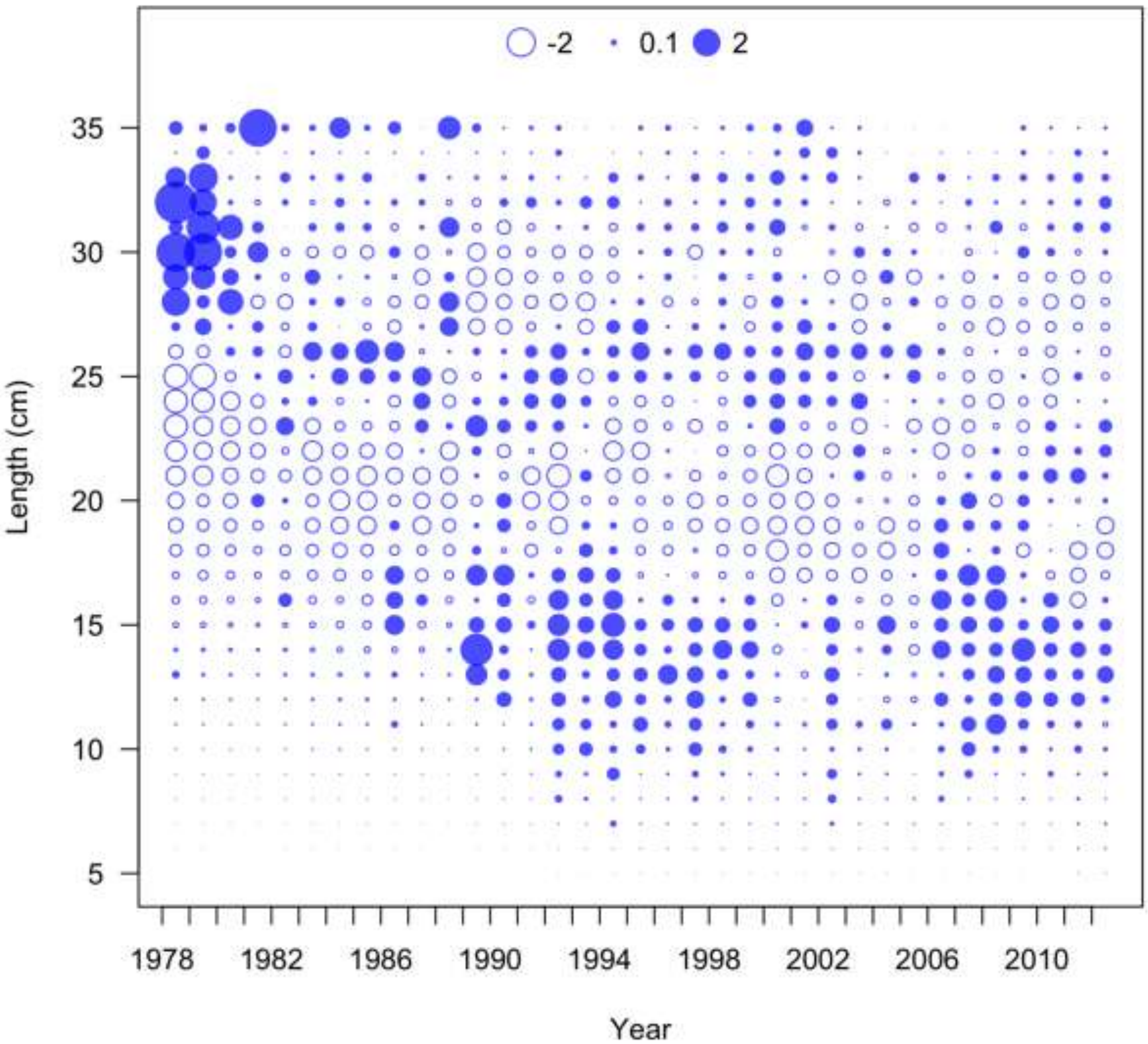



**Figure 24: Residual plots to the fishery retained catch. Maximum is 4.57.**

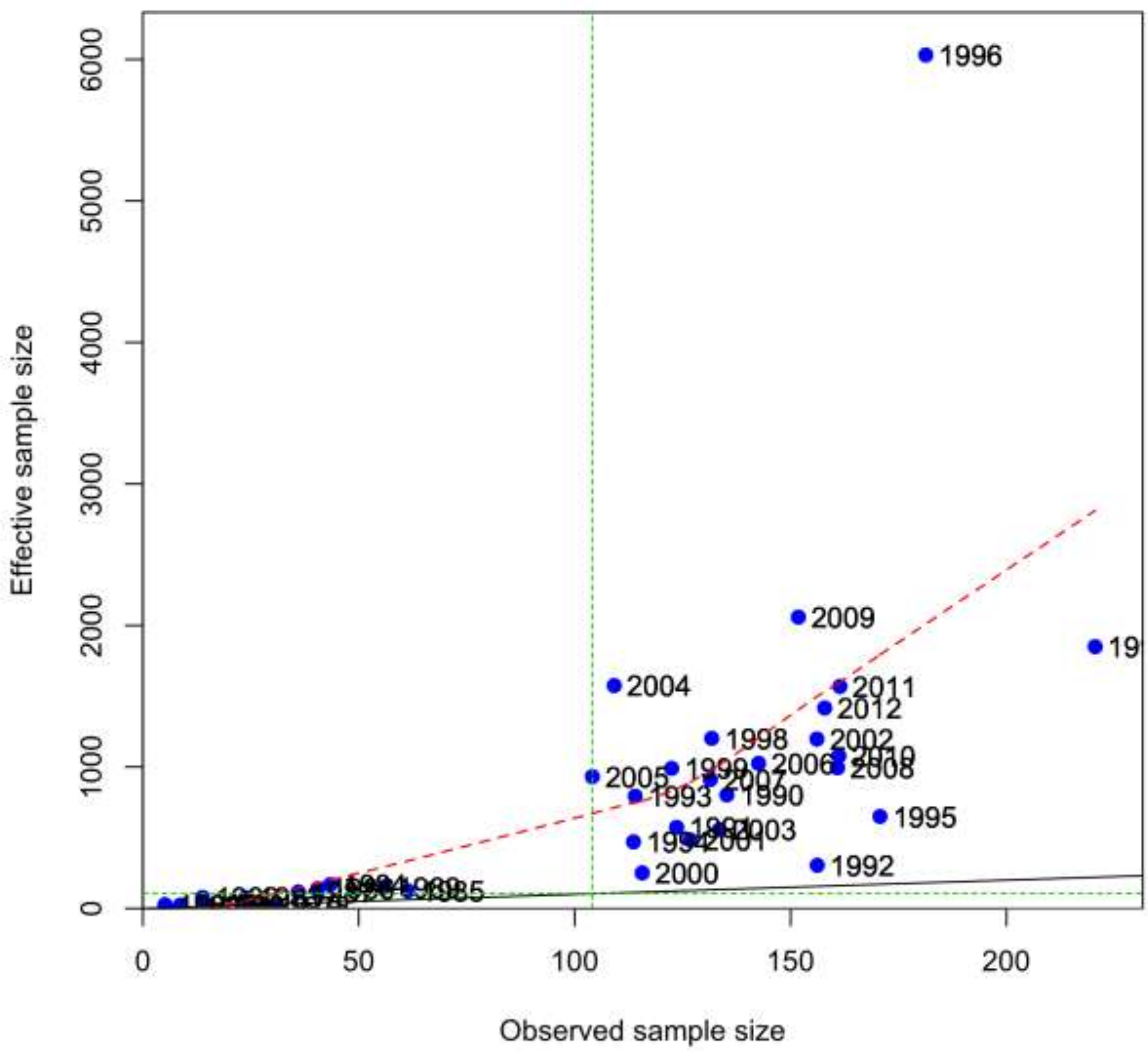



**Figure 25: Observed vs. expected sample sizes for the retained catch. Red line is loess; vertical green line is the arithmetic mean of the observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

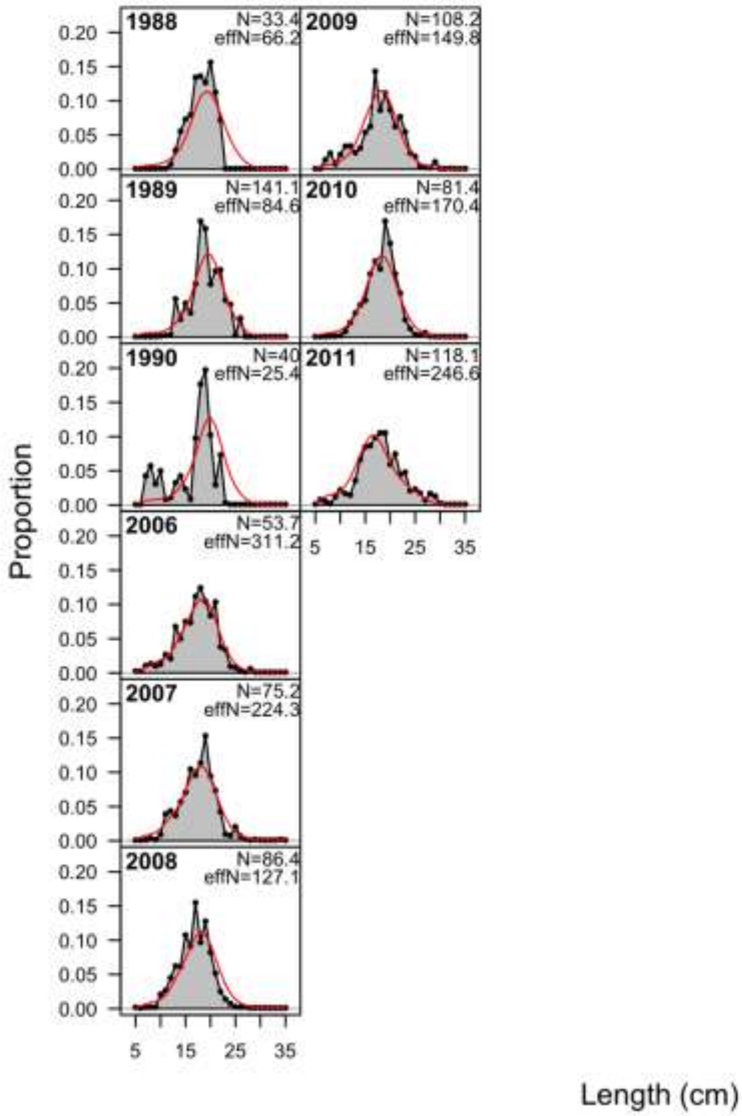



**Figure 26: Base case fits to the fishery discards combined-sex length composition data. Data sources are from Pikitch, EDCP and WCGOP.**

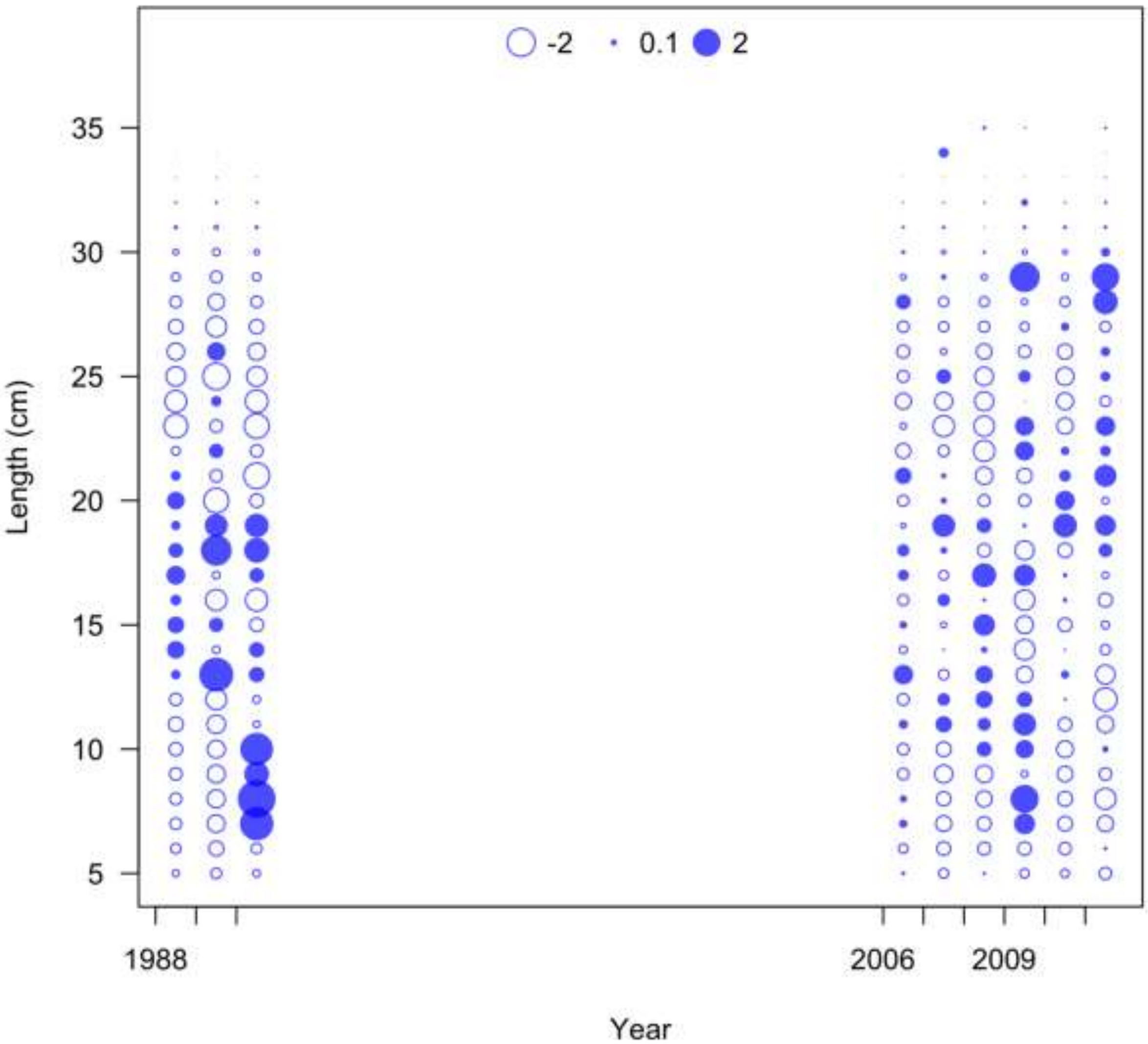



**Figure 27: Residual fits to the fishery discard length compositions. Maximum is 3.7.**

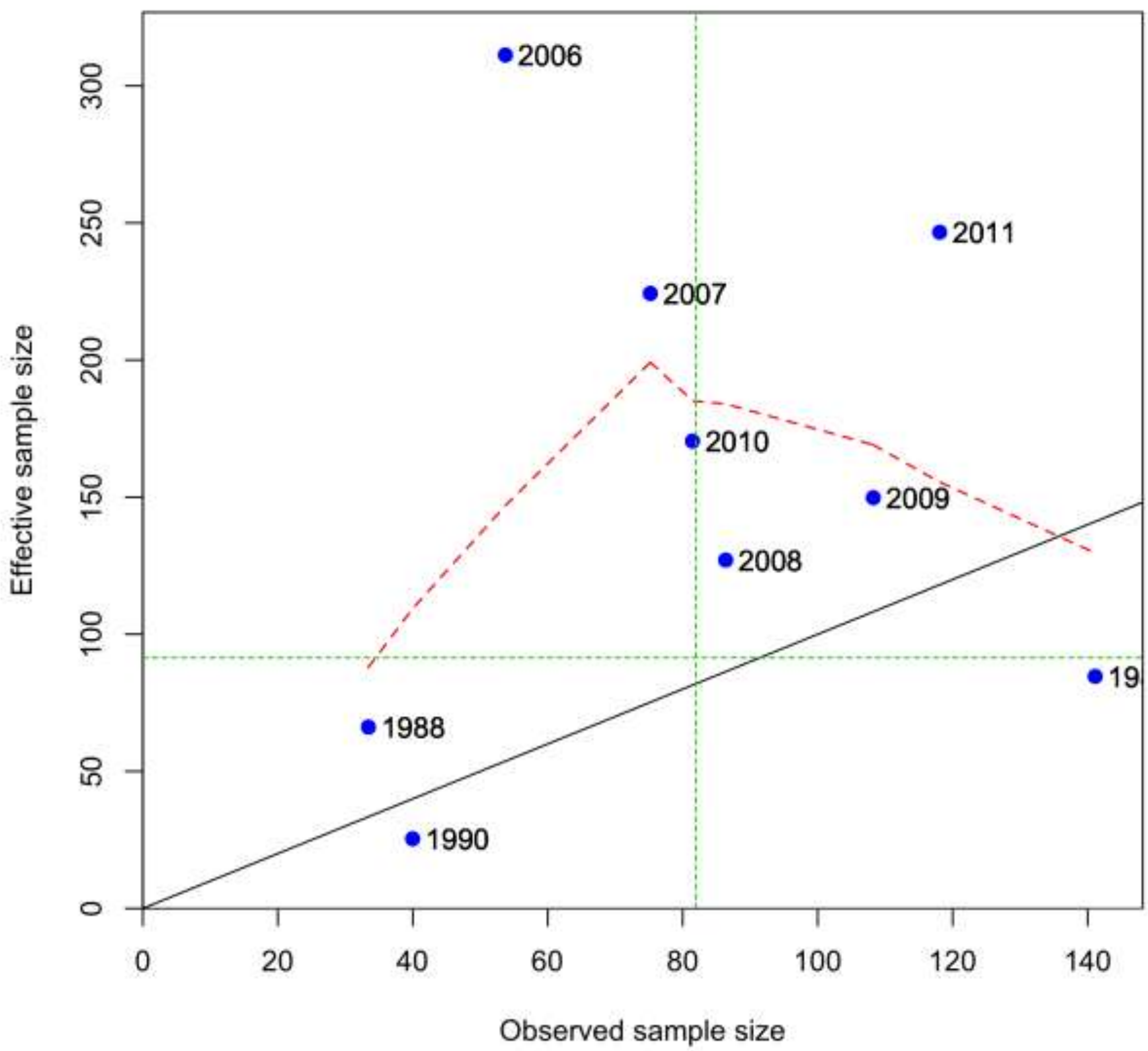



**Figure 28: Observed vs. expected fishery discard length composition sample sizes. Red line is loess; vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

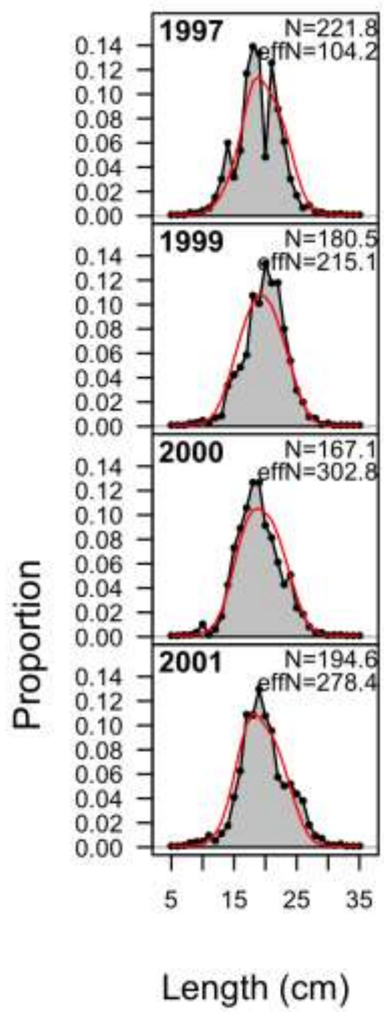



**Figure 29: Base model fits to the AFSC slope combined-sex length compositions.**

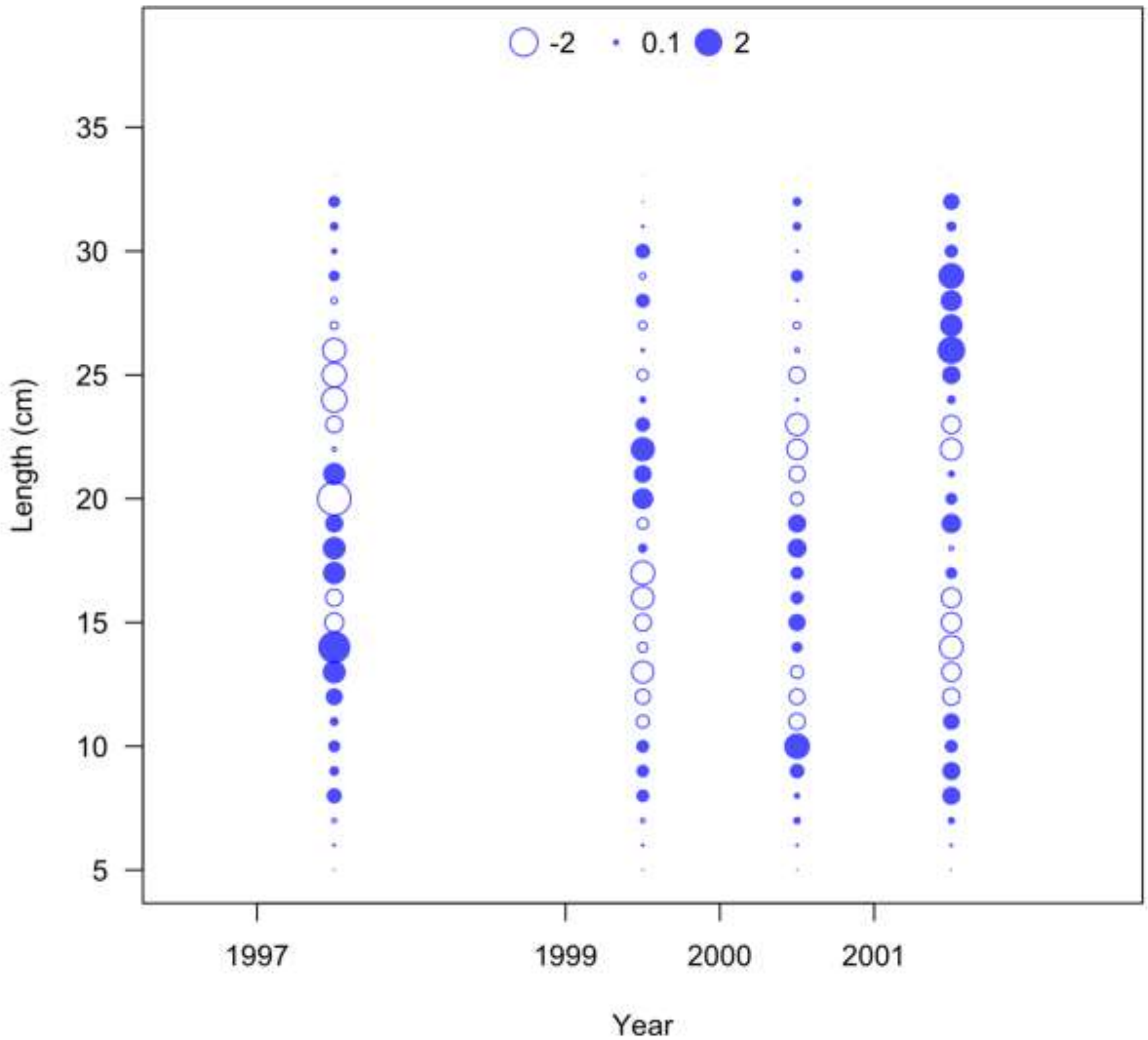



**Figure 30: Residual fits to the AFSC slope length compositions. Maximum is 2.73.**

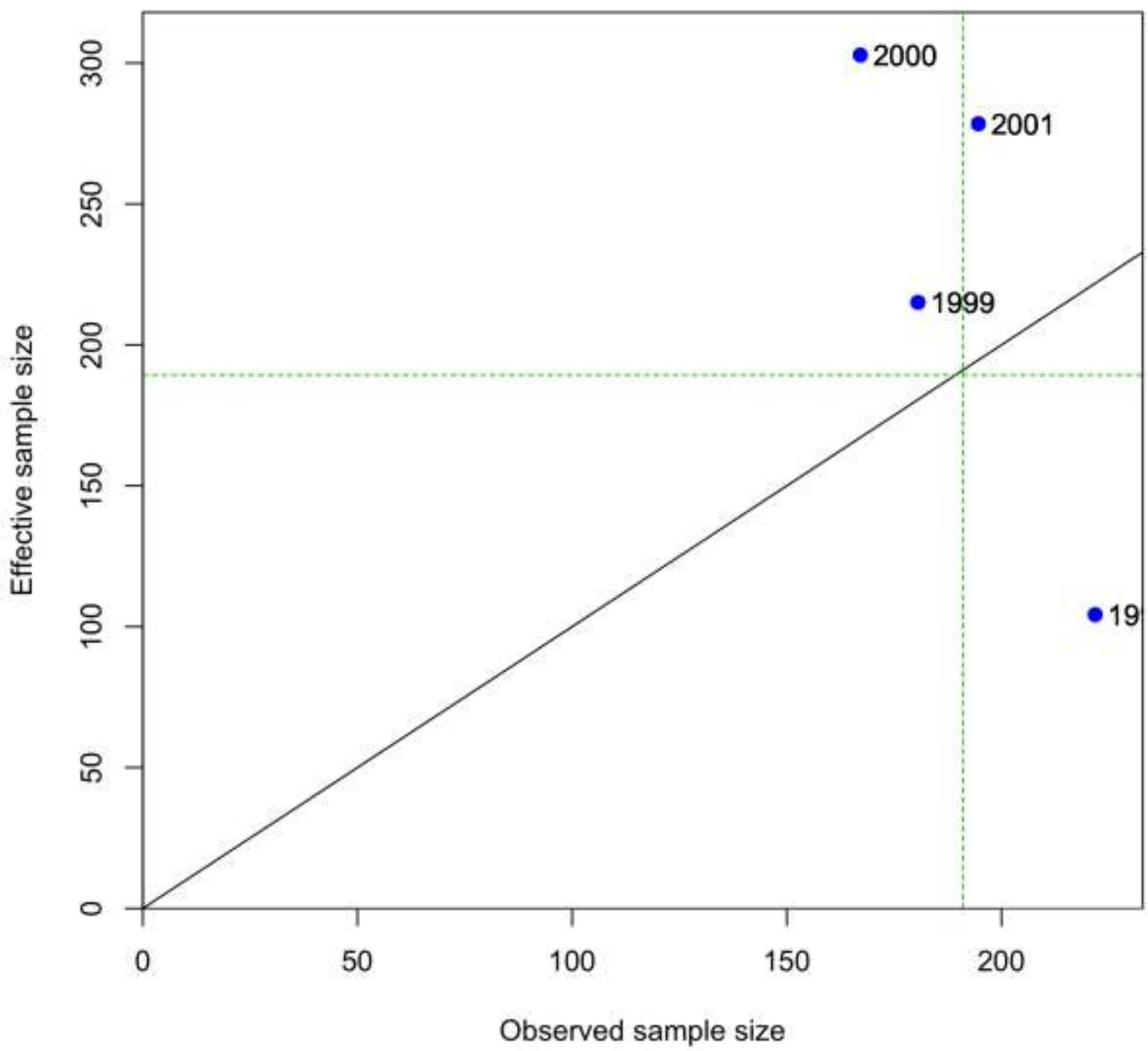



**Figure 31: Observed vs. expected AFSC slope length composition sample sizes. Red line is loess; vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

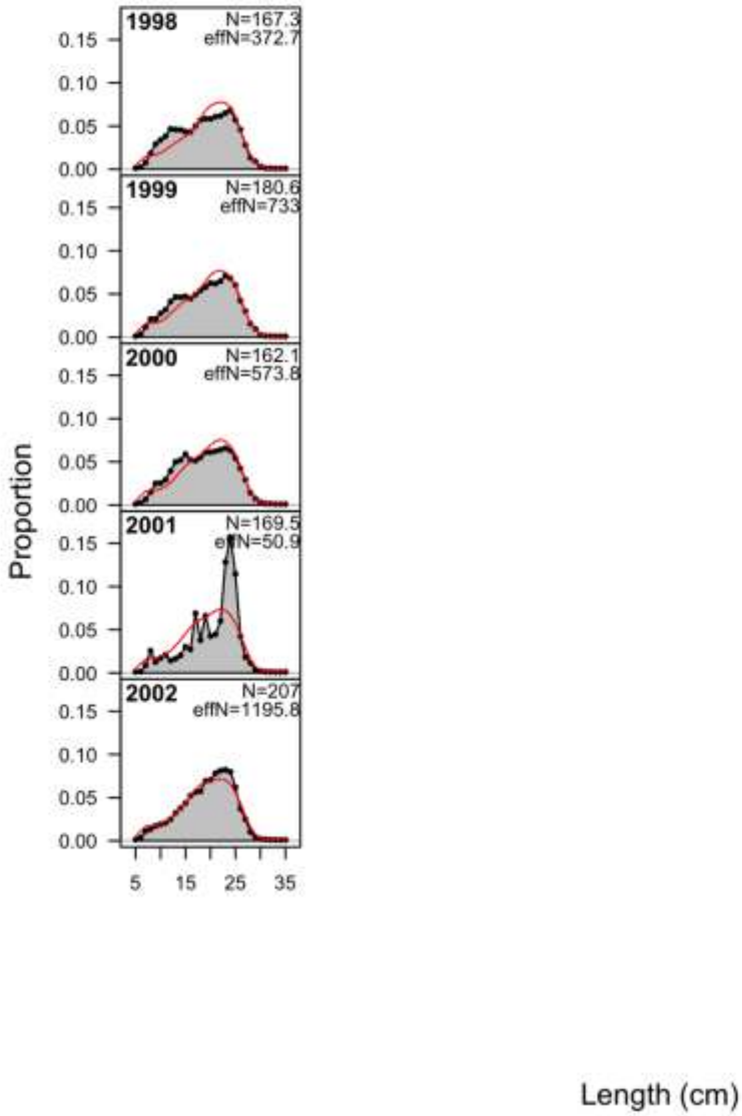



**Figure 32: Base model fits to the NWFSC slope combined-sex length compositions.**

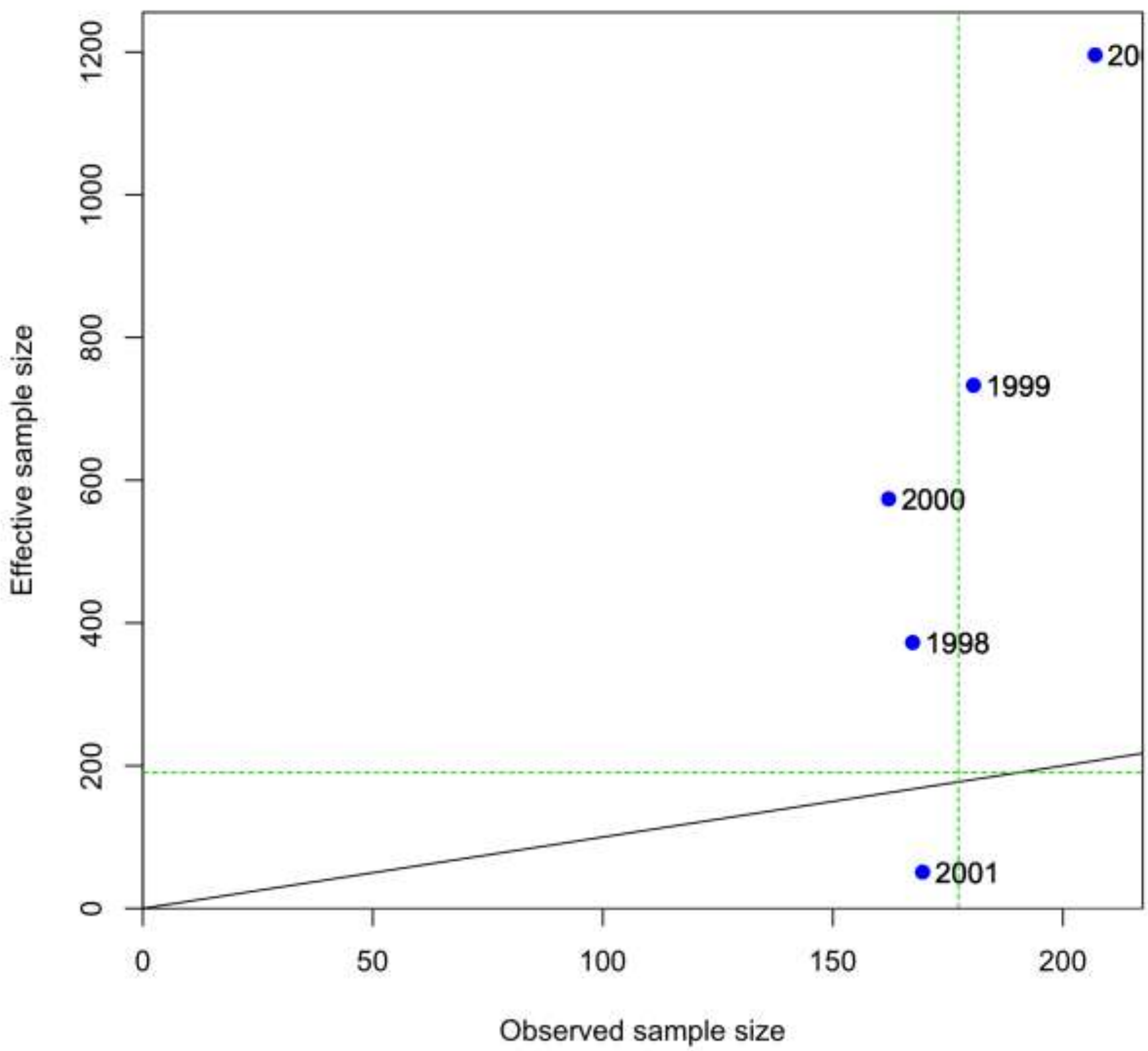



**Figure 33: Observed vs. expected AFSC slope length composition sample sizes. Red line is loess; vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

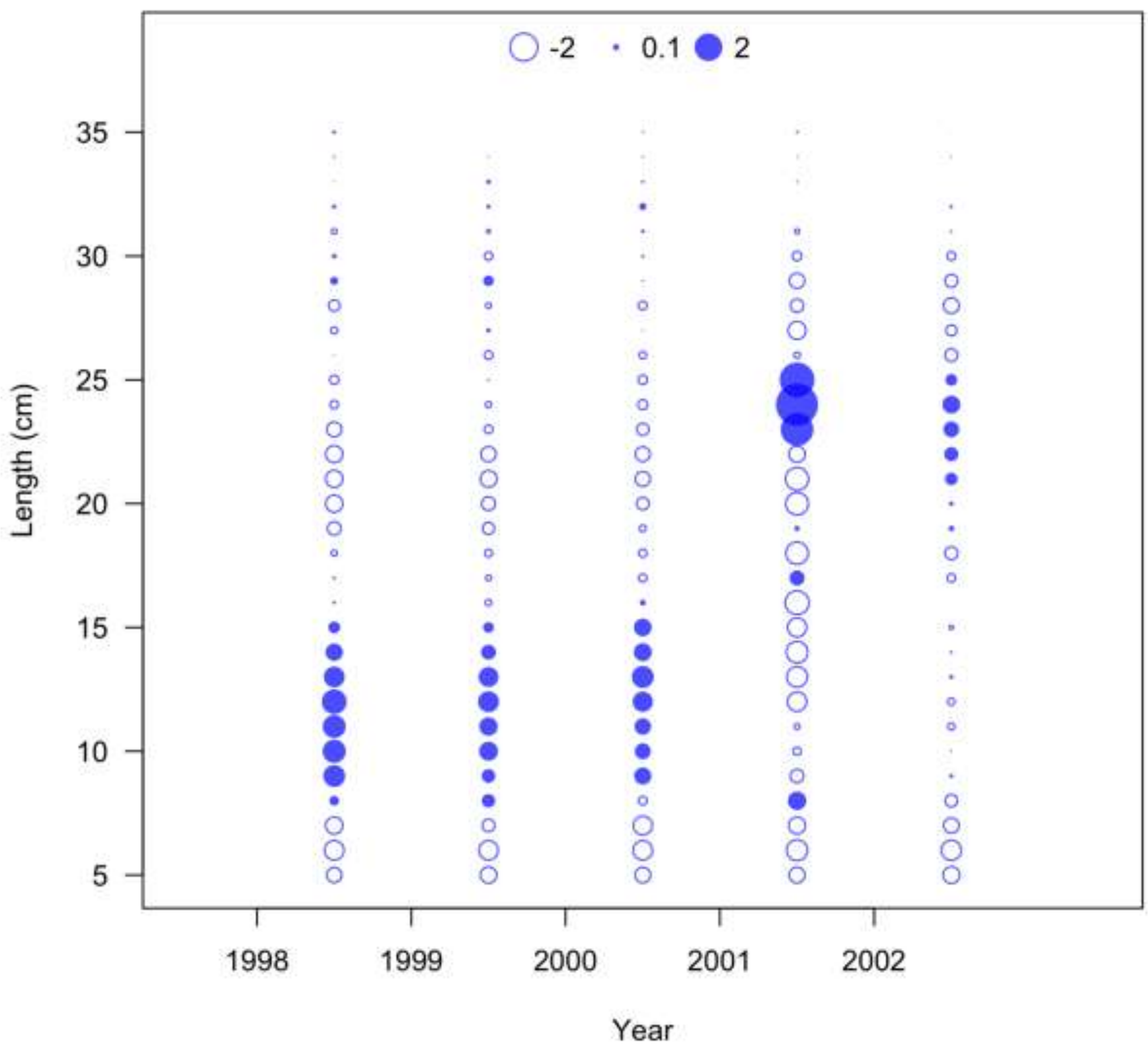



**Figure 34: Pearson residuals for the NWFSC slope length compositions. Maximum is 4.65.**

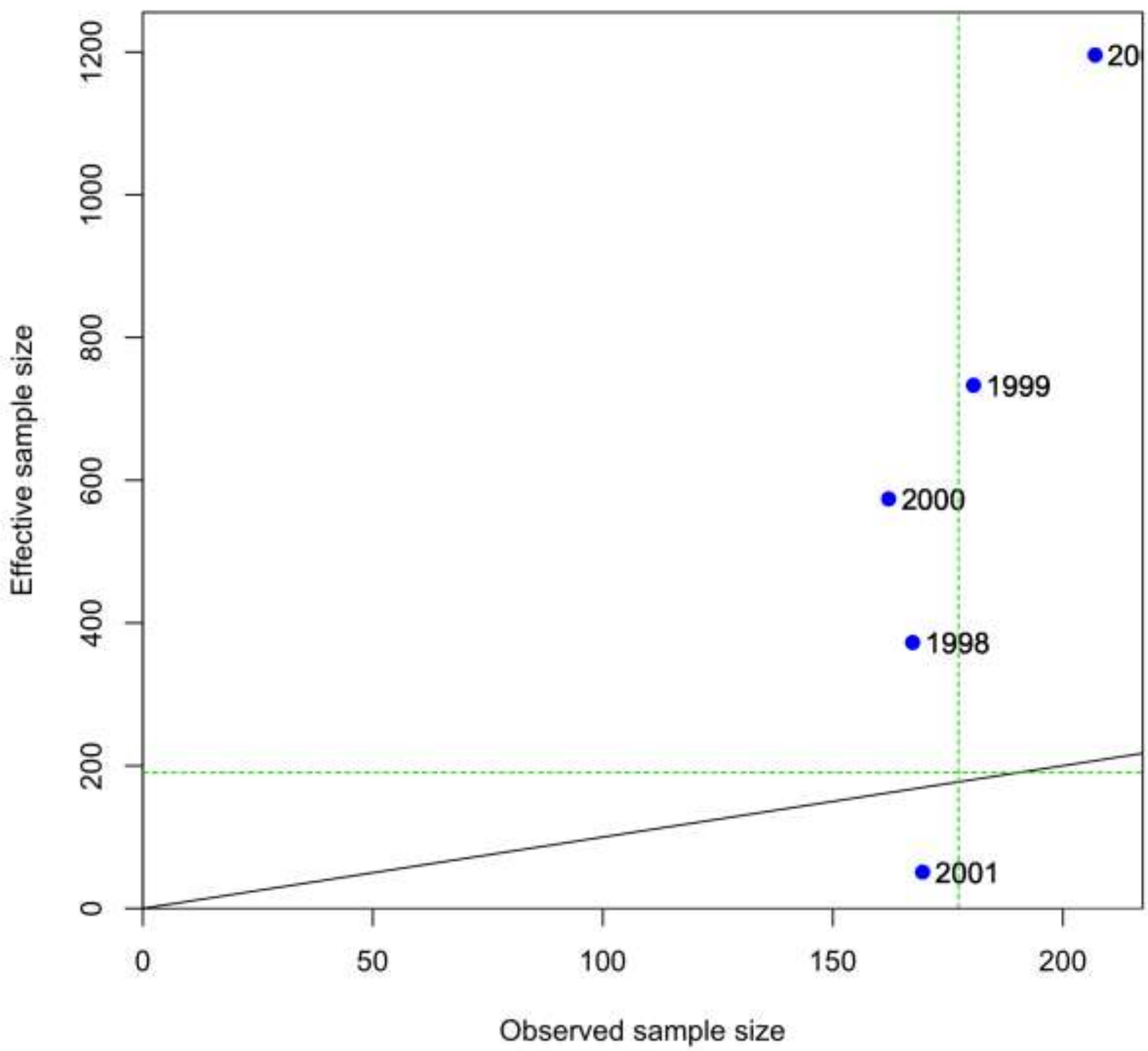



**Figure 35: Observed vs. expected NWFSC slope length composition sample sizes. Vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

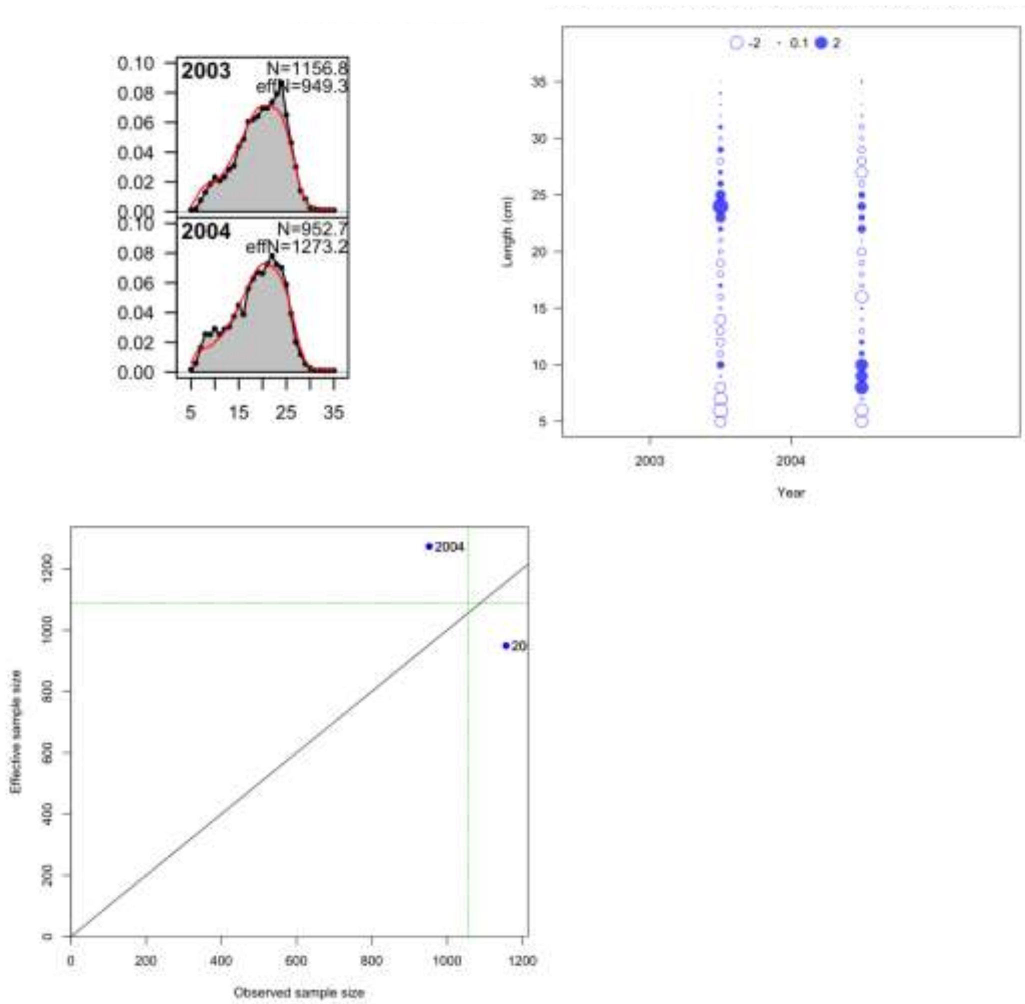



**Figure 36: Combined-sex years (2003-34) base model fits to the NWFSC combo combined sex length compositions (top left), Pearson residuals (top right, maximum is 3.11), and effective sample sizes (bottom panel). The vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

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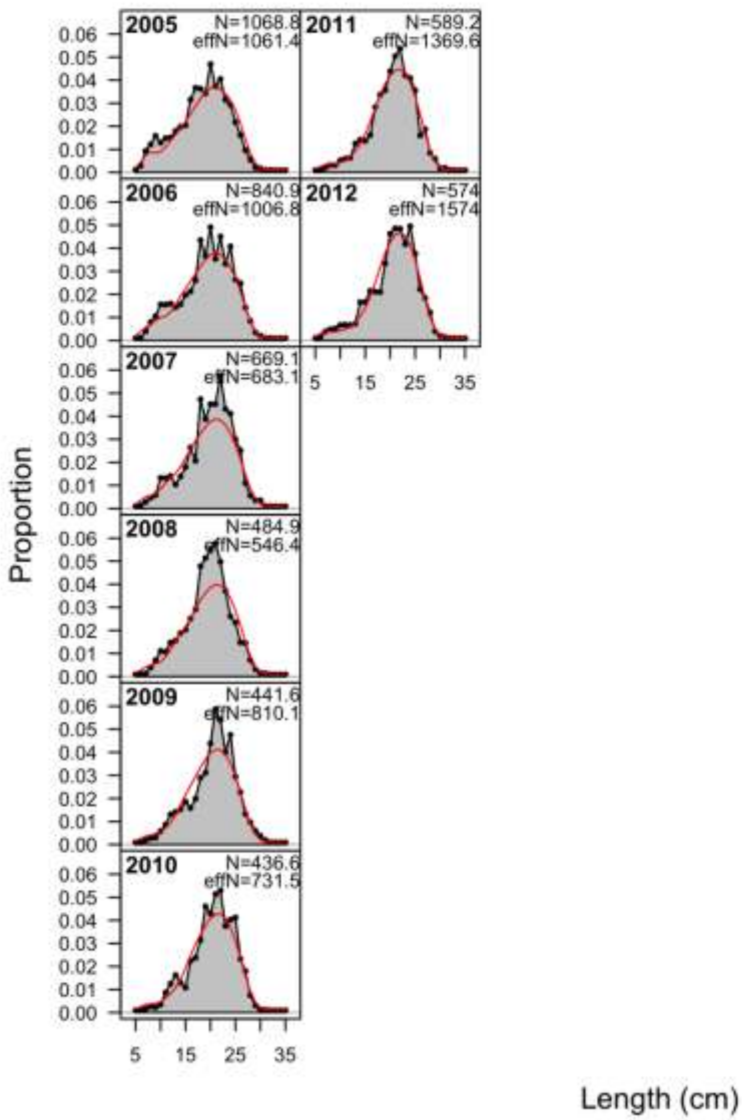



**Figure 37: Base model fits to the later years of the NWFSC combo female length compositions.**

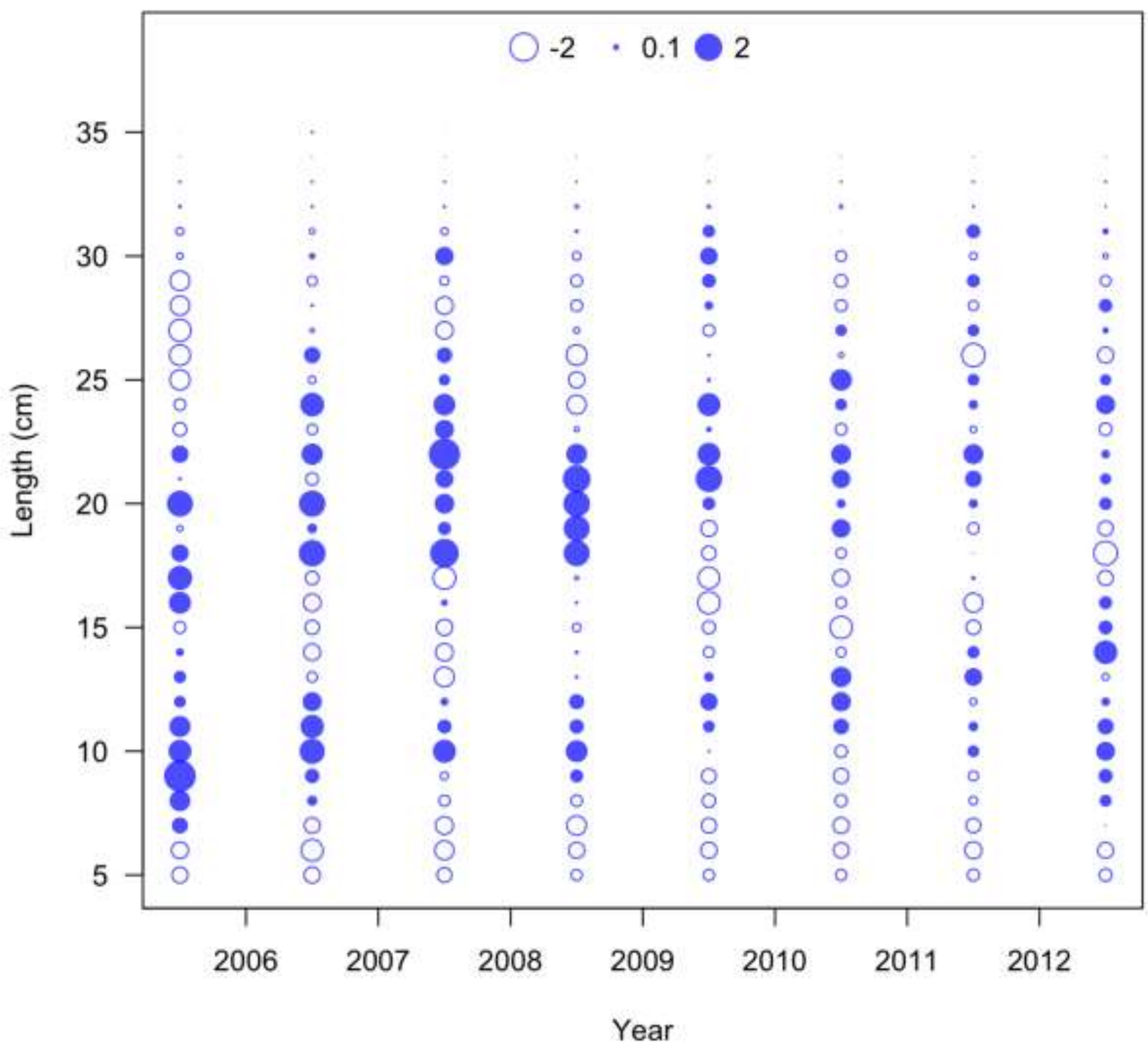



**Figure 38: Pearson residuals for the later years of the NWFSC combo female length compositions. Maximum is 2.65.**

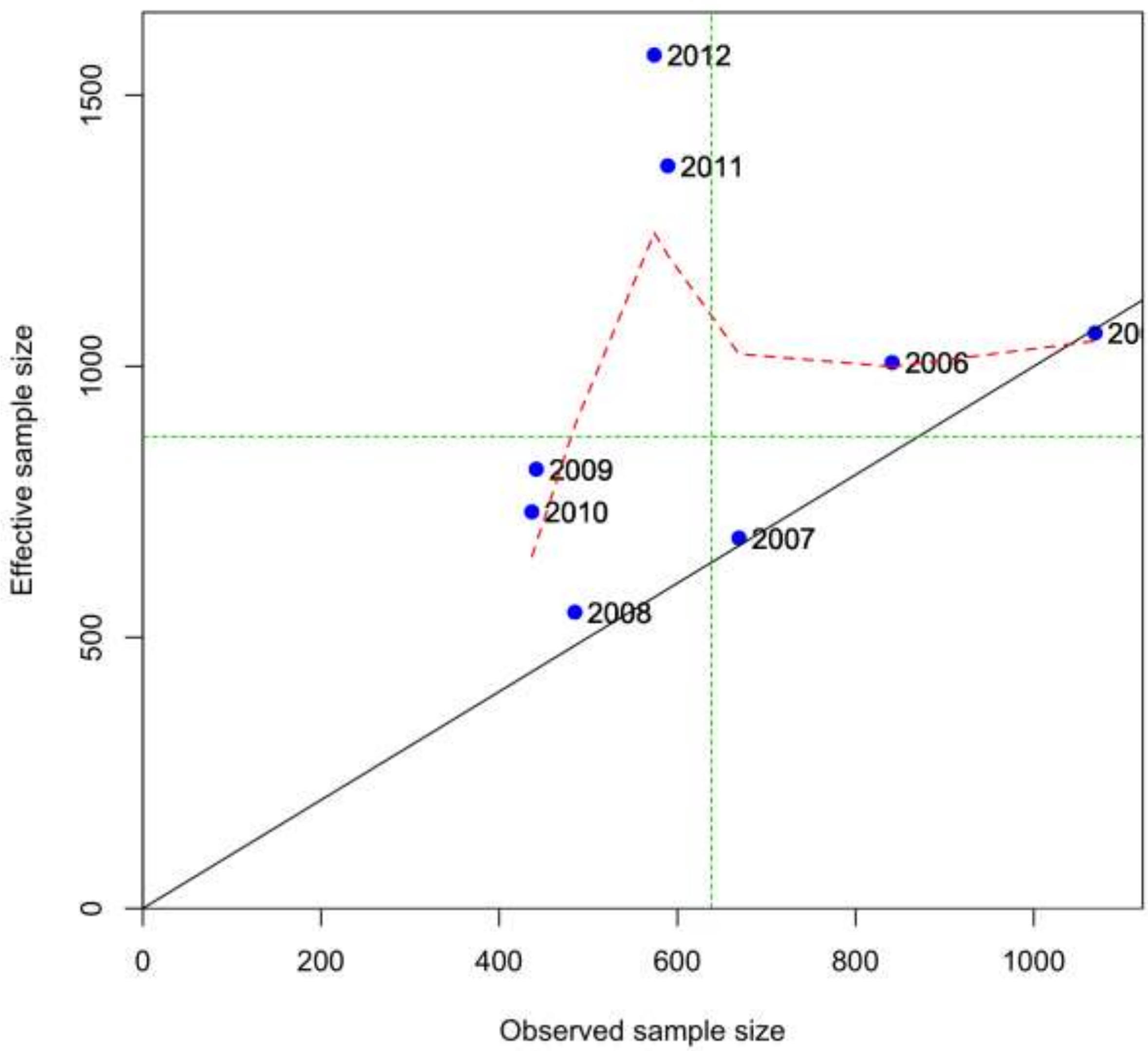



**Figure 39: Observed vs. expected for the later years of the NWFSC combo female length composition sample sizes. Red line is loess; vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

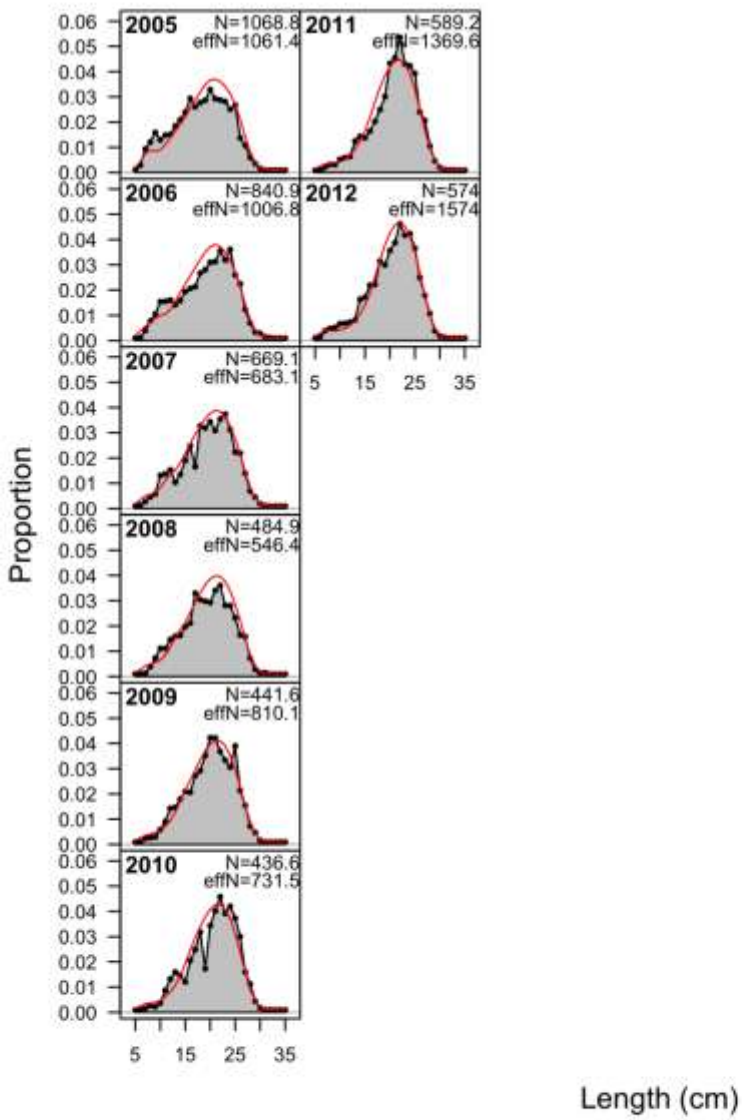



**Figure 40: Base model fits to the later years of the NWFSC combo male length compositions.**

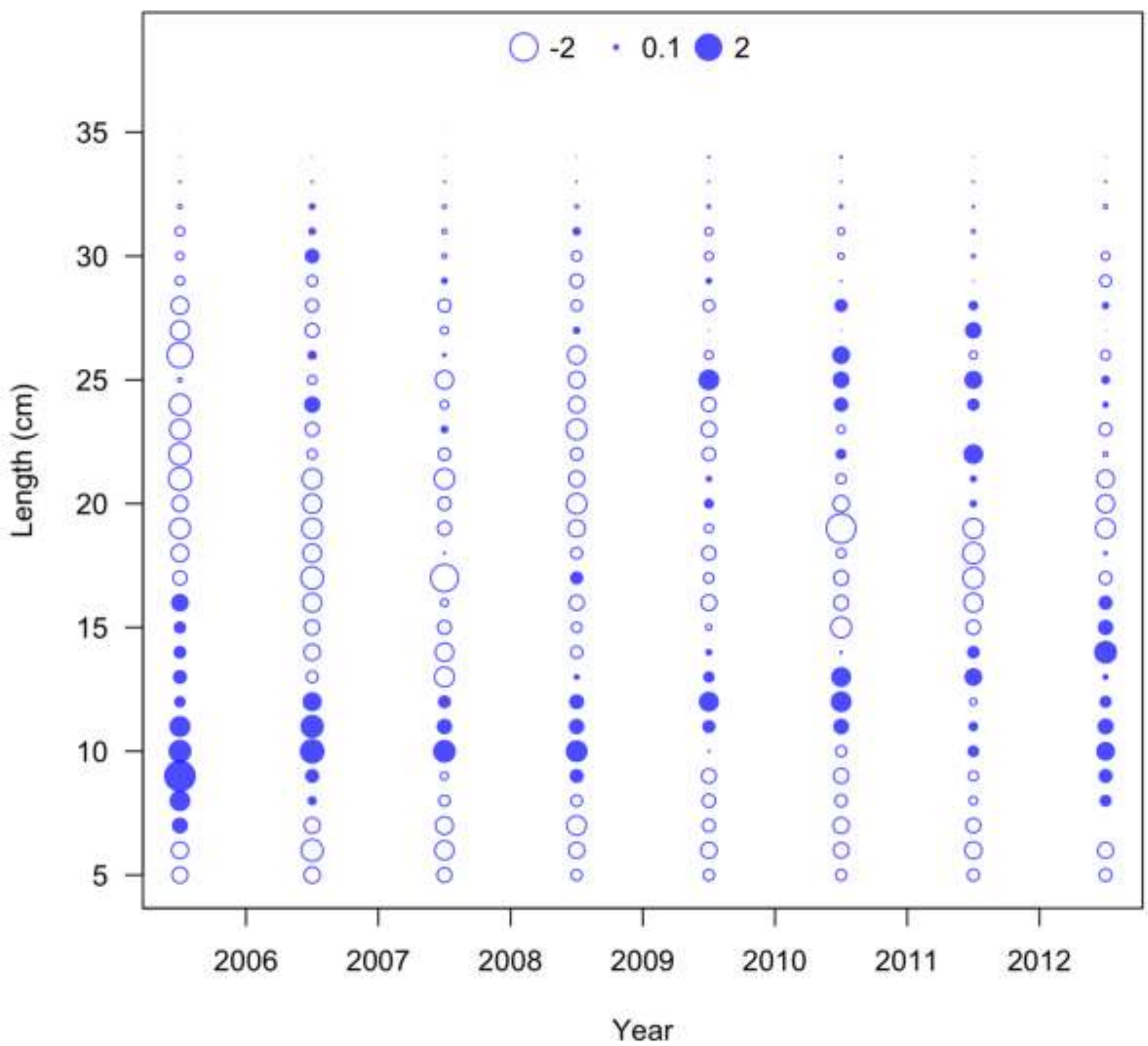



**Figure 41: Pearson residuals for the later years of the NWFSC combo male length compositions. Maximum is 2.65.**

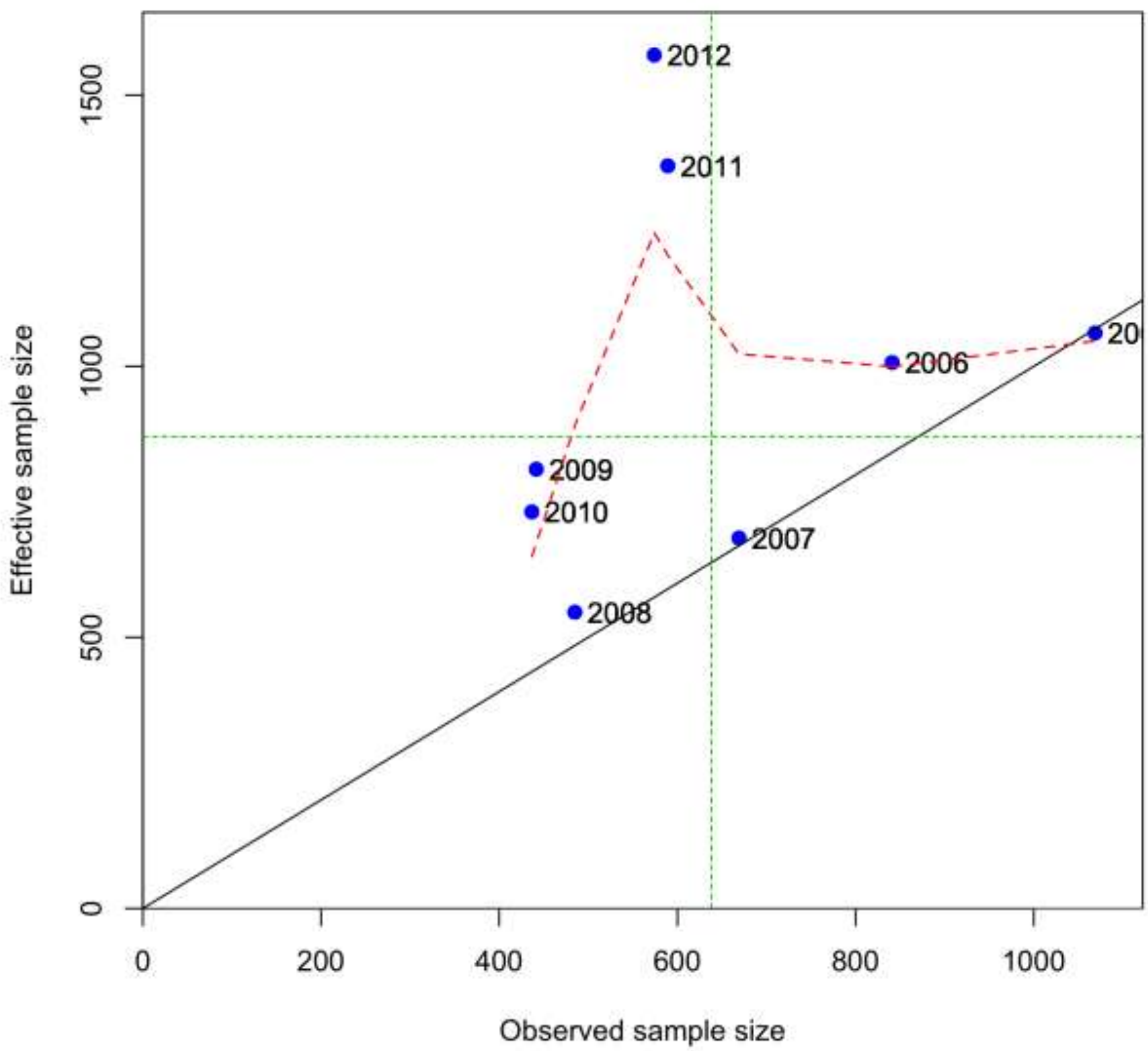



**Figure 42: Observed vs. expected in the later years of the NWFSC combo male length compositions. Red line is loess; vertical green line is the arithmetic mean of observed sample size, horizontal green line is the harmonic mean of the effective sample size.**

### 9.6.4 Selectivity

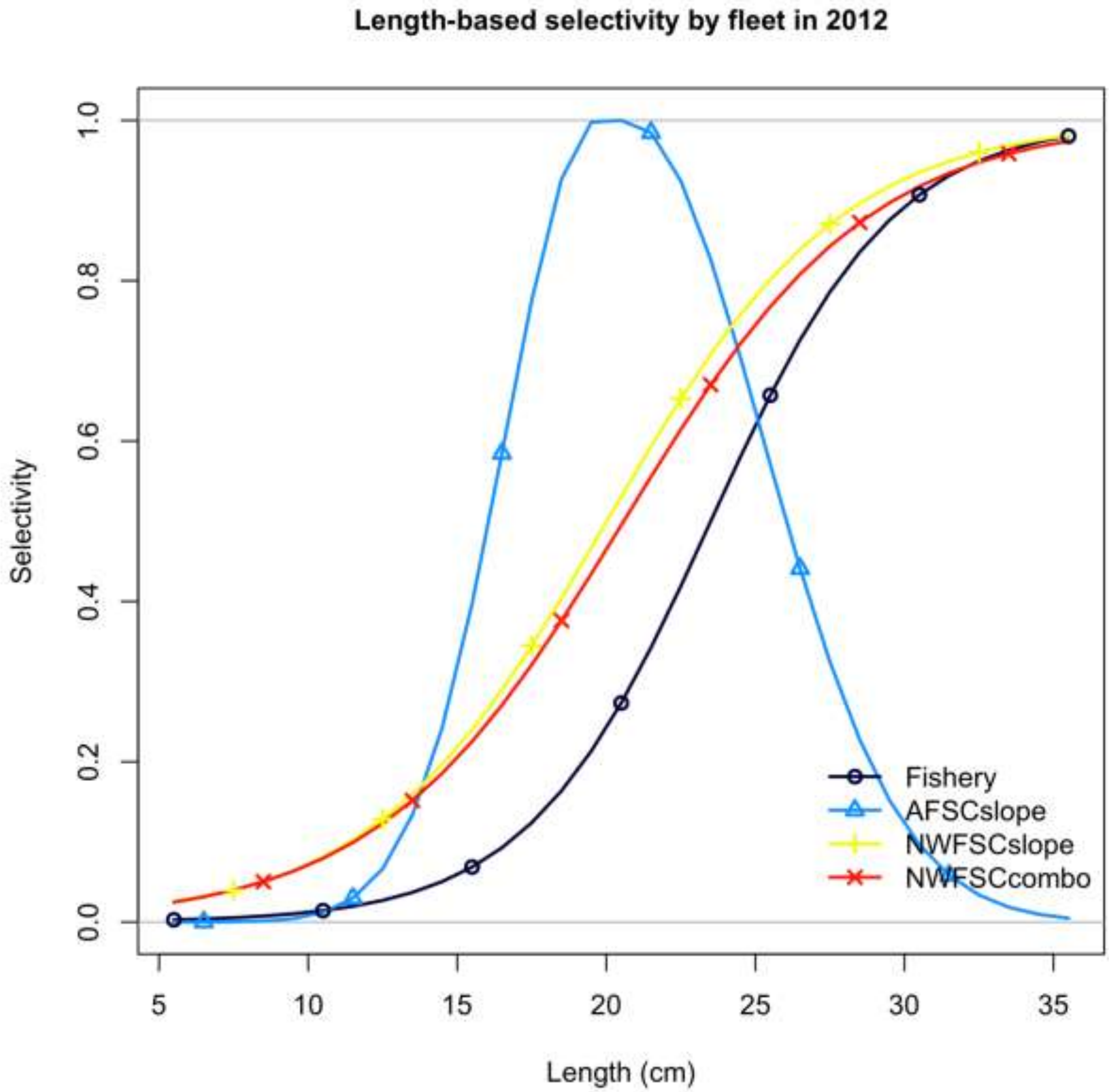



**Figure 43: Estimated length-based selectivity by fishery and survey for longspine thornyhead.**

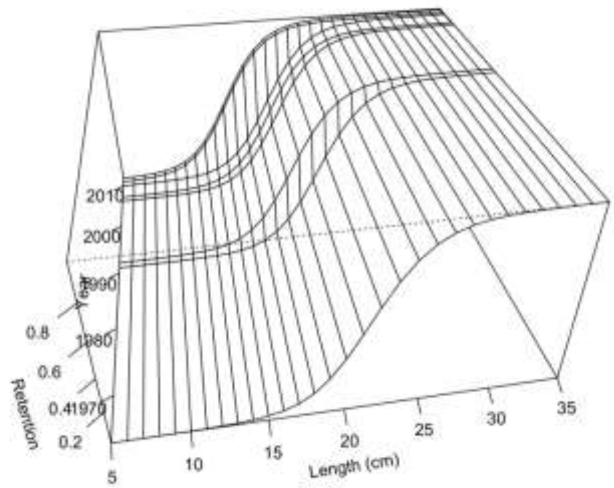



**Figure 44: Estimates of the retention curves for each time block in the longspine thornyhead base case model.**

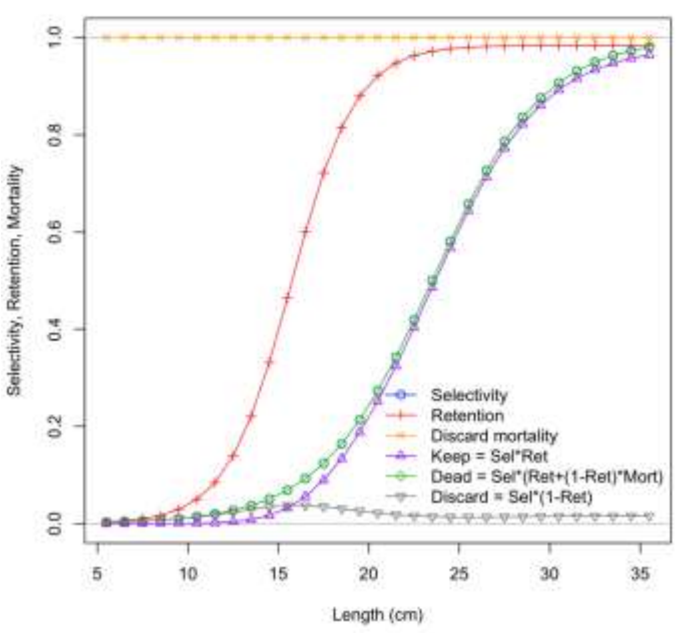



**Figure 45: Selectivity, retention, and mortality curves for the fishery as estimated from the longspine thornyhead base case model.**

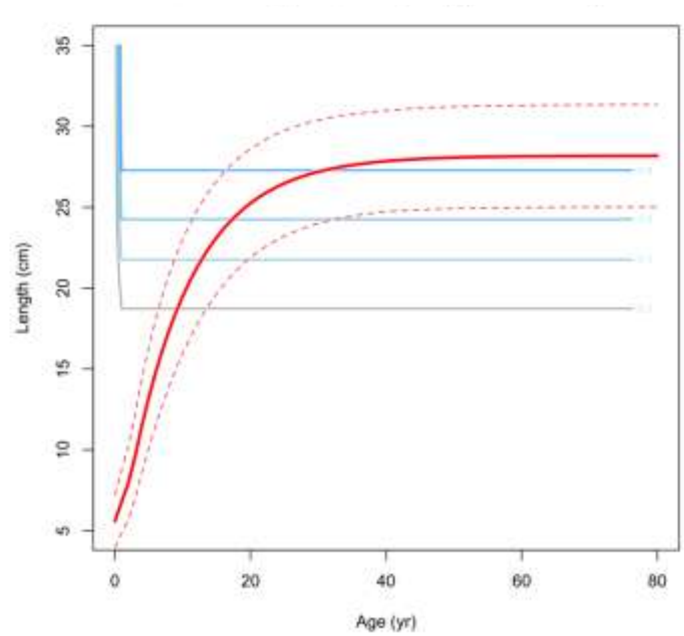



**Figure 46: Age and growth (red lines) relative to selectivity curves (blue lines) for the fishery from the longspine thornyhead base case model.**

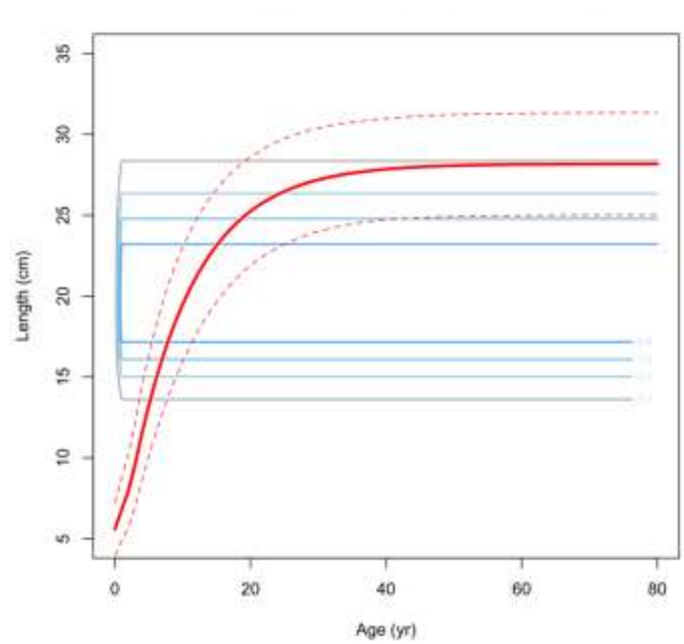



**Figure 47: Age and growth (red lines) relative to selectivity curves (blue lines) for the AFSC slope from the longspine thornyhead base case model.**

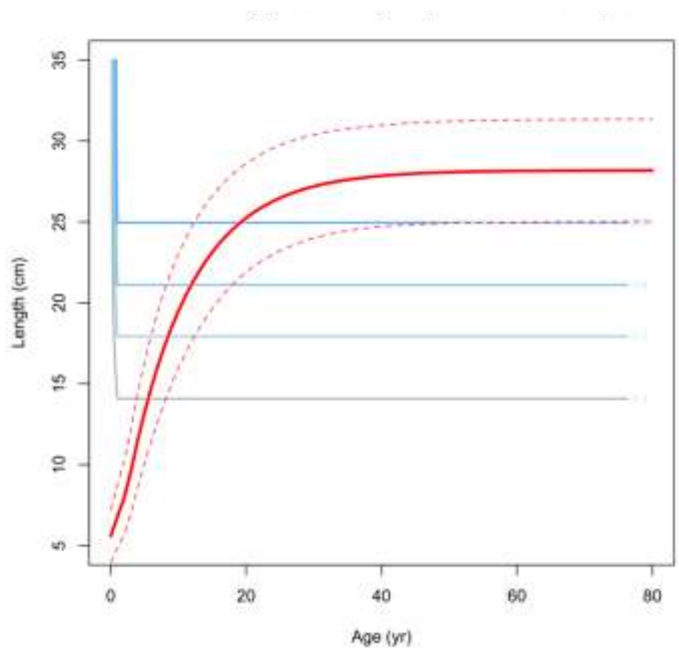



**Figure 48: Age and growth (red lines) relative to selectivity curves (blue lines) for the NWFSC slope from the longspine thornyhead base case model.**

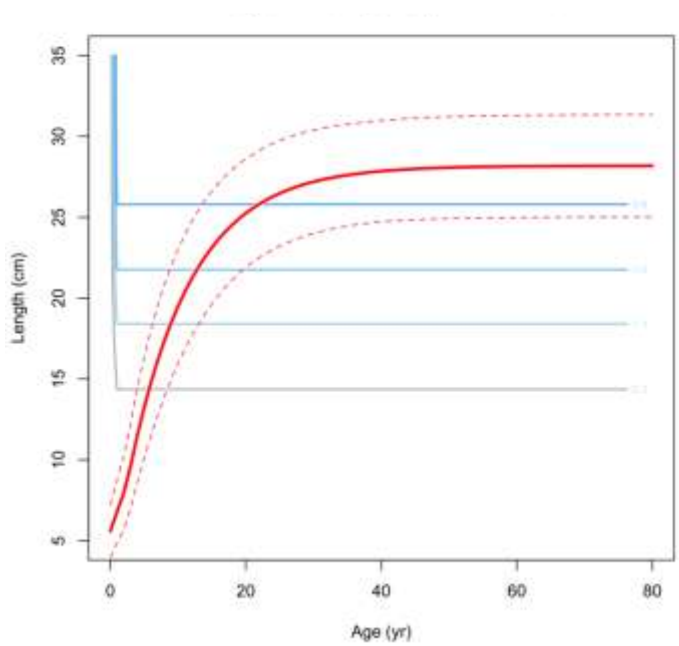



**Figure 49: Age and growth (red lines) relative to selectivity curves (blue lines) for the NWFSC Combo from the longspine thornyhead base case model.**

### 9.6.5 Recruitment

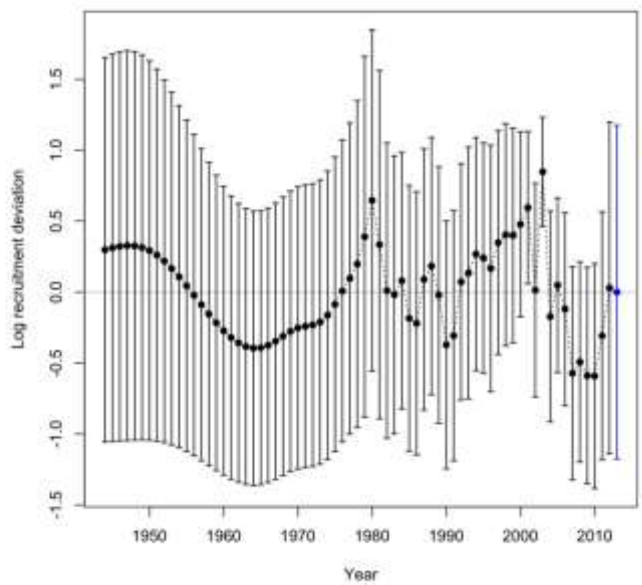



**Figure 50: Time series of estimated recruitment deviations from the longspine thornyhead base case model. Vertical lines indicate the 95% CIs.**

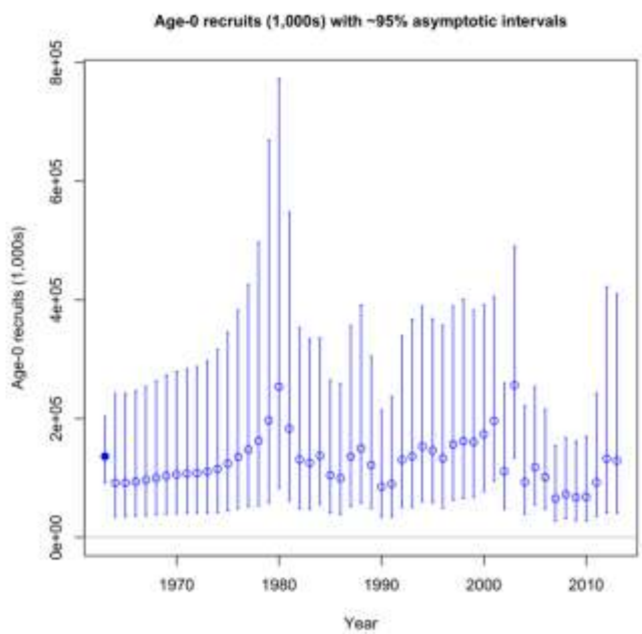



**Figure 51: Time series of recruitment with asymptotic estimated 95% CIs for the longspine thornyhead base case model.**

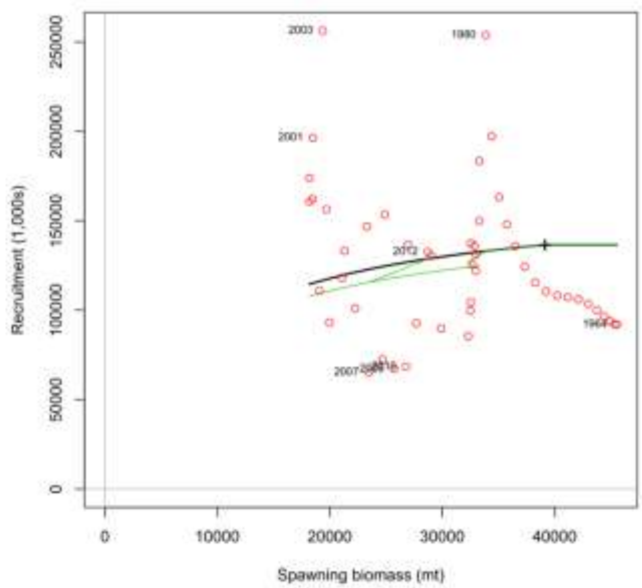



**Figure 52: Spawner-recruit time series from the longspine thornyhead base case model. Reference years (beginning, ending, and high points) are labeled.**

### 9.6.6 Biomass and status

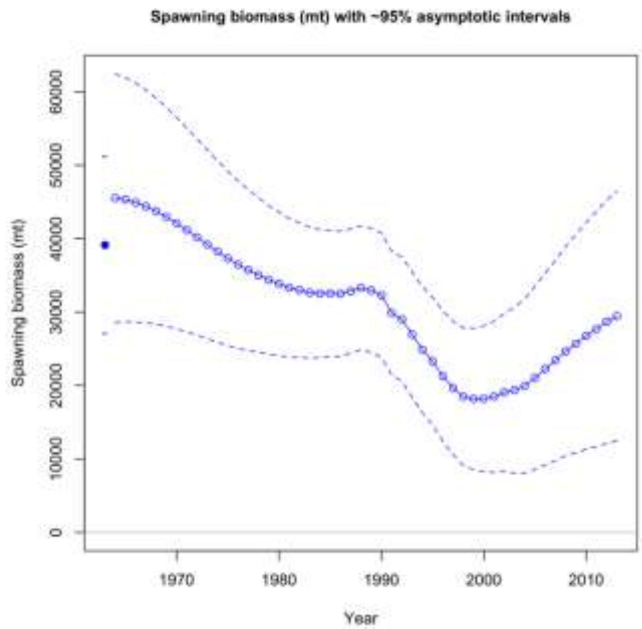



**Figure 53: Time series of spawning biomass with asymptotic estimated 95% CIs for the base case model.**

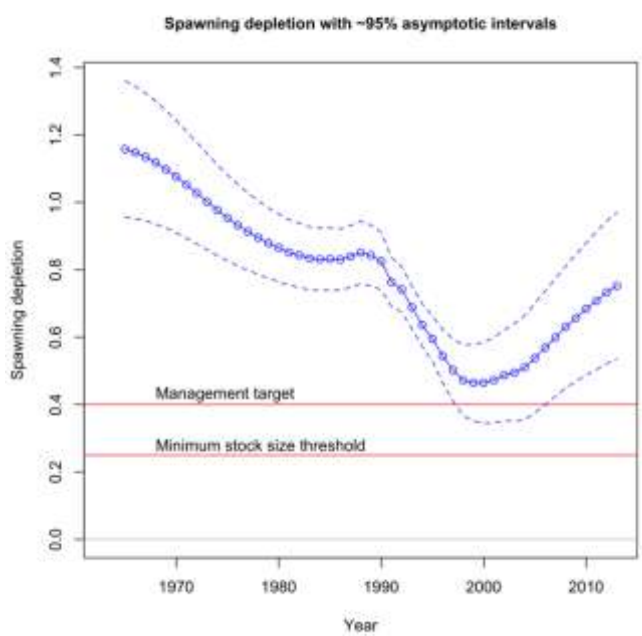



**Figure 54: Time series of stock status (depletion) with asymptotic estimated 95% CIs for the longspine thornyhead base case model.**

### 9.6.7 Management outputs

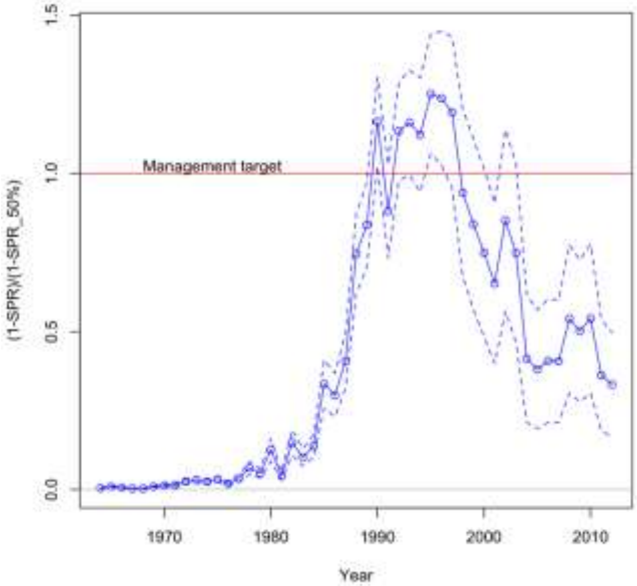



**Figure 55: Time series of exploitation relative to the management target from the longspine thornyhead base case model. Symbols and line are the mean values. Broken lines indicate asymptotically estimated 95% CIs**

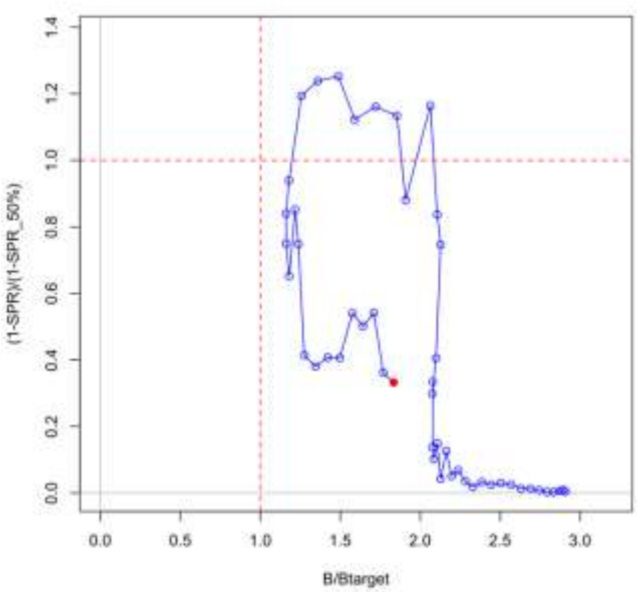



**Figure 56: Quadrant plot showing the time series of stock status (x-axis) and exploitation metrics (y-axis) from the base case model. Red vertical broken line indicates biomass target; red horizontal broken line indicates exploitation target. Red dot is the current year.**

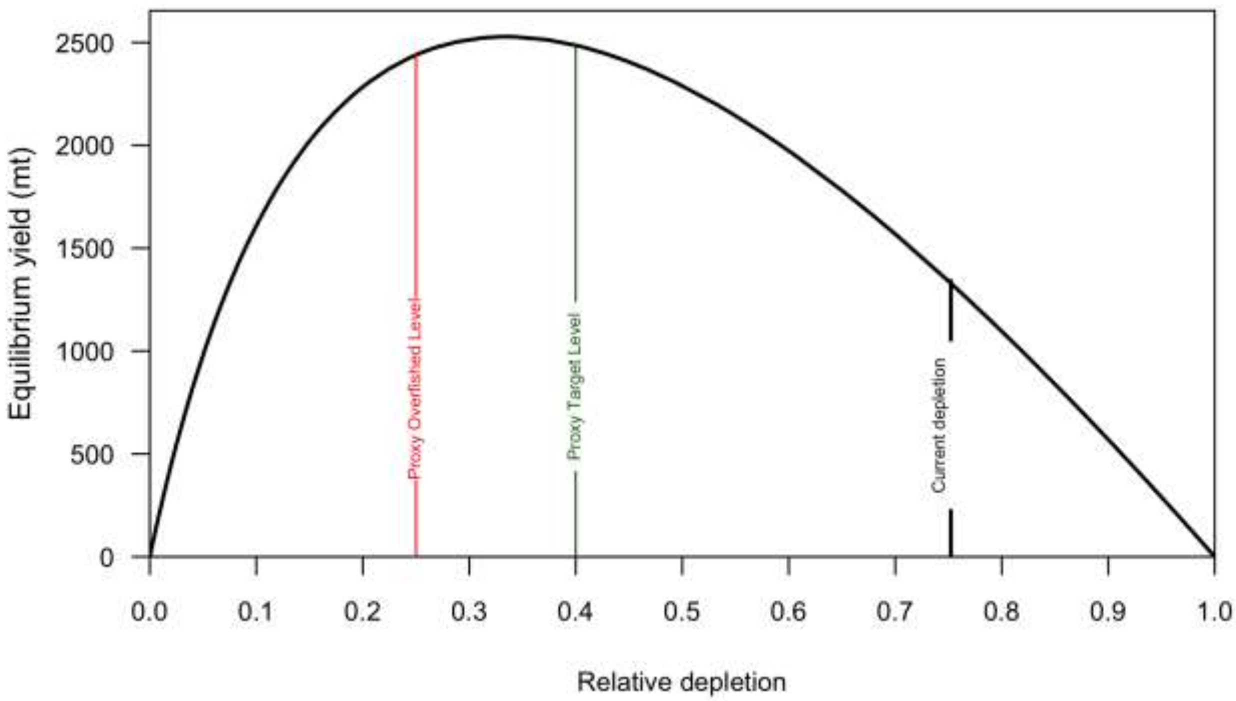



**Figure 57: Equilibrium yield curve (derived from reference point values reported in Table i) for the base case model. Values are based on 2012 fishery selectivity and allocation between fleets. The depletion is relative to unfished spawning biomass.**

### 9.6.8 Sensitivity to Historical Catch Reconstruction

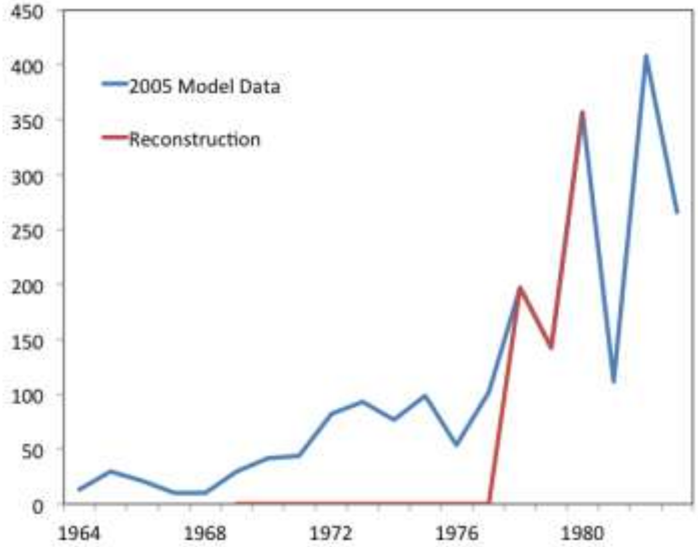



**Figure 58: The reconstructed catch (in red) lies well below the values used in 2005 (blue) for the period 1969-1977.**

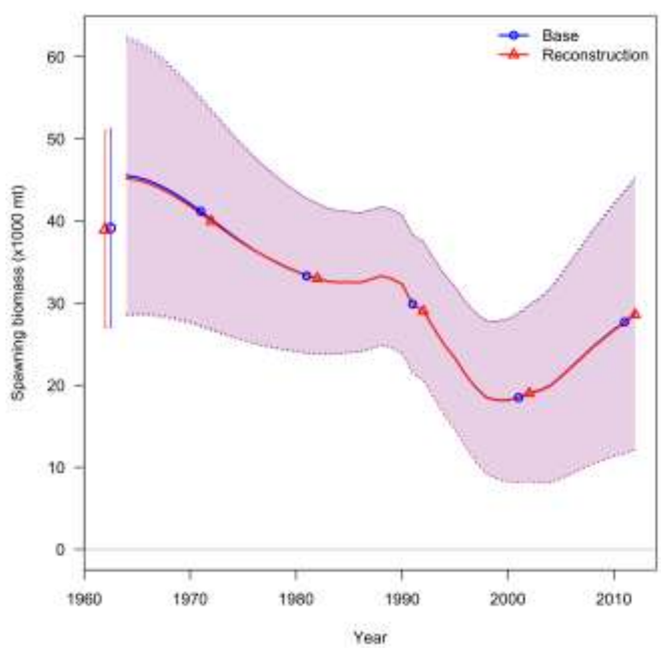



**Figure 59: Biomass in the base model (blue circles) and model using the reconstructed catches (red triangles).**

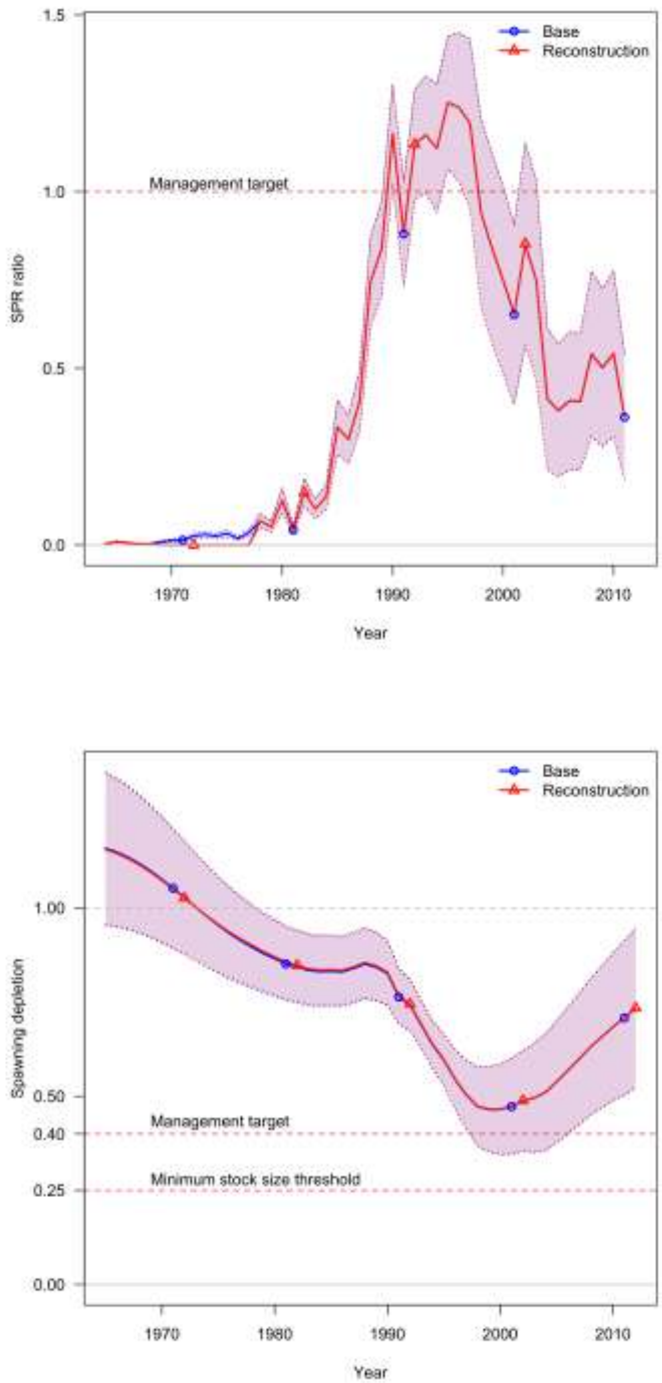
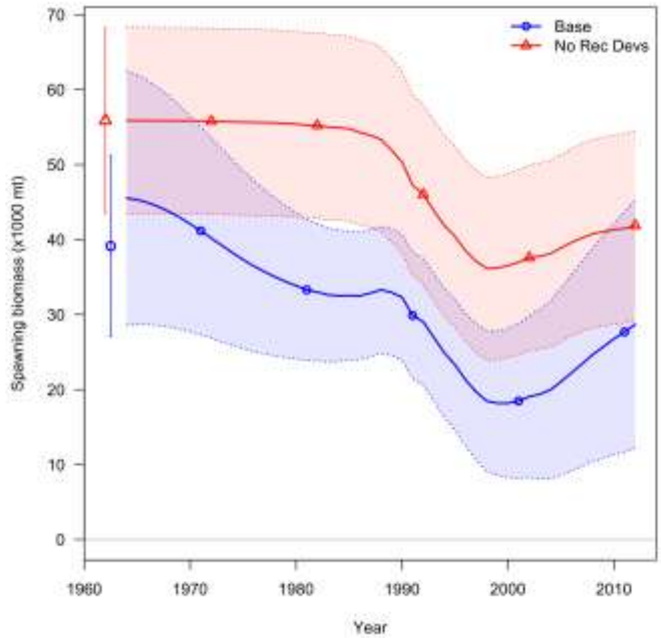



**Figure 60: Stock status in terms of SPR target (top panel) and Spawning Depletion (bottom) for the base-case model and the model using the reconstructed catch.**

### 9.6.9 Sensitivity to Recruitment Deviations



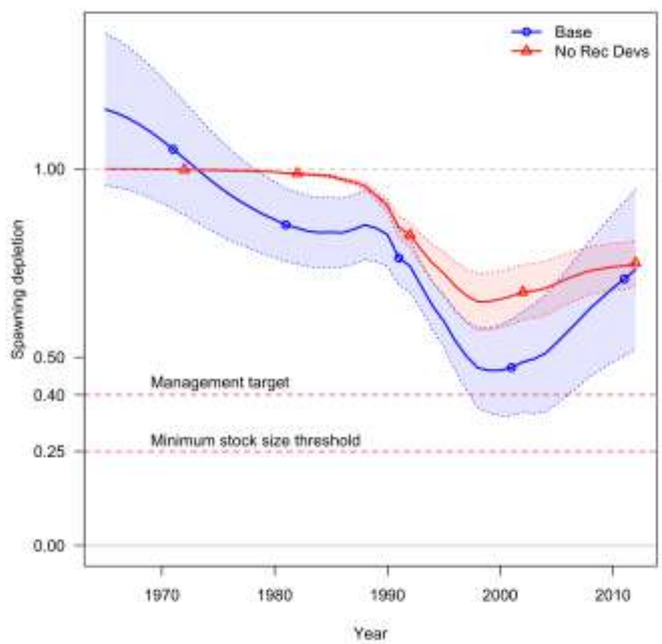




**Figure 61: Stock status in terms of Spawning Biomass (top panel) and Spawning Depletion (bottom) for the base-case model and the model without estimated recruitment deviations.**

### 9.6.10 Profiles

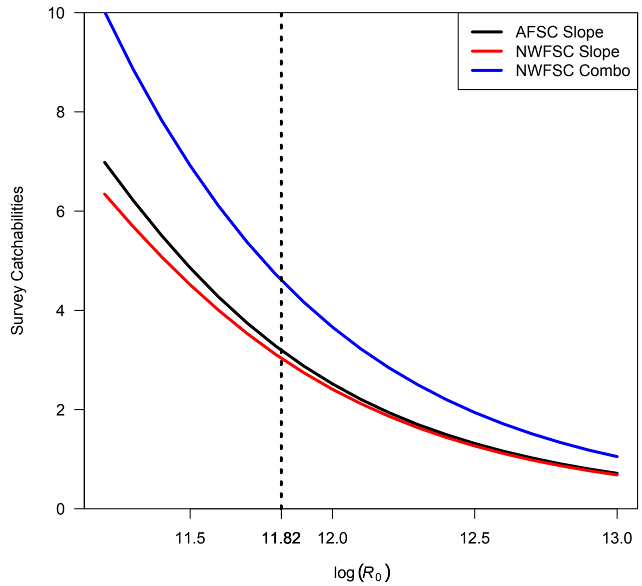



**Figure 62: Survey catchability (Q values) profiled over ln($R_0$). Base case value was estimated at 11.82.**

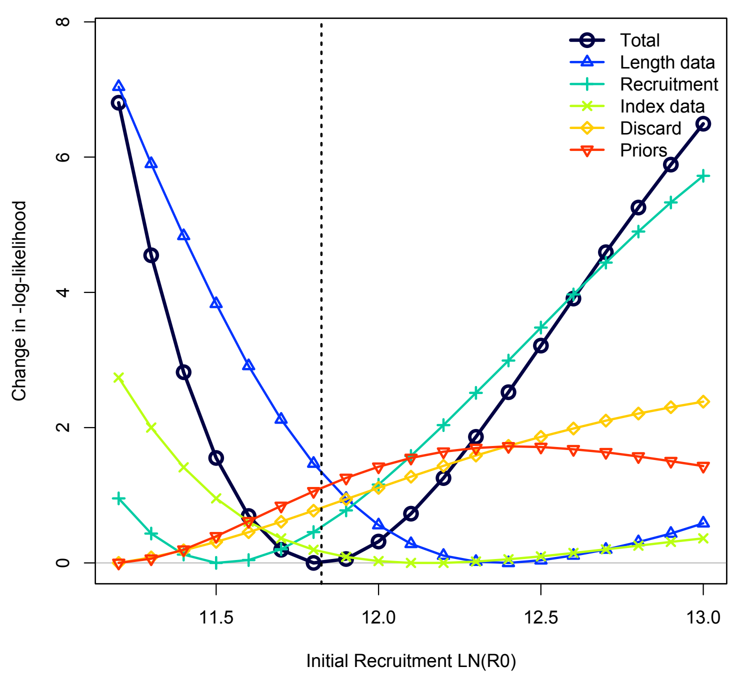



**Figure 63: Change in –log-likelihood profiled over LN($R_0$). Base case value was estimated at 11.82.**

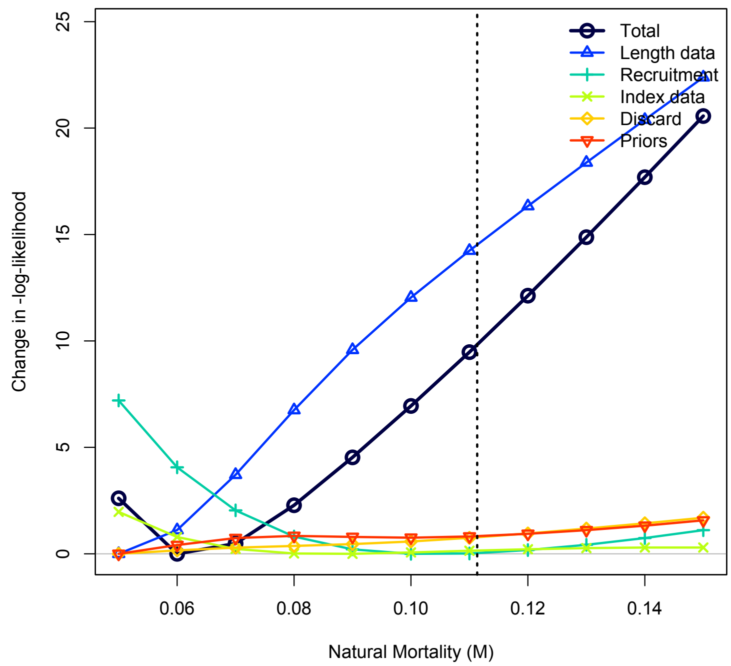



**Figure 64: Change in -log-likelihood profiled over M. Base case value was fixed at 0.1113.**

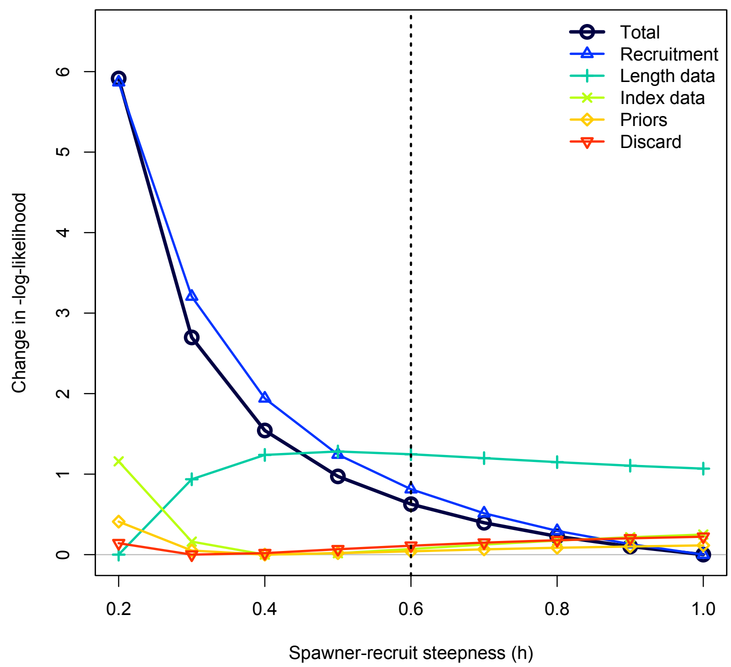



**Figure 65: Change in -log-likelihood profiled over spawner-recruit steepness (h). Base case value fixed at 0.6.**

### 9.6.11 Retrospective runs

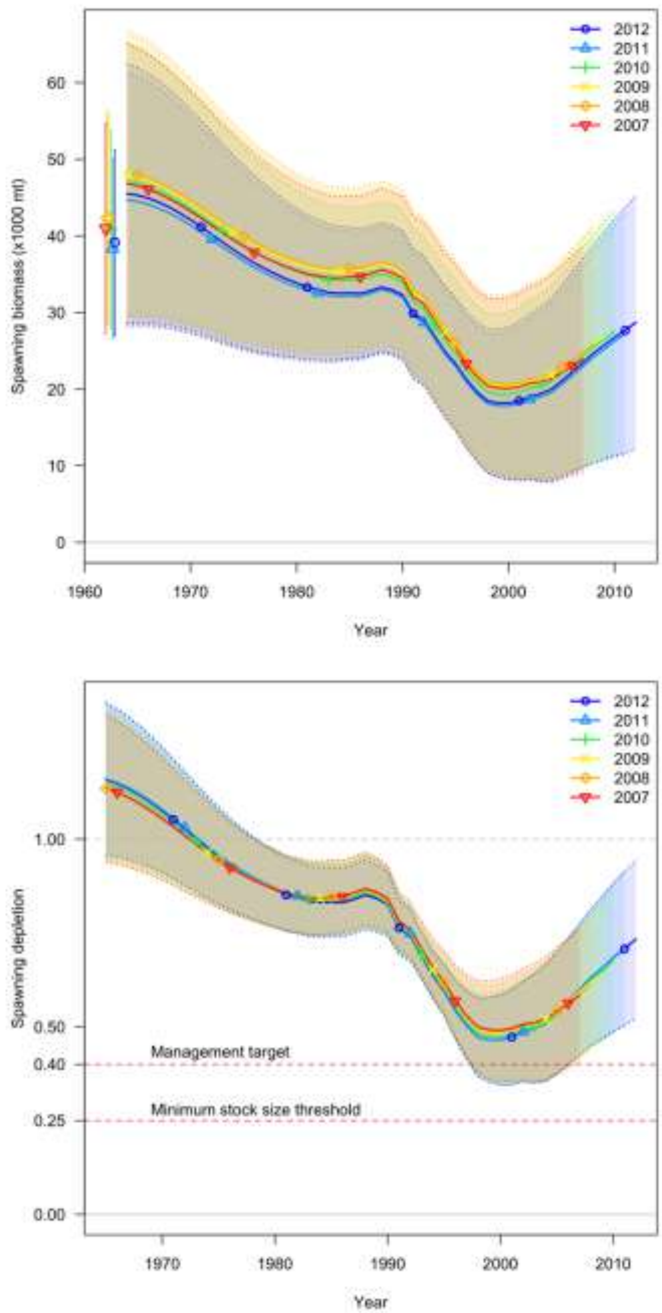



**Figure 66: Spawning biomass (top) and depletion (bottom) for the base case and each retrospective run. Solid lines and symbols are median values; polygons are the 95% CI.**

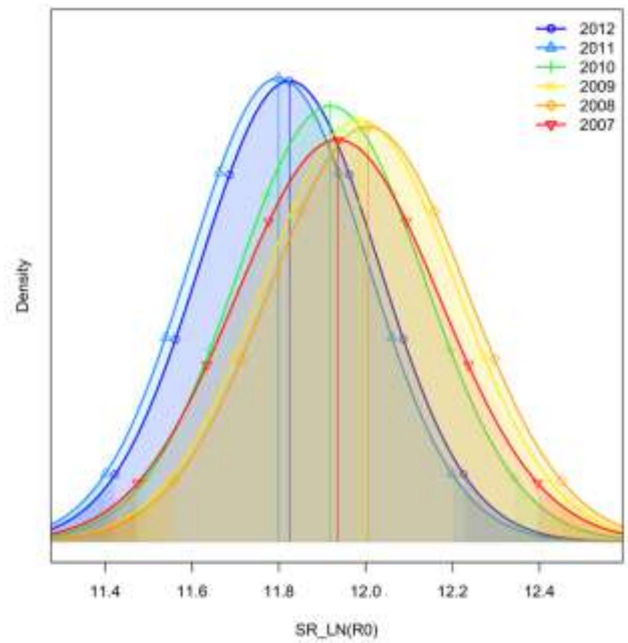



**Figure 67: Value of initial recruitment across different retrospective years and the base case.**

### 9.6.12 Comparison with 2005 results

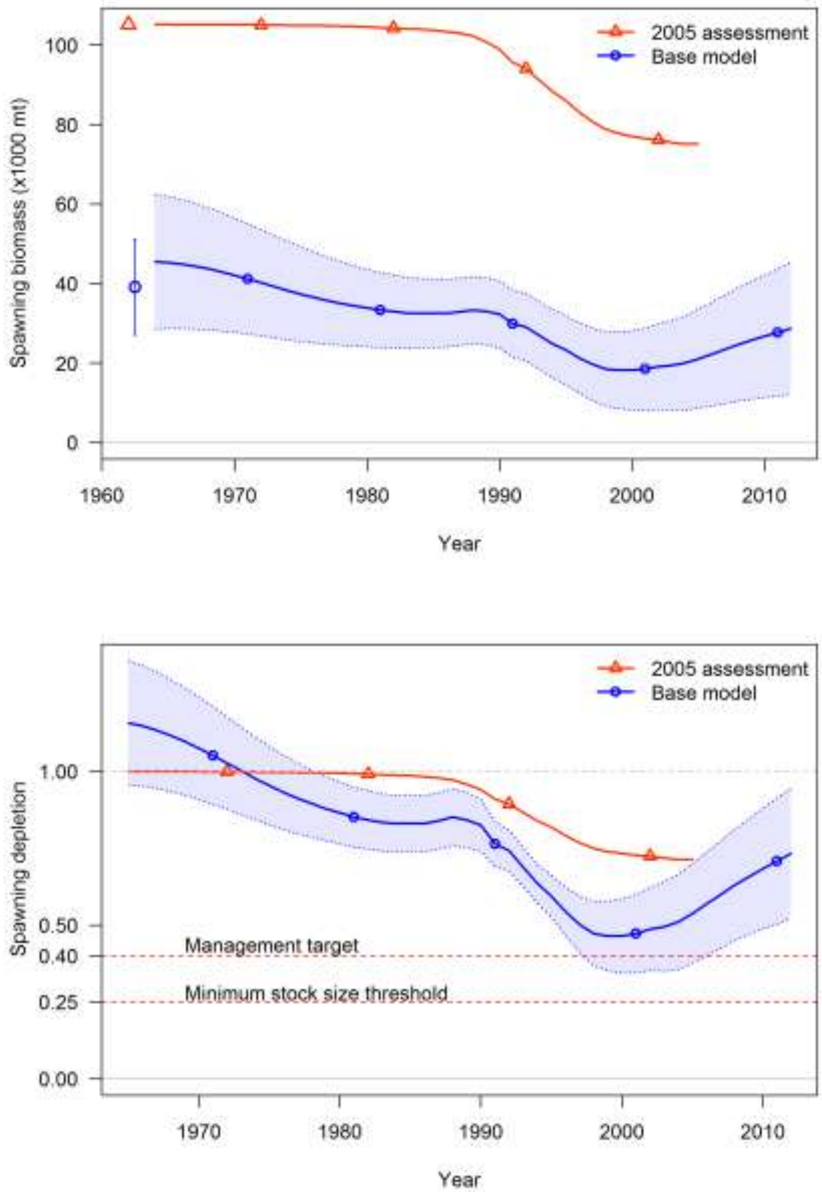



**Figure 68: The base-case model (blue) and 2005 (red) in terms of Spawning Biomass (top panel) and Depletion (bottom). Note that estimates of uncertainty were unavailable for the 2005 model.**

## Appendix A. SS data file

```
############################################
# longspine thornyhead datafile
############################################
1964 # Start_year
2012 # End_year
1    # N seasons per year
12   # Months per season
1    # Spawning season - spawning will occur at beginning of
this season
1    # N fishing fleets
3    # N surveys
1    # N areas
#
# Fishery/Survey Names
#
Fishery%AFSCslope%NWFSCslope%NWFSCcombo
#
# Further specifications
#
0.5 0.5 0.5 0.5 # Timing of each fishery/survey
1 1 1 1         # Area of each fleet
1               # Units for catch per fleet: 1=Biomass(mt)
2=Numbers(1000s)
0.01            # SE of log(catch) per fleet for equilibrium
and continuous options
2               # Number of genders
80              # N ages
#
### Catch section ###
#
# Initial equilibrium catch (landings + discard) by fishing fleet
0
# Single fishery: Commercial Trawl + a small amount of Other
catch
# Nyears Catch
49
# Catch (mt) per fleet Year Season
13 1964 1 # 13 1964
30 1965 1 # 30 1965
21 1966 1 # 21 1966
10 1967 1 # 10 1967
10 1968 1 # 10 1968 Data from 2005 subbed for data from 2013
compilation .
29 1969 1 # 0.001361162 1969 1
42 1970 1 # 0.000453721 1970 1
44 1971 1 # 0.000453721 1971 1
82 1972 1 # 0.001361162 1972 1
93 1973 1 # 0.006805808 1973 1
77 1974 1 # 0.033121597 1974 1
99 1975 1 # 0.02722323  1975 1
54 1976 1 # 0.029945554 1976 1
102 1977 1 # 0.02722323  1977 1
196.9080349 1978 1
142.5617102 1979 1
357.24058   1980 1
111.9759881 1981 1
408.404017  1982 1
266.2773766 1983 1
360.4190546 1984 1
```

```
968.7333302  1985  1
826.8462204  1986  1
1181.688087  1987  1
2735.965568  1988  1
3171.021804  1989  1
5870.494222  1990  1
2971.941759  1991  1
5480.596298  1992  1
5353.908704  1993  1
4562.964115  1994  1
5566.973651  1995  1
4880.512721  1996  1
4053.096081  1997  1
2252.073967  1998  1
1809.718289  1999  1
1496.483279  2000  1
1220.99394    2001  1
1924.118701  2002  1
1556.46079    2003  1
688.8054141  2004  1
651.511277    2005  1
749.7898044  2006  1
810.2573874  2007  1
1243.354542  2008  1
1171.299471  2009  1
1358.880388  2010  1
926.0077125  2011  1
871.2645952  2012  1
#
#
###  Abundance  Indices  ###
#
19  #  N  observations
#
#  Units:  0  =  numbers;  1=biomass;  2=F
#  Errtype:  -1=normal;  0  =  lognormal;  >0=T
#  Fleet  Units  Errtype
#
1  1  0  #  Fishery
1  1  0  #  AFSC  Slope
1  1  0  #  NWFSC  Slope
1  1  0  #  NWFSC  Combo
#
#AFSC  Slope
#Year Seas  Fishery     Value sd_log
1997  1     2     103403.46   0.07
1999  1     2     100312.67   0.07
2000  1     2     99337.47    0.07
2001  1     2     100570.80   0.07
#     1
#NWFSC Early (Slope)   1
1998  1     3     72691.60132 0.091559319
1999  1     3     84620.04893 0.085720483
2000  1     3     87038.26335 0.085497757
2001  1     3     85590.11609 0.084363494
2002  1     3     88957.39726 0.085767303
#     1
#NWFSC Late (Combo)    1
2003  1     4     139365.9881 0.084141453
2004  1     4     148930.7932 0.087330546
2005  1     4     132760.1457 0.091581854
```

```
2006 1     4     138479.7418 0.08465656
2007 1     4     138958.9279 0.080515143
2008 1     4     166410.8445 0.085368044
2009 1     4     172435.7467 0.086629996
2010 1     4     175257.335  0.076032812
2011 1     4     160827.9806 0.09402891
2012 1     4     189656.2745 0.079835471
#
#
# N fleets with discard
1
# Fleet Units Errtype
1 2 0
#
# N Observations
18
#
# Year Seas Type Value CV
### Pikitch data
# Year Seas Fishery Value CV
1985 1 1 0.2213098 0.946207082
1986 1 1 0.2220301 0.943095553
1987 1 1 0.4583943 0.420839875
#
### EDCP discard rates taken directly from 2005 model
#
#Year Seas Fishery    Value CV
1995 1     1     0.1   0.2
1996 1     1     0.12  0.2
1997 1     1     0.13  0.2
1998 1     1     0.17  0.2
1999 1     1     0.2   0.2
#
### Discard rates from WCGOP program calculated by adapting
example from Jason Jannot
### code is in
c:/SS/Thornyheads/discards/discard_rates_code_from_JJ/OB_DisRatios_CVs_Tho
rnyheads_IGT.R
### and more processing is done in
C:/ss/Thornyheads/discards/discard_rate_processing_code.R
### pot and shrimp trawl gears had negligible catch so H&L is
assumed to represent all non-trawl catch
# Year Seas Fishery Value CV     #_note
2002 1 1 0.197879077 0.077680068 #_Bottom_Trawl_whole_coast
2003 1 1 0.193096748 0.08500084   #_Bottom_Trawl_whole_coast
2004 1 1 0.176612635 0.155446156 #_Bottom_Trawl_whole_coast
2005 1 1 0.158121474 0.154715063 #_Bottom_Trawl_whole_coast
2006 1 1 0.121278141 0.186157304 #_Bottom_Trawl_whole_coast
2007 1 1 0.149661649 0.167588813 #_Bottom_Trawl_whole_coast
2008 1 1 0.134236906 0.105575198 #_Bottom_Trawl_whole_coast
2009 1 1 0.285072989 0.117006944 #_Bottom_Trawl_whole_coast
2010 1 1 0.226891516 0.111513558 #_Bottom_Trawl_whole_coast
2011 1 1 0.047029151 0.001       #_Bottom_Trawl_WAORCA_catch-
shares_fully_observed_has_assumed_tiny_CV
#
### Average weight of discards
# Value is from Wghtd_AVG_W
# CV is ratio of AVG_WEIGHT.SD/AVG_WEIGHT.MEAN
10 # N observations
30 # Degrees of freedom for StudentÕs T distribution used to
evaluate mean body weight deviations. (Not conditional
```

```
#      must  be  here  even  if  no  mean  body  wt  observations.)
#  Year  Seas  Fleet  Partition  Value  CV
2002  1  1  1  0.159467638  0.563913943
2003  1  1  1  0.150435453  0.960761427
2004  1  1  1  0.174619516  0.81528541
2005  1  1  1  0.179495188  0.793306514
2006  1  1  1  0.159584003  0.532926081
2007  1  1  1  0.142406689  0.711785211
2008  1  1  1  0.137950633  0.66127181
2009  1  1  1  0.165980374  0.49431266
2010  1  1  1  0.161415023  0.595418723
2011  1  1  1  0.158557023  0.985295096
#
#
#
#  Length  data
#
#  Bin  type  1  means  use  databins
1
#2 # Use population bins
#1    5     45
#
#  min  proportion  for  compressing  tails  of  observed  composition
frequencies
-1     # 0.000001
#  constant  added  to  expected  proportions  to  make  LogL  calculation
more  robust
0.001  # 0.0000001
#  Combine  males  into  females  at  or
0
#
#  Number  of  bins
31
#  Lower  edge  of  length  bins
5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24
25  26  27  28  29  30  31  32  33  34  35
#
#  N  observations
67  # number of observations
# combined sexes
#fishyr     fleet season      gender      partition   inputN      U5    U6
      U7    U8    U9    U10   U11   U12   U13   U14   U15   U16   U17   U18
      U19   U20   U21   U22   U23   U24   U25   U26   U27   U28   U29   U30
      U31   U32   U33   U34   U35   M5    M6    M7    M8    M9    M10   M11
      M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22   M23
      M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34   M35
1978  1     1     0     2     39    0     0     0     0     0     0     0
      0     50.68181818 0     0     0     55    0     0     114.2307692
      57.11538462 385.1497816 510.2143888 1640.817275 2617.604042 6589.730286
      8377.036332 11396.93675 6637.688772 6537.743273 723.1231007 1980.891978
      361.6202825 0     140.9951613 0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
1979  1     1     0     2     36.3  0     0     0     0     0     0     0
      0     0     0     0     0     0     0     102.6044129 264.0361953 0
      549.8311853 891.9810099 1042.799398 1098.261383 3924.60401  5848.579247
      3997.997709 3766.371378 3750.610406 1520.571192 524.5142907 412.1744271
      79.43103448 28.52678571 0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0
```

```
1980 1 1 0 2 19.2 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 25 95.71428571
90.47391304 347.0307108 814.8161684 2547.488239 4003.524924 3476.909991
5535.209216 2280.994642 842.0596121 953.5945854 48.66666667 0 0
48.66666667 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
1981 1 1 0 2 6.6 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 17059.03517 0 0
0 17059.03517 52605.21501 68950.19544 68236.14069 17059.03517
23960.64362 34118.07035 6901.608444 0 0 0 17059.03517 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
1982 1 1 0 2 17.7 0 0 0 0 0 0 0
0 0 0 0 7144.020949 0 0 7144.020949 23501.62372
16357.60277 46324.0546 135242.8656 112756.6313 178162.7454 113653.904
125734.0167 58805.01545 48092.67996 16359.23009 6243.293724 2639.917537
2639.917537 0 1319.958769 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
1983 1 1 0 2 30.5 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 8443.676032 7593.183447
9005.964431 40772.60066 102764.1699 115332.0042 185975.7863 134559.7328
96866.95488 73857.44924 11246.63258 8203.068227 656.3554428 604.890091
276.7123696 656.3554428 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1984 1 1 0 2 55.6 0 0 0 0 0 0 0
0 0 0 0 843.5464563 0 0 352.3884247 941.311648
23444.12465 48531.07924 89649.36723 125598.0953 208814.6484 233657.796
172030.8949 141348.9967 71979.1459 18840.81493 11554.47861 3675.310323
1304.071229 0 6682.404258 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
1985 1 1 0 2 78.6 0 0 0 0 0 0 0
0 0 0 0 0 3925.015743 7354.713555 3986.371239
16115.32122 38952.8182 103734.0941 180400.944 258477.1389 373502.9099
498952.0544 307097.4789 225181.7541 135418.8254 33639.84783 19819.94653
4016.847241 2903.082439 0 1060.842471 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0
1986 1 1 0 2 51.9 0 0 0 0 0 0
1075.451335 0 1075.451335 0 12665.94033 13441.58125 22581.35717
7175.82429 31944.05067 28581.58813 34788.45595 65986.92793 122467.5827
149758.9173 240984.2258 319153.3672 176503.7639 132607.9474 84244.3876
47823.57746 7367.35628 3463.476758 299.8104127 0 3511.056202 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0
1987 1 1 0 2 46.1 0 0 0 0 0 0 0
0 642.8989408 0 0 11983.87766 0 11747.51813 0
26436.70751 49027.11203 145651.7643 250943.3067 337983.9426 411772.624
304207.7705 282631.7444 163023.7117 69461.60095 24181.08641 15638.09585
4779.132646 2552.013842 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0
1988 1 1 0 2 11.1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
```

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 62163.65876 | 41442.43917 | 42251.61552 | 82884.87835 | 134687.9273 | 113966.7077 | | | | | | |
| | 41442.43917 | 10360.60979 | 20721.21959 | 0 | 0 | 0 | 8539.211395 | 0 | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| 1989 | 1 | 1 | 0 | 2 | 71.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 64033.98285 | 154052.318 | 51227.18628 | 27061.92586 | 183141.8098 | | | | | | |
| | 155293.879 | 257777.7625 | 338872.4343 | 673322.8182 | 1005351.163 | 1729137.298 | | | | | | |
| | 1451330.55 | 1423834.295 | 1638125.946 | 1077859.252 | 596590.7829 | 273251.3994 | | | | | | |
| | 54537.82947 | 44309.53618 | 1270.043737 | 0 | 0 | 10746.22886 | 0 | 0 | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | | | | | | | |
| 1990 | 1 | 1 | 0 | 2 | 173.2 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 1477.109409 | 40813.42186 | 28462.75561 | 23257.22932 | 72932.13797 | 93864.69886 | | | | | | |
| | 267401.5047 | 219365.5384 | 648160.0968 | 1174900.155 | 1393534.293 | 1772301.448 | | | | | | |
| | 2799367.081 | 2986517.858 | 3132551.011 | 3093232.548 | 2298415.409 | 1611509.548 | | | | | | |
| | 764870.937 | 316662.0896 | 45709.81248 | 41910.18534 | 1039.84184 | 1604.275915 | | | | | | |
| | 1477.109409 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| 1991 | 1 | 1 | 0 | 2 | 158.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 4222.951527 | 5314.525397 | 20951.14997 | 17118.45486 | 70821.84639 | | | | | | |
| | 90160.07372 | 288546.4201 | 421510.5699 | 766494.4634 | 1436596.296 | 1943977.07 | | | | | | |
| | 2226005.731 | 2285028.888 | 2122386.885 | 1564950.827 | 999998.5228 | 528837.0666 | | | | | | |
| | 211619.4648 | 57055.84399 | 33448.75597 | 6263.126937 | 1374.966366 | 2823.275096 | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 1992 | 1 | 1 | 0 | 2 | 200 | 0 | 0 | 0 | 12125.59615 | 9278.235652 | | |
| | 27053.26759 | 34540.22729 | 48191.84105 | 62213.88246 | 147732.4853 | 199725.4509 | | | | | | |
| | 277042.5905 | 351251.771 | 475682.1087 | 659796.7461 | 1251779.707 | 1677835.839 | | | | | | |
| | 2792117.153 | 3903103.864 | 4090726.91 | 4044998.568 | 3566507.033 | 2523581.643 | | | | | | |
| | 1334541.95 | 802163.8073 | 248543.6437 | 108868.4056 | 29266.16466 | 5743.575251 | | | | | | |
| | 9363.542216 | 6677.228081 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 1993 | 1 | 1 | 0 | 2 | 146 | 0 | 0 | 0 | 3284.75426 | 3284.75426 | | |
| | 31279.29195 | 22047.44923 | 14415.20574 | 19936.46098 | 85662.63933 | 112584.6997 | | | | | | |
| | 141605.3065 | 288282.0968 | 468775.6628 | 727602.0421 | 1084248.157 | 2014419.5 | | | | | | |
| | 2399998.717 | 2745279.731 | 2901407.402 | 2130414.536 | 2210807.349 | 1354150.107 | | | | | | |
| | 737203.095 | 463048.9336 | 142311.4389 | 72157.82539 | 43835.66213 | 2751.687216 | | | | | | |
| | 325.2283847 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 1994 | 1 | 1 | 0 | 2 | 145.5 | 0 | 0 | 4715.875581 | 0 | 18863.50232 | | |
| | 7177.4987 | 6957.821423 | 35342.24438 | 27428.31841 | 75454.35316 | 138570.6668 | | | | | | |
| | 157225.8038 | 193618.5708 | 265407.3203 | 465429.1694 | 709658.1188 | 1002243.205 | | | | | | |
| | 1234300.841 | 1631159.73 | 1827256.349 | 1883799.725 | 1588563.329 | 1247550.17 | | | | | | |
| | 705182.5196 | 290063.2678 | 108902.0284 | 25311.28981 | 28921.14701 | 12735.95922 | | | | | | |
| | 486.0787146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| 1995 | 1 | 1 | 0 | 2 | 218.6 | 0 | 0 | 0 | 0 | 957.2707907 | | |
| | 11947.03022 | 28156.24739 | 17943.75471 | 32551.29581 | 38692.12676 | 67062.36561 | | | | | | |
| | 90439.8373 | 161872.6819 | 285514.7568 | 469443.3146 | 908489.1867 | 1290347.094 | | | | | | |
| | 1729592.003 | 2292642.852 | 2400499.207 | 2504459.547 | 2239983.082 | 1582367.195 | | | | | | |
| | 870621.3623 | 423942.1047 | 164878.6509 | 56969.9902 | 9636.191727 | 6147.87462 | | | | | | |
| | 971.882232 | 3162.712885 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

```
1996 1 1 0 2 232.2 0 0 0 0 0 3997.758363
7889.063283 11838.39013 66352.94054 28330.92114 75419.59049 134925.8675
215462.5696 359248.1332 666891.8056 1071486.883 1671877.102 2330717.712
2724725.808 2815851.252 2793165.828 2213342.989 1515893.531 818235.2505
465344.4669 187403.8916 58617.58096 17866.0962 683.1743773 2718.878484
4870.96431 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
1997 1 1 0 2 282.4 0 0 0 3823.651858 5580.522928
21204.12018 21242.71026 40670.58641 43825.04234 47440.12956 83862.24138
98933.48727 184997.601 386975.8161 595401.7111 935557.4278 1488543.025
2098614.52 2340397.871 2712267.596 2647126.109 2216785.231 1405703.125
763616.02 367333.1478 76059.26133 48501.60095 9297.801147 9642.678706
1526.220037 729.3180527 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1998 1 1 0 2 168.7 0 0 0 0 2330.415034
6627.266516 4165.725064 7594.945934 21378.96282 62491.53106 68961.09263
66858.97329 112615.8942 205956.8883 380764.6816 696425.2577 1047034.783
1302424.507 1574710.495 1704431.516 1571685.508 1588843.838 926546.2602
545628.2759 257903.7797 92781.02276 41064.99405 9221.743348 10249.08562
976.3075799 1967.787232 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
1999 1 1 0 2 156.8 0 0 0 0 0 3428.423022
6516.782472 20589.063 12899.92128 46673.46392 52405.13515 76117.5389
94619.26915 163999.334 258325.5562 529658.5197 775840.8048 1049567.718
1343184.61 1548086.922 1443695.047 1172853.527 669983.8306 343210.5874
175068.2618 73758.05925 26221.07285 12657.72106 5961.036556 0
4426.887416 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2000 1 1 0 2 148.1 0 0 0 0 0 0 0
488.5280351 3353.335501 3905.33348 23295.32268 26189.76405 43497.98511
46678.44203 170223.3671 359761.3226 413588.3197 725801.1307 1165372.033
1214001.282 1181237.598 889311.8143 613575.8458 368288.3324 161208.2814
38032.85417 37392.30457 6525.384113 13676.70545 2498.087872 4450.405684
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2001 1 1 0 2 162.4 0 0 0 0 852.7470191
875.2867392 0 1728.033758 1312.492027 8597.643967 24502.88307
43479.46956 47635.54941 113217.1994 162077.9768 288193.53 475224.3405
645366.8949 826025.3972 1001238.472 929782.4453 854052.9854 570727.9296
279033.9102 115561.4762 39354.52963 8220.217949 4723.028491 2924.756025
5824.396056 14175.28188 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2002 1 1 0 2 199.9 0 0 1620.45031 5432.287865
7423.578337 2305.854564 10265.69905 13625.03537 24563.64607 26634.96631
64714.7635 85396.59747 104113.8324 167876.6174 313340.483 537724.4654
852472.9504 975391.6968 1256124.074 1458408.491 1383634.71 1194457.004
775394.6639 402663.5826 125853.5113 55547.60999 19800.12677 2516.558783
9332.689328 8732.609036 720.0231411 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0
2003 1 1 0 2 171 0 0 0 0 0 0
4240.088489 2309.339183 5561.347221 9877.157644 19398.87196 50303.92462
66914.89021 167869.1839 346568.5612 546426.5654 824117.1752 1046466.773
959071.8115 1352534.294 1038915.537 1069788.351 534618.2039 256417.8267
```

111577.8299 70137.00268 8248.156441 3106.438207 0 1345.730581
1188.450463 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2004 1 1 0 2 139.8 0 0 0 0 0 0
3566.631494 0 2538.400456 7865.355239 25903.6341 13220.32649
31873.84844 45364.38875 96772.211 201291.4618 263403.733 334966.4925
389266.9723 410896.2879 394881.9785 360947.7102 235166.242 115320.9602
74815.24813 22291.53023 4697.22679 0 114.6875002 72.48746605 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0
2005 1 1 0 2 133.3 0 0 0 0 181.3436358
181.3436358 181.3436358 0 1478.305754 694.3497007 8210.987919
16476.19082 47343.90407 71617.27027 133303.1938 215822.9048 323126.5229
395396.6595 390457.1635 470615.4796 494187.2448 424771.1345 251158.8006
157532.1674 37866.76883 22786.84219 1927.823315 572.2874173 3127.144
46.66497468 46.66497468 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2006 1 1 0 2 182.6 0 0 0 1209.051664 996.2429925
1764.494557 1481.560642 7341.690664 1786.32549 21077.07441 24437.39196
58377.62075 71136.93699 140294.2037 219046.2267 302905.4985 380003.2815
416826.2191 468018.7275 550031.2302 507038.5115 446126.5945 289871.638
148643.7842 72001.71648 24209.02681 2503.208975 1290.220392 2258.822742
179.7028037 34.0428567 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2007 1 1 0 2 168.3 0 0 0 0 2589.863892
7407.666063 9041.88648 4371.052196 9760.072437 17945.04903 36416.42325
54667.8433 135829.8454 134848.5095 253347.4087 411443.4357 464289.324
501672.33 547347.7505 555078.9048 513669.3206 434146.4925 293156.7349
149117.4795 60608.08009 21798.41558 5472.336851 2926.691758 568.0477418
0 7.996355138 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
2008 1 1 0 2 206 0 0 0 0 0 2764.723249
20879.01878 12118.20229 22606.19572 25379.81364 46685.95984 117082.1096
173682.6515 214327.3226 366076.3493 444049.1729 724272.6396 845228.0268
886488.1397 803625.2036 757548.3725 673315.4653 367977.9126 228945.9957
120514.788 37753.24657 21426.84103 1193.779855 2859.881103 0
8.006042714 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
2009 1 1 0 2 194.4 0 0 0 334.0999246 0
2033.00511 3891.457846 9892.567458 12008.96905 30563.03219 21431.30905
33697.54653 66977.33737 90955.10456 225875.2312 339082.2899 439458.1535
480050.0002 519584.1741 537931.6591 519460.3827 399218.2974 256040.2343
152129.6821 60942.91159 34163.65674 3969.668918 670.7287783 1756.471964
972.8322645 918.4855542 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0
2010 1 1 0 2 206.4 0 0 0 0 1786.356311
1037.12074 3624.14391 12043.94053 11842.66598 21518.62456 48102.46622
78129.5837 88984.21125 193580.2489 329506.6382 513324.5767 783140.195
906893.315 1008261.898 877172.5559 754488.1192 647759.1358 443674.6564
211341.0433 100014.1385 48111.75246 13565.44929 3406.696966 3100.219655
0 658.3638399 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0

```
2011  1     1     0     2     206.7 0     0     0     0     723.8617691
      3017.607365 3859.59461  13007.35201 17177.6583  41377.27955 59008.86777
      57485.40446 117320.6567 179058.2388 338580.1406 429745.4045 611192.0395
      620307.9812 630625.2012 627010.5657 582744.8072 448189.7471 285789.017
      137748.7129 51923.44427 22050.52752 11238.71618 3240.448558 3907.830735
      1863.058959 339.7293919 0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0
2012  1     1     0     2     202.2 0     0     0     318.5351657 838.9022517
      1306.836285 480.031548  5258.888362 19981.16716 24460.11102 46499.16734
      69317.92492 106345.9661 141166.8174 214555.9324 378562.3166 468758.0214
      573297.8829 617613.825  551200.4808 481491.2174 374378.4417 255700.5059
      139495.6673 53296.62888 24055.18519 10304.0009  6425.600075 2144.150262
      800.8795628 534.367309  0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0
2013  1     1     0     2     46.4  0     0     0     0     0     0     0
      1717.122417 1909.737679 2960.914149 4949.293427 7009.147939 9122.240654
      9359.429638 11316.82409 16483.48497 18156.41272 15205.40102 12674.84483
      9737.98072  8309.406372 4805.573738 2703.507133 966.8874101 180.3786234
      179.0566038 0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0
### Length comps from Pikitch discard study
# discards (partition 1)
      #_year      season      fleet gender      partition   inputN      U5
      U6    U7    U8    U9    U10   U11   U12   U13   U14   U15   U16   U17
      U18   U19   U20   U21   U22   U23   U24   U25   U26   U27   U28   U29
      U30   U31   U32   U33   U34   U35   M5    M6    M7    M8    M9    M10
      M11   M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22
      M23   M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34
      M35
1988  1     1     0     1     42.8  0     0     0     0     0     0     0
      0.012656531 0.055068793 0.11255384  0.148637837 0.162276671 0.274830511
      0.278742523 0.25922707  0.319720836 0.230063804 0.146221583 0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0
1989  1     1     0     1     180.7 0     0.000238448 0     0     0.000238448
      0.001615896 0.00369051  0.004767175 0.113197844 0.052158179 0.100076721
      0.070929438 0.159300072 0.347618488 0.324813646 0.157573055 0.197544
      0.200860201 0.109660317 0.096843329 0.003748341 0.055125891 0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0
1990  1     1     0     1     51.2  0     0     0.085657121 0.116329682
      0.061345121 0.100993401 0.01533628  0.020121838 0.065287424 0.085657121
      0.04600884  0.01533628  0.199381702 0.362181276 0.405084782 0.208808414
      0.058717805 0.148967354 0.004785558 0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0
# utilized (partition 2) Setting these to have negative fleet number
because they are less complete than the PacFIN comps from the same years
```

```
1988 1     -1    0     2     135.6 0     0     0     0     0     0     0
     0     0     0     0     0     0     0.00014464  7.23E-05    0.00043392
     0.001977454 0.015412638 0.123313394 0.338030105 0.247302481 0.433234235
     0.498505741 0.200772452 0.106316335 0.03294075  0.001326573 0.00014464
     0     7.23E-05    0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
1989 1     -1    0     2     437.3 0     0     0     0     0     2.15E-05
     1.07E-05    3.22E-05    3.22E-05    0.000214565 0.000171652 0.000197617
     0.000304923 0.003331268 0.009108738 0.026596131 0.063954435 0.100674878
     0.138620444 0.198606417 0.284550243 0.356934888 0.362419851 0.226260991
     0.145553224 0.055310824 0.020047373 0.006669116 0.000366197 9.67E-06
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
1990 1     -1    0     2     179.5 0     0     0     0     0     0     0
     0     0     0.000513457 0.001540371 0.001540371 0.002053828 0.003594198
     0.007697198 0.012976919 0.02015382  0.093529582 0.12703754  0.252371198
     0.253848026 0.410396857 0.265215032 0.291650355 0.148638322 0.054975556
     0.022677991 0.007679968 0.019111651 0.00279776  0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0
### Length comps from WCGOP discard observations
### a single fish for 2005 is probably not worth including so that line
commented out
# zero values in columns for males (unsexed fish are all put into columns
for females)
#_year     season     fleet gender     partition  inputN     U5    U6
     U7    U8    U9    U10   U11   U12   U13   U14   U15   U16   U17   U18
     U19   U20   U21   U22   U23   U24   U25   U26   U27   U28   U29   U30
     U31   U32   U33   U34   U35   M5    M6    M7    M8    M9    M10   M11
     M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22   M23
     M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34   M35
#2005 1    1     0     1     1     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     1     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0
2006 1     1     0     1     68.8  0.001741332 0.001907503 0.009867579
     0.01273067  0.009236091 0.012120287 0.026722643 0.02043581  0.068880731
     0.050510855 0.076334183 0.074775836 0.114199417 0.126963035 0.107176839
     0.08523667  0.105776408 0.038076981 0.034121049 0.008860006 0.007050238
     0.001522939 0.000304647 0.00535132  5.19E-05    4.50E-05    0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0
2007 1     1     0     1     96.3  0     0     0.000354873 0.002821058
     0.000705898 0.008506643 0.039341112 0.044009857 0.037244917 0.057592368
     0.071892935 0.10692387  0.097820934 0.116246651 0.157152875 0.096225226
     0.07470993  0.042920636 0.008929009 0.007003372 0.020108407 0.005955308
     0.001471442 6.05E-05    0.000997819 0     6.57E-06    0     0
     0.000997819 0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0
2008 1     1     0     1     110.6 0.001105738 0     0.001165885 0.001113835
     0.001317688 0.020710282 0.026474975 0.045246942 0.063357808 0.06213943
```

```
     0.109940117 0.092849609 0.158562094 0.09871086  0.130676193 0.083747937
     0.052362581 0.024886679 0.013469754 0.006836322 0.001782374 0.001250495
     0.00142682  0.000233649 0.000254855 0.000156152 7.06E-05    0     0
     0     0.000150368 0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0
2009 1     1     0     1     138.6 0     0     0.013357575 0.023271255
     0.007174821 0.021108189 0.033845009 0.034220617 0.024085545 0.031042812
     0.054737359 0.063432155 0.146384695 0.088035626 0.113837959 0.088735388
     0.063278891 0.078328637 0.055287871 0.023287239 0.018383461 0.00393441
     0.002378128 0.001258149 0.010126835 7.58E-06    0     0.000416635 0
     5.68E-06    3.75E-05    0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0
2010 1     1     0     1     104.3 0     0     0     0.000493606 0.000623113
     0.001195655 0.007690074 0.021202663 0.035248331 0.047584206 0.054688432
     0.094317153 0.113561001 0.101775657 0.17380651  0.140226915 0.09424215
     0.065215649 0.025044451 0.011930148 0.003248901 0.001764644 0.005650563
     0.000342233 0.000145253 0     2.69E-06    0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0
2011 1     1     0     1     151.2 0.00030884  0.007299507 0.004932291
     0.001237584 0.011489519 0.021794153 0.016260896 0.014166736 0.0359562
     0.067725428 0.086817202 0.088505627 0.100715037 0.107722635 0.10760128
     0.060338546 0.076196391 0.04506025  0.048296126 0.020814651 0.022809649
     0.016806521 0.006337889 0.016472284 0.012505895 0.001549359 0.000127367
     7.96E-06    4.46E-05    1.67E-05    8.29E-05    0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0
### Length comps from AK slope survey
###      note: combining males and females due to lack of trust is sex
determination from this survey
# zero values in columns for males (unsexed fish are all put into columns
for females)
#_year     season     fleet gender     partition  inputN     U5    U6
     U7    U8    U9    U10   U11   U12   U13   U14   U15   U16   U17   U18
     U19   U20   U21   U22   U23   U24   U25   U26   U27   U28   U29   U30
     U31   U32   U33   U34   U35   M5    M6    M7    M8    M9    M10   M11
     M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22   M23
     M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34   M35
1997 1     2     0     0     520.3 0     0     0     0.188238049 0.163862078
     0.355955009 0.575084663 1.49045055  3.037827814 6.077630074 3.184339614
     5.44945716  11.95621773 14.23896139 13.67447088 4.889904622 12.84905294
     8.927045778 6.192713443 3.038768191 1.642770352 0.60005815  0.790656904
     0.297744717 0.198806405 0.049130512 0.049130512 0.081722462 0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
1999 1     2     0     0     423.5 0     0     0     0.157368147 0.223246236
     0.392789133 0.252217851 0.629366359 0.794151358 3.356655054 4.267412314
     4.910379363 5.955449408 10.97601766 10.31178143 13.64064331 12.03313454
     12.05555349 8.140102865 5.438543168 2.975394708 1.955767197 0.732826195
     0.571746514 0.057363424 0.172090273 0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0
2000 1     2     0     0     392   0     0     0.054417379 0.067784366
     0.287612622 0.974303432 0.071534067 0.530955977 1.637381327 4.283729313
     7.428000353 9.076911031 10.80902169 12.96267601 12.93727644 9.334150127
```

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     8.287934743 6.212004355 4.321296783 5.135851261 2.355084919 1.806081342
     0.752042216 0.305879526 0.229315224 0.027751098 0.055502197 0.055502197
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0
2001 1     2     0     0     456.5 0     0     0.048025391 0.267450208
     0.364152859 0.398656097 0.893366532 0.461135727 1.063404707 1.711097544
     4.127943521 6.358083521 11.12876881 11.07563491 13.27523143 11.00782773
     9.744408244 5.827647436 5.10114797  5.248820467 4.410595738 3.830553064
     1.784386232 0.863045236 0.637936418 0.135990926 0.067995463 0.166693825
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0
### Length comps from NWFSC surveys
### sex determination seems to have been sorted out in 2005, so combining
earlier years. Note that only one 2000 from early survey had length
measurements
# zero values in columns for males (unsexed fish are all put into columns
for females)
#_year     Season     Fleet gender     partition   inputN     U5    U6
     U7    U8    U9    U10   U11   U12   U13   U14   U15   U16   U17   U18
     U19   U20   U21   U22   U23   U24   U25   U26   U27   U28   U29   U30
     U31   U32   U33   U34   U35   M5    M6    M7    M8    M9    M10   M11
     M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22   M23
     M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34   M35
1998 1     3     0     0     423.5 0.040095902 0.139823539 0.693941655
     1.776716073 2.91212925  3.403125194 3.849204164 4.715554358 4.642959777
     4.616458398 4.399956727 4.354866464 5.067788109 5.789014488 5.938952761
     5.915990384 6.188022974 6.275559814 6.623662739 6.969699121 5.802884915
     4.634402534 2.805676313 1.282313592 0.83915405  0.238510159 0.042581304
     0.025201884 0.003422187 0.003501732 0.008829437 0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0
1999 1     3     0     0     457   0.008110969 0.222703686 1.123893087
     2.062806483 2.075232938 2.743532626 3.177178196 4.146741321 4.698014818
     4.6759803   4.760950426 4.518884186 4.997476608 5.492150003 5.877266402
     6.350830255 6.284917494 6.593958365 7.248777607 6.929541556 6.102847715
     4.268292856 3.009091199 1.503381215 0.884214468 0.156254651 0.049163193
     0.023013767 0.014793611 0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0
2000 1     3     0     0     410.3 0.018639172 0.161420047 0.587728669
     1.452839013 2.490374954 2.538029712 2.922931336 3.967866169 5.043304745
     5.267076254 5.971619157 5.284498075 5.214062294 5.588041777 6.199083757
     6.207419148 6.328299571 6.497800305 6.693738713 6.428665525 5.51486381
     4.281181122 2.925664323 1.371472376 0.680167195 0.235616347 0.068323212
     0.045843623 0.00773289  0.002735408 0.0029613   0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0
2001 1     3     0     0     429   0.017771055 0.054686203 0.799430791
     2.55205497  1.198545234 1.687053619 2.067356937 1.373842888 1.600723974
     1.988286806 3.034438516 2.707954155 7.020351731 3.808336591 6.715423568
     4.291183436 4.505762731 6.100295695 13.14294381 16.03297937 11.7160238
     4.275645318 1.78360412  1.099250455 0.255771847 0.11828539  0.035607805
     0.010174927 0.000965656 0     0.005248609 0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0     0     0     0     0
     0     0
```

```
2002  1     3     0     0     523.9 0.036836403 0.266378242 1.058771049
      1.314498559 1.673912096 1.867333259 2.055824944 2.491282713 3.226137348
      3.795345338 4.414418486 5.28307977  5.718795901 5.822866256 7.030160244
      7.144500506 7.969261268 8.278632467 8.369427024 8.126222048 6.292781104
      3.732977109 2.482392066 0.963029101 0.381827514 0.133722374 0.051133842
      0.016802564 0.001650406 0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0
# first two years of combo survey have sexes combined
2003  1     4     0     0     325.9 0.016977298 0.10729549  0.685954667
      1.245908999 1.812414002 2.294604174 2.049417247 2.306002954 2.836962205
      3.096995047 4.408095077 4.927655468 6.13508316  6.291431807 6.514241881
      7.05868904  7.079448637 7.502597158 8.043806064 8.848537121 6.603377687
      4.681184539 3.00704544  1.353034361 0.788505413 0.189761584 0.084455676
      0.013645784 0.005538015 0.008981887 0.00235212  0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0
2004  1     4     0     0     268.4 0.075136828 0.513641998 1.592444219
      2.537090666 2.503320792 2.913740372 2.504211668 2.882245288 3.042862318
      3.765655242 4.539418494 3.896340736 5.702031811 6.357266043 6.824147993
      6.744996533 7.386009732 7.970996425 7.363909018 7.126007053 5.960521235
      3.953121145 1.990893296 1.145704392 0.479692695 0.183004845 0.013770245
      0.017423088 0.00471061  0     0.009685218 0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0     0     0     0     0     0     0     0     0     0     0
      0     0
# later years with split sexes


                  # positive values for males for later years of NWFSC
survey


#_year      Season      Fleet gender      partition   inputN      F5    F6
      F7    F8    F9    F10   F11   F12   F13   F14   F15   F16   F17   F18
      F19   F20   F21   F22   F23   F24   F25   F26   F27   F28   F29   F30
      F31   F32   F33   F34   F35   M5    M6    M7    M8    M9    M10   M11
      M12   M13   M14   M15   M16   M17   M18   M19   M20   M21   M22   M23
      M24   M25   M26   M27   M28   M29   M30   M31   M32   M33   M34   M35
2005  1     4     3     0     301.1 0.023834044 0.209429608 0.891503967
      1.188157993 1.585361664 1.27425186  1.480040069 1.507411541 1.811418691
      2.00380362  2.073663213 3.249457068 3.79426374  3.756947572 3.542267166
      4.886348727 3.859849221 4.206661029 3.247162394 3.019972001 2.21710185
      1.621131972 0.925147977 0.487363563 0.123309025 0.091124087 0.008163022
      0.008713279 0     0     0     0.023833972 0.209429608 0.891503894
      1.18815792  1.585361664 1.274251716 1.47875486  1.500990625 1.861407013
      2.120323496 2.440414234 3.020655544 2.665979127 2.846801297 2.943514091
      3.392601406 3.006101282 2.958022793 2.890876506 2.559877526 2.740229801
      1.360608907 1.049024226 0.533703194 0.282193627 0.081521703 0     0
      0     0     0
2006  1     4     3     0     236.9 0.003873379 0.025142815 0.325001932
      0.739195599 1.025132917 1.559009414 1.549358764 1.600101453 1.427153547
      1.56542852  1.990364678 2.160134853 2.675703349 4.523524682 3.792145038
      5.116656746 3.654881451 4.689761834 3.430520275 4.234459015 2.704364777
      2.536443857 1.41446536  0.792560718 0.27175922  0.125953411 0.016160268
      0.008274891 0     0     0.003208503 0.003873304 0.02514274  0.322898254
      0.722912322 1.016991241 1.536645885 1.549325291 1.602870308 1.399984057
      1.581788349 1.95856342  2.096947367 2.168486897 2.740126549 2.881308245
      3.190593835 3.217598213 3.674955175 3.2875282   3.731337342 2.6621493
```

2.283190622 1.216973921 0.637265768 0.260763357 0.202243965 0.046920495
0.019874314 0 0 0
2007 1 4 3 0 188.5 0 0.041310689 0.196127802 0.394162903
0.521143093 1.309597741 1.302679895 1.397163094 1.00954718 1.373847573
1.807053725 2.70927443 2.093343041 4.933775647 4.011022635 4.706956184
4.708156517 6.011515937 4.479277369 4.270923627 3.081429554 2.574648643
1.069345754 0.494798041 0.282514986 0.273704129 0.007960922 0.008972985
0 0 0 0 0.041310689 0.196127802 0.394163065 0.52114293
1.29650019 1.348995529 1.526704372 1.00408256 1.33400789 1.919215793
2.536998462 1.655405377 3.377763345 3.289383536 3.549875886 3.179268976
3.662508993 3.873419358 3.222988124 2.272080834 2.224312704 1.377575302
0.633816063 0.375067504 0.099239391 0.01779123 0 0 0 0
2008 1 4 3 0 136.6 0.006434331 0.021015627 0.037608431
0.308448936 0.652008535 1.078780953 1.039638754 1.462027734 1.556573719
1.897688512 2.056922412 2.575431554 2.991685016 4.97639675 5.357631767
5.720556927 6.028160978 5.182828492 3.83932443 2.672837007 2.3886907
1.472256075 1.436021887 0.657442427 0.237428129 0.072397227 0.035529872
0 0 0 0 0.006434331 0.021015627 0.037608431 0.308448808
0.675647513 1.081317273 1.077452499 1.454103567 1.593198938 1.628675784
1.994831463 2.145981223 3.402510797 3.129855195 3.069417321 3.009745178
3.518696867 3.727449112 2.891466972 2.880914203 2.366089753 1.646682024
1.579468611 0.675233299 0.198948236 0.057658777 0.059381015 0 0
0 0
2009 1 4 3 0 124.4 0 0.001470907 0.103846854 0.186975791
0.215530015 0.522796182 0.822698472 1.291686037 1.404210314 1.52238319
1.87569801 1.586033364 2.007498998 2.976083384 3.208986653 4.554169235
6.13032388 5.631803833 4.139272797 4.947430157 3.029746702 2.312959179
1.311789571 0.930161831 0.528311055 0.304420917 0.101451096 0.001071405
0 0 0 0 0.001470907 0.155148995 0.186975651 0.215529806
0.522796182 0.860247421 1.418928239 1.457720804 1.80880141 2.123185478
2.095509601 2.793901061 2.997678881 3.634663793 4.38814402 4.383347694
3.807123224 3.452089847 3.148431958 4.042236723 2.174019233 1.539844362
0.667484078 0.399316203 0.072093614 0 0 0 0.004500988 0
2010 1 4 3 0 123 0 0.011939107 0.070103392 0.176694214
0.135831163 0.269067363 0.824793102 1.223563841 1.623179184 1.283977019
1.047553635 2.284455384 2.425440961 3.246306387 4.791873452 4.463005621
5.353375906 5.518588199 3.887824403 4.180952674 4.279420462 2.372079047
1.813464533 0.692045568 0.227943231 0.052399523 0.029604825 0 0
0 0 0 0.011939038 0.070103461 0.176694353 0.135831232
0.296096544 0.824793172 1.301636204 1.596786409 1.45462781 1.1835718
2.078492408 2.543003009 3.280009143 1.734322205 3.547219407 4.167239372
4.767395941 4.066574184 4.362432996 3.85786517 3.083109565 1.600073926
1.094430923 0.369815107 0.098906837 0.006295331 0 0 0.005252259
0
2011 1 4 3 0 166 0 0.002176549 0.123885702 0.241919387
0.237792034 0.458049235 0.529471711 0.5792734 1.230554293 1.40762895
1.35123436 1.625081989 2.906427333 3.482005642 3.692117555 4.556533089
5.257471451 5.602344471 4.373089917 4.240969689 3.680901861 1.602159869
1.892615347 0.802210007 0.526486235 0.097755553 0.109677274 0.009109501
0 0 0 0 0.002176389 0.123885622 0.241919627 0.237792113
0.458049395 0.529471551 0.579273479 1.227759064 1.420815791 1.361826268
1.644558692 2.058923404 2.549141701 3.097934328 4.490814821 4.729045259
5.588419458 4.46926455 4.394541356 4.069333691 2.448065248 2.092669638
1.019396222 0.392803831 0.118944476 0.024114652 0.01011697 0 0
0
2012 1 4 3 0 161.7 0.006334615 0.056531 0.311972555
0.411345122 0.448239813 0.607996266 0.625949877 0.60297571 0.676480614
1.663470163 1.667461339 2.182965997 2.149854946 2.128303432 3.445778854
4.820393509 5.058503455 5.044430401 4.333623282 5.155798837 3.890119752
2.261115936 1.855058028 1.179622452 0.324257759 0.120892158 0.050201851
0.008423679 0 0 0 0.006334548 0.056531067 0.309057261

```
      0.411345055 0.448239813 0.607413949 0.62594981  0.670384514 0.76372422
      1.630237763 1.724707884 2.2327766   2.259741876 3.242326662 3.079010978
      3.683478789 4.015369633 4.812729514 4.328038362 4.398509457 3.782370682
      2.557599128 1.792935157 1.035062651 0.309145809 0.096584224 0.032293189
      0    0    0    0
#  End  Comps
0  #  N  age'  bins
0  #  number  of  ageerr  matrices  to  generate
0  #  N  age  observations
2  #  Length  bins  range  method
0  #  Combine  males  into  females  below  this  age  bin  number.
0  #  N  size@age  observations;  values  on  row1;  N  on  row2
0  #  environmental  data  N  variables
0  #  environmental  data  N  observations
0  #  No  WtFrequency  methods
0  #  No  Tagging  data
0  #  No  Morph  data
999  #  end  of  file
```

## Appendix B. SS control file

```
##########################################
# Longspine Thornyhead control file
##########################################
#
1  # N growthmorphs
1  # N submorphs within growth patterns
#
#
2 # Block designs
3 3 # Blocks in each design
# design 1
1992 2006 # design 1, block 1
2007 2010 # design 1, block 2
2011 2012 # design 1, block 3
# design 2
1992 2006 # design 1, block 1
2007 2010 # design 1, block 2
2011 2012 # design 1, block 3
#
# Mortality and growth specifications
0.5     # Fraction female at birth
1       # M setup: 0=single
Par,1=N_breakpoints,2=Lorenzen,3=agespecific;_4=agespec_withseasinterpolat
e
2       # Number of M breakpoints
11 12   # Ages at M breakpoints
1       # Growth model: 1=VB with L1 and L2, 2=VB with A0 and Linf,
3=Richards, 4=Read vector of L@A
3       # Age for growth Lmin
# Try changing to 45
40      # Age for growth Lmax or 999 = Linf
#
# Try changing to 0, since that's what they now do.
#
0.1     # SD constant added to LAA (0.1 mimics v1.xx for compatibility
only)
#
0       # Variability about growth: 0=CV~f(LAA) [mimic v1.xx], 1=CV~f(A),
2=SD~f(LAA), 3=SD~f(A)
1       # Maturity option: 1=length logistic, 2=age logistic, 3=read age-
maturity matrix by growth_pattern
2       # First age allowed to mature
1       # fecundity option
0       # hermaphro
3       # mg parm offset option:
#
#old key: 1=direct assignment, 2=each pat. x gender offset from pat. 1
gender 1, 3=offsets as SS2 V1.xx with M old
#new key: 1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2
V1.x)
#
1       # mg parm adjust method 1=do V1.23 approach, 2=use logistic
transform between bounds approach
#
#
# LO  HI  INIT  PRIOR  PR type  SD  PHASE  env-variable  use dev  dev
minyr  dev maxyr  dev stddev
#
```

```
# Females
#
# Fixed prior, prior type, sd
# Try estimating VBK
0.001  0.3    0.11131269618101   -2.195436 3 0.52067   -4  0  0  0  0  0.5
0  0  #M1 natM young
-1.001  3      0         0         -1  99  -5  0  0  0  0  0.5  0  0  #M1
natM old as exponential offset(rel young)
5       25     8.573     10        -1  99  -2  0  0  0  0  0.5  0  0  #M1
Lmin
5       40     27        30        -1  99   2  0  0  0  0  0.5  0  0  #M1
Lmax
0.05    0.2    0.064     0.1       -1  99   3  0  0  0  0  0.5  0  0  #M1
VBK
0.015   0.25   0.131     0.1       -1  99  -6  0  0  0  0  0.5  0  0  #M1
CV-young
-3      5     -0.892     0         -1  99  -6  0  0  0  0  0.5  0  0  #M1
CV-old as exponential offset(rel young)
#
# Males
#
-3  3  0   0   -1  99  -4   0  0  0  0  0.5  0  0  #M1 natM young
-3  3  0   0   -1  99  -3   0  0  0  0  0.5  0  0  #M1 natM old as
exponential offset(rel young)
-3  3  0   0   -1  99  -2   0  0  0  0  0.5  0  0  #M1 Lmin
-3  3  0   0   -1  99  -2   0  0  0  0  0.5  0  0  #M1 Lmax
-3  3  0   0   -1  99  -2   0  0  0  0  0.5  0  0  #M1 VBK
0  0  0  0  -1  99  -6  0  0  0  0  0.5  0  0  #M1 CV-young
-3  5  -0.892  0  -1  99  -6  0  0  0  0  0.5  0  0  #M1 CV-old as
exponential offset(rel young)
#
# gender lines to read the wt-Len and mat-Len parameters
#
-3  3  4.3E-06  4.4E-06  -1  99 -3  0  0  0  0  0.5  0  0  #Female wt-len-
1
-3  8  3.352  3.34694  -1  99 -3  0  0  0  0  0.5  0  0  #Female wt-len-2
0.001  40  17.826  20  -1  99 -3  0  0  0  0  0.5  0  0  #Female mat-len-1
-3  3  -1.79  -0.8  -1  99  -3  0  0  0  0  0.5  0  0  #Female mat-len-2
-3  3  1.  1.  -1  99  -3  0  0  0  0  0.5  0  0  #Female eggs/gm
intercept
-3  3  0.  0.  -1  99  -3  0  0  0  0  0.5  0  0  #Female eggs/gm slope
#
# Male wt-len
-3  3  4.3E-06  4.4E-06  -1  99  -3  0  0  0  0  0.5  0  0  #Male wt-len-1
-3  8  3.352  3.34694  -1  99  -3  0  0  0  0  0.5  0  0  #Male wt-len-2
#
0  1  1  1  -1  50  -50  0  0  0  0  0  0  0  # Recruitment apportionment
by growth pattern
0  1  1  1  -1  50  -50  0  0  0  0  0  0  0  # Rec app by Area
0  1  1  1  -1  50  -50  0  0  0  0  0  0  0  # Rec app by Season
0  1  1  1  -1  50  -50  0  0  0  0  0  0  0  # Cohort growth deviation
#
#
# Seasonal effects on biology parameters (0=none)
 0 0 0 0 0 0 0 0 0 0
#
# Spawner-Recruitment parameters
6  # SR fxn:  1=Beverton-Holt
#  LO  HI  INIT  PRIOR  Pr_type  SD    PHASE
3     31   12.   9.3     3      99     1  #Ln(R0)
0.2    1   0.6   0.6    -1       0.2   -4  #steepness
```

```
0      2   0.6   0.65   -1       99    -4  #SD recruitments
-5     5   0     0      -1       99    -3  #Env link
-5     5   0     0      -1       99    -4  #init eq
-1     1   0     0      -1       100   -1  # placeholder for
Autocorrelation
#
0 # index of environmental variable to be used
0 # env target parameter: 0=none, 1=rec devs, 2=R0, 3=steepness
#
#  Recruitment residuals
1     #_do_recdev:  0=none; 1=devvector; 2=simple deviations
1944  # first year of main recr_devs; early devs can preceed this era
2012  # last year of main recr_devs; forecast devs start in following year
3     #_recdev phase
1     # (0/1) to read 13 advanced options
0     #_recdev_early_start (0=none; neg value makes relative to
recdev_start)
-4    #_recdev_early_phase
5     #_forecast_recruitment phase (incl. late recr) (0 value resets to
maxphase+1)
1     #_lambda for Fcast_recr_like occurring before endyr+1
1980  #_last_early_yr_nobias_adj_in_MPD
1986  #_first_yr_fullbias_adj_in_MPD
2007  #_last_yr_fullbias_adj_in_MPD
2012  #_first_recent_yr_nobias_adj_in_MPD
0.3388     #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0
for all estimated recdevs)
0     #_period of cycles in recruitment (N parms read below)
-5    #min rec_dev
5     #max rec_dev
0     #_read_recdevs
#
# Fishing mortality setup
0.06    # F ballpark for tuning early phases
1999    # F ballpark year
1       # F method:  1=Pope's; 2=Instan. F; 3=Hybrid (recommended)
0.9     # max F or harvest rate, depends on F_Method
#
# Initial Fishing Mortality Parameters
0  1  0  0.01  -1  99  -1
#
# Catchability Specification (Q_setup)
#_Den-dep  env-var  extra_se  Q_type
0          0        0         0 # 1 Fishery
0          0        0         0 # 2 AFSC Slope
0          0        0         0 # 3 Early Slope
0          0        0         0 # 4 Late Slope
#
#
# Selectivity Specification
# Type   Retent  Moffset Special
# Length
#24  1  0  0  # Comm. Trawl
#24  0  0  0  # Alaska SLope
#24  0  0  0  # Early Slope
#24  0  0  0  # Late Slope
1   1  0  0  # Comm. Trawl
24  0  0  0  # Alaska SLope
1   0  0  0  # Early Slope
1   0  0  0  # Late Slope
# Age selex
```

```
10  0  0  0  # Comm. Trawl
10  0  0  0  # Alaska Slope survey
10  0  0  0  # Early Slope survey
10  0  0  0  # Late Slope survey
#
#
# Size selectivity for commercial fishery
#
#_LO    HI    INIT   PRIOR   PR_type SD  PHASE   env-var use_dev dev_min
dev_max dev_SD  Block   Block_Fxn
 6.5    25      10    20       0      1    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
.01     25      5     -0.5    -1      2    3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
# 6.5   34.5     20   20      -1      5    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
#-7     7         0   -0.5    -1      2   -3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
#-5     10        3   1.75    -1      5    3   0    0    0    0    0    0
0    # SizeSel_3P_3_Type24_size_double-normal
#-5     20       10   0.1     -1      2   -4   0    0    0    0    0    0
0    # SizeSel_3P_4_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_5_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_6_Type24_size_double-normal
#
# Retention for Commercial Fishery
#
2       40  10  19  -1  99  3    0  0  0  0  0.5  1  3  #infl for logistic
0.00001 30   3  10  -1  99  3    0  0  0  0  0.5  0  0  #95%width for
logistic
0.0001  1.   .97  1  -1  99  4  0  0  0  0  0.5  2  3  #final
-10.    5  0.0 0.0  -1  99  -4   0  0  0  0  0.5  0  0
#
# Size selectivity for slope surveys (double normal)
#
#_LO    HI    INIT   PRIOR   PR_type SD  PHASE   env-var use_dev dev_min
dev_max dev_SD  Block   Block_Fxn
 6.5   34.5     20   20      -1      5    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
#-7     7       -2   -0.5    -1      2    3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
-20     7       -2   -0.5    -1      2    3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
-5     10        3   1.75    -1      5    3   0    0    0    0    0    0
0    # SizeSel_3P_3_Type24_size_double-normal
-5     20        5   0.1     -1      2    4   0    0    0    0    0    0
0    # SizeSel_3P_4_Type24_size_double-normal
-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_5_Type24_size_double-normal
-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_6_Type24_size_double-normal
#
#_LO    HI    INIT   PRIOR   PR_type SD  PHASE   env-var use_dev dev_min
dev_max dev_SD  Block   Block_Fxn
 6.5    25      10    20       0      1    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
.01     25      5     -0.5    -1      2    3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
```

```
# 6.5   34.5     20   20      -1      5    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
#-7     10        0   -0.5    -1      2   -3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
#-5     10        3   1.75    -1      5    3   0    0    0    0    0    0
0    # SizeSel_3P_3_Type24_size_double-normal
#-5     20       10   0.1     -1      2   -4   0    0    0    0    0    0
0    # SizeSel_3P_4_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_5_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_6_Type24_size_double-normal
#
#_LO    HI    INIT   PRIOR   PR_type SD  PHASE   env-var use_dev dev_min
dev_max dev_SD  Block   Block_Fxn
 6.5    25      10     20       0      1    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
.01     25      5     -0.5    -1      2   3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
# 6.5   34.5     20   20      -1      5    2   0    0    0    0    0    0
0    # SizeSel_3P_1_Type24_size_double-normal
#-7     7         0   -0.5    -1      2   -3   0    0    0    0    0    0
0    # SizeSel_3P_2_Type24_size_double-normal
#-5     10        3   1.75    -1      5    3   0    0    0    0    0    0
0    # SizeSel_3P_3_Type24_size_double-normal
#-5     20       10   0.1     -1      2   -4   0    0    0    0    0    0
0    # SizeSel_3P_4_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_5_Type24_size_double-normal
#-999   15     -999   0       -1      5   -99  0    0    0    0    0    0
0    # SizeSel_3P_6_Type24_size_double-normal
##
1 #_custom_sel-blk_setup (0/1)
#### BLOCK PARAMETERS FOR EACH FLEET
#_LO  HI    INIT  PRIOR PR_type    SD    PHASE
-10   10    0     0     0     5     5     #
      Retain_1P_1_Fishery_BLK1delta_1992
-10   10    0     0     0     5     5     #
      Retain_1P_1_Fishery_BLK1delta_2006
-10   10    0     0     0     5     5     #
      Retain_1P_1_Fishery_BLK1delta_2011
-0.3  0.3   0     0     0     0.2   5     #
      Retain_1P_3_Fishery_BLK2delta_2006
-0.3  0.3   0     0     0     0.2   5     #
      Retain_1P_3_Fishery_BLK2delta_2006
-0.3  0.3   0     0     0     0.2   5     #
      Retain_1P_3_Fishery_BLK2delta_2011
#
2 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in
base parm bounds; 3=standard w/ no bound check)
#
0   # TG_custom
#
#
### Likelihood related quantities ###
# variance/sample size adjustment by fleet
1 # Do variance adjustments
0 0 0 0 #_add_to_survey_CV
0 0 0 0 #_add_to_discard_stddev
0 0 0 0 #_add_to_bodywt_CV
#0.5805589 0.4230162 0.3483933 1 #_mult_by_lencomp_N
```

```
0.7808988  0.426327 0.39508358 3.549658
1 1 1 1 #_mult_by_agecomp_N
1 1 1 1 #_mult_by_size-at-age_N
#
5  # max lambda phases: read this Number of values for each componentxtype
below
1  # include (1) or not (0) the constant offset For Log(s) in the
Log(like) calculation
#
3  # N lambda changes
# Like_comp  Fleet  Phase  Value  Size_Freq_Method
17  999  2  0.1  999
17  999  3  0.01  999
17  999  5  0  999
#
0 # Extra SC pointer
#
999  # End-of-file
```

# Appendix C. SS starter file

```
# Longspine Thornyhead starter file for SS v3.x

LST_data.SS      # Data file
LST_control.SS  # Control file

0     # Read initial values from .par file: 0=no,1=yes
1     # DOS display detail: 0,1,2
2     # Report file detail: 0,1,2
0     # Detailed checkup.sso file (0,1)
0     # Write parameter iteration trace file during minimization
2     # Write cumulative report: 0=skip,1=short,2=full
1     # Include prior likelihood for non-estimated parameters
0     # Use Soft Boundaries to aid convergence (0,1) (recommended)
1     # N bootstrap datafiles to create
25    # Last phase for estimation
1     # MCMC burn-in
1     # MCMC thinning interval
0     # Jitter initial parameter values by this fraction
-1    # Min year for spbio sd_report (neg val = styr-2, virgin state)
-2    # Max year for spbio sd_report (-1=endyr+1, -2=entire forecast)
0     # N individual SD years
0.0001     # Ending convergence criteria
0     # Retrospective year relative to end year (i.e. -4)
2     # Min age for summary biomass
1     # Depletion basis: denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel
X*B_styr
1     # Fraction (X) for Depletion denominator (e.g. 0.4)
1     # (1-SPR)_reporting:  0=skip; 1=rel(1-SPR); 2=rel(1-SPR_MSY);
3=rel(1-SPR_Btarget); 4=notrel
1     # F_std reporting: 0=skip; 1=exploit(Bio); 2=exploit(Num);
3=sum(frates)
#0 45    #_min and max age over which average F will be calculated
0     # F_report_basis: 0=raw; 1=rel Fspr; 2=rel Fmsy ; 3=rel Fbtgt

999 # end of file marker
```

## Appendix D. SS forecast file

```
#V3.21d
#
#C LST 2013 forecast file
#
# for all year entries except rebuilder; enter either: actual year, -999
for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to
F(endyr)
0.5 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
# Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF
(enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0 0 0
#  2010 2010 2010 2010 2010 2010 # after processing
1 # Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast
below
#
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-
last relF yrs); 5=input annual F scalar
12 # N forecast years
0.20 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual
year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0
#  1180659524 1667592815 7631713 0 # after processing
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.40 # Control rule Biomass level for constant F (as frac of Bzero, e.g.
0.40); (Must be > the no F level below)
0.10 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
1 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch
with allocations applied)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
#-65534 #_Forecast loop control #5 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2013  #FirstYear for caps and allocations (should be after years with
fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0
to cause active impl_error)
1 # Do West Coast gfish rebuilder output (0/1)
2001 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1
to set to 1999)
2011 # Rebuilder:  year for current age structure (Yinit) (-1 to set to
endyear+1)
1 # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x
fleet(col) below
# Note that fleet allocation is used directly as average F if
Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation
(2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F:  rows are seasons, columns are fleets
#_Fleet:  FISHERY
#  0
```

```
# max totalcatch by fleet (-1 to have no max) must enter value for each
fleet
-1
# max totalcatch by area (-1 to have no max); must enter value for each
fleet
-1
# fleet assignment to allocation group (enter group ID# for each fleet, 0
for not included in an alloc group)
0
#_Conditional on >1 allocation group
#_allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from
forecast F)
2 # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input
Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
#
999 # verify end of input
```

# Longspine Thornyhead

# Stock Assessment Review (STAR) Panel Report

**NOAA Fisheries**
**Northwest Fisheries Science Center**
**2725 Montlake Blvd.**
**July 22-26, 2013**

**STAR Panel Members**

| | |
|---|---|
| Meisha Key (Chair) | California Department of Fish and Wildlife, PFMC Scientific and Statistical Committee (SSC) |
| Ray Conser | Fish Stock Assessment Consulting, LLC |
| Yan Jiao | Center for Independent Experts (CIE) |
| Jean Jacques Maguire | Center for Independent Experts (CIE) |

**Pacific Fishery Management Council (PFMC) Advisors**

| | |
|---|---|
| Corey Niles | Washington Department of Fish and Wildlife, PFMC Groundfish Management Team (GMT) |
| Pete Leipzig | Fishermen's Marketing Association, PFMC Groundfish Advisory Subpanel (GAP) |
| John DeVore | PFMC Staff |

**Stock Assessment Team (STAT)**

| | |
|---|---|
| Andi Stephens | NMFS, Northwest Fisheries Science Center |
| Ian Taylor | NMFS, Northwest Fisheries Science Center |

## Overview

A draft assessment of the longspine thornyhead (*Sebastolobus altivelis*) off the U.S. west coast was reviewed by the STAR panel during July 22-26, 2013. This assessment was presented to the STAR Panel by Dr. Andi Stephens (lead STAT author) and used the Stock Synthesis platform (version 3.24o). The last full assessment of longspine thornyhead was conducted in 2005 (Fay 2005). This Panel also reviewed the shortspine thornyhead assessment during the same week (see separate Shortspine Thornyhead STAR Panel Report) and to the extent possible, strove to ensure a consistent treatment of the catch data, influence of fishery regulations, and population vital rates.

Longspine thornyhead occur from the southern tip of Baja, California, to the Aleutian Islands. There appears to be no distinct geographic breaks in stock abundance along the west coast. Adult longspine thornyhead are bottom dwellers, and inhabit the deep waters of the continental slope throughout their range. They are associated with Dover sole, sablefish and shortspine thornyhead.

Dr. Stephens reviewed the fisheries and the data used in the analysis. Following the initial presentation and discussion of the assessment, the Panel made written requests to the STAT for additional analyses. Upon completion, the STAT presented the results to the Panel which in turn, made additional requests related to the questions and issues arising from the new material. This process was repeated four times during the week until a base case was achieved and the uncertainty was fully characterized, to the extent possible given the time available.

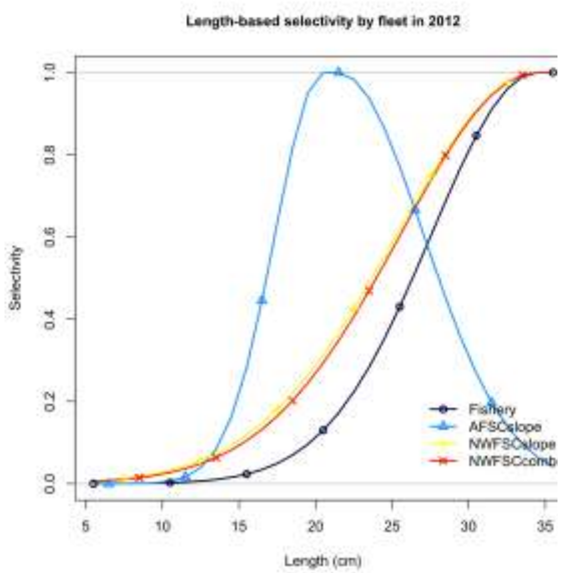
Stock depletion in 2013 ($SSB_{2013}/SSB_0$) is estimated to be 0.752 with an increasing trend in SSB during recent years. The stock status appears to be healthy and robust to the data and modeling scenarios explored by the Panel. Recent fishing mortality rates are less than the $F_{MSY}$ proxy and recent SSB are well above the target and limit reference points. However, important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are particularly lacking for longspine thornyhead, making the stock assessment only marginally sufficient to estimate the status of the resource. In particular, although the SSB trend is fairly robust, the data and modeling are not informative as to the scale of SSB. $R_0$ is used as a proxy to bracket the uncertainty in the decision table.

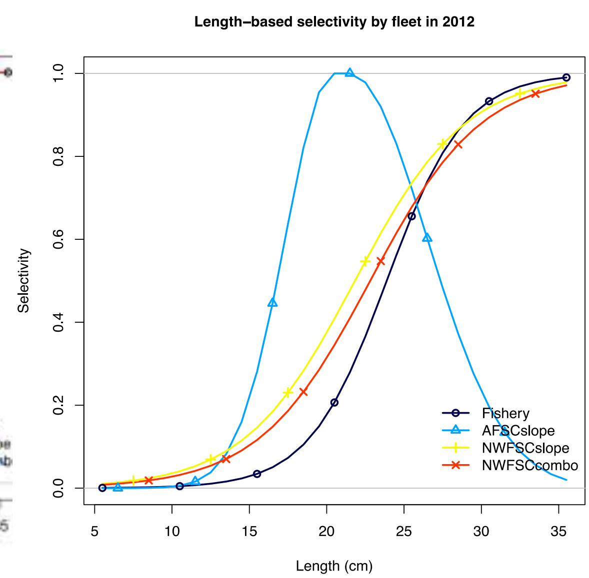
The STAR panel thanks the STAT for their willingness to respond to panel requests. The STAR panel would also like to thank the contributions from the GMT and GAP Advisors. The STAR panel concluded that the longspine thornyhead assessment was based on the best available data, and that this new assessment constitutes the best available information on longspine thornyhead off the U.S. west coast.

## Discussion and Additional Analyses Requested by the STAR Panel

### STAR Panel Requests

1. Reformulate the selectivities for the 2 NWFSC surveys and the fishery using a logistic selectivity function (keep double normal for AFSC slope survey). Fix or put a strong prior for hitting selectivity of 1 in the range of the observations. *Rationale: This would give a selectivity that is more intuitive with the data and may help reduce the catchability (q) estimates that are currently greater than 1. [The selectivity parameters were hitting bounds.]*
**Response: The selectivity patterns look similar with the normal distribution curve, and the posterior of the size at 50% selectivity is far greater than the mean of the prior. These changes were in the right direction with a higher selection of observed lengths and *q* for the surveys decreased. The STAR panel recommended logistic curves be used for the fishery and the 2 NWFSC surveys.**




2. Slide 19 of the presentation – the variability in growth for males and females are different. Need to explain why there is a difference. *Rationale: These were expected to be the same as growth parameters were fixed at the same values for both genders (offsets set to zero). The male 95% CIs were slightly larger than the female.*
**Response: There was a mis-setting in the offset for male growth CV. This was corrected.**

3. Calculate gender ratio for NWFSC combo survey. *Rationale: To validate model assumption of 1:1 gender ratio by length.*
**Response: The ratios were randomly varying around 1:1.**

4. Estimate growth parameter K instead of fixing it. *Rationale: Growth does not reach asymptote until well after the assumed maximum age of 45. This may have an influence on selectivity and catchability (q).*
**Response: Estimating K provided more intuitive growth curves. Visually there were some differences observed in the estimated selectivity for the fishery and the 3 surveys. The estimated *q* for all 3 surveys doubled, which implied that the estimated biomass would be 50% of the model fixing K if other parameters didn't change.**

5. Slide 50 of the presentation - in the likelihood profile, clarify if "discards" are for discards rates or discard length composition? *Rationale: For clarification of the results.*
**Response: Discard rates are used.**

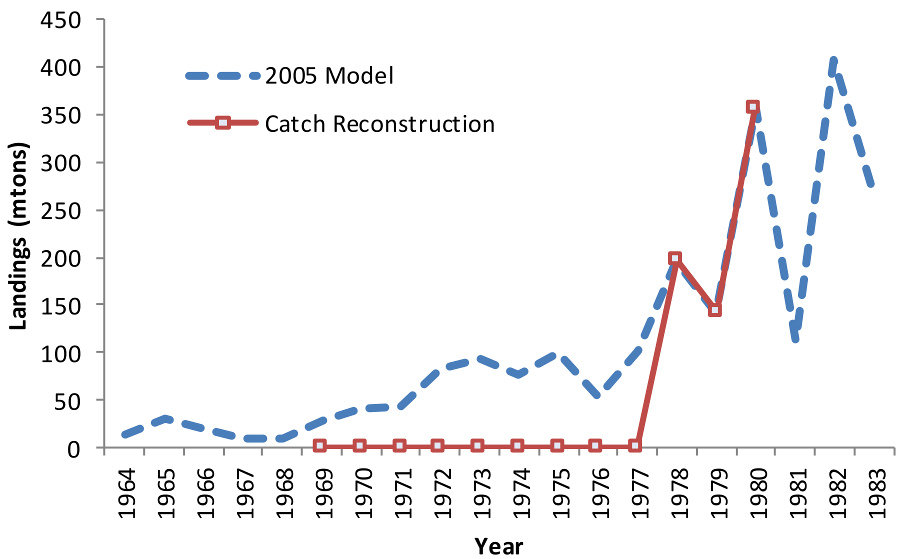
6. Implement the selectivity change (logistic except for AFSC slope survey) and estimate K. *Rationale: To compare these changes with original base case results. (This is a followup from #1 and #4 above – combining the two.)*
**Response: STAT provided corresponding results for further diagnostics. The estimated biomass was about 10% lower although *q* doubled, which can be explained by a higher % of selectivity for both the fishery and the 2 NWFSC surveys. This new model indicated an improvement in the size of selected fish and expected growth patterns.**

| | Base Model | New Model |
|---|---|---|
| Estimated | Ln(R0) LRef2 | Ln(R0) LRef2 K |
| Selectivities | Double-Normal | Double-Normal and Logistic |
| Likelihood | 135.26 | 126.21 |
| K | 0.064 | 0.106 |
| L Ref2 | 27.01 | 27.8 |
| LN(R0) | 12.73 | 11.85 |
| Q | 1.44 2.32 4.03 | 3.29 3.01 4.77 |
| Depletion | 0.8 | 0.7 |
| SPB | 45065 | 40194 |
| Gradient | 2.5 e -04 | 3.8 e -04 |

7. Blocks for retention curve: 1964-2006, 2007-2010, from 2011 onward. *Rationale: There are no obvious reasons to have 7 blocks. This suggestion is based on the comments from panel members and the GMT and GAP advisors.*
**Response: The results of retention and estimated discard fractions were compared with the original 7 blocks and the sensitivity run in Request 8. The discard fraction appeared more reasonable through time with less blocking.**

8. Sensitivity to #7 block retention: 1964-1991, 1992-2006, 2007-2010, from 2011 onward. *Rationale: Add a block to consider the change in mesh size beginning in 1992. Minimum mesh size changed from 3 to 4.5".*
**Response: This blocking scheme is recommended to be used in the base model. 4 blocks (over the 3 block scenario) provided a better fit, with reasonable time blocking, and lower *q*s.**

9. Use historical catch reconstruction estimates with the addition of the foreign fleet catch from the 2005 assessment. *Rationale: To be consistent with the request for shortspine thornyheads, as well as with other stock assessments. Efforts were made to improve historical catch estimates for stock assessments and the comparison needs to be evaluated.*
**Response: The reconstructed catches from the 1969-1977 time period were extremely low and impractical. The GMT and GAP advisors discussed the port sampling and market category problems. However, this doesn't influence the results. The STAR panel suggested that the 2005 stock assessment catch reconstruction be used until there is a better understanding of how species compositions were applied for the thornyhead market category in the earlier years.**



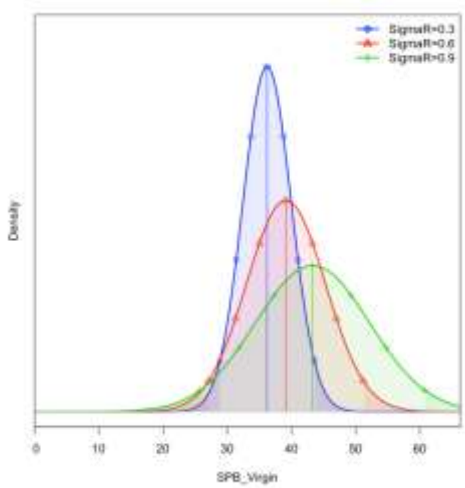

The STAT team provided one extra sensitivity run involving turning off the recruitment deviations. It turns out that the estimated biomass is 3 times of that with recruitment deviation.

10. Sensitivity: If blocking retention curves does not reduce discard rates in 1964-1988, assume smaller discard rates (25% rather than 50%) for 1964-1988. This will imply changing the retention function. *Rationale: Investigate how the estimated discarding rate, which seemed high to the GAP and GMT advisors, in the earlier years influence the results.*

**Response: The new blocking retention curves (requests 7 & 8) did reduce the discard rate.**

11. Show the retention curves and estimated discard rates for new base, 3 blocks and 4 blocks? *Rationale: To determine an appropriate retention time blocking.*
**Response: 4 blocks were suggested after balancing model fits, differences among retention curves and fishery history. [Already concluded in request 8.]**

12. Sensitivity to sigmaR that is fixed at 0.6, for the values of 0.3 and 0.9. *Rationale: Investigate the influence of using fixed sigmaR.*
**Response: The results were sensitive to sigmaR as to both the mean and the uncertainty of the SSB.**




13. Compare actual biomass (SSB) estimates to the 2005 stock assessment. *Rationale: Scales of the results changed largely among different model/data runs.*
**Response: The scales of the SSB were very different with the SSB in 1964 from this assessment estimated at 45,523 mt compared to 105,157 mt from the 2005 assessment. The overall trends of the two assessments were generally the same. Reasons were not explored because of time limitations.**

14. Do the retrospective analysis with the new base case, and jitter. *Rationale: These are standard model diagnostics.*
**Response: Nothing unusual; results were very stable, with data being removed one year at a time, back to 2007. The jitter runs indicated model stability and good convergence.**

15. Show profiles on $R_0$, M and $h$, with SSB and depletion presented across different parameter values. *Rationale: Further to justify parameter values to be fixed or estimated, and help identify critical parameters to bracket uncertainty.*
**Response: M=0.06 resulted in a likelihood profile with the lowest position. The STAT felt this did not reflect the life history of longspine thornyhead according to**

**the maximum age observed. The conclusion was to use 0.111 (the mean of the prior developed by Hamel 2013) and not to use M to bracket uncertainty. The model has no information to estimate M and the scale of biomass led to more focus on the $R_0$ profile. The profile on *h* reached 1 for the best estimate. Ln($R_0$) likelihood profile was provided, and the results indicated that this parameter is more appropriate to be used to bracket uncertainty. The longspine thornyhead assessment did not have quite the scaling problem, compared to the shortspine thornyhead assessment.**

## Description of Base Model and Alternative Models Used to Bracket Uncertainty

The changes made to the 2005 assessment, prior to this STAR were as follows: fisheries are grouped into one fleet because the non-trawl fishery component is minimal; the estimate of M was changed from 0.06 (estimated in the 2005 model) to 0.111313 (fixed at the mean of the prior developed by Hamel 2013); and steepness (*h*) was changed from 0.75 to 0.6.

Data used in the base model:

- Full catch history (with discard estimates) from 1964-2012 and fishery length frequency data (as available).
- Three surveys along with their respective length frequency data:
    - AFSC Slope: 1997, 1999-2001
    - NWFSC Slope: 1998-2002
    - NWFSC Shelf/Slope Combo: 2003-2012

Model structure:

- Single stock in USA waters – Canadian border to Mexican border
- One fishery (trawl and non-trawl combined)
- Begin model in 1964
- Recruitment deviations estimated from 1944+
- Beverton-Holt stock recruit relationship
- M = 0.111 fixed
- h = 0.6 fixed
- sigma-R = 0.6 fixed
- K and L at $A_{max}$ growth parameters estimated
- Ln($R_0$) estimated
- Selectivities estimated for all fisheries and surveys

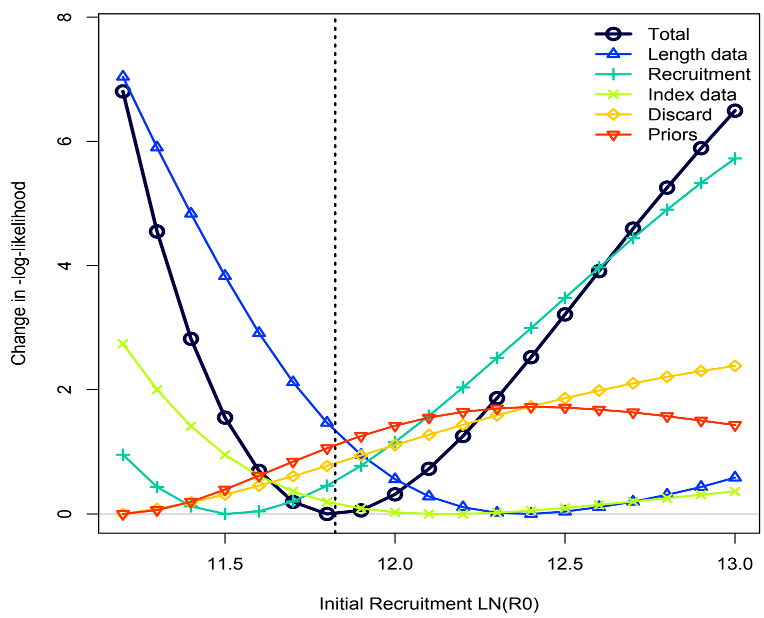
Starting with the model configuration described in the draft assessment document, the following changes were made to create a new base case:

- Errors were corrected (offset for male growth CV).
- Selectivities of the fishery and the 2 NWFSC surveys were changed to logistic instead of double normal.
- Growth parameter K was estimated instead of being fixed.

- Retention blocking: 1964-1991, 1992-2006, 2007-2010, from 2011 onward instead of 7 time blocks.

Uncertainty boundaries (low and high states of nature) were determined as follows:

a. Take the 12.5% quantile in 2013 spawning biomass estimate from the base model as the low state of nature (from the Delta Method normal approximation of variance).
b. Calculate the approximate $R_0$ value associated with it from the likelihood profile on $R_0$.
c. Determine the change in likelihood at the alternative $R_0$ value.
d. Add the change in the likelihood to the base model to determine the upper $R_0$ value from the likelihood profile to get the high state of nature. If the upper state of nature is over the largest reasonable value from sensitivity runs, then instead choose an $R_0$ value that represents a change in likelihood of 1.2 units from the low state of nature (the distance in log likelihood space from the 12.5% to 87.5% quantiles).




## Comments on the Technical Merits of the Assessment

The STAR panel agreed that this stock assessment is based on the best available data and best available science. However, important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are particularly lacking for longspine thornyhead, making the stock assessment only marginally sufficient to estimate the status of the resource.

This Panel suggests not conducting another full stock assessment on this stock until pertinent information is available for improvement. In the meantime, using an index of abundance (ie. NWFSC Combo Survey) to detect trends should be sufficient.

## Areas of Disagreement

There were no areas of disagreement among the Panel members nor between the Panel and the STAT.

## Unsolved Problems and Major Uncertainties

The STAT and the STAR Panel were not able to conclude whether the historical catch reconstruction is correct or not. Further investigation on how the species compositions were applied to the thornyhead market category in earlier years needs to be evaluated and documented.

The validation of the scale of the SSB is difficult, and the scale of SSB is sensitive to minor changes in re-parameterization and data scenarios.

## Concerns Raised by the GMT and GAP Advisors During the Meeting

The GMT and GAP Advisors expressed many of the same concerns over the historical catch, estimating discards in the model, and the retention and selectivity curves that were raised and described in this STAR Panel's report for Shortspine Thornyhead. In particular for Longspine, the GAP Advisor highlighted that the differences in the survey and the fishery selectivity do not match expectations. Both advisors were satisfied with the Panel and STAT's exploration of these issues and believe the sensitivity and uncertainty in model results were adequately captured in the Decision Table's states of nature.

## Research Recommendations

1. Investigate historical catch reconstruction for thornyheads. Potentially have a workshop to sort out the catch histories for longspine and shortspine thornyheads. Washington also needs to complete their historical catch reconstruction so there is a move in a forward direction for formally reviewing all of the west coast estimates.
2. Evaluate the influence of the fixed parameters by providing likelihood profiles for these parameters for different values, or release some of the fixed parameters step by step to investigate the influence of each.
3. Ageing method validation and further otolith reading.
4. Use simpler methods of providing management advice based on the estimated biomass from the NWFSC combo survey.

## References

Ralston, S., D.E. Pearson, J.C. Field, and M. Key. 2010. Documentation of the California catch reconstruction project. NOAA Technical Memorandum. NMFS, NOAA-TM-NMFS-SWFSC-461.

Agenda Item G.3.a
Attachment 9 (Full Version, Electronic Only)
September 2013

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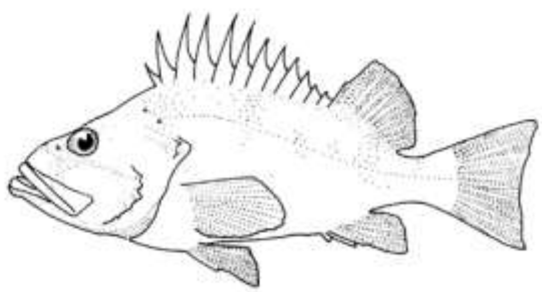
# Status and Productivity of Cowcod, *Sebastes levis*, in the Southern California Bight, 2013

by

E.J. Dick and Alec D. MacCall



Fisheries Ecology Division
Southwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
110 Shaffer Road
Santa Cruz, California 95060

DRAFT
August 19, 2013

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# Executive Summary

## Stock

This is an assessment of *Sebastes levis* ("cowcod" rockfish) in the Southern California Bight (SCB), defined as U.S. waters off California and south of Point Conception (34° 27' North latitude). Waters north and south of the SCB are not considered in the assessment due to sparse data. Hess et al. (submitted) recently used genetic tools to study cowcod population structure from California to Oregon. Specifically, they tested the hypothesis that a phylogeographic boundary exists at Point Conception. Their results supported a hypothesis of two primary lineages with a geographic boundary falling in the vicinity (slightly south) of Point Conception. Both lineages co-occur in the Southern California Bight (SCB), with no clear pattern of depth stratification or spatial structure within the Bight. Within lineages, there is evidence for considerable gene flow across the Point Conception boundary. Cowcod found north of Point Conception consist primarily of a single lineage, also found in northern areas of the SCB. No information is available regarding dispersal between U.S. and Mexican waters.

## Catches

Commercial catches of cowcod declined in the 1930s and 1940s due to changes in targeting (effort shifts to shark and sardine fisheries) and the Second World War. Post-war increases in commercial and recreational landings through the early 1980s were followed by a rapid declines in catch through the 1990s (Figure a). The stock was declared overfished in 2000, and retention of cowcod was prohibited from January 2001 until January 2011. Since then, a small quota has been allocated to the trawl fishery as part of the Pacific Groundfish Trawl Rationalization Program, but retention remains prohibited in all other sectors. Recreational and commercial catch estimates in this assessment are identical to those in the previous assessment for years prior to 1969. Commercial catches 1969 and recreational catches since 1981 were updated with the latest available estimates, resulting in only minor changes since the last assessment. Estimates of total annual removals for cowcod over the last ten years have not exceeded 1 mt (Table a).

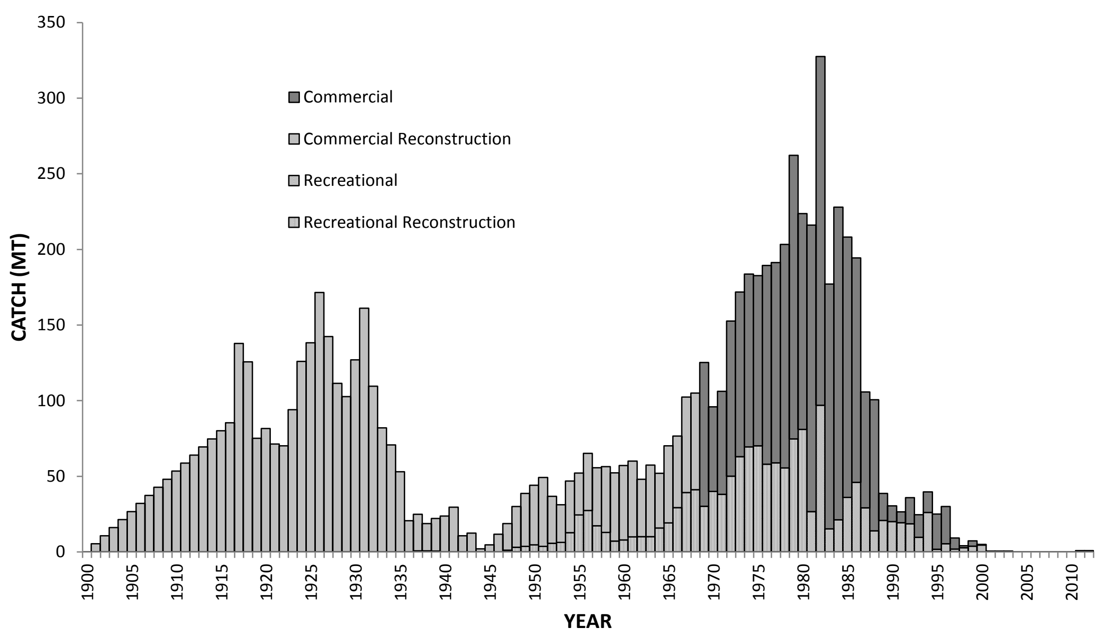


Figure a. Estimated commercial and recreational removals of cowcod in the Southern California Bight, 1900-2012.

Table a: Recent cowcod removals (mt).

| Year | Recreational | Commercial | Total |
|---|---|---|---|
| 2003 | 0.48 | 0.00 | 0.48 |
| 2004 | 0.45 | 0.41 | 0.86 |
| 2005 | 0.15 | 0.00 | 0.15 |
| 2006 | 0.07 | 0.00 | 0.07 |
| 2007 | 0.11 | 0.10 | 0.21 |
| 2008 | 0.25 | 0.00 | 0.25 |
| 2009 | 0.21 | 0.00 | 0.21 |
| 2010 | 0.17 | 0.00 | 0.17 |
| 2011 | 0.83 | 0.00 | 0.83 |
| 2012 | 0.82 | 0.00 | 0.82 |

## Data and assessment

This assessment uses Extended Depletion-Based Stock Reduction Analysis (XDB-SRA) to estimate stock status, scale, and productivity. The population dynamics are approximated by a biomass dynamic equation with lagged recruitment. The model incorporates a flexible production function, and all model parameters are estimated in a fully Bayesian framework, unlike previous assessments, where important parameters were assigned fixed values. XDB-SRA input data are restricted to abundance indices. Length and age composition data are summarized in this document, but were not included in the assessment due to poor temporal coverage and small sample sizes.

The base model is fit to five fishery-independent data sources: four time series of relative abundance (CalCOFI larval abundance survey, Sanitation District trawl surveys, NWFSC trawl survey, and NWFSC hook-and-line survey), and a visual survey estimate of absolute abundance in 2002. A trip-based CPUE time series (1980-1999) derived from Commercial Passenger Fishing Vessel logbook records was considered at length, but ultimately excluded due to difficulties identifying effective effort for cowcod. Importantly, all four fishery-independent time series show increasing trends in recent years. These trends are consistent with the high-productivity alternative presented in the previous assessment and are in agreement with the 2002 visual survey estimate of absolute abundance. Very little recent information is available from fishery-dependent sources due to regulatory restrictions.

## Stock biomass

The base case model suggests that median spawning biomass (defined as one half of vulnerable biomass) decreased until the early 1930s, then increased as effort targeting cowcod declined. The model indicates rapid decreases in spawning biomass from the 1970s to mid-1980s. Median spawning biomass fell below the Minimum Stock Size Threshold (MSST) from 1983 through 2004, with a low of 9% of unfished biomass in 1987. Since then, the base model median result suggests the stock has increased to 34% of unfished equilibrium biomass ($SB_0$) in 2013, with a 95% posterior credibility interval (hereafter “interval”) of 15.0% to 65.6% (Table b, Figures b and c). Relative to the previous assessments, changes in the perception of stock status and productivity reflect increasing trends in the fishery-independent surveys as well as exclusion of a fishery-dependent index (CPFV logbook) with a strong pattern of hyperdepletion (showing an exaggerated decline). Median unfished female spawning biomass in the base model is 1549 mt (compared to 2183 mt in the previous assessment), with a 95% interval of 990 to 2683 mt. Median female spawning biomass in 2013 is estimated at 524 mt (95% interval of 273-924 mt). For purposes of calculating ABCs, the estimated standard deviation of the natural logarithm of spawning biomass in 2013 was 0.32.

Table b: Recent trend in beginning of the year median biomass and median depletion (percentage of unfished biomass)

| Year | Spawning Biomass (mt) | ~95% credibility interval | Estimated depletion | ~95% credibility interval |
|---|---|---|---|---|
| 2004 | 375 | (204, 716) | 24.4% | (11.4%, 45.6%) |
| 2005 | 396 | (216, 738) | 25.6% | (11.9%, 47.9%) |
| 2006 | 414 | (228, 761) | 26.9% | (12.4%, 50.5%) |
| 2007 | 433 | (236, 783) | 28.1% | (12.8%, 52.8%) |
| 2008 | 448 | (243, 807) | 29.1% | (13.2%, 54.8%) |
| 2009 | 463 | (250, 828) | 30.1% | (13.6%, 56.4%) |
| 2010 | 479 | (256, 852) | 31.0% | (14%, 58.6%) |
| 2011 | 495 | (261, 875) | 32.0% | (14.3%, 61%) |
| 2012 | 509 | (267, 900) | 32.9% | (14.6%, 63.3%) |
| 2013 | 524 | (273, 924) | 33.9% | (15%, 65.6%) |

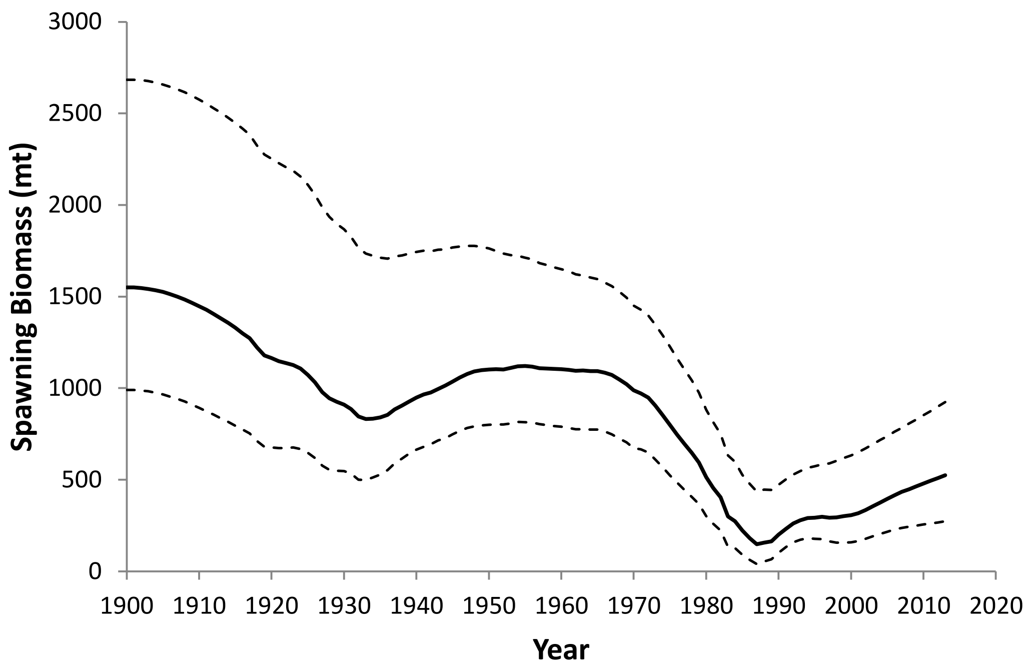


Figure b: Median biomass trajectory with 95% credibility intervals

## Recruitment

As in the previous assessment, production in the population model is assumed to be a deterministic function of spawning biomass. Recruitment pulses may be evident in the abundance indices, but insufficient information is available to reliably estimate the relative strength of individual year classes.

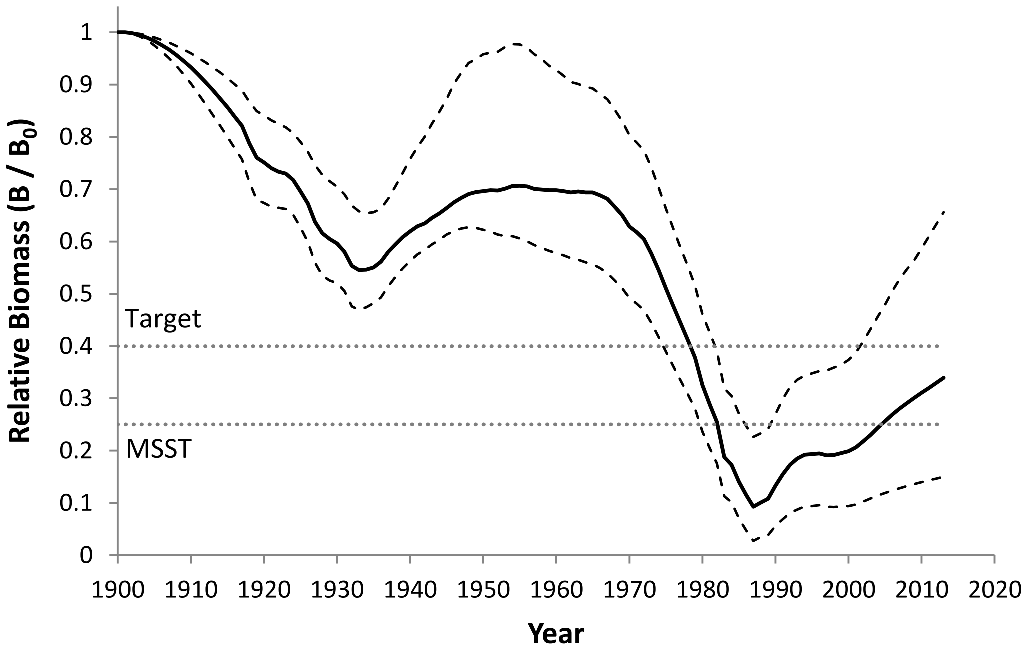


Figure c. Median relative biomass ("depletion," solid line) with 95% posterior credibility intervals (dashed lines) for the base case assessment model.

## Exploitation status

Estimated harvest rates for cowcod were highest during the mid-1980s (Figures d and e). Retention of cowcod was prohibited from January 2001 to January 2011. Even with limited allocations to the rationalized trawl fleet in 2011 and 2012, the base model suggests that removals of cowcod have been less than 0.2% of vulnerable biomass since 2003 (Table c). The estimated harvest rate that produces long-term MSY (5.5%) is nearly twice the proxy (SPR 50%) harvest rate from the last assessment (2.7%). Unlike previous assessments, the recent increasing trends in fishery-independent surveys allow the model to estimate the rate of increase in stock size. However, the 95% posterior interval for the MSY harvest rate (2.2% - 12.6%) reflects uncertainty in the data regarding overall productivity of the stock.

Table c. Recent harvest rates (catch as a percentage of biomass of age-11 and older fish)

| Year | Median Harvest Rate |
|---|---|
| 2003 | <0.2% |
| 2004 | <0.2% |
| 2005 | <0.2% |
| 2006 | <0.2% |
| 2007 | <0.2% |
| 2008 | <0.2% |
| 2009 | <0.2% |
| 2010 | <0.2% |
| 2011 | <0.2% |
| 2012 | <0.2% |

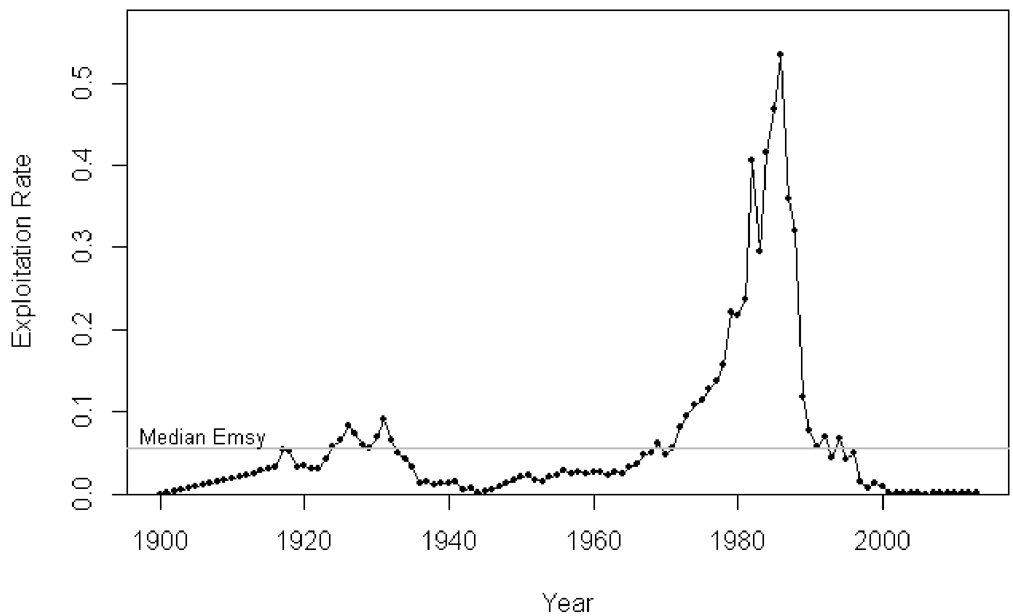


Figure d. Time-series of median harvest rates (total catch divided by age-11 and older biomass) for the base case model. The gray line is the estimated median harvest rate producing MSY.

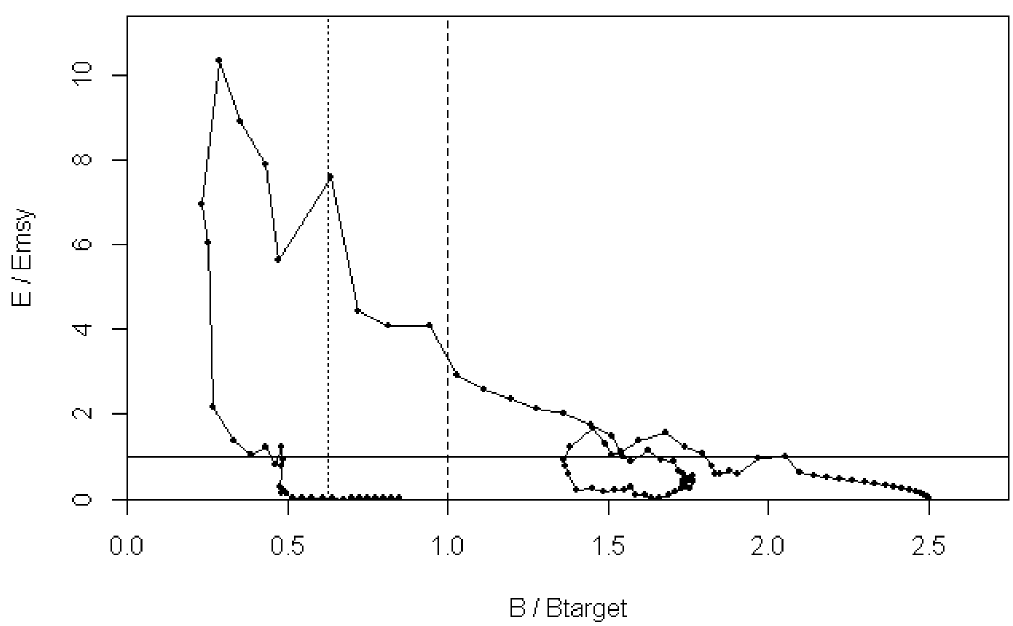


Figure e. Phase plot of median annual harvest rates divided by the median MSY harvest rate vs. median spawning biomass divided by the target spawning biomass (40% of unfished spawning biomass) for the base case model. Target and limit reference points are shown for Emsy (solid horizontal line), target biomass (dashed vertical line), and the minimum stock size threshold for biomass (dotted vertical line).

## Ecosystem considerations

No environmental correlations or food web considerations were considered explicitly in the model. Possible "cultivation effect" predator-prey effects on recruitment dynamics were considered by means of the flexible production function used in the assessment.

## Reference points

This assessment suggests that cowcod in the Southern California Bight constitute a smaller, but more productive stock than was estimated from previous assessments. Reference points estimated from the data are consistent with the PFMC's proxy for $B_{MSY}$ (40% of unfished biomass). Proxies for MSY harvest rates based on spawning potential ratios (e.g. SPR 50%) rely on an age-structured modeling framework. Although nominal SPR-based proxies can be calculated external to the model (e.g. a life table approach) their utility is limited for biomass dynamic models which combine growth and recruitment into the net production function.

Table d. Summary of reference points for the base case model.

| Quantity | $2.5^{th}$ percentile | Median | $97.5^{th}$ percentile |
|---|---|---|---|
| Unfished Spawning Biomass ($SB_0$, mt) | 990 | 1549 | 2684 |
| Unfished age 11+ biomass (mt) | 1981 | 3099 | 5368 |
| Spawning Biomass in 2013 | 273 | 524 | 924 |
| Depletion in 2013 (% of $SB_0$) | 15.0% | 33.9% | 65.6% |
| ***Reference points based on estimated MSY*** | | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 256 | 629 | 1162 |
| $SB_{MSY} / SB_0$ | 0.121 | 0.422 | 0.745 |
| Exploitation rate corresponding to *MSY* | 2.2% | 5.5% | 12.6% |
| *MSY* (mt) | 30 | 69 | 103 |
| ***Reference points based on $SB_{40\%}$ proxy MSY harvest rate*** | | | |
| Proxy spawning biomass ($SB_{40\%}$) | 396 | 620 | 1074 |
| Exploitation rate resulting in $B_{40\%}$ | 1.2% | 5.0% | 11.3% |
| Yield from $B_{40\%}$ proxy harvest rate at $B_{40\%}$ (mt) | 25 | 62 | 98 |

## Management performance

From 2003-2012, total mortality of cowcod has remained below the target level (Table e). The majority of discard mortality during this time period comes from the limited-entry trawl fishery north of 34° 27′ N. latitude (NWFSC, 2013). The establishment of coastwide Rockfish Conservation Areas and Cowcod Conservation Areas south of Point Conception (34° 27′ N. latitude) has been effective at minimizing cowcod bycatch.

The procedure for calculating the cowcod OFL was revised for the 2011-2012 management cycle. The Council's Scientific and Statistical Committee classified the stock assessment for cowcod in the SCB as a Category 2 (data-moderate) assessment. Sustainable yield from Point Conception to Cape Mendocino was estimated using a new Category 3 (data-poor) method, Depletion-Based Stock Reduction Analysis or DB-SRA. The 2011-2012 OFLs for the combined stock south of 40° 10′ N. latitude were defined as the sum of the OFLs from these two regions. The Acceptable Biological Catch (ABCs) for each region was derived from the Council's ABC control rule. The ACL calculation followed the convention of previous management cycles, and was set equal to twice the ACL associated with the SCB.

An estimate of sustainable yield for the area north of Point Conception and south of Cape Mendocino (40° 10' North latitude) was produced for the 2011-12 management cycle (component OFL = 6.8 mt), but has not been updated as part of this assessment.

Table e. Total mortality (mt) of cowcod by year and area. Commercial mortality estimates (retained + discarded catch) are from the West Coast Groundfish Observer Program and recreational estimates are from RecFIN (weight of catch types A and B1).

| | **COMMERCIAL** | | **RECREATIONAL** | | | | | |
|---|---|---|---|---|---|---|---|---|
| **YEAR** | **North of 34° 27′** | **South of 34° 27′** | **North of 34° 27′** | **South of 34° 27′** | **TOTAL** | **OFL** | **ABC** | **OY (ACL)** |
| **2003** | 0.22 | 0.00 | -- | 0.48 | 0.70 | -- | 24 | 4.8 |
| **2004** | 0.54 | 0.41 | -- | 0.45 | 1.40 | -- | 24 | 4.8 |
| **2005** | 1.15 | 0.00 | -- | 0.15 | 1.30 | -- | 24 | 4.2 |
| **2006** | 2.20 | 0.00 | -- | 0.07 | 2.27 | -- | 24 | 4.2 |
| **2007** | 1.93 | 0.10 | 0.19 | 0.11 | 2.33 | -- | 36 | 4 |
| **2008** | 0.48 | 0.00 | -- | 0.25 | 0.73 | -- | 36 | 4 |
| **2009** | 1.45 | 0.00 | -- | 0.21 | 1.66 | -- | 13 | 4 |
| **2010** | 1.00 | 0.00 | 0.02 | 0.17 | 1.20 | -- | 14 | 4 |
| **2011** | 0.02 | 0.00 | -- | 0.83 | 0.85 | 13.00 | 8 | (3) |
| **2012** | 0.00 | 0.00 | 0.02 | 0.82 | 0.84 | 13.00 | 8 | (3) |
| **Grand Total** | **9.00** | **0.51** | **0.23** | **3.53** | **13.28** | | | |

## Unresolved problems and major uncertainties

Although every fishery-independent time series in the base model suggests recent increases in cowcod biomass, the rate of increase is variable among data sources. Continued monitoring of each data source is essential to verify current estimates of stock productivity as the stock rebuilds.

The STAT questions whether catch rates from the CPFV logbook data can be standardized to accurately reflect changes in abundance of cowcod. Given the length of the CPUE time series, indices derived from these data are highly influential to the assessment but are not consistent with existing fishery-independent surveys and cannot be updated to inform future productivity.

Uncertainty in this assessment is characterized in a fully Bayesian framework. However, posterior distributions from the base model do not account for other sources of uncertainty, including alternative model structures (e.g., process error) and the magnitude of historical catch (a problem shared with other methods used to assess West Coast groundfish stocks).

## Decision table

Projections of yield, biomass, and stock depletion presented in this assessment are preliminary, and will be replaced by results from a separate cowcod rebuilding analysis.

The STAT prepared a decision table using low, medium, and high states of nature defined as the 12.5%, 50%, and 87.5% percentiles of the posterior distributions. A range of fixed catch alternatives with sufficient contrast was selected to illustrate the implications of alternative management actions under the three states of nature (Table g).

Table f. [TBD] Projection of median OFL, ABC catch, spawning biomass (age-11 and older), and depletion for the base case model projected with status quo catches in 2013 and 2014, and catches at the OFL from 2015 onward. The 2013 and 2014 OFLs are values specified by the PFMC and not predicted by this assessment. The OFL in years later than 2014 is the calculated as the MSY exploitation rate multiplied by vulnerable biomass.

| Year | Predicted OFL (mt) | ABC Catch (mt) | Landings (mt) | Age 11+ biomass (mt) | Spawning Biomass (mt) | Depletion (%) |
|---|---|---|---|---|---|---|
| 2013 | 6 | 5 | 1.5 | 1049 | 525 | 34% |
| 2014 | 6 | 5 | 1.5 | 1084 | 542 | 35% |
| 2015 | | | | | | |
| 2016 | | | | | | |
| 2017 | | | | | | |
| 2018 | | | | | | |
| 2019 | | | | | | |
| 2020 | | | | | | |
| 2021 | | | | | | |
| 2022 | | | | | | |
| 2023 | | | | | | |
| 2024 | | | | | | |

Table g. Summary table of 12-year projections beginning in 2015 for alternate states of nature based on an axis uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.

| | | | Model Results (Possible True State of Nature) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Low (12.5%) | | Median | | High (87.5%) | |
| | Year | Catch | spBio | depl | spBio | depl | spBio | depl |
| Reference | 2015 | 0 | 386 | 0.223 | 559 | 0.360 | 787 | 0.554 |
| | 2016 | 0 | 399 | 0.229 | 577 | 0.372 | 816 | 0.575 |
| | 2017 | 0 | 413 | 0.235 | 598 | 0.384 | 841 | 0.596 |
| | 2018 | 0 | 426 | 0.242 | 619 | 0.396 | 865 | 0.615 |
| | 2019 | 0 | 441 | 0.248 | 638 | 0.408 | 888 | 0.638 |
| | 2020 | 0 | 454 | 0.255 | 658 | 0.420 | 913 | 0.659 |
| | 2021 | 0 | 468 | 0.262 | 679 | 0.432 | 938 | 0.679 |
| | 2022 | 0 | 482 | 0.268 | 700 | 0.445 | 960 | 0.699 |
| | 2023 | 0 | 494 | 0.275 | 721 | 0.457 | 983 | 0.720 |
| | 2024 | 0 | 507 | 0.281 | 741 | 0.469 | 1007 | 0.741 |
| Current ACL | 2015 | 1.5 | 386 | 0.223 | 559 | 0.360 | 787 | 0.554 |
| | 2016 | 1.5 | 398 | 0.228 | 577 | 0.372 | 815 | 0.575 |
| | 2017 | 1.5 | 412 | 0.234 | 597 | 0.383 | 839 | 0.594 |
| | 2018 | 1.5 | 424 | 0.240 | 617 | 0.395 | 863 | 0.614 |
| | 2019 | 1.5 | 438 | 0.246 | 636 | 0.407 | 886 | 0.636 |
| | 2020 | 1.5 | 451 | 0.253 | 655 | 0.418 | 909 | 0.656 |
| | 2021 | 1.5 | 464 | 0.259 | 675 | 0.430 | 934 | 0.676 |
| | 2022 | 1.5 | 477 | 0.266 | 696 | 0.442 | 956 | 0.696 |
| | 2023 | 1.5 | 489 | 0.272 | 716 | 0.454 | 978 | 0.716 |
| | 2024 | 1.5 | 502 | 0.278 | 736 | 0.466 | 1002 | 0.737 |
| Possible ACL | 2015 | 5 | 386 | 0.223 | 559 | 0.360 | 787 | 0.554 |
| | 2016 | 5 | 397 | 0.227 | 575 | 0.371 | 813 | 0.573 |
| | 2017 | 5 | 408 | 0.232 | 593 | 0.381 | 836 | 0.592 |
| | 2018 | 5 | 419 | 0.238 | 612 | 0.392 | 858 | 0.610 |
| | 2019 | 5 | 432 | 0.243 | 629 | 0.403 | 879 | 0.631 |
| | 2020 | 5 | 443 | 0.249 | 647 | 0.414 | 902 | 0.650 |
| | 2021 | 5 | 455 | 0.255 | 666 | 0.424 | 925 | 0.669 |
| | 2022 | 5 | 467 | 0.260 | 685 | 0.435 | 945 | 0.689 |
| | 2023 | 5 | 478 | 0.266 | 705 | 0.447 | 967 | 0.707 |
| | 2024 | 5 | 489 | 0.272 | 724 | 0.457 | 989 | 0.726 |
| Possible ACL | 2015 | 10 | 386 | 0.223 | 559 | 0.360 | 787 | 0.554 |
| | 2016 | 10 | 394 | 0.226 | 572 | 0.369 | 811 | 0.571 |
| | 2017 | 10 | 403 | 0.229 | 588 | 0.378 | 831 | 0.588 |
| | 2018 | 10 | 412 | 0.234 | 605 | 0.388 | 851 | 0.604 |
| | 2019 | 10 | 423 | 0.238 | 620 | 0.397 | 870 | 0.623 |
| | 2020 | 10 | 433 | 0.243 | 637 | 0.407 | 890 | 0.641 |
| | 2021 | 10 | 442 | 0.248 | 654 | 0.416 | 911 | 0.659 |
| | 2022 | 10 | 451 | 0.253 | 670 | 0.426 | 930 | 0.678 |
| | 2023 | 10 | 461 | 0.258 | 688 | 0.437 | 950 | 0.694 |
| | 2024 | 10 | 471 | 0.262 | 705 | 0.446 | 971 | 0.712 |
| Possible ACL | 2015 | 15 | 386 | 0.223 | 559 | 0.360 | 787 | 0.554 |
| | 2016 | 15 | 392 | 0.224 | 570 | 0.367 | 808 | 0.569 |
| | 2017 | 15 | 399 | 0.227 | 583 | 0.375 | 826 | 0.585 |
| | 2018 | 15 | 405 | 0.230 | 598 | 0.383 | 844 | 0.599 |
| | 2019 | 15 | 413 | 0.233 | 611 | 0.391 | 860 | 0.616 |
| | 2020 | 15 | 422 | 0.237 | 625 | 0.399 | 879 | 0.633 |
| | 2021 | 15 | 429 | 0.241 | 640 | 0.408 | 898 | 0.648 |
| | 2022 | 15 | 436 | 0.244 | 656 | 0.416 | 915 | 0.667 |
| | 2023 | 15 | 445 | 0.249 | 671 | 0.426 | 934 | 0.682 |
| | 2024 | 15 | 453 | 0.252 | 688 | 0.435 | 953 | 0.699 |

## Research and data needs

Annual Catch Limits for the area south of Cape Mendocino are currently defined as twice the ACL set for the SCB. A reliable estimate of absolute abundance and/or a time series of relative abundance is needed to assess the status of cowcod in waters between Point Conception and Cape Mendocino.

Fishery-independent (extractive) surveys are not currently sampling inside the Cowcod Conservation Areas, which likely contain a large fraction of the population. To better understand rebuilding progress, this policy could be reconsidered given the more optimistic results of the assessment.

Additional information is needed on cowcod stock structure and life history traits, including but not limited to dispersal between U.S. and Mexican waters, and potential differences in life history characteristics (e.g. growth, maturity, fecundity, longevity) among the recently identified genetic lineages.

Consider regular, but not necessarily annual, visual surveys of absolute cowcod abundance in the SCB (inside & outside the CCAs) and central California.

## Rebuilding projections

* This section should be included in the Final/SAFE version assessment document but is ***not required for draft assessments undergoing review***.

Table h. Summary table of the results. Reported OFLs and ACLs are for the combined Conception and Monterey INPFC areas. Catch is SCB only.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Estimated Total catch (mt) | 0.48 | 0.86 | 0.15 | 0.07 | 0.21 | 0.25 | 0.21 | 0.17 | 0.83 | 0.82 | NA |
| OFL (mt) | 24 | 24 | 24 | 24 | 36 | 36 | 13 | 14 | 13 | 13 | |
| ACL (mt) | 4.8 | 4.8 | 4.2 | 4.2 | 4 | 4 | 4 | 4 | 3 | 3 | |
| Exploitation rate (catch/ age 11+ biomass) | 0.001 | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 | NA |
| Age 11+ biomass (mt) | 711 | 749 | 791 | 829 | 867 | 895 | 927 | 958 | 990 | 1018 | 1049 |
| Spawning Biomass (mt) | 355 | 375 | 396 | 415 | 433 | 448 | 463 | 479 | 495 | 509 | 525 |
| 2.5$^{th}$ percentile | 191 | 204 | 216 | 228 | 236 | 243 | 250 | 256 | 261 | 267 | 273 |
| 97.5$^{th}$ percentile | 694 | 716 | 738 | 761 | 783 | 807 | 828 | 852 | 875 | 900 | 924 |
| Depletion (%) | 23.0% | 24.4% | 25.6% | 26.9% | 28.1% | 29.1% | 30.1% | 31.0% | 32.0% | 32.9% | 33.9% |
| 2.5$^{th}$ percentile | 10.8% | 11.4% | 11.9% | 12.4% | 12.8% | 13.2% | 13.6% | 14.0% | 14.3% | 14.6% | 15.0% |
| 97.5$^{th}$ percentile | 43.2% | 45.6% | 47.9% | 50.5% | 52.8% | 54.8% | 56.4% | 58.6% | 61.0% | 63.3% | 65.6% |

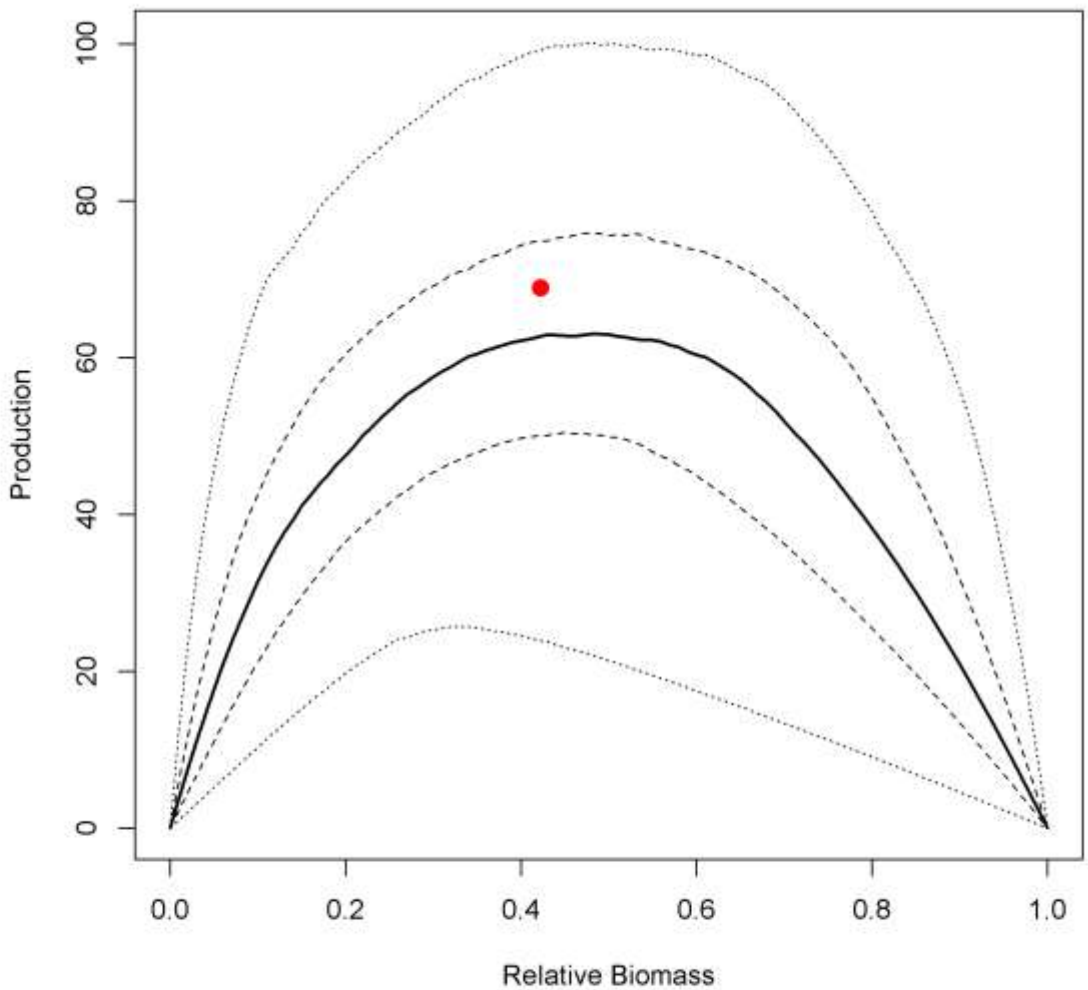


Figure f. Distribution of yield curves from the base model. The solid, dashed, and dotted lines are median, interquartile, and 95th percentiles of production, respectively, given relative biomass. The red circle represents the marginal medians of $B_{MSY}/B_0$ and MSY.

# 1 Introduction

## 1.1 Basic Information

Cowcod, *Sebastes levis*, is a member of the family Scorpaenidae with a distribution from Newport, Oregon, to central Baja California, Mexico (Love et al., 2002). They are most common from Cape Mendocino (California) to northern Baja California, in depths from 50-300 m. Hess et al. (submitted) recently used genetic and otolith microchemistry tools to study cowcod population structure from California to Oregon. Specifically, they tested the hypothesis that a phylogeographic boundary exists at Point Conception. Their results supported a hypothesis of two primary lineages with a geographic boundary falling south of, rather than at Point Conception. Both lineages co-occur in the Southern California Bight (SCB), with no clear pattern of depth stratification or spatial structure within the Bight. Within lineages, there is evidence for considerable gene flow across the Point Conception boundary. Cowcod found north of Point Conception consist primarily of a single lineage, also found in northern areas of the SCB.

## 1.2 Map

Assumed stock boundaries for the 2013 cowcod assessment are shown in Figure 1.

## 1.3 Life History

Cowcod are a long-lived, slow-growing species that require a decade or more to reach sexual maturity. Fertilization is internal, with females giving birth to planktonic larvae mainly during winter months. Larvae develop into a pelagic juvenile stage, settling to benthic habitats after about 3 months. Adults are piscivorous, with a diet consisting mainly of fishes, squids, and octopi. Cowcod are easily identified at all life stages, including larvae.

*Natural Mortality*
Maximum observed age for cowcod is 55 years (Love et al. 2002). Dick et al. (2007) estimated the natural mortality rate using three methods, reporting a range of values from 0.027 to 0.064 based on Beverton's (1992) method, a range of total mortality (Z) estimates from 0.038 to 0.072 based on catch curve analysis and Hoenig's geometric mean regression. Additional details regarding treatment of natural mortality in this assessment are in section 2.3.4.

*Maturation, spawning, and fecundity*
Love et al. (1990) reported length at 50% maturity as 43 cm, or roughly 11 years old. They found no evidence of sexual dimorphism in size at maturity. Peak spawning occurs in January in Southern California and December in Northern California, with larval extrusion observed from November through May in Southern California. Love et al. also reported evidence of multiple broods in cowcod, particularly large individuals in Southern California. Cowcod are a highly fecund species, with large females producing 2 million eggs (Love et al. 1990). Dick (2009) found no evidence of increasing weight-specific fecundity (i.e. spawning output is roughly proportional to spawning biomass).

*Growth*
Cowcod are among the largest species in the genus *Sebastes* (94 cm max. length). The model used for this assessment does not explicitly account for growth, but von Bertalanffy growth parameters ($L_\infty$ = 870 mm, k = 0.052 $yr^{-1}$, and t0 = -1.94 years) were estimated by Dick et al in the 2007 cowcod assessment (Figure 2). Love et al. (1990) found a roughly cubic relationship

between cowcod weight (grams) and length (cm), with approximate parameter values $a$=0.01 and $b$=3.1 for the power function $W=aL^b$.

*Habitat associations*
Juvenile cowcod were once thought to associate primarily with soft sediments, but recent research (Love and Yoklavich, 2008) using visual surveys found juveniles mainly associate with low-relief, hard substrate. Young-of-the-year were observed over a wide depth range (52-277 m), with juveniles slightly deeper, and adults mainly deeper than 150 m. Larger juveniles increasingly associate with high-relief, complex rocky substrate, the primary habitat for adult cowcod.

## 1.4 Ecosystem Considerations

Cowcod is a piscivore, sharing a trophic position with lingcod as the top-level groundfish predators in rocky habitat. No environmental correlations or food web considerations were considered explicitly in the model. However, a food web effect in which adults crop down forage species that are potential competitors/predators of their own juveniles is implicitly considered in the Pella-Tomlinson-Fletcher production function (and would have been excluded by a Beverton-Holt SRR). This phenomenon, termed a "cultivation effect" was explored by Walters and Kitchell (2001) who concluded that this phenomenon is widespread (occurring in approximately one-third of the cases examined) and that it should not be ignored. Specifically, they suggested that spawning stock abundance goals should generally be no less than 50% of unfished spawning biomass. MacCall (2002) independently obtained similar results from a simple simulation of "cultivation effect" recruitment dynamics of a cowcod-like predator-prey system, where resulting predator Bmsy/B0 ≈ 0.6.

## 1.5 Fishery Information

Since retention of cowcod was prohibited in 2001, the vast majority of removals have been regulatory discards. Historically, cowcod was a highly-sought-after trophy fish in the recreational fishery, due to their large size. Despite their appeal to anglers, cowcod made up only a small fraction of the recreational catch, amounting to less than 1% of the total rockfish catch in onboard CPFV surveys from the 1960s-1980s (Miller and Gotshall, 1965; Collins and Crooke, unpublished manuscript; Ally et al. 1991). The CPFV fleet began ca. 1919 in California, numbering about 200 vessels by 1939. After WWII, the fleet increased to about 590 vessels by 1953, then declined to approximately 256 vessels in 1963. The 1970s saw an increase in rockfish-directed effort, primarily during winter months in Southern California. Dick et al. (2007) evaluated historical (1970s) length composition data from the CPFV fleet, and found that length at 50% selectivity was around 34 cm. The current base model assumes knife-edge selectivity at age 11 (roughly 40cm).

Historically, the majority of commercial cowcod landings in California have been to ports south of Point Conception (Figure 3). Hook and line gear dominated the fishery prior to 1944, with trawl landings becoming common after 1943 in Santa Barbara county and northward. Prior to 1968, no trawl gear could be processed south of Ventura County. Set net gear was introduced in the 1970s, and became the primary source of cowcod landings in the mid-1980s. Net landings declined in the 1990s following passage of Proposition 132. Dick et al. (2007) evaluated length composition data for the three primary commercial gears (trawl, hook-and-line, and net fisheries) and found considerable variability in the size composition among years. Selectivity for the combined commercial fleet was set equal to the maturity curve, which is consistent with the assumptions in the XDB-SRA base model. Increases in commercial landings during the late 1970s and early 1980s were largely due to expansion of the set net fishery (Figure 4, Figure 5).

## 1.6 Summary of Management History

*Commercial Fisheries*

Prior to the first cowcod assessment in 1999, cowcod were managed as part of the PFMC's "remaining rockfish" complex. The ABC for remaining rockfish in the combined Conception, Monterey, and Eureka areas was initially 9,500 mt, and was reduced to 7000 mt in 1994 (Rogers, 1996). Butler et al. (1999) reported an ABC of 4731 mt (OY = 2705 mt) for 1999, and that catches of cowcod were unlikely to have been affected by historical trip and monthly limits for the complex. Beginning in 2000, an ABC of 5 mt was adopted for the Conception INPFC, which was added to an ABC of 19 mt for the Monterey area (based on average landings from 1983-1997). ABCs and OYs after 2002 are shown in Table 1. Since 2011, a small allocation of cowcod can be retained by the rationalized trawl fishery.

*Recreational Fisheries*

Prior to 2000, cowcod were originally counted toward 20-fish, and subsequently 15-fish, bag limits for rockfish. The 15 rockfish bag limit continued through 1999. Following the first assessment, a bag limit of 1 cowcod was enacted for 2000. Since January, 2001, retention of cowcod has been prohibited for recreational fishermen.

*Cowcod Conservation Areas (CCA)*

In 2001, two depth-based area closures were implemented to reduce fishing mortality of cowcod, prohibiting bottom-fishing deeper than 20 fm (Figure 6). The larger of the two areas (CCA West) is a 4200 square mile area west of Santa Catalina and San Clemente Islands. A smaller area (CCA East) is about 40 miles offshore of San Diego, and covers about 100 square miles.

*Rockfish Conservation Areas (RCA)*

In 2002 the PFMC established trawl- and non-trawl area closures known as the Rockfish Conservation Areas. These closed areas are gear-specific, and have seasonally changing boundaries to help reduce fishing mortality.

## 1.7 Management Performance

Total removals of cowcod have been below the maximum catch limits (Table 1). Without an assessment for waters north of Point Conception, it is difficult to assess management performance for that area. However, total removals are so low it is unlikely that overfishing is occurring. If removals in the northern portion of the stock increase, the STAT recommends prioritization of research to inform estimates of stock abundance and trends in that area.

# 2 Assessment

## 2.1 Data

### 2.1.1 Removals (Landings and Discard)

A complete summary of cowcod removals in the Southern California Bight, by year and data source, is provided in Table 2 and Table 3.

#### *2.1.1.1 Commercial Landings Reconstruction, 1900-1968*

Commercial landings of cowcod prior to 1969 (prior to landings data available in CALCOM) were reconstructed for the 2007 cowcod assessment (Dick et al., 2007). Subsequently, Ralston et al. (2010) developed a reconstruction of commercial landings for California. Dick et al. (2009) compared the reconstruction used in 2007 and that of Ralston et al., noting that Ralston et al. stratified historical catch across the boundary of the Monterey and Conception INPFC areas (36° N. latitude), rather than at the assumed cowcod stock boundary (Point Conception, 34° 27′ N. latitude). Relevant text, tables, and figures from the 2007 and 2009 cowcod assessments are included here for convenience.

Butler et al. (1999) developed a time series of historical landings of cowcod by the commercial fisheries (1916-1981) using a ratio estimator applied to published landings of total rockfish in California (CDF&G Fish Bulletin No. 149, 1970). Since their assessment, other sources of information have become available that provided us an opportunity to revise the historical landings. As described below, we used this information to develop a ratio estimator stratified by port complex and gear group, based on the earliest available data from the SCB.

In his "Rockfish Review" (CDF&G Fish Bulletin No. 105, 1958), J.B. Phillips provided a record of total rockfish landings by region (Southern, Central, and Northern California) for the period 1916-1956 (Table 4). These data combine the genus *Sebastolobus* (thornyheads) with *Sebastes*, and include rockfish caught in foreign waters but landed at U.S. ports. The regional data show that the relative proportion of California's commercial rockfish landed in each area has changed dramatically over time (Figure 7). This result prompted us to develop a ratio estimator that tracks rockfish landings in the SCB rather than statewide rockfish landings.

The NMFS SWFSC Environmental Research Division (ERD) currently hosts a live-access server (http://las.pfeg.noaa.gov/LAS/CA_market_catch.html) with commercial landings originally published in the CDF&G Fish Bulletin series. Similar to the data from Fish Bulletin No. 105, rockfish landings in this dataset include thornyheads (up to 1977); however, the ERD data exclude fish caught in foreign waters. We queried this database to obtain total rockfish landings by region for the period 1928-1968 (Table 4). The 6 geographic regions in the ERD database are San Diego (San Diego County), Los Angeles (Los Angeles and Orange Counties), Santa Barbara (San Luis Obispo Santa Barbara, and Ventura Counties), Monterey (Santa Cruz and Monterey Counties), San Francisco (Sonoma, Marin, San Mateo and San Francisco Counties, plus San Francisco Bay), and Eureka (Del Norte, Humboldt and Mendocino Counties). The "Southern" area described by Phillips (CDF&G Fish Bulletin No. 105, 1958) is spatially equivalent to the San Diego, Los Angeles, and Santa Barbara regions in the ERD database. The "Central" area is spatially equivalent to the ERD's Monterey and San Francisco areas, and the "Northern" area is equivalent to the ERD's Eureka region. When the ERD data from Southern California are spatially aggregated to mimic the Southern rockfish landings in Fish Bulletin No. 105, the ERD landings are consistently smaller than the Fish Bulletin landings. This is expected, because the ERD data only include fish caught in U.S. waters. To account for this difference, we calculated annual estimates of "foreign-caught rockfish" (Table 5) as the difference between the sum of the ERD landings in the San Diego, Los Angeles, and Santa Barbara regions and the "Southern" landings in Fish Bulletin No. 105. To estimate the amount of foreign-caught rockfish prior to 1928, we used a ratio estimator based on the years 1928-1933. This estimate (0.74%) was applied as a correction factor to the Fish Bulletin Southern-area data for years 1916-1927.

The "Santa Barbara" region as defined in the Fish Bulletin series (and hence the ERD database) includes San Luis Obispo (SLO) County, which is north of Point Conception and is therefore outside the stock boundary as defined in this assessment. Therefore, it was necessary to adjust the rockfish landings in this region to exclude catches north of Point Conception. Beginning in 1949, CDF&G's Fish Bulletin series reported port-specific rockfish landings for the Santa Barbara region. We entered these data and observed that in the mid-1950s rockfish landings in the Santa Barbara region increased dramatically due to landings at Morro Bay and Avila (Figure 8, Table 5). We subtracted the rockfish landed at these two ports to create an "adjusted Santa Barbara" region that reflects rockfish catch within the assumed stock boundary (Table 5). In doing so, we assume that annual rockfish landings are zero at other ports north of Point Conception but within the Santa Barbara region (e.g. San Simeon). This is unlikely to have a major effect on our results due to the relative size of landings at Morro Bay and Avila compared to other ports in the region. For the years 1928-1949, we extrapolated Morro Bay and Avila landings using a ratio estimator based on the fraction of rockfish in the Santa Barbara region landed at each port during the years 1949-1951 (Table 5). The rockfish catch in Avila was not reported in 1952-53 or 1958-61, so we calculated ratio estimates for these years using catches in proximal years (Table 5).

To extend our time series of rockfish landings in the Los Angeles, San Diego, and adjusted Santa Barbara regions back to 1916, we subtracted our estimates of foreign-caught rockfish from the total rockfish landings in the Southern area. We then used a ratio estimator based on landings from 1928-1933 to estimate the fraction of rockfish caught in each region during the period 1916-1927. For example, we divided the sum of rockfish landings in the Los Angeles region from 1928-1933 by the sum of rockfish landings in the San Diego, Los Angeles, and adjusted Santa Barbara regions during the same years. We assume that this percentage (64.6%) of rockfish caught in the Southern area and landed in the Los Angeles region is constant from 1916-1927. By the same method, ratio estimates for the San Diego and adjusted Santa Barbara regions were 33.4% and 0.97%, respectively. The final time series of historical rockfish landings by region, 1916-1968, is illustrated in Figure 9.

The final step in deriving the historical commercial landings was to determine the fraction (by weight) of the rockfish landings that was cowcod. We based our estimates on 5-year averages from the earliest years for which we have actual samples (1984-1988) in all port complexes (Table 6). Gear types were chosen to be consistent with the historical fisheries. Hook & line was the dominant gear group for rockfish prior to 1944 (CDF&G Fish Bulletin No. 126, 1964), and prior to 1968 it was illegal to process a trawl net south of Ventura County (Frey, 1971). Therefore, we estimated the percentage of rockfish that was cowcod in the Los Angeles and San Diego regions from their respective hook and line fisheries. In Santa Barbara the trawl fishery developed in the mid-1940s, so we based our estimates on the combination of line and trawl gears beginning in 1944, and on the hook and line fishery for years prior to 1944. The annual fraction of cowcod in rockfish landings was variable, but without trend, in the San Diego hook and line fishery, whereas the fraction in the Los Angeles and Santa Barbara fisheries showed steep declines during the 1980s (Figure 10).

The 1984-88 ratio estimate of the fraction of cowcod in the Los Angeles hook & line fishery is large relative to other fisheries and relative to subsequent years in the same fishery. Most of the strata were well-sampled during this period (Table 7), but it is unknown whether estimates based on these five years are representative of previous years.

Estimated commercial catches of cowcod from Ralston et al. (2010) are slightly larger than those reported by Dick et al. (2007). This is not unexpected, because the estimates in Ralston et al. represent landings in the Conception INPFC area rather than the area south of Point Conception (Figure 11). This assessment uses the reconstruction from Dick et al. (2007), as it best matches the available evidence regarding stock structure in cowcod. Final estimates of commercial landings were assumed to increase linearly from 0 mt in 1900 to the reconstructed estimate in

1916. See the “Uncertainty and Sensitivity Analyses” section for effects of alternative commercial catch reconstructions on model outputs.

#### *2.1.1.2 Commercial Landings, 1969-2000*

We queried the CALCOM database (CALCOM, 2013), the source of California’s commercial landings estimates, for cowcod landings from 1969-2012. Landings from 2002-2012 were replaced with total commercial mortality estimates from the West Coast Groundfish Observer Program (WCGOP, see section 2.1.1.3). Total commercial mortality in 2001 was assumed to be equal to the 2002 estimate from WCGOP.

A comparison of estimates from CALCOM and those available from PacFIN suggests that that species compositions in PacFIN have not been updated to reflect the most recent species composition data (i.e. have not used the most recent species composition data). Preliminary analysis suggests that over 90% of the observed differences in catch for cowcod are attributed to outdated species compositions (Table 8).

Under the current CALCOM data management policy, two annual expansions are done at the beginning of each year: the preliminary expansion for the most recent year, and the final expansion for the previous year. Occasionally there is a need to perform expansions that are not part of the regular schedule. This can happen when a significant amount of new data is added to CALCOM (e.g. historical port sample data are recovered) or when a major issue is detected (e.g. when it was determined that a market category definition changed over time). When new expansions are performed in CALCOM, PacFIN is notified and data feeds (percentages of each species for each landed strata) are made available upon request. Updates to the species composition data in PacFIN are underway.

#### *2.1.1.3 Commercial mortality, 2002-2012*

From January 2001 to January 2011 retention of cowcod was prohibited in all commercial sectors. Removals during this time period primarily consisted of regulatory discards. The STAT received estimates of total commercial mortality from the West Coast Groundfish Observer Program for the years 2002-2012 (Table 3, J. Jannot, pers. comm.). Since cowcod are generally not retained due to regulations, a discard ratio was developed using the ratio of observed discard to the sum of removals for species associated with cowcod (based on NWFSC trawl survey data). Specifically, the denominator of the discard ratio was the sum of removals for *Sebastes elongatus, S. paucispinis, S. entomelas, S. saxicola,* and *S. chlorostictus*. Total commercial mortality in 2001 (the first year retention was prohibited) was assumed to be equal to the 2002 estimate from WCGOP.

#### *2.1.1.4 Reconstructed Recreational Removals, 1928-1980*

The 2009 cowcod assessment (Dick et al., 2009) updated estimates of recreational removals prior to 1981, based on catch reconstructions by Ralston et al. (2010). Unlike the commercial landings estimates in that report, the recreational catch reconstruction included estimates of discard and was stratified at Point Conception, and the estimates were used in this assessment without modification. Dick et al. (2009) compared the revised catch history for Southern California to that of Butler et al. (1999), which was derived from average expansions of CPFV logbook and L.A. Times catch reports to RecFIN cowcod catch during 1980-1997.

Ralston et al. partitioned estimates of total rockfish catch to species using CDFW block-specific species composition data and average weight data from onboard CPFV sampling programs conducted in the SCB during the 1970s and 1980s. The composition data mainly reflects fishing practices (e.g. distance from shore, species targeting) in the mid-to-late 1970s, and may not represent catch composition or average weights in earlier years.

#### *2.1.1.5 Recreational Removals, 1981-2012*

Recreational removals (retained and discarded catch) were queried from the RecFIN database (www.recfin.org). If catch in numbers were reported for a stratum and no weight was reported, estimates of catch in weight were obtained by borrowing average weight information from adjacent years. Years with missing data were estimated using linear interpolation (e.g. interruptions of sampling due to lack of funding).

Specifically, recreational removals were taken to be the weight (mt) of catch types A + B1, with linear interpolation of years 1989-92 between 2-year averages for 1987-88 and 1993-94. Removals in 2001 were set equal to 2002, and catch in weight for 2003 was estimated as the reported catch in numbers for 2003 times the average weight of cowcod in 2002. Estimated removals in 2009 (0.21 mt) were interpolated from adjacent years.

### 2.1.2 Length and age composition data

Historically, length and age composition data for cowcod have not provided reliable information about the relative strength of cohorts (Butler et al. 1999, Piner et al. 2005, Dick et al. 2007). The modeling framework chosen for this assessment is tuned to abundance indices, but we do not rule out the potential utility of composition data in future assessments. We briefly summarize composition information from previous assessments (although additional details are available in those documents) and describe data sources that have become available since the last assessment.

*Length composition data from the recreational fishery*
Length data from the recreational fishery are sparse, with only 262 lengths available from RecFIN for the period 1980-2000 in Southern California (114 lengths in Northern California). Reported lengths prior to 1993 appear to be estimates from weight measurements, further reducing the sample sizes. The best available length composition data for cowcod are from onboard CPFV observers in the mid-1970s (Table 9 and Figure 12; Collins and Crooke, unpublished manuscript). These data consist of about 300 cowcod lengths per year from 1975-1977, with an additional ~100 fish from 1974 and 1978 (combined).

*Length composition data from the commercial fishery*
Length data from CALCOM are more abundant, particularly for the net fishery (Figure 13). However, even in the net fishery sample sizes and compositions differ greatly among years, with no evidence of modal progression or consistent information about size-dependent vulnerability to the gear (Figure 14).

*Age composition data*
Cowcod age data are limited in terms of both sample size and temporal coverage. We present sample sizes for the NWFSC trawl and hook-and-line surveys in their respective sections (below), and summarize the data available from other sources in Table 10.

### 2.1.3 Fishery-Independent Indices of Abundance

### *2.1.3.1 CalCOFI Ichthyoplankton*

Raw CalCOFI Survey sample data for 1951-2011 were downloaded from the IchthyoDB website (https://oceaninformatics.ucsd.edu/ichthyoplankton/secure/login.php), producing data from 19,296 ichthyoplankton tows, of which 213 were positive for cowcod larvae. After re-coding years to begin in November (the traditional CalCOFI pattern), the monthly distribution of samples is shown in Table 11.

Cowcod were not identified in CalCOFI data prior to 1966 in central California (north of Avila, CalCOFI line 77). Since then, 21 positive cowcod observations have been recorded in central California, but only 3 positives have occurred since 1982 (2 of which were in 2011). For these reasons, a CalCOFI index for central California was not considered further.

The bulk of positive stations are in southern California waters. Cowcod larvae were regularly encountered before 1976 and after 1999, but were very rare from 1979 to 1998, during which there were only four positive samples of cowcod larvae (Figure 15). During the past decade there has been a clear increase in cowcod occurrences. A closer look at the within-year pattern is provided by assigning samples to ten-day period beginning on November 1. The distribution of southern California CalCOFI sampling dates is shown in Table 12, indicating that recent sampling done mainly in January and April misses much of February and March when fraction positive tends to be highest (Table 11).

The list of sampling stations was reduced to 24 regularly-sampled locations where cowcod larvae have been taken historically in southern California (CalCOFI lines 80 through 93). Frequency of occurrence at these stations was calculated for three roughly equivalent periods, 1951-60 (25 positive locations, Figure 16), 1961-75 (23 positive locations, Figure 17), and 1999-2011 (19 positive locations, Figure 18). The most notable change is a northward shift during the 1960s.

Seasonality was represented by three SEASONS (Table 13) that were chosen to divide the number of positives into approximately equal numbers (EARLY is 1 Nov to 5 Feb; MID is 6 Feb to 17 March; LATE is 18 March to May). In order to eliminate zeroes, YEARS consisted of 5-year time blocks, except that the low abundance period of 1976 to 1996 was a single block. Use of five-year time blocks addresses the difficulties with CalCOFI data that were described in previous assessments. An exploratory fixed-effect GLM of the proportion positive in southern California used 9 time-blocked YEAR strata, 25 LOCATION strata (Figure 19), and 3 SEASON strata (Figure 20). All interaction terms were rejected by BIC. The estimated YEAR effects are the abundance index; precision was estimated by jackknife (Table 14, Figure 21).

The long string of zero (16 sampled years) and near-zero (4 years) observations from 1975 to 1998 is difficult to treat in an assessment model. Clearly, cowcod larval production was very low during this period, indicative of a depleted spawning population. However, 1976 to 1998 was also a warm period of low oceanic productivity, which may have contributed to reduced fecundity. Variability in fecundity is a source of error that is not adequately addressed by simple sampling statistics, but may justify added variance in the assessment model.

### *2.1.3.2 Sanitation District demersal trawl surveys*

In the first cowcod assessment (Butler et al., 1999), an index was developed using data from the Orange County and Los Angeles County Sanitation Districts. This index was deleted from more recent attempts due to an apparent lack of new information. The Sanitation District trawl surveys are re-evaluated here in view of more recent data indicating an increase in cowcod abundance.

*Orange County Sanitation District Trawl Survey*

The Orange County Sanitation District conducts benthic trawl surveys at fixed stations on the shelf roughly between the cities of Newport Beach and Seal Beach, CA (Figure 22). Four stations have been surveyed every year, and one station has been sampled in all years except one. Four stations were sampled for 28 or more consecutive years, but were either started or discontinued in the middle of the time series. In 2011, 6 new stations were added, with an additional 3 in 2012. Four stations were sampled for 3 years or less. Sampling was conducted on a quarterly basis from 1970 through 1984, but subsequently reallocated to quarters 1 and 3, with twice the number of hauls per quarter.

Stations T15-T25, TBC, and TC, were excluded from our analysis because they were occupied in fewer than four years. Data from quarters 2 and 4 were removed, because total sampling effort was reallocated to quarters 1 & 3 beginning in 1986. Since peak parturition for cowcod in Southern California occurs in January (Love et al., 1990) and is followed by a pelagic juvenile stage lasting several months, it is unlikely that cowcod observed in 1st quarter hauls represent production from that year. Therefore, data from the 1st quarter of each year were reassigned to the 4th quarter of the previous year. The re-coding of the year effect reduced sample sizes for the first year and the last year, and data from these two "shift-years" (1969 and 2012) were not included in the final analysis.

The final data set from the Orange County Sanitation District includes 819 hauls conducted at 8 stations over 42 years, with 58 cowcod observed in 35 positive hauls (4.3% positive; Table 15). Average size of cowcod caught in the OCSD trawls was 13 cm, consistent with an advanced stage young-of-the-year.

*Los Angeles County Sanitation District Trawl Survey*

The Los Angeles County Sanitation District has sampled 3 depths (23m, 61m, and 137m) along four cross-shelf transects since 1972 (Figure 22). In 1991, a fourth station was added to each transect at 305m. Quarterly trawl data for 1972 to 2012 were obtained from Bill Furlong (LACSD, Pers Comm), consisting of 2179 samples of which 128 were positive for cowcod, most (65%) of which were young-of-the-year. Positive samples occurred mostly (75%) in the fourth quarter and before 1999 cowcod presence was restricted almost entirely to the fourth quarter. Consequently, only the fourth quarter trawl samples are used for the abundance index. Average size of cowcod in the selected hauls was 13 cm, which is consistent with advanced young-of-the-year. Piner et al. (2005) described the survey gear specifications as "otter trawls with a 7.6 m headrope with a 1.25-1.3cm cod end mesh. Trawl speed was 1.5-2.5 knots and durations were ~10min."

The final data set from the Los Angeles County Sanitation District consisted of 325 hauls conducted at 9 stations during the fourth quarter (stations T0-61, T0-137, T1-61, T1-137, T1-305, T4-61, T4-137, T5-61, and T5-137). A total of 150 cowcod were observed in 60 positive hauls (18% positive, Table 16). All stations were sampled annually, excluding 1978 and 2003, except for station T1-305 which was occupied since 1991. A single 4th-quarter haul was completed at each station each year, except for station T5-61 which was sampled twice in 1975. The lack of replication within quarter precludes testing for differences in trends among stations.

*Combined LA/OC Sanitation District Trawl Survey Index*

The proportion of hauls that encountered cowcod in the two surveys shows a similar pattern over time, with a lower overall fraction positive and earlier decline in the Orange County data (Figure 23).

As noted for the CalCOFI survey in previous assessments, the Sanitation District data are imprecise for any given year, but appear to track long-term trends. The absence of cowcod in some years also presents a problem for analysis using binomial models. For these reasons, we binned the data into eight, roughly 5-year time blocks: 1970-75, 1976-80, 1981-85, 1986-90, 1991-95, 1996-2000, 2001-05, and 2006-2011.

We fit a binomial GLM to the combined data set, with block-year, station, and quarter as factors. Analysis of deviance and stepwise AIC model selection supported the inclusion of all variables in the final model, and excluded two-way interaction terms between block-year, site, and quarter. The final index was estimated from the back-transformed year coefficients of the binomial GLM. The average of the coefficients for each covariate were included in the back-transformation to scale the index to an 'average' proportion positive across the factor levels for station and quarter (e.g. a "least-squares mean" estimate). The GLM index (Table 17), which accounts for differences among stations (Figure 24) and quarters, shows a slightly faster decline between the first two block-years, but is otherwise very similar to the raw proportion of positive tows across years (Figure 25).

#### *2.1.3.3 NWFSC trawl survey*

Raw data from the 2003-2012 NWFSC Trawl Surveys were provided in spreadsheet format by Beth Horness (NWFSC, Pers. Comm.). A total of 166 tows were positive for cowcod, 162 of which were south of Cape Mendocino (Figure 26, Figure 27). The fraction of positive tows was highest between 100-250 meters (Figure 28). An increasing trend in abundance of small (<1 kg) cowcod is apparent for Southern California, but no clear trend is evident north of Point Conception (Figure 29). Average weights for small cowcod (<1 kg) show no trend over time (Figure 30). The largest portion of the sampled population was in the northern portion of the southern California Bight, with local concentrations encountered off Monterey and Point Reyes (Table 18).

The distribution of cowcod mean weights indicates that trawl survey tows strongly favor small, young fish (Figure 31). A 1-kg fish tends to be about 10 years old. Mean age of cowcod caught by the survey south of Point Conception was 4 years (Table 19).

In southern California waters between 32.5 N Lat and 34.5 N Lat large cowcod (>1 kg) are not encountered frequently enough (average Npos is 1.5 per year) to support a direct index of large fish abundance. However, trawl catches of small cowcod (<1 kg, mean age 4 years) average 6.6 per year, and can support an index of recent production in southern California waters. We developed an index of small (<1 kg) cowcod abundance, modeling the proportion of positive hauls (N = 240 tows between 100 and 250m depth) using a binomial GLM with year and depth effects (Table 20, Figure 32). Given the average age of the small cowcod, we treat this as an index of adult abundance 4 years earlier (1999-2008).

#### *2.1.3.4 NWFSC hook-and-line survey*

Since 2004, the NWFSC has conducted a hook-and-line survey targeting shelf rockfish at fixed stations in the Southern California Bight. Given the rarity of cowcod encounters, the STAT developed an index using "drop" as an approximate unit of effort. The STAT was provided data on the number of cowcod encountered by year, site, vessel, and drop number (Jim Benante, PSMFC, and John Harms, NWFSC, pers. comm.). At each 'drop,' three deckhands simultaneously deploy five, 5-hook sampling rigs (75 hooks total per site) for a maximum of 5 minutes per line, but individual lines may be retrieved sooner at the angler's discretion (e.g. to avoid losing fish). See Harms et al. (2008) for a complete description of sampling methods. Sampling coverage (# of drops) over time for sites that have encountered cowcod at least once has varied in some cases, but is generally consistent (Table 21). The survey aims to complete five drops per site each year, but unavoidably sites are missed in some years, and only 2 drops were completed at site 414 in 2005 and site 6 in 2006. Available otoliths were aged (Table 24).

Catch (in weight; Table 22) per drop was modeled using a delta-GLM with year and site effects, with uncertainty estimates calculated from a jackknife algorithm (Table 23, Figure 33). Compared to raw CPUE (catch per drop), the standardized index suggests a slightly slower rate of increase due to differences in site occupancy over time and site-specific catch rates (Figure 34). Sites with fewer than 2 positive observations were dropped (sites 17, 21, 24, 29, 36, 43, 77, 137, 147, 149, 154, 168, 181, 186, 200, and 205), with the final data set consisting of 907 drops (136 positive) from 23 sites over the period 2004-2012. The year effects from the binomial model in the delta-GLM are largely responsible for the trend in the index (Figure 35). No trend is evident in the positive component (i.e. conditional mean) of the index.

#### *2.1.3.5 Visual (Submersible) Survey of Cowcod in the CCAs, 2002*

Yoklavich et al. (2007) describe a line-transect survey of cowcod abundance in 2002 conducted from a submersible inside the Cowcod Conservation Areas (CCAs). They estimated cowcod biomass inside the CCAs at 524 mt (CV=0.26) The area surveyed encompassed eight offshore banks having characteristics consistent with known cowcod habitat (75-300 m depth, mixed sediment and rock substrata). 94 dives were completed over 28 days, The survey estimated 524 mt of cowcod biomass (CV=0.26) within the CCAs. See Yoklavich et al. (2007) for additional details regarding the survey design. Yoklavich (pers. comm.) estimated the percentage of total biomass that was mature (95.5% of total biomass, or 501 mt) based on a cut-off of 40 cm. This adjustment was applied to the total biomass estimate to better reflect the selectivity assumptions in XDB-SRA.

The cowcod biomass estimate from the survey represents fish inside the CCAs (the survey area), and therefore must be expanded to represent the biomass in the entire SCB. Since the 2005 cowcod assessment, the biomass estimate has been treated as a relative index with an informative prior on the catchability coefficient ($q$) reflecting uncertainty in the expansion factor. Methods used to derive the prior for $q$ are in Appendix IV of Piner et al. (2005). In short, CPFV catch rates by statistical block were used as a proxy for relative density in the SCB. The density proxies for blocks inside and outside the CCA were multiplied by "habitat" area (70-300 m depth) and summed to estimate the proportion of cowcod inside vs. outside the CCAs. The results of that analysis suggested that approximately 1/3 of cowcod biomass in the SCB was outside the CCAs ($q \cong 0.75$). Following Piner et al. (2005), the prior for $q$ in this assessment is specified as a normal prior on $\log(q)$, with mean -0.2863 and log-scale standard deviation of 0.5.

#### *2.1.3.6 Southern California Bight Cowcod Assessment Survey (2012)*

Between October and December 2012, the SWFSC used a remotely operated vehicle (ROV) to survey cowcod habitat (K. Steirhoff, pers. comm.). The survey encountered 189 cowcod during 167 transects, stratified by depth and substrate type, at 18 sites in the SCB. Sites were inside and outside the CCAs, between 67 and 268 m depth.(Figure 44). Survey results are pending.

#### 2.1.3.7 SWFSC Rockfish Recruitment and Ecosystem Assessment Survey

In 2013 the NOAA Fisheries Santa Cruz Laboratory encountered the highest numbers of cowcod in the 30 year history of their annual rockfish recruitment and ecosystem assessment survey. Note that the survey was originally confined to central California (Monterey Bay to Point Reyes) from 1983-2003 and was expanded in 2004 to include almost the entire California coast (San Diego to Mendocino). While cowcod were more consistently collected from 2004 onward due to the expanded survey area, the catches in 2013 exceed all previous years combined (Table 25). Although the observed cowcod occurred primarily in the core survey area (Central California), lower numbers in Southern California are likely due to earlier settlement of pelagic juveniles prior to sampling (K. Sakuma, pers. comm.). If this turns out to be a strong year class, it would recruit to the reproductive population ca. 2024, but may be encountered as bycatch or in surveys (e.g. Sanitation Districts, NWFSC trawl and/or hook-and-line) before that time.

### 2.1.4 Fishery-Dependent Indices of Abundance

#### 2.1.4.1 CPFV logbook CPUE index

The catch of cowcod has been reported in CPFV logbooks since 1963, but trip-specific data are available beginning only since 1980. The earlier logbook data exist as summarized aggregate monthly catch and effort by CDFW reporting block. The catch rate data cease being informative after 1999 when restrictive regulations were enacted for the purpose of rebuilding a depleted stock.

Logbook data for cowcod in the area north of Point Conception are highly variable, showing little trend, relative to catch in the SCB (Figure 36). Seventy-eight percent of cowcod recorded as kept north of Point Conception from 1964-1999 were caught in 4 years. For these reasons, no attempt was made to derive an index of cowcod abundance north of Point Conception.

Cowcod assessments and updates in 1999, 2005, 2007, and 2009 utilized CPFV-based abundance indexes based on the aggregate data from 1963 to 2000. Since 2005, various STAR Panels have recommended analysis of the individual CPFV trip records that are available since 1980. However, since the 2007 assessment was initially scheduled as an update (and later changed to a full) and the 2009 assessment was an update, the aggregated index was retained with minor changes. The present assessment (2013) is the first attempt to examine the trip-based data. As with all of the abundance indexes previously used in cowcod assessments, their utility for assessing cowcod has been debated. Although the aggregate CPFV index was only remaining time series of abundance in the 2005 and 2007 assessments, both STAR Panels questioned whether the CPFV index itself should be used.

*Aggregated CPUE*
The 2007 (and 2009 update) assessment used a spatial stratification that is based largely on the assumption that adjacent (or nearby) blocks are likely to have similar trends in CPUE (a recommendation of the 1999 STAR panel). These groups of blocks formed 10 REGIONs (Figure 37). Blocks below the first quartile of mean CPUE were excluded, as well as any data from the months of May-October due to seasonal changes in target species. The analysis also excluded blocks that represent data of uncertain location, and catch reported in blocks that don’t exist. Blocks with very sparse time series (<3 years with positive catch of cowcod) were dropped from the analysis. The fishing season was defined to include the months of November through April

the following year. The index was derived from the YEAR effect from a delta-lognormal GLM. YEAR-REGION strata were too sparse (excessive numbers of zeroes and unsampled strata) to allow rigorous evaluation of interaction terms, and a main effects model was adopted. As with previous treatments of the aggregated month-block data, the resulting index showed a pattern of "hyperdepletion," especially at the beginning and end of the time series (Figure 38). The 1999 and 2000 index values were anomalously low, and could not be fit satisfactorily by the assessment models. The reason for the hyperdepletion is not known, but speculation includes possible shifts in targeting and reporting behavior, and possible localized depletion at favored fishing sites.

*Trip-Based CPUE*

From this data set we developed three versions of trip-based CPUE before and during the STAR Panel review. These are referred to as "Cowcod-Only CPUE", "Rockfish Trip CPUE", and "Filtered CPUE."

*Cowcod-Only CPUE*

Anticipating difficulty in determining which trips were targeting cowcod (see following methods), we considered that the only reliable indicator that the fishing trip sampled cowcod habitat may be the presence of cowcod itself. Distributions of catch per angler hour appeared to be approximately exponential (as might be suspected for a rare, non-aggregating species), in which case it is justified to use the "first" cowcod to indicate a valid trip, and to calculate CPUE from the remainder of the catch, i.e., CPUE = (N-1)/angler-hour. Trips that only caught a single cowcod now form the "zero" observations contributing to the binomial portion of the delta-GLM. Further support for the exponential assumption was provided by the estimated gamma shape parameter (1.13) from the final delta-GLM. A value of 1 corresponds to an exponential distribution.

The full data set included 5482 trips in which cowcod were recorded, of which 1595 trips recorded a single cowcod. Months of October-December were assigned the YEAR value of the following January. Logs were filed by 896 unique vessels, of which 76 vessels recorded more than 15 positive trips. These vessels were assumed to be relatively consistent targeters of cowcod, and the remaining logs were deleted from consideration, leaving 5265 trips. Of these, 5021 trips were in CDFW reporting blocks that could be assigned to one of 11 REGIONS based, with minor modifications, on the regions in the 2007 and 2009 assessments (Figure 39). After deleting trips from nominal YEAR 2000 (October to December of 1999), the final data consisted of 4898 trips (1336 with a single cowcod, and 3562 with multiple cowcod). Preliminary delta-gamma GLMs supported collapse of MONTH effects into two SEASONs: October-January plus September, and February-August. Vessel IDs were not used as explanatory variables, but merit possible consideration as random effects in a future mixed-model (GLMM) analysis. The final delta-gamma GLM used fixed effects of YEAR (20), REGION (11) and SEASON (2). The Gamma main effects model was favored over a model with a YEAR:REGION interaction term by an AIC difference of 62. Including a YEAR:REGION interaction term in the binomial model failed to converge, in part due to sparse data (strata containing all zero observations). Standard errors of YEAR effects in the delta-GLM index were estimated by jackknife (Table 26).

The Cowcod-Only CPUE index is fairly similar to the aggregated CPUE index from 1980 to 1994 (Figure 40). From 1995 to 1999 the trip-based index holds steady while the aggregated CPUE drops tenfold. While the new trip-based index clearly addresses the issue of hyperdepletion in the original, aggregated index, it is possible that the data selection criteria have introduced a property of hyperstability. We evaluate the property of hyperstability by examining properties of the binomial and lognormal components of a delta-GLM based on "Rockfish-Trip CPUE."

A final consideration is the best specification for the distribution of positives in the delta-GLM. We have adopted a delta-gamma specification with an estimated gamma shape parameter that supports the assumption of an exponential distribution. However when the alternative specification of a delta-lognormal GLM is considered, both AIC and other diagnostics very strongly favor a lognormal distribution for the positives! The trajectory of YEAR effects from the alternative delta-lognormal model appears roughly similar to that from the adopted delta-gamma GLM, and link-scale predictions from both models show no clear indication of bias (Figure 41). The STAT preferred the delta-gamma GLM as being formally justifiable (supporting the exponential assumption) despite the information criterion supporting a delta-lognormal GLM.

*Rockfish-Trip CPUE*

The Rockfish-Trip CPUE analysis was an intermediate work product developed 1) as a step toward the following Filtered CPUE, and 2) as a tool for understanding the properties of the Cowcod-Only CPUE. It was not used as an index of abundance in the assessment modeling. A total of 373975 CPFV trip logs cover the years 1980-1999; subsequent years are not considered due to regulatory changes. Unlike the Cowcod-Only CPUE, we did not use vessel information to filter the data. Of the documented trips, 69781 logs showed more rockfish taken than non-rockfish taxa (and catch rate was at least one fish per angler); further pre-filtering consisted of dropping any trip in which the following taxa were present: yellowfin, skipjack, bluefin, bigeye, albacore, dolphinfish, wahoo, salmon, scallop, lobster), leaving 69057 trips. Finally, trips were deleted if they did not occur within the 11 cowcod REGIONS in Figure 39, leaving 58900 trips of which 4961 were positive for cowcod; this subset is referred to as “rockfish trips.”

We analyzed catch per trip (ignoring number of anglers or hours fished) by a main-effects delta-lognormal GLM, using YEAR, REGION and MONTH effects. The time series of estimated YEAR effects from the two components of the delta-GLM (Figure 42) reveal probable hyperstability in the cowcod-only model. The binomial portion shows that the fraction of trip catching cowcod declined during the 1980s, and stabilized at a lower level in the 1990s. There was an insignificant drop in the last two years, suggesting that the cowcod encounter rate was similar to previous years. The number of cowcod caught on positive trips shows a drop from 6.5 to 4.5 fish per trip during the early 1980s, a stable catch rate of 4 fish from the mid-1980s to the mid-1990s, and then a sharp drop in the late 1990s. Changes in the binomial probabilities appear to be more important than changes in catch rates for positive trips. This is consistent with a pattern of serial depletion, and may indicate that the Cowcod-Only CPUE is hyperstable, and should be considered to be unreliable.

*Filtered CPUE*

Presences and absences of non-rockfish species in the Rockfish-Trip subset of the logbooks were used to filter the logbook record down to those most likely to have fished in cowcod habitat (Stephens and MacCall 2004). The logistic regression coefficients (Figure 43) were unusual in that lingcod was the only positive indicator, while all of the other taxa were negative to strongly negative indicators (as expected from knowledge of their biology). The consequence for filtering is that the indicator species are unable to identify likely cowcod habitat, but are effective only in identifying unlikely habitat. The highest estimated probability that cowcod should be present was only 0.2, which indicates very poor reliability. The rate of false negatives is also unacceptable: 79% of the positive cowcod trips are discarded with estimated probabilities below the conventional threshold where false negatives equal false positives. Of the 5270 trips that were retained, only 1088 were positive for cowcod. The discarded trips included 3873 that were positive for cowcod. The filtered data set was used in a delta-lognormal GLM, giving YEAR effects that tend to resemble the aggregated CPUE series until the mid-1990s (Figure 40). The filtered data show a drop in 1998-99 CPUE, but not as severe as seen in the aggregate CPUE.

#### 2.1.4.2 RecFIN dockside CPUE data

A query of RecFIN sample data showed 184 cowcod observations in about 200000 angler-hours of fishing. The data set is too thin to support Stephens-MacCall sorting for relevant trips, and three years reported zero cowcod. Therefore, a RecFIN-based CPUE index was not considered.

#### 2.1.4.3 Onboard CPFV observer data

Monk et al. (in prep) recently created a relational database for onboard CDFW CPFV observer data collected from 1999-2011. This database was recently used to develop indices of abundance for assessments of three nearshore species (china rockfish, copper rockfish, and brown rockfish). We queried the database for the number of cowcod kept and returned by year and county (Table 27). Too few cowcod were observed to provide information on trends in abundance, probably due to depth restrictions designed to reduce the number of cowcod encounters. A larger number of cowcod were reported in 2011 than in previous years.

## 2.2 History of Modeling Approaches Used for this Stock

The first assessment of cowcod (Butler et al. 1999) used Schnute's (1985) generalization of Deriso's (1980) delay-difference model. The assessment was tuned to three indices of abundance (the CalCOFI larval survey, CPUE from CPFV logbook data, and demersal trawl surveys conducted by the Los Angeles and Orange County Sanitation Districts). Butler et al. estimated spawning biomass in 1998 to be about 7% of the unfished level.

The next assessment (Piner et al., 2005) was an age-structured production model coded in Stock Synthesis (Methot and Wetzel, 2013). The assessment considered updated versions of the three indices used in the first assessment, as well as RecFIN CPUE indices and a visual transect survey of the Cowcod Conservation Areas. The CalCOFI, RecFIN, and Sanitation District indices were excluded from the final analysis, as were all length composition data. The number of zero observations in the indices presented a problem for the assumed lognormal error structure, and the composition data were highly variable and poorly fit by the model. The final model was tuned to the CPFV logbook index and the visual transect survey, estimating unfished recruitment given deterministic recruitment and fixed values of steepness and natural mortality.

In 2007, Dick et al. used a similar age-structured model fit to a slightly revised CPFV logbook index. Commercial and recreational landings were modeled as separate fleets and selectivity curves were updated, as were the growth curve, spatial stratification of the CPFV logbook index, and historical commercial catch estimates.

Dick et al. (2009) prepared an update to the 2007 assessment, which included a revision to the historical (1928-1980) recreational catch time series based on California's catch reconstruction effort (Ralston et al. 2010).

### 2.2.1 Response to STAR panel recommendations from the most recent previous assessment

STAR panel recommendations are provided below (italics), followed by STAT comments.

*Present and consider all available data potentially relevant to abundance trends in recent and historical years (e.g., outfall surveys, CalCOFI data, NWFSC bottom trawl data, observer data, and hook and line survey data). Data for recent and current trends are important in tracking progress towards rebuilding. Historical data may be useful in corroborating trends in CPFV logbook data.*

This is a primary goal of the new assessment. The STAT evaluated all of the requested data sources, and incorporated information from each in the new model.

*Enhance modeling procedures for standardizing CPFV data, particularly in representing potential interactions between year and region.*

The STAT developed a trip-based index from the CPFV data that lacks the hyperdepletion pattern evident in the previous assessments. The Gamma (exponential) model did not support interactions between year and region (ΔAIC=65). The proportion of positive observations was too small to evaluate the interaction term in the binomial model. The revised (trip-based) CPFV index was not included in the final base model due to evidence of hyperstable properties.

*Provide reviewers with complete sets of model diagnostics for standardized abundance indices based on CPFV and other types of data.*

The STAT provided descriptions of our model selection procedures.

*Conduct additional video surveys to provide direct measures of current cowcod biomass and to facilitate interpretation of the existing video survey data. Ideally, video sampling should be carried out both inside and outside the Cowcod Conservation Areas so that extrapolation to the entire stock is not required.*

The STAT agrees with this recommendation and suggests that the next assessment consider results from the recently-completed SWFSC Southern California Bight Cowcod Assessment Survey.

*Reconstruct the cowcod rockfish catch history using all available data including catch by gear and by region. The reconstruction should include an envelope of high and low values to set bounds for exploration of alternative catch histories. As has been recommended previously by a variety of STAR Panels, the reconstruction of historical rockfish landings needs to be done comprehensively across all rockfish species to ensure efficiency and consistency.*

The historical catch reconstruction in this assessment was developed using regional estimates of total rockfish catch and gear-specific species compositions (proportion cowcod). Sensitivity of the model to alternative reconstructions was tested. The STAT recommends additional research on methods to incorporate catch uncertainty in stock assessments.

*A preliminary query of the RecFIN database showed a very small number of cowcod in the RecFIN sample data. The Panel recommended that a thorough investigation of these data be prepared for the next assessment of this stock.*

The STAT did not have time to address this concern, and considered the weight of catch types A+B1 in RecFIN to be the best available record of recreational removals.

*Re-examine the assumption that commercial selectivity at length is the same as maturity at length.*

The current model assumes that age 11+ fish are mature and 100% selected by the fishery.

*Conduct a full Bayesian assessment if possible. Cowcod are an ideal potential case because of the simple model structure and uncertainties about key model parameters and data.*

The XDB-SRA base model is fully Bayesian.

*General or long term*
*Develop surveys that track trends in abundance of cowcod. The NWFSC bottom trawl shelf and slope surveys should, in particular, be evaluated for cowcod.*

The STAT developed and incorporated a NWFSC trawl survey index into the base model. Results from the Southern California Bight Cowcod Assessment Survey are pending.

*For the historical and recent fisheries, evaluate the relative capacity of fishing fleets and markets for cowcod to determine how much catch might have reasonably been taken during historical periods and whether relatively high fishing mortality rates during the late 1980s are plausible.*

Exploitation rates in the base model are much lower than the previous assessment.

*Evaluate the hypothesis that CPFV indices are nonlinear measures of stock biomass.*

The STAT chose to work with the trip level CPFV data instead of the month/block aggregate data to address this issue. A revised, trip-based CPFV index did not have the hyperdepletion pattern from the previous assessment, but appeared to have hyperstable properties.

### 2.2.2 Report of consultations with AP and MT representatives

During the pre-STAR panel data webinar, the STAT provided a description of historical catch estimates and abundance indices used in the draft assessment base model. The GMT representative requested clarification regarding the choice to use CALCOM landings estimates rather than PacFIN. Comparison of CALCOM and PacFIN estimates showed that PacFIN landings did not reflect the most recent species composition data in CALCOM (see section 2.1.1.2 for additional details). CDFW provided a list of comments and questions on an earlier draft of the assessment. The STAT has attempted to address each of these in the current version, and thanks CDFW staff for their input.

## 2.3 Model Description

### 2.3.1 Extended Depletion-Based Stock Reduction Analysis (XDB-SRA)

This assessment uses a Bayesian extension of Depletion-Based Stock Reduction Analysis (DB-SRA; Dick and MacCall 2011). Prior predictive distributions from DB-SRA are updated by specification of likelihood functions for a set of abundance indices, generating posterior distributions for model parameters and derived quantities such as stock status, biomass, and sustainable yield (OFL).The model is coded in the R language/environment, and the base model used version 24.

### 2.3.2 Population Dynamics Model

We revise the dynamics equation used by Dick and MacCall (2011) to better approximate a time lag in recruitment, rather than a lag in net production. Biomass in each year is defined as

$$B_t = B_{t-1} + P(B_{t-A}) - C_{t-1} + (1 - e^{-M})(B_{t-A} - B_{t-1}) \quad (1)$$

where $B_t$ represents mature and vulnerable biomass at time *t* and $C_t$ represents catch at time *t*. Biomass in the first year is assumed equal to unfished equilibrium biomass, and spawning biomass is nominally 50% of total mature biomass. All removals were combined into one fleet, with assumed 'knife-edge' selectivity set equal to age at maturity (*A* = 11 years). *P* is a latent production function based on biomass *A* years earlier. Following Dick and MacCall (2011), we use a hybrid production function based on the Pella-Tomlinson-Fletcher (PTF) and Graham-Schaefer models. The last term in equation (1) adjusts the natural mortality component of net production to reflect biomass at time $B_{t-1}$ rather than $B_{t-a}$ (Aalto et al., in prep.). If, for example, $B_{t-A}$ is larger than $B_{t-1}$, a model without this correction factor would underestimate production, and vice versa. Note that the correction term disappears when lag times for recruitment and survival are the same.

### 2.3.3 Likelihood Components

For each abundance index, *I*, we assume a normal likelihood function for log-scale biomass and index values, scaled by a catchability coefficient, $q$.

$$l(B, q, a; I) = \prod_{i=1}^{n} N(log(I_i/q); log(B_i), v_i + a). \quad (2)$$

Where *n* is the number of years in the index. The variance of the normal likelihood is composed of an annual variance component, $v_i$ (estimated external to the model and assumed known for the $i^{th}$ year), and an additive variance term, *a*, that is common to all years and estimated in the model.

### 2.3.4 Prior Distributions

Prior probability distributions for parameters in the population dynamics model are shown in Figure 45, with details and derivations provided below.

Relative Depletion ($\Delta$): Since $\Delta$ (= $1\text{-}B_t/B_0$) is constrained to be between 0 and 1, we use a truncated beta distribution as a prior. The distribution was truncated below 0.01 and above 0.99 to exclude improbable values of stock status.

Previous STAR Panels recommended using PSA vulnerability scores (Cope et al. 2011) to establish depletion priors for data-moderate assessments. We adopt the truncated beta prior used for the data-moderate stock assessments, with mean = 0.7 and standard deviation of 0.2.

Natural mortality rate (M): We specify a lognormal prior distribution for M with an arithmetic mean of 0.055 based on catch curve analysis (Butler et al., 1999) and log-scale standard deviation of 0.4 based on Hoenig's (1983) regression data. M was fixed at 0.055 in the previous assessment. Dick et al. (2007) compared alternative estimators of M for cowcod, reporting a range of 0.027 – 0.072. For comparison, the $2.5^{th}$ and $97.5^{th}$ percentiles of the lognormal prior used for the base model are 0.023 and 0.111, respectively.

$B_{MSY}/B_0$: We assume a diffuse (nearly uniform) prior for the location of $B_{MSY}$ relative to unfished biomass. Specifically, we use a truncated beta distribution for this parameter with bounds 0.05 and 0.95, chosen to exclude unrealistic parameter values. The prior mean was 0.5 with standard deviation 0.285.

$F_{MSY}/M$: We assume a lognormal prior distribution, with arithmetic mean 0.97 and log-scale standard deviation 0.46. These parameter values are based on the work of Zhou et al. (2012) who conducted a meta-analysis of the ratio Fmsy/M for 245 stocks. Specifically, we used the prior for teleosts (n=88 species) and approximated the log-scale standard deviation of the prior by multiplying the reported standard error by the square root of the sample size.

Additive variance (a): Additive variance parameters were assigned a uniform prior in log space. A lower bound of 50 kg was chosen as a practical minimum estimate of variability in observed biomass, with an upper bound chosen through visual inspection of preliminary importance sampling results to confirm that posterior draws were not truncated.

Catchability (q): Catchability coefficients for most indices were not estimated. Their likelihood was derived by integrating over $log(q)$ with a diffuse, improper prior (uniform from $-\infty$ to $+\infty$). The exception is the catchability coefficient for the 2002 visual survey, which was assigned a normal prior on log(q) with mean -0.2863 and standard deviation 0.5.

### 2.3.5 Monte Carlo Simulation of Posterior Distributions

Sampling Importance Resampling (SIR; Rubin 1988) is implemented by calculating the total likelihood associated with each DB-SRA biomass trajectory (parameter vector) followed by resampling from the prior distributions using the likelihoods as weights. One performance measure is the size of the maximum resampling weight. All runs had acceptably small maximum weights (<0.01).

## 2.4 Model Selection and Evaluation

### 2.4.1 Transition from the 2009 Assessment

The 2009 cowcod assessment was an age-structured production model with deterministic recruitment, fit to the aggregated CPFV logbook index and the 2002 visual survey biomass estimate. Productivity parameters were fixed (steepness = 0.6, natural mortality = 0.055), leaving only virgin recruitment ($R_0$) to be estimated.

The XDB-SRA model, when fit to the data in the 2009 assessment, produces results that are consistent with the age-structured production model. The assumed level of productivity in the 2009 base model produces a lower estimate of unfished biomass than the XDB-SRA model with all parameters estimated (a smaller, more productive stock; Figure 46). When the steepness parameter is freely estimated in the 2009 base model, the decline in the aggregate CPFV logbook index pushes steepness to its lower bound of 0.2, with unfished biomass larger than the XDB-SRA model (a larger stock with no surplus production). Differences in the production functions for XDB-SRA and the age-structured model preclude an exact match, but the trends are qualitatively similar and the scale of the population is consistent with the range produced by the 2009 assessment under alternative productivity assumptions (Figure 46).

### 2.4.2 Alternative Treatments of the CPFV Logbook Data

Initial efforts to fit the model to CPFV logbook data resulted in population trends similar to those observed in the previous assessment. STAR panel reports from previous assessments recommended further examination of the CPFV logbook index, so we evaluated several treatments of the CPFV logbook data. First, we fit the model to the aggregated CPUE time series estimated by Dick et al. (2007), but dropped the year 2000 data point and included the 2002 visual survey as in the last assessment (run "agg_63-99" in Figure 47). We dropped the 2000 data point because the bag limit for cowcod was set at 1 fish per angler and it is likely that the results of the previous year's assessment affected angler behavior. Even without the 2000 data point, the time series was qualitatively similar to the previous assessment, showing a heavily depleted stock (7% of unfished; Figure 48) with an estimated MSY harvest rate of 1.3% and maximum harvest rates just under 0.4 (Figure 49). Interesting results from this run include a bimodal posterior distribution for $B_{MSY}/B_0$, with one mode centered above values greater than 0.5 (Figure 50, third row, far left). $B_{MSY}/B_0 > 0.5$ is a region of the generalized production function's parameter space that is unavailable under the assumption of a Beverton-Holt Stock Recruitment Relationship in the previous assessment (BH-SRR).

To show the effects of truncating the time series (from 1963-1999 to 1980-1999) and excluding trips not encountering cowcod (the "Cowcod Only" version of the index), we first truncated the time series of aggregated data (run "agg_80-99" in Figure 47 through Figure 50), which had little effect apart from the perception of a slightly less depleted stock with a greater fraction of the $B_{MSY}/B_0$ density above 0.5. However, a greater change was evident in both stock status and productivity when the more recent, trip-level index was appended to the earlier (1963-1979) time series based on aggregated data (Figure 47 through Figure 50). In fact, both runs containing trip-level data (runs "agg+trip" and "trip_80-99") produce similar results: a significantly less depleted stock with slight upward shifts in both M and Fmsy/M.

As a final "treatment" of the CPFV logbook data, we excluded the index but included all fishery-independent indices (run "noCPFV"). Whereas the bimodality in Bmsy/B0 was present to varying degrees in all models fit to the CPFV logbook data (regardless of treatment), excluding the CPFV data and fitting only the fishery-independent indices resulted in a unimodal posterior for Bmsy/B0 (Figure 50). This 'fishery-independent' model also suggested a more productive, but smaller stock, with higher estimates of M and Fmsy/M and a median unfished biomass almost half of the runs containing the CPFV data (Figure 47).

### 2.4.3 Influence of Individual Data Sources

We evaluated the sensitivity of model results to each data set by dropping one source at a time. Removing individual fishery-independent indices had little effect on the model results compared to the impact of removing the CPFV logbook index (Figure 51 through Figure 54). Dropping the CPFV index has the greatest effect on the model results (and suggests it is inconsistent with the other data sources). However, maximum harvest rates resulting from the "Fishery Independent" model (fit to all indices except the CPFV index) are 2-3 times as high as the models fit to the CPFV data (Figure 53). This is due to the reduction in scale of estimated biomass when the CPFV index is removed. The STAR panel for the last assessment suggested that the plausibility of high exploitation rates should be considered during selection of a final model for cowcod. We considered this criterion when selecting data to include in the base model, but ultimately chose to exclude the CPFV index after determining that 1) the index was extremely sensitive to alternative definitions of effective effort for cowcod, and 2) noting that peak harvest rates in the "fishery-independent" model, although still questionable, were much lower than estimates in the 2007 and 2009 assessments (Figure 55).

### 2.4.4 Convergence of Base Model

The base model was fit to the five fishery-independent indices with 500000 simulations. 20% of the trajectories were rejected due to negative biomass estimates. We resampled 15000 draws from the retained set of trajectories with weights proportional to the likelihoods, generating a maximum resampling weight less than 0.004.

## 2.5 Responses to STAR Panel Recommendations

The STAT presented the STAR panel with estimated medians and the percentage change relative to the pre-STAR panel base model for all requested runs ().

**Request 1**: Investigate the influence of the delta model parameter  prior on the model results by modeling a non-informative prior.
**Rationale**: To examine the influence of the delta model parameter prior.
**Response**: The STAT fit the data in the pre-STAR panel base model (including the CPFV logbook index) after changing the prior for relative stock biomass in 2000 (Delta) to a nearly uniform distribution over the interval 0.01 to 0.99 (Figure 56). The number of simulations was reduced to 100,000, resulting in less smooth posterior distributions, but provides adequate estimates of median values for purposes of this comparison. The diffuse prior had little effect on trajectories of annual median spawning biomass (Figure 57), relative biomass (Figure 58), or harvest rates (Figure 59).

**Request 2**: Investigate the Fmsy/M model parameter prior by 1) using a non-informative prior; and 2) using the prior based only on Sebastes data.
**Rationale**: To examine the influence of the Fmsy/M model parameter prior.
**Response**:  The STAT compared model results based on alternative priors for Fmsy/M (Figure 60, Table 32). The prior in the base model ("Teleost" case) was compared to a prior with the same arithmetic-scale mean, but twice the log-scale standard deviation ("Twice Sigma" case). Results based on a uniform distribution with bounds (0,4) were also evaluated. Lastly, a prior derived from Zhou et al. (2012) for Scorpaenids was developed, as described below. All runs were based on 100,000 simulations.
Zhou et al. (2012) reports a median-unbiased estimate of Fmsy/M = 0.694 (SE = 0.095) for the order Scorpaeniformes. From these reported values, we construct a prior for Fmsy/M that approximates the posterior predictive distribution of Fmsy/M for Scorpaenids. If we assume the standard error of the mean-unbiased estimate is also 0.095, then the standard deviation, $\sigma$, of the data should be roughly 0.095*sqrt(35)=0.562, where 35 is the number of observed Scorpaenid species. Given this estimate of the standard deviation, the arithmetic-scale mean of the lognormal distribution is roughly $0.694*\exp(\sigma^2/2) = 0.813$. Since we want a log-scale standard deviation (the prior is lognormal), we approximated a CV of 0.562/0.813 = 0.691, which converts to a log-scale standard deviation of 0.625 using the relationship $CV=\sqrt{\exp(\sigma^2)-1}$. The "Zhou" prior for Scorpaenids is specified as a lognormal distribution with mean 0.813 (arithmetic scale) and log-scale standard deviation of 0.625. The alternative priors had little effect on median spawning biomass, depletion, and harvest rates (shown in Figure 61, Figure 62, and Figure 63, respectively).

**Request 3**: Investigate the use of a more informative prior for Bmsy/B0 based on the life history of cowcod by modeling the data-moderate prior.
**Rationale**: To examine the impact of a more informative Bmsy/B0 prior.
**Response**: The STAT compared model results based on alternative priors for Bmsy/B0 (Figure 64, Table 33). The prior in the base model was compared to a prior used in assessments of Data-Moderate (D-M) stocks completed earlier this year (PFMC, 2013). The alternative prior had little effect on spawning biomass, depletion, and harvest rates (shown in Figure 65, Figure 66, and Figure 67, respectively).

**Request 4**: Plot the proportion positive (in log and arithmetic space) in the regions in the CPFV index by year (with rockfish present) to see if there are spatial changes over time.
**Rationale**: To investigate possible hyperstability.
**Response**: The STAT team presented CPUE results that included only trips that caught more rockfish than all other taxa as a proxy for rocky habitat (~70,000 trips). Results of standardizing n-1 cowcod filtering and rockfish trips filtering were similar with a bit more hyperstability in the n-1cowcod data. STAT team also noted an unreliable drop in CPUE in 1998 and 1999, possibly due to changing fishery behaviors. (See request 9). STAR Panel agreed that dropping 1998 and 1999 may be reasonable pending new standardization.

Specifically, the STAT compared annual trip-based CPUEs without reference to season or location, for all of southern California combined. Two sorting approaches were compared. The first used cowcod to identify relevant trips (5287), and defined CPUE as (N-1)/ang-hr. In calculating the average CPUE, trips that caught 1 cowcod were treated as zeroes. The second sorting approach was to use rockfish as indicating relevant trips, so a trip was counted if the rockfish catch exceeded the catch of all other taxa, and the catch rate was at least 1 fish per angler (69781 trips). In this case CPUE was simply N/ang-hr (Figure 68).

**Request 5**: Plot the proportion (n-1) (in log and arithmetic space) of the cowcod-only trips in CPFV regions (using the dataset in the base model index).
**Rationale**: To investigate possible hyperstability.
**Response**: STAT tem provided plots of CPUE. CPUE (N-1 per angler-hour) estimates show serial depletion based on distance from shore (Figure 69). The presence of serial depletion may be indicative of hyper-stability in the cowcod only trips.

**Request 6**: Plot the number of CalCOFI larvae by tow and number of tows by station (using the five-year block stratification).
**Rationale**: To better understand the quality of the data behind the binomial model and validate the binomial model used to represent abundance.
**Response**: STAT team presented the number of larvae captured and the proportion positive by station and year. 80% of positives stations are 1 larva and 13% are 2 larvae (Table 34). Proportion positive stations are also quite low (average 2.7% positive, Table 35).

**Request 7**: Profile on q (range from 0.375-1.5) for the visual survey.

**Rationale**: To determine the influence of the estimated q for the visual survey.
**Response**: STAT team provided results based on alternative priors for q (half and double in arithmetic space, same log-scale SD). If prior is large (1.5) data prefer a smaller q. At a q=.375 prior and posterior are similar. Prior affects scale (Figure 70) and only increasing the median of q will affect stock status (Figure 71). This request was a pure sensitivity analysis and did not provide a motivation to change from the historical base model prior.

**Request 8**: Provide sensitivity runs of historical catch uncertainty (recreational: pre 1981; commercial: pre 1969) by doubling and halving the catches in these years.  Do these runs with and without the CPFV index included.
**Rationale**: To determine how historical catch uncertainty influences the production model.
**Response**:  STAT team provided results of model runs that altered historical catch (Figure 72) and either used or dropped the CPFV index. Use of CPFV index in the model affected the scale of the population, increasing biomass and decreasing harvest rates (Figure 73, Figure 74). Higher historical catches leads to higher levels of B0 and higher depletion in 2013 (Figure 75). The converse is true for low historical catches. Changing historical catch did not greatly affect estimates of current biomass. Use of CPFV has influence on depletion for higher historical catch likely due to rejection of implausible runs at very low biomasses. The model was sensitive to assumptions about historical catch (and inclusion of CPFV index), which led to request 10.

**Request 9**: Based on the findings of request 4, continue filtering the data informing the CPFV index based on rockfish trips only(with further filtering criteria explored by the STAT) and including regions and seasons in the CPFV dataset to produce new delta GLM estimates of CPUE.
**Rationale**: To explore more representative CPUE data for cowcod.
**Response**: The STAT team filtered CPFV trip logs rockfish trips (>50% rockfish), the number of rockfish per angler, and no-groundfish catch to produce a dataset of rockfish trips.  Data were further subdivided by non-rockfish species thought to co-occur with cowcod (~59,000 obs). Only trips with lingcod were consistently caught with cowcod, which further reduced the observations(5270 trips). This resulted in only 1088 positive cowcod trips, which was only a small fraction of the trips taking cowcod. The STAT team presented results from a delta-GLM using the reduced dataset. The binomial portion of the index indicated a decline in number of locations taking cowcod through time. CPUE of positives observations were relatively stable. STAT team concluded that using positive cowcod only trips likely produced a hyper-stable index. The STAT team recommends not using the CPFV index in the assessment model due to difficulty in getting a representative subset of CPFV observations to standardize. STAR Panel accepted this decision.

Specific steps taken to standardize the index were as follows:

- Consider years 1980 to 1999: total data set of 373975 trips
- Keep trips where rockfish were the majority of the catch (in numbers) and the number caught exceeded the number of anglers, leaving 69781 trips

- Delete trips that caught tuna, yellowfin, skipjack, Bluefin, bigeye, albacore, dolphinfish, wahoo, salmon, scallop, or lobster: 69057 trips
- Delete explanatory species if less than 1000 positive trips (deletes jack mackerel, mako shark, blue shark, white seabass, black croaker, yellow croaker, white croaker, opaleye, blacksmith, sargo) leaves 14 explanatory taxa (rockfish deleted because always present) plus cowcod.
- Remove halfmoon as an indicator—slightly positive for cowcod, but too rare to be meaningful.
- Assign blocks to regions as in previous CPFV. Trips outside assigned regions were dropped, leaving 58900 trips
- Species filtering (with region offsets) gives probability of encountering a cowcod on a trip, given the presence/absence of indicator species in catch. There are 4961 positives in the raw data, so retain the top 4961 trips (ranked in descending order by probabilities), giving a cutoff threshold of 0.205977. Take the rest of the trips at that probability level, giving 5270 retained trips. This retains 1088 positive cowcod trips and discards 3873 positive trips. This seemed questionable.

The species coefficients in the binomial model were negative for all species (counter-indicators of cowcod) except lingcod (Figure 76). The filtering was unable to recognize "cowcod effort" but it could determine if cowcod were unlikely to be encountered. Given the number of records to be retained, which is approximately equal to the original number of positives, the filter discarded the trip if anything other than lingcod was present. This resulted in 78% of the positive cowcod trips being discarded.

To complete the analysis, 5270 trips were put into a delta-GLM, and a lognormal error structure for the positive data was strongly favored by AIC. Month effects were collapsed into two "seasons": July & August, and all other months. Region effects (Figure 77) were only somewhat similar to expectations, but not satisfying (San Nicolas Island, SNI, is too low; San Pedro Channel, SPC, is too high, etc.). The index resembled the patterns previously shown for raw CPUE, with an initial decline, followed by a flat trend (Figure 78). The index was also noisy, with year-to-year variability exceeding estimated measurement error.

Examination of the two delta-GLM components is revealing (Figure 79).The main source of the declining trend is in the binomial portion, indicating that locations containing cowcod were becoming scarcer, with chances of encounter dropping by half. However the trend for the positives indicates that if cowcod were encountered, catch rates were fairly constant over much of the time period, with a slight decrease at the beginning. This combination of patterns suggests localized depletion. We can also look at the entire trip catch in the same way. The binomial portion is the same, but the positive portion shows how many fish were caught by all of the anglers on the trip (Figure 80).The trend is a gradual decline from about 6 fish to about 4 fish per trip, with some leveling toward the end. The last two points raise a suspicion that the number of cowcod may have been under-reported. Taken together, these patterns suggest that use of positive cowcod trips is likely to produce a hyperstable index.

**Request 10**: Provide a table of all likelihood components for alternative historical catch scenarios.
**Rationale**: To get a better understanding of model fits to these alternative catch scenarios.
**Response**: The STAT team presented the distribution of total and component likelihoods for models fit assuming the base level of historical catch and 0.5x and 2x levels of catch (Figure 81 to Figure 87). There were essentially no differences in the fit to the data for each of the catch series indicating the model cannot provide information of the magnitude of historical catches.

**Request 11**: Examine the sensitivity to the assumption of time-lagged (i.e., knife-edge) maturity and selectivity with 8-year and 14-year time lags.
**Rationale**: To explore the sensitivity to a reasonable range of time lag assumptions.
**Response:** STAT team presented SSB and depletion from models with alternative time-lagged maturity and found it did make a difference. A shorter time lag resulted in SSB that was smaller and less depleted and converse for longer time-lag (Figure 88). Depletion was 33%, 39% and 29% depletion for base, $a_{mat}$ =8 yr and $a_{mat}$ 14 yr (Figure 89). Harvest rates were only slightly affected, with higher rates for shorter time lags (Figure 90). The STAT team recognized that the model results are sensitive to this assumption but noted that the current assumption is consistent with available data. STAR panel is in agreement with keeping this assumption for the base model.

Based on discussion from preceding requests and original documentation, the STAT team and STAR panel agreed to a base model that was the same as the original model except for the removal of the CPFV index. The final base model includes the following likelihood components:

- Visual (submersible) Survey of CCA (biomass estimate with prior on q)
- CalCOFI larval abundance index (fraction positive)
- NWFSC Trawl fraction positive index
- NWFSC Hook and Line Survey catch-per-drop index
- Sanitation District Trawl fraction positive index

**Request 12**: Present base model with 10-year projection with 3mt future catch. Provide the full diagnostics, especially the fit to the indices. Present a series of runs with each index included as the only index in the model.
**Response:** The STAT presented results of the base model described above to the STAR Panel, with 20-year projections assuming 1.5 mt catch in the SCB (one half the combined ACL for the Conception and Monterey INPFC areas). Base model results are described in Section 2.6.

Compared to the revised base model that is fit to the 5 fishery-independent indices, the scale of median spawning biomass is generally consistent among models fit to single indices (Figure 91). Median biomass in 2013, as a percentage of unfished biomass, is about 34% for the base model, bracketed by the fit to the Sanitation District index (22%) and the fit to the CalCOFI index (48%) (Figure 92). Interestingly, the base model has the lowest estimate of median unfished biomass when compared to the 'individual' model fits, and accordingly the highest harvest rates (peaking over 50%; Figure 93).

## 2.6 Base-Model Results

Nine parameters are estimated in the XDB-SRA base model (Table 36). These include the four parameters in the population dynamics equation (natural mortality rate, M [$yr^{-1}$], the ratio of the MSY fishing mortality rate to natural mortality rate, $F_{MSY}/M$, relative biomass producing MSY, $B_{MSY}/B_0$, and "delta" ($\Delta$) = $1-B_{2000}/B_0$), a catchability coefficient for the visual transect survey, and additive variance parameters for all indices except the visual transect survey. The marginal posterior density for the natural mortality rate, M, is similar to the prior, with a median of 0.054. The posterior for $F_{MSY}/M$ shows a slight shift toward higher values, relative to the prior (median $F_{MSY}/M = 1.05$). The posterior distribution for the visual survey q has an (arithmetic scale) median of 0.746, very similar to the analysis presented in the 2005 assessment (Piner et al. 2005, Appendix IV), which found that approximately 75% of cowcod biomass was in the CCA. This result differs from previous assessments, in which the posterior for *q* suggested the survey over-counted cowcod biomass by 2-3 times (due to the influence of the aggregated CPFV index). The STAT considers the current estimates of survey q to be more credible, particularly given the potential issues associated with aggregated CPFV logbook data (e.g. hyperdepletion and difficulty in defining effective effort for cowcod). The two long-term fishery-independent indices (CalCOFI and the Sanitation District) are more variable than the short-term indices (NWFSC trawl and hook-and-line), resulting in larger median estimates of additive variance.

Median 2013 spawning biomass in the base model is below target biomass, but above the minimum stock size threshold (Figure 94), with tails of the distribution extending below the MSST and above target (Table 37). The data in the base model considerably reduce uncertainty in stock status, relative to the prior distributions (Figure 95). The median estimate of depletion in 2013 from the base model is 33.9% with $2.5^{th}$ and $97.5^{th}$ percentiles of 15% and 67%, respectively (Table 37, Figure 96).

The base model suggests that median harvest rates around 1930 were near the MSY rate, then declined due to shifts in fishing effort and WWII (Figure 97). Following the war, catch rates slowly increased until about 1970, then rose quickly to a maximum of approximately 54% of vulnerable biomass in the mid-1980s. The model-estimated MSY harvest rate is 5.5%, similar to the proxy ($B_{40\%}$) harvest rate of 5% (Table 37), but higher than the SPR harvest rate in the 2009 assessment (2.7%). Median harvest rates were roughly 8-10 times the median MSY harvest rate in the mid-1980s, then declined to near zero after 2000, followed by steady increases in stock biomass (Figure 98).

The bivariate posterior distribution for $F_{MSY}/M$ and $B_{MSY}/B_0$ (Figure 99) shows a slight shift toward higher values of $F_{MSY}/M$, overall, with a slight negative correlation between $F_{MSY}/M$ and $B_{MSY}/B_0$. One third of the posterior parameter vectors support $B_{MSY}$ values greater than 50% of unfished biomass (the limit at which productivity goes to zero under the Beverton-Holt and Ricker stock-recruitment relationships). Trajectories generated from the prior predictive distributions were increasingly rejected as values of $B_{MSY}/B_0$ exceeded 0.7 (Figure 100, dotted and dashed lines in bottom left panel). However, the fishery-independent data sources in the base model clearly update $B_{MSY}/B_0$ relative to the "post-model, pre-data" distribution, and favor values of $B_{MSY}$ near the proxy biomass target of $B_{40\%}$ (Figure 100, solid line in bottom left panel). Rejection regions for $F_{MSY}/M$ and M are insignificant, as were rejection regions for Delta except for trajectories that were extremely depleted in 2000 (comparing dotted and dashed lines in Figure 100). The posterior distribution for stock depletion in the year 2000 ("Delta") shows the greatest amount of updating relative to the prior, but the data contain little information about natural mortality, *M*, producing a posterior distribution similar to the prior (Figure 100).

No strong correlations are evident between parameters in the population model (Figure 101). The model predicts higher values of unfished biomass for lower values of $B_{MSY}/B_0$ (Figure 102) and greater maximum yields (as a fraction of $B_0$) for higher $B_{MSY}/B_0$ (Figure 103). This pattern is possible due to the generalized production curve, which decouples the location of maximum production ($B_{MSY}/B_0$) from its magnitude.

The Bayesian model does not identify a single, most likely trajectory, and therefore presentation of the distribution of yield curves is something the STAT continues to refine. We plotted percentiles (2.5%, 50%, and 97.5%) of production over a grid of values for $B_{MSY}/B_0$ (Figure 104). Medians of the marginal distributions for MSY and $B_{MSY}/B_0$ (red dot in Figure 104) do not correspond to the peak of any particular trajectory, but the data and model clearly support a range of possibilities, with peak production occurring over a wide range of biomass levels relative to unfished biomass.

The posterior distributions for the additive variance components provide some information about which indices are best fit by the biomass dynamics (Figure 105). The model fits the two NWFSC indices with little need for added variance, but adds considerable variance to the CalCOFI and Sanitation District indices. This is due, in part, to the fluctuations in the early part of the CalCOFI index and the first year of the Sanitation District index. Larger additive variance estimates reduce the influence of the two long-term indices in the model.

As mentioned before, the posterior distribution for catchability of the visual survey is very consistent with the prior, suggesting the survey observed roughly 75% of the SCB biomass (Figure 106). Catchability parameters for the other indices were integrated across a uniform prior for log(q), but implied distributions are shown for reference. Apart from the expected relationship between these implied values and stock status (Delta), no strong correlations were apparent between model parameters (Figure 107).

### 2.6.1 Fits to Indices of Abundance

We illustrate how the base model scales the various time series of relative abundance by plotting each index divided by its median *q* (i.e. rescaled to biomass units) over time (Figure 108). The relative precision of each index, specifically the effect of the larger additive variance estimates in the CalCOFI and Sanitation District indices, is evident through comparison of posterior predictive biomass intervals for all indices (Figure 109).

For each individual data source, we present two figures comparing predicted biomass to the index. We first compare log-scale biomass to the log-scale index with error bars, and then show the index observations relative to 90% posterior predictive intervals and the expected biomass.

The fit to the NWFSC trawl survey index does not show any obvious patterns in the residuals, and all observations are within the predictive intervals (Figure 110, Figure 111).

The model does not match the rate of decline suggested by the first time-blocked point in the Sanitation District (SCCWRP) trawl survey index (Figure 112, Figure 113). The last four observations are below the posterior median, but all observed points fall within the posterior predictive intervals.

The fit to the NWFSC hook and line index is quite good, with no strong trends in the residuals (Figure 114, Figure 115). The first observation (survey year 2004) is at the lower edge of the predictive interval.

The biomass dynamics in the model are unable to match the variability of the CalCOFI index, but the long-term trend is consistent with the other data sources (Figure 116, Figure 117). The model predictions pass between the lower observations in the 1950s and the higher estimates from the late 1960s and 1970s, and do not match the rate of increase suggested by the index in later years. The amount of added variance reduces the influence of this index, relative to other data sources.

The posterior median estimate for the visual survey almost exactly matches the observed biomass estimate (Figure 118, Figure 119).

### 2.6.2 Discard

Discard in years prior to 2001 is assumed to be zero in the commercial fleet, and is part of the A+B1 catch estimate obtained from RecFIN. with RecFIN A+B1 catch. Ally et al. (1991) report 100% retention for cowcod recorded by onboard observers in the Southern California CPFV fishery between 1985 and 1987. Beginning in 2001, WCGOP estimates of total commercial mortality are combined.

## 2.7 Uncertainty and Sensitivity Analyses

Uncertainty in the Bayesian Model is represented by the posterior distributions. These distributions reflect uncertainty in the generalized production function, but may still underestimate uncertainty due to assumptions of the population dynamics equation (e.g. deterministic recruitment).

### 2.7.1 Uncertainty in commercial catch reconstruction data

Dick et al. (2007) expressed concern that the proportion of cowcod estimated from port sample data in the 1980s might not be representative of species compositions in earlier years. In particular the 5-year average proportion of cowcod observed in the Los Angeles hook and line fishery (12.85%) seemed high, despite the relatively large number of samples supporting the estimate. A sensitivity analysis based on a 50% reduction in the assumed proportion of cowcod in this fishery was prepared for the draft assessment, but was extended as part of STAR Panel Request #8 to include a wider range of historical catch levels (see section 2.5).

### 2.7.2 Alternative Prior Distributions

Sensitivity of model results to alternative prior distributions are described in the Responses to STAR Panel Requests (see Requests 1, 2, and 3 in section 2.5).

### 2.7.3 Influence of Individual Indices on Model Results

To evaluate the influence of each index on the base model results, we removed one index at a time and re-ran the model. Removing the CalCOFI index has the greatest effect, increasing median unfished spawning biomass by 23% to about 1900 mt, and reducing median depletion (2013 biomass as a percentage of unfished) to 22% (Figure 120 and Figure 121). Removing the

Sanitation District index has the next largest effect, this time reducing unfished stock biomass to just above 1400 mt, with 2013 stock status above target (41% of unfished). Peak median harvest rates are lower when the CalCOFI index is removed (45%) and highest when the NWFSC Trawl survey index was removed (59%) (Figure 122).

### 2.7.4 Retrospective Analysis

We evaluated the sensitivity of the model to recent data by truncating time series of relative abundance and refitting the model. We truncated data in two blocks (first including data through 1999, then through 2004) and compared results to the base model. Time series of catch through 2012 were retained in the model, effectively serving as forecasts in the runs with truncated data.

Truncating the time series had little effect on the scale of the population, even back to1999 (Figure 123). Median relative biomass in 2013 decreased from 34% in the base model to 28% and 26% when the data were truncated to 2004 and 1999, respectively (Figure 124). The change in depletion is caused by removing the increasing trends in recent years. Median harvest rates estimated using the truncated data sets were very similar to the base model (Figure 125).

# 3 Reference Points

### 3.1.1 Base Model Parameter Estimates

The data in the cowcod base model are most informative about stock status (relative biomass), as seen by the reduction in variance relative to the prior (Figure 100, lower right panel). The posterior distribution for Delta did not change when a less informative (nearly uniform) prior was used, demonstrating that estimates of stock status are driven by the data, not the priors. The location of $B_{MSY}$ relative to unfished biomass ($B_0$) had a posterior median near the PFMC proxy for $B_{MSY}$, with considerable support for values greater than 0.5. The posterior distribution for Fmsy/M was only slightly shifted toward larger values (median of 1.05), and the posterior for natural mortality changed little from the prior. Additive variance parameters were larger for the longer time series, reducing the influence of these data sources. Finally, the posterior distribution of the catchability coefficient for the visual survey was centered almost exactly on the prior mean, with a slightly reduced variance relative to the prior. See Table 36 for summary statistics of the estimated model parameters.

### 3.1.2 Base Model Reference Points

Reference points for the base model describe a smaller, more productive stock than in past cowcod stock assessments (Table 37). Median unfished and current (2013) spawning biomasses are 1549 mt and 524 mt, respectively. Stock depletion is 33.9% of unfished biomass. Reference points based on model-estimated parameters are only slightly higher than the $B_{40\%}$ proxy values (Table 37).

### 3.1.3 Base Model Time Series

Time series of median age 11+ biomass, spawning stock biomass, depletion, exploitation rate, and relative exploitation rate, are provided in Table 38.

# 4 Harvest Projections and Decision Tables

Harvest projections presented in this assessment are preliminary and will be replaced by a separate rebuilding analysis.

The STAT prepared a decision table using low, medium, and high states of nature defined as the 12.5%, 50%, and 87.5% percentiles of the posterior distributions. A range of fixed catch alternatives with sufficient contrast was selected to illustrate the implications of alternative management actions under the three states of nature (see Table g in the Executive Summary).

# 5 Regional Management Considerations

Cowcod OFLs are estimated as the sum of the assessment for the Southern California Bight, and a DB-SRA yield estimate for the area between Point Conception and Cape Mendocino. As a results of this assessment, the yield estimate for the northern portion of the stock may need to be revisited.

# 6 Research Needs

1. Investigate stock structure of cowcod in adjacent areas, especially the population in waters off Mexico.
2. Reinvestigate the CPFV data to attempt to produce a CPUE time series to be used as an index of relative abundance. CPFV has a historical basis for inclusion and produces time-series that has a smaller interannual variability than other indices.
3. Age-at-maturity and other life history parameters are inherently uncertain for cowcod and require further investigation. Future assessments should consider incorporating the uncertainty associated with age at 50% maturity.
4. Investigate methods to include uncertainty in historical catches in the modeling.
5. Evaluate methods used to reconstruct historical catches of cowcod and other rockfish.
6. The STAT team expressed the most confidence in the NWFSC Hook-and-Line and visual surveys. The STAT and STAR panel recommend continuing these indices into the future and extending the survey into the CCAs.
7. Consider using $F_{MSY}/M$ priors based on rockfish rather than teleosts.

# 7 Acknowledgments

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Other contributors of data essential to the assessment include John Harms and Jim Benante (Hook and Line survey data), Beth Horness (NWFSC trawl survey data), Jason Jannot (WCGOP mortality estimates), John Hess, Carlos Garza, and Libby Gilbert (genetic stock structure information), Mary Yoklavich (visual survey), Don Pearson (cowcod age estimates and commercial landings), Keith Sakuma (SWFSC juvenile rockfish survey), and Kevin Stierhoff (description of forthcoming cowcod ROV survey).

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# 9 Tables

Table 1. Total mortality (mt) of cowcod by year and area. Commercial mortality estimates (retained + discarded catch) are from the West Coast Groundfish Observer Program and recreational estimates are from RecFIN (weight of catch types A and B1).

| | COMMERCIAL | | RECREATIONAL | | | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | North of 34° 27′ | South of 34° 27′ | North of 34° 27′ | South of 34° 27′ | TOTAL | OFL | ABC | OY (ACL) |
| **2003** | 0.22 | 0.00 | -- | 0.48 | 0.70 | -- | 24 | 4.8 |
| **2004** | 0.54 | 0.41 | -- | 0.45 | 1.40 | -- | 24 | 4.8 |
| **2005** | 1.15 | 0.00 | -- | 0.15 | 1.30 | -- | 24 | 4.2 |
| **2006** | 2.20 | 0.00 | -- | 0.07 | 2.27 | -- | 24 | 4.2 |
| **2007** | 1.93 | 0.10 | 0.19 | 0.11 | 2.33 | -- | 36 | 4 |
| **2008** | 0.48 | 0.00 | -- | 0.25 | 0.73 | -- | 36 | 4 |
| **2009** | 1.45 | 0.00 | -- | 0.21 | 1.66 | -- | 13 | 4 |
| **2010** | 1.00 | 0.00 | 0.02 | 0.17 | 1.20 | -- | 14 | 4 |
| **2011** | 0.02 | 0.00 | -- | 0.83 | 0.85 | 13.00 | 8 | (3) |
| **2012** | 0.00 | 0.00 | 0.02 | 0.82 | 0.84 | 13.00 | 8 | (3) |
| **Grand Total** | **9.00** | **0.51** | **0.23** | **3.53** | **13.28** | | | |

Table 2. Estimated cowcod removals (1900-1956) in the SCB, by year and data source.

| Year | Dick et al. Comm. Recon. | CALCOM | WCGOP | Ralston et al. Rec. Recon. | RecFIN | TOTAL |
|---|---|---|---|---|---|---|
| 1900 | 0.01 | | | | | 0.01 |
| 1901 | 5.34 | | | | | 5.34 |
| 1902 | 10.68 | | | | | 10.68 |
| 1903 | 16.01 | | | | | 16.01 |
| 1904 | 21.35 | | | | | 21.35 |
| 1905 | 26.68 | | | | | 26.68 |
| 1906 | 32.02 | | | | | 32.02 |
| 1907 | 37.35 | | | | | 37.35 |
| 1908 | 42.68 | | | | | 42.68 |
| 1909 | 48.02 | | | | | 48.02 |
| 1910 | 53.35 | | | | | 53.35 |
| 1911 | 58.69 | | | | | 58.69 |
| 1912 | 64.02 | | | | | 64.02 |
| 1913 | 69.35 | | | | | 69.35 |
| 1914 | 74.69 | | | | | 74.69 |
| 1915 | 80.02 | | | | | 80.02 |
| 1916 | 85.36 | | | | | 85.36 |
| 1917 | 137.73 | | | | | 137.73 |
| 1918 | 125.59 | | | | | 125.59 |
| 1919 | 75.1 | | | | | 75.10 |
| 1920 | 81.57 | | | | | 81.57 |
| 1921 | 71.26 | | | | | 71.26 |
| 1922 | 70.11 | | | | | 70.11 |
| 1923 | 93.94 | | | | | 93.94 |
| 1924 | 125.94 | | | | | 125.94 |
| 1925 | 138.15 | | | | | 138.15 |
| 1926 | 171.48 | | | | | 171.48 |
| 1927 | 142.3 | | | | | 142.30 |
| 1928 | 111.3 | | | 0.05 | | 111.35 |
| 1929 | 102.48 | | | 0.11 | | 102.59 |
| 1930 | 126.78 | | | 0.16 | | 126.94 |
| 1931 | 160.8 | | | 0.22 | | 161.02 |
| 1932 | 109.27 | | | 0.27 | | 109.54 |
| 1933 | 81.64 | | | 0.33 | | 81.97 |
| 1934 | 70.36 | | | 0.38 | | 70.74 |
| 1935 | 52.56 | | | 0.44 | | 53.00 |
| 1936 | 20.19 | | | 0.44 | | 20.63 |
| 1937 | 24.22 | | | 0.66 | | 24.88 |
| 1938 | 18.08 | | | 0.63 | | 18.71 |
| 1939 | 21.5 | | | 0.51 | | 22.01 |
| 1940 | 23.28 | | | 0.41 | | 23.69 |
| 1941 | 29.1 | | | 0.38 | | 29.48 |
| 1942 | 10.4 | | | 0.2 | | 10.60 |
| 1943 | 12.18 | | | 0.19 | | 12.37 |
| 1944 | 1.83 | | | 0.16 | | 1.99 |
| 1945 | 4.38 | | | 0.21 | | 4.59 |
| 1946 | 11.3 | | | 0.36 | | 11.66 |
| 1947 | 17.58 | | | 1.18 | | 18.76 |
| 1948 | 26.87 | | | 3.05 | | 29.92 |
| 1949 | 35.05 | | | 3.63 | | 38.68 |
| 1950 | 39.37 | | | 4.63 | | 44.00 |
| 1951 | 45.57 | | | 3.62 | | 49.19 |
| 1952 | 31.05 | | | 5.62 | | 36.67 |
| 1953 | 24.88 | | | 6.33 | | 31.21 |
| 1954 | 34.05 | | | 12.76 | | 46.81 |
| 1955 | 27.62 | | | 24.43 | | 52.05 |
| 1956 | 37.8 | | | 27.37 | | 65.17 |

Table 3. Estimated cowcod removals (1957-2012) in the SCB, by year and data source.

| Year | Dick et al. Comm. Recon. | CALCOM | WCGOP | Ralston et al. Rec. Recon. | RecFIN | TOTAL |
|---|---|---|---|---|---|---|
| 1957 | 38.43 | | | 17.25 | | 55.68 |
| 1958 | 43.54 | | | 12.82 | | 56.36 |
| 1959 | 45.09 | | | 7.21 | | 52.30 |
| 1960 | 49.18 | | | 7.87 | | 57.05 |
| 1961 | 50.05 | | | 9.99 | | 60.04 |
| 1962 | 37.92 | | | 10.11 | | 48.03 |
| 1963 | 47.21 | | | 10.13 | | 57.34 |
| 1964 | 36.07 | | | 15.82 | | 51.89 |
| 1965 | 50.97 | | | 19.11 | | 70.08 |
| 1966 | 47.41 | | | 29.22 | | 76.63 |
| 1967 | 63.22 | | | 39.15 | | 102.37 |
| 1968 | 63.87 | | | 41.15 | | 105.02 |
| 1969 | | 95.00 | | 30.13 | | 125.13 |
| 1970 | | 55.93 | | 39.92 | | 95.85 |
| 1971 | | 68.07 | | 38.03 | | 106.10 |
| 1972 | | 102.52 | | 50.1 | | 152.62 |
| 1973 | | 108.81 | | 62.98 | | 171.79 |
| 1974 | | 114.28 | | 69.38 | | 183.66 |
| 1975 | | 112.49 | | 70.06 | | 182.55 |
| 1976 | | 131.38 | | 57.97 | | 189.35 |
| 1977 | | 132.46 | | 58.77 | | 191.23 |
| 1978 | | 147.77 | | 55.41 | | 203.18 |
| 1979 | | 187.55 | | 74.6 | | 262.15 |
| 1980 | | 142.65 | | 80.98 | | 223.63 |
| 1981 | | 189.42 | | | 26.55 | 215.97 |
| 1982 | | 230.52 | | | 96.99 | 327.51 |
| 1983 | | 161.92 | | | 15.13 | 177.05 |
| 1984 | | 206.66 | | | 21.22 | 227.88 |
| 1985 | | 172.12 | | | 35.99 | 208.11 |
| 1986 | | 148.37 | | | 45.99 | 194.36 |
| 1987 | | 76.64 | | | 29.14 | 105.78 |
| 1988 | | 86.62 | | | 13.91 | 100.53 |
| 1989 | | 17.87 | | | 20.79 | 38.66 |
| 1990 | | 10.41 | | | 20.06 | 30.46 |
| 1991 | | 7.10 | | | 19.32 | 26.42 |
| 1992 | | 17.22 | | | 18.58 | 35.80 |
| 1993 | | 14.85 | | | 9.68 | 24.54 |
| 1994 | | 13.63 | | | 26.01 | 39.65 |
| 1995 | | 23.30 | | | 1.75 | 25.05 |
| 1996 | | 24.58 | | | 5.36 | 29.93 |
| 1997 | | 7.30 | | | 1.85 | 9.15 |
| 1998 | | 1.21 | | | 2.81 | 4.03 |
| 1999 | | 3.47 | | | 3.77 | 7.24 |
| 2000 | | 0.45 | | | 4.49 | 4.94 |
| 2001 | | | 0.09 | | 0.49 | 0.58 |
| 2002 | | | 0.09 | | 0.49 | 0.58 |
| 2003 | | | 0.00 | | 0.48 | 0.48 |
| 2004 | | | 0.41 | | 0.45 | 0.86 |
| 2005 | | | 0.00 | | 0.15 | 0.15 |
| 2006 | | | 0.00 | | 0.07 | 0.07 |
| 2007 | | | 0.10 | | 0.11 | 0.21 |
| 2008 | | | 0.00 | | 0.25 | 0.25 |
| 2009 | | | 0.00 | | 0.21 | 0.21 |
| 2010 | | | 0.00 | | 0.17 | 0.17 |
| 2011 | | | 0.00 | | 0.83 | 0.83 |
| 2012 | | | 0.00 | | 0.82 | 0.82 |

Table 4. Regional rockfish landings (metric tons) from CDF&G Fish Bulletin No. 105 (1958) and the NMFS SWFSC ERD Live-Access Server (http://las.pfeg.noaa.gov/LAS/CA_market_catch.html).

| | CDF&G Fish Bulletin No. 105 | | | NMFS ERD Live Access Server | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| year | Southern | Central | Northern | San Diego | Los Angeles | Santa Barbara | Monterey | San Francisco | Eureka |
| 1916 | 966.62 | 1258.10 | 6.48 | | | | | | |
| 1917 | 1559.70 | 1953.81 | 12.74 | | | | | | |
| 1918 | 1422.29 | 2286.85 | 29.72 | | | | | | |
| 1919 | 850.46 | 1591.24 | 6.84 | | | | | | |
| 1920 | 923.72 | 1622.13 | 9.28 | | | | | | |
| 1921 | 806.94 | 1339.01 | 13.91 | | | | | | |
| 1922 | 794.00 | 1151.53 | 10.37 | | | | | | |
| 1923 | 1063.85 | 1244.55 | 3.39 | | | | | | |
| 1924 | 1426.24 | 715.81 | 9.29 | | | | | | |
| 1925 | 1564.44 | 895.04 | 30.12 | | | | | | |
| 1926 | 1941.86 | 1448.95 | 29.71 | | | | | | |
| 1927 | 1611.49 | 1230.84 | 56.40 | | | | | | |
| 1928 | 1373.50 | 1489.87 | 48.65 | 554.76 | 769.85 | 46.65 | 1037.07 | 452.80 | 48.65 |
| 1929 | 1389.53 | 1231.60 | 116.94 | 641.80 | 687.26 | 44.60 | 744.37 | 487.23 | 116.94 |
| 1930 | 1415.63 | 1747.90 | 113.84 | 477.91 | 906.13 | 21.15 | 1281.84 | 466.06 | 113.84 |
| 1931 | 1617.81 | 1635.24 | 48.06 | 400.30 | 1182.35 | 30.91 | 1162.02 | 473.23 | 48.06 |
| 1932 | 1135.48 | 1380.64 | 40.48 | 298.47 | 797.37 | 34.76 | 929.54 | 451.10 | 40.48 |
| 1933 | 907.47 | 1250.11 | 14.12 | 252.63 | 588.30 | 46.54 | 734.27 | 515.84 | 14.12 |
| 1934 | 857.00 | 1178.65 | 52.70 | 129.53 | 510.38 | 127.60 | 762.08 | 413.50 | 57.76 |
| 1935 | 741.23 | 1377.44 | 72.72 | 77.85 | 373.92 | 177.65 | 975.39 | 402.05 | 72.72 |
| 1936 | 424.05 | 1579.23 | 85.01 | 69.72 | 122.80 | 181.88 | 1188.37 | 390.87 | 85.01 |
| 1937 | 460.65 | 1425.30 | 60.52 | 65.18 | 156.84 | 166.26 | 954.94 | 470.30 | 60.52 |
| 1938 | 309.18 | 1092.21 | 248.39 | 33.82 | 126.04 | 72.76 | 838.72 | 253.49 | 248.15 |
| 1939 | 389.66 | 779.56 | 342.66 | 92.01 | 140.83 | 91.19 | 602.61 | 176.25 | 341.65 |
| 1940 | 396.32 | 958.58 | 264.72 | 66.63 | 153.11 | 136.40 | 752.37 | 206.21 | 264.06 |
| 1941 | 470.11 | 867.78 | 206.88 | 42.15 | 202.95 | 131.57 | 662.24 | 205.29 | 206.26 |
| 1942 | 192.96 | 329.34 | 123.36 | 10.13 | 74.46 | 38.27 | 297.51 | 31.76 | 123.36 |
| 1943 | 226.43 | 402.58 | 623.90 | 5.17 | 89.07 | 38.61 | 310.60 | 91.98 | 623.75 |
| 1944 | 43.38 | 363.18 | 2506.52 | 4.63 | 10.34 | 22.14 | 331.89 | 31.28 | 2505.76 |
| 1945 | 92.92 | 617.92 | 5315.58 | 4.56 | 26.97 | 44.95 | 533.96 | 84.16 | 5313.17 |
| 1946 | 161.19 | 608.31 | 4293.16 | 8.71 | 79.60 | 48.78 | 508.01 | 100.30 | 4005.49 |
| 1947 | 185.46 | 785.98 | 2883.46 | 8.79 | 131.60 | 26.85 | 690.04 | 95.94 | 2496.14 |
| 1948 | 287.68 | 886.56 | 1792.71 | 24.12 | 200.08 | 36.11 | 748.25 | 122.98 | 1594.18 |
| 1949 | 412.09 | 847.60 | 1492.66 | 36.64 | 258.88 | 61.88 | 611.25 | 236.35 | 1274.85 |
| 1950 | 427.87 | 1555.09 | 1698.35 | 33.67 | 294.00 | 85.96 | 1106.22 | 448.88 | 1555.57 |
| 1951 | 470.81 | 2440.55 | 2074.55 | 14.55 | 328.93 | 121.63 | 1440.72 | 999.83 | 2051.35 |
| 1952 | 366.25 | 3301.04 | 1195.31 | 9.47 | 218.59 | 108.15 | 1676.93 | 1624.11 | 1089.52 |
| 1953 | 298.74 | 3845.54 | 1402.36 | 14.71 | 179.44 | 88.66 | 1953.92 | 1891.82 | 1335.43 |
| 1954 | 583.02 | 3702.04 | 1448.42 | 14.10 | 247.22 | 263.09 | 2348.59 | 1353.71 | 1262.75 |
| 1955 | 1810.39 | 2595.75 | 1346.19 | 48.45 | 199.07 | 1532.34 | 1886.96 | 708.79 | 1224.17 |
| 1956 | 1481.43 | 3882.16 | 1414.68 | 35.07 | 257.45 | 1168.67 | 2547.45 | 1334.71 | 1304.76 |
| 1957 | | | | 32.08 | 227.86 | 1522.51 | 2481.72 | 1278.15 | 1675.42 |
| 1958 | | | | 141.03 | 228.89 | 1425.89 | 2656.71 | 1902.85 | 1609.67 |
| 1959 | | | | 94.83 | 264.46 | 671.00 | 2130.96 | 2232.76 | 1365.33 |
| 1960 | | | | 89.91 | 238.78 | 1280.67 | 1616.42 | 1492.34 | 1299.30 |
| 1961 | | | | 98.52 | 174.94 | 1052.77 | 1464.21 | 1007.77 | 884.82 |
| 1962 | | | | 70.09 | 172.42 | 916.79 | 1294.95 | 902.29 | 808.21 |
| 1963 | | | | 112.15 | 220.54 | 1180.38 | 1118.88 | 1069.85 | 1331.18 |
| 1964 | | | | 87.01 | 207.47 | 718.63 | 986.50 | 793.93 | 767.33 |
| 1965 | | | | 132.79 | 248.71 | 786.04 | 1187.70 | 714.95 | 1081.89 |
| 1966 | | | | 136.44 | 226.38 | 1026.92 | 1535.84 | 731.57 | 821.78 |
| 1967 | | | | 167.07 | 250.56 | 1313.09 | 1155.41 | 388.93 | 1074.81 |
| 1968 | | | | 126.06 | 242.67 | 1187.51 | 1086.20 | 264.96 | 1271.15 |

Table 5. Data and derived quantities used to develop ratio estimates of total rockfish landings in the SCB. Gray shading indicates ratio estimate (see text for details). “Ratio years” shows the range of years over which ratio estimates were calculated. Sources include the NMFS SWFSC ERD Live Access Server and several volumes of the CDF&G Fish Bulletin (FB) series.

| | FB 105 | NMFS ERD live-access server | | | foreign catch | Major SLO Ports | | Source of | adjusted | ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| year | Southern | San Diego | Los Angeles | Santa Barbara | landed in U.S. | Morro Bay | Avila | SLO catch | Santa Barbara | years |
| 1916 | 966.62 | 330.18 | 620.06 | | 7.11 | | | ratio | 9.27 | 1928-33 |
| 1917 | 1559.70 | 532.76 | 1000.51 | | 11.47 | | | ratio | 14.96 | 1928-33 |
| 1918 | 1422.29 | 485.83 | 912.36 | | 10.46 | | | ratio | 13.64 | 1928-33 |
| 1919 | 850.46 | 290.50 | 545.55 | | 6.26 | | | ratio | 8.16 | 1928-33 |
| 1920 | 923.72 | 315.52 | 592.54 | | 6.80 | | | ratio | 8.86 | 1928-33 |
| 1921 | 806.94 | 275.63 | 517.63 | | 5.94 | | | ratio | 7.74 | 1928-33 |
| 1922 | 794.00 | 271.21 | 509.33 | | 5.84 | | | ratio | 7.61 | 1928-33 |
| 1923 | 1063.85 | 363.39 | 682.43 | | 7.83 | | | ratio | 10.20 | 1928-33 |
| 1924 | 1426.24 | 487.18 | 914.90 | | 10.49 | | | ratio | 13.68 | 1928-33 |
| 1925 | 1564.44 | 534.38 | 1003.54 | | 11.51 | | | ratio | 15.00 | 1928-33 |
| 1926 | 1941.86 | 663.30 | 1245.65 | | 14.29 | | | ratio | 18.62 | 1928-33 |
| 1927 | 1611.49 | 550.45 | 1033.73 | | 11.86 | | | ratio | 15.45 | 1928-33 |
| 1928 | 1373.50 | 554.76 | 769.85 | 46.65 | 2.24 | 17.44 | 13.90 | ratio | 15.31 | 1949-51 |
| 1929 | 1389.53 | 641.80 | 687.26 | 44.60 | 15.86 | 16.68 | 13.28 | ratio | 14.64 | 1949-51 |
| 1930 | 1415.63 | 477.91 | 906.13 | 21.15 | 10.44 | 7.91 | 6.30 | ratio | 6.94 | 1949-51 |
| 1931 | 1617.81 | 400.30 | 1182.35 | 30.91 | 4.25 | 11.56 | 9.21 | ratio | 10.14 | 1949-51 |
| 1932 | 1135.48 | 298.47 | 797.37 | 34.76 | 4.88 | 13.00 | 10.35 | ratio | 11.41 | 1949-51 |
| 1933 | 907.47 | 252.63 | 588.30 | 46.54 | 19.99 | 17.40 | 13.86 | ratio | 15.27 | 1949-51 |
| 1934 | 857.00 | 129.53 | 510.38 | 127.60 | 89.49 | 47.72 | 38.01 | ratio | 41.88 | 1949-51 |
| 1935 | 741.23 | 77.85 | 373.92 | 177.65 | 111.81 | 66.43 | 52.92 | ratio | 58.30 | 1949-51 |
| 1936 | 424.05 | 69.72 | 122.80 | 181.88 | 49.65 | 68.02 | 54.18 | ratio | 59.69 | 1949-51 |
| 1937 | 460.65 | 65.18 | 156.84 | 166.26 | 72.37 | 62.17 | 49.52 | ratio | 54.56 | 1949-51 |
| 1938 | 309.18 | 33.82 | 126.04 | 72.76 | 76.56 | 27.21 | 21.67 | ratio | 23.88 | 1949-51 |
| 1939 | 389.66 | 92.01 | 140.83 | 91.19 | 65.63 | 34.10 | 27.16 | ratio | 29.93 | 1949-51 |
| 1940 | 396.32 | 66.63 | 153.11 | 136.40 | 40.18 | 51.01 | 40.63 | ratio | 44.76 | 1949-51 |
| 1941 | 470.11 | 42.15 | 202.95 | 131.57 | 93.44 | 49.20 | 39.19 | ratio | 43.18 | 1949-51 |
| 1942 | 192.96 | 10.13 | 74.46 | 38.27 | 70.11 | 14.31 | 11.40 | ratio | 12.56 | 1949-51 |
| 1943 | 226.43 | 5.17 | 89.07 | 38.61 | 93.57 | 14.44 | 11.50 | ratio | 12.67 | 1949-51 |
| 1944 | 43.38 | 4.63 | 10.34 | 22.14 | 6.27 | 8.28 | 6.60 | ratio | 7.27 | 1949-51 |
| 1945 | 92.92 | 4.56 | 26.97 | 44.95 | 16.45 | 16.81 | 13.39 | ratio | 14.75 | 1949-51 |
| 1946 | 161.19 | 8.71 | 79.60 | 48.78 | 24.10 | 18.24 | 14.53 | ratio | 16.01 | 1949-51 |
| 1947 | 185.46 | 8.79 | 131.60 | 26.85 | 18.22 | 10.04 | 8.00 | ratio | 8.81 | 1949-51 |
| 1948 | 287.68 | 24.12 | 200.08 | 36.11 | 27.37 | 13.50 | 10.76 | ratio | 11.85 | 1949-51 |
| 1949 | 412.09 | 36.64 | 258.88 | 61.88 | 54.69 | 20.62 | 22.95 | FB 80 | 18.30 | |
| 1950 | 427.87 | 33.67 | 294.00 | 85.96 | 14.24 | 41.23 | 28.68 | FB 86 | 16.05 | |
| 1951 | 470.81 | 14.55 | 328.93 | 121.63 | 5.71 | 38.91 | 28.63 | FB 89 | 54.08 | |
| 1952 | 366.25 | 9.47 | 218.59 | 108.15 | 30.04 | 32.53 | 25.91 | FB 95, ratio | 49.72 | 1949-51 |
| 1953 | 298.74 | 14.71 | 179.44 | 88.66 | 15.94 | 56.38 | 5.04 | FB 102, ratio | 27.23 | 1954-56 |
| 1954 | 583.02 | 14.10 | 247.22 | 263.09 | 58.61 | 183.91 | 43.30 | FB 102 | 35.88 | |
| 1955 | 1810.39 | 48.45 | 199.07 | 1532.34 | 30.52 | 1393.82 | 119.73 | FB 105 | 18.79 | |
| 1956 | 1481.43 | 35.07 | 257.45 | 1168.67 | 20.23 | 1026.90 | 69.94 | FB 105 | 71.83 | |
| 1957 | | 32.08 | 227.86 | 1522.51 | | 1298.20 | 71.55 | FB 108 | 152.76 | |
| 1958 | | 141.03 | 228.89 | 1425.89 | | 1136.08 | 88.64 | FB 108, ratio | 201.17 | 1954-57 |
| 1959 | | 94.83 | 264.46 | 671.00 | | 470.07 | 36.68 | FB 111, ratio | 164.25 | 1954-57 |
| 1960 | | 89.91 | 238.78 | 1280.67 | | 910.70 | 71.06 | FB 117, ratio | 298.92 | 1954-57 |
| 1961 | | 98.52 | 174.94 | 1052.77 | | 550.97 | 42.99 | FB 121, ratio | 458.81 | 1954-57 |
| 1962 | | 70.09 | 172.42 | 916.79 | | 602.72 | 56.92 | FB 125 | 257.15 | |
| 1963 | | 112.15 | 220.54 | 1180.38 | | 652.24 | 230.78 | FB 129 | 297.36 | |
| 1964 | | 87.01 | 207.47 | 718.63 | | 467.92 | 114.14 | FB 132 | 136.56 | |
| 1965 | | 132.79 | 248.71 | 786.04 | | 453.99 | 40.04 | FB 135 | 292.00 | |
| 1966 | | 136.44 | 226.38 | 1026.92 | | 666.11 | 82.68 | FB 138 | 278.13 | |
| 1967 | | 167.07 | 250.56 | 1313.09 | | 721.16 | 96.73 | FB 144 | 495.20 | |
| 1968 | | 126.06 | 242.67 | 1187.51 | | 612.31 | 34.81 | FB 149 | 540.39 | |

Table 6. Estimated percentages (by weight) of cowcod in rockfish landings based on 5-year averages (1984-1988). Estimates for the Los Angeles, San Diego, and Santa Barbara (1916-1943) strata are from their respective hook-and-line fisheries. The estimate for the Santa Barbara (1944-1968) stratum is based on the combined trawl and hook-and-line fisheries.

| Region (time period) | % cowcod, 1984-88 |
|---|---|
| Santa Barbara (1916-1943) | 4.95% |
| Santa Barbara (1944-1968) | 5.56% |
| Los Angeles (1916-1968) | 12.85% |
| San Diego (1916-1968) | 2.10% |

Table 7. Number of port samples and number of sampled rockfish (RF) by stratum (year, gear, port complex) for the five earliest-sampled years in the SCB (1984-1988).

| Year | SB Hook & Line | | SB Trawl | | LA Hook & Line | | SD Hook & Line | |
|---|---|---|---|---|---|---|---|---|
| | # samp. | # RF | # samp. | # RF | # samp. | # RF | # samp. | # RF |
| 1984 | 11 | 297 | 11 | 366 | 15 | 485 | 19 | 492 |
| 1985 | 19 | 514 | 6 | 196 | 38 | 1098 | 19 | 739 |
| 1986 | 43 | 1335 | 5 | 215 | 38 | 1262 | 64 | 2388 |
| 1987 | 3 | 99 | 7 | 315 | 37 | 1422 | 55 | 2007 |
| 1988 | 15 | 537 | 0 | 0 | 9 | 316 | 25 | 848 |

Table 8. List of differences in cowcod landings between CALCOM and PacFIN and probable cause (sorted by absolute differences in descending order). Error Type Codes: SP = species composition in PacFIN different than in CALCOM, CE=possible error in CALCOM from manual updating, UK=could not determine source of error.

| YEAR | CALCOM | PACFIN | % DIFF | abs(P-C) | Error Type |
|---|---|---|---|---|---|
| 1984 | 555163 | 531002 | -4% | 24161 | SP |
| 1982 | 568623 | 554153 | -3% | 14470 | SP |
| 1981 | 473878 | 486180 | 3% | 12302 | SP |
| 1989 | 86888 | 96293 | 11% | 9405 | SP |
| 1998 | 37927 | 43190 | 14% | 5263 | SP |
| 1985 | 410038 | 404775 | -1% | 5263 | SP |
| 1997 | 118010 | 123169 | 4% | 5159 | SP |
| 1999 | 22932 | 27275 | 19% | 4343 | SP |
| 1988 | 217735 | 221431 | 2% | 3696 | CE |
| 1995 | 146984 | 149661 | 2% | 2677 | SP |
| 1986 | 357810 | 355186 | -1% | 2624 | CE |
| 1996 | 108060 | 110493 | 2% | 2433 | SP |
| 1994 | 79237 | 77129 | -3% | 2108 | SP |
| 1983 | 401369 | 402476 | 0% | 1107 | SP |
| 1991 | 58926 | 59530 | 1% | 604 | UK |
| 2001 | 1767 | 2118 | 20% | 351 | UK |
| 1990 | 76118 | 75926 | 0% | 192 | |
| 2000 | 3069 | 3217 | 5% | 148 | UK |
| 2002 | 217 | 356 | 64% | 139 | UK |
| 1992 | 131644 | 131511 | 0% | 133 | |
| 1987 | 191054 | 190969 | 0% | 85 | |
| 1993 | 103657 | 103635 | 0% | 22 | |
| 2003 | 112 | 113 | 1% | 1 | |
| 2004 | 68 | 68 | 0% | 0 | |
| 2005 | 85 | 85 | 0% | 0 | |
| 2006 | 0 | 0 | | 0 | |
| 2007 | 888 | 888 | 0% | 0 | |
| 2008 | 0 | 0 | | 0 | |
| 2009 | 135 | 135 | 0% | 0 | |
| 2010 | 66 | 66 | 0% | 0 | |
| 2011 | 32 | 32 | 0% | 0 | |

Table 9. Length composition sample sizes (number of trips and number of cowcod) from a 1970s onboard CPFV sampling program in the Southern California Bight.

| CPFV observer data, Nov-Apr only | | |
|---|---|---|
| **Shift year** | **No. Trips** | **No. Cowcod** |
| **1974** | 11 | 47 |
| **1975** | 105 | 318 |
| **1976** | 70 | 303 |
| **1977** | 62 | 276 |
| **1978** | 12 | 68 |

Table 10. Number of cowcod ages by region, source, and year (see separate tables for age data from NWFSC trawl and hook-and-line surveys).

**South of Point Conception**

| Source | Region | Year | Number of ages |
|---|---|---|---|
| CALCOM | So. CA | 1985 | 34 |
| CALCOM | So. CA | 1986 | 30 |
| Butler "Sport" | So. CA | 1975 | 17 |
| Butler "Sport" | So. CA | 1976 | 60 |
| Butler "Sport" | So. CA | 1977 | 29 |
| Butler "Sport" | So. CA | 1978 | 19 |
| Butler "Sport" | So. CA | 1979 | 1 |
| Butler "Sport" | So. CA | 1980 | 1 |
| Butler "Sport" | So. CA | 1981 | 2 |
| **Total** | | | **193** |

**North of Point Conception**

| Source | Region | Year | Number of ages |
|---|---|---|---|
| CALCOM | No. CA | 1982 | 4 |
| CALCOM | No. CA | 1983 | 3 |
| CALCOM | No. CA | 1984 | 25 |
| CALCOM | No. CA | 1985 | 11 |
| CALCOM | No. CA | 1986 | 1 |
| SWFSC/FED GF Ecology | No. CA | 2001 | 3 |
| SWFSC/FED GF Ecology | No. CA | 2002 | 56 |
| SWFSC/FED GF Ecology | No. CA | 2003 | 18 |
| SWFSC/FED GF Ecology | No. CA | 2004 | 31 |
| SWFSC/FED GF Ecology | No. CA | 2005 | 11 |
| SWFSC/FED GF Ecology | No. CA | 2006 | 1 |
| Triennial Survey | No. CA | 2004 | 14 |
| Slope Survey | No. CA | 2002 | 15 |
| **Total** | | | **193** |

Table 11. Monthly distribution of cowcod samples in CalCOFI surveys

| | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Npos | 4 | 5 | 66 | 49 | 27 | 31 | 16 | 10 | 4 | 0 | 0 | 1 | 213 |
| Nsamp | 1246 | 579 | 2618 | 1780 | 1368 | 2972 | 1591 | 1057 | 2420 | 1125 | 677 | 1863 | 19296 |
| fracpos | 0.3% | 0.9% | 2.5% | 2.8% | 2.0% | 1.0% | 1.0% | 0.9% | 0.2% | 0.0% | 0.0% | 0.1% | |

Table 12. Date distribution of CalCOFI samples in southern California waters. Horizontal lines indicate time blocks used for abundance index.

| Year\Date | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 | 230 | 240 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | | | | | | | 16 | 3 | | 17 | 1 | 4 | 12 | | 13 | 8 | | 15 | 2 | 10 | | 10 | | 111 |
| 1952 | | 13 | 4 | | | | 11 | 10 | 5 | 16 | | 20 | | 8 | 16 | | | 28 | 3 | 7 | 38 | | | 179 |
| 1953 | | | | | | 20 | 12 | 3 | 30 | | | 26 | 5 | | 29 | 8 | 8 | 24 | 13 | 17 | 41 | | | 236 |
| 1954 | | 12 | 16 | | | 35 | | 6 | 29 | | | 34 | | | 13 | 26 | | 5 | 35 | | 12 | 24 | | 247 |
| 1955 | | 15 | 20 | | | 9 | 14 | | 9 | 12 | | 12 | 11 | | 17 | 7 | | | 6 | 24 | 8 | 25 | | 189 |
| 1956 | | 14 | 10 | | | 23 | | 6 | 18 | | | 24 | 1 | | 4 | 23 | | 33 | | 18 | 14 | | | 188 |
| 1957 | | | 30 | | | | | | 27 | | | 16 | 11 | | 15 | 13 | | 33 | | | 34 | | | 179 |
| 1958 | 28 | | 3 | 10 | | | 5 | 16 | 25 | | 10 | 22 | | 6 | 23 | 7 | 7 | 27 | | 3 | 24 | 7 | | 223 |
| 1959 | 22 | 4 | 25 | | | | 13 | 17 | 12 | 12 | 11 | 10 | 5 | 5 | 7 | 30 | | 37 | | | 23 | 14 | | 247 |
| 1960 | 26 | 2 | 16 | 13 | | 27 | 6 | | | 17 | 13 | 8 | 22 | 16 | 21 | | | | 18 | 7 | | 29 | 7 | 248 |
| 1961 | | | | | | 7 | 6 | 13 | 14 | | | | | | 7 | 25 | 2 | | | | | | 6 | 80 |
| 1962 | | | | | | 6 | 1 | 27 | | | | | 7 | | 26 | 1 | | | | | | | | 68 |
| 1963 | | | | | | 8 | 1 | 27 | | | | | | | 21 | 12 | 7 | | | | | | | 76 |
| 1964 | | | | | | 15 | 9 | 2 | 30 | | | | | | 8 | 30 | | | | | | 26 | 2 | 122 |
| 1965 | | | | | | | 26 | 14 | | | | | | 15 | 24 | | | | | | | 24 | | 103 |
| 1966 | | | | | | 1 | 7 | 12 | 8 | 37 | | | | 31 | 4 | | 6 | 37 | | | | 29 | 8 | 180 |
| 1967 | | 8 | 29 | | | | | | | | | | | | | | | | | | | 13 | 15 | 65 |
| 1968 | | | | | | 12 | 24 | | | | | | | | | | | | | | 29 | 8 | | 73 |
| 1969 | | | | | | 15 | 21 | | 7 | 28 | | 2 | | 1 | 35 | | | 36 | | | | | | 145 |
| 1970 | | 35 | 1 | | | | | | | | | | | | | | | | | | | | | 36 |
| 1972 | | | | | | 8 | 22 | | 35 | | | 3 | 31 | | 6 | 7 | | | | | | | | 112 |
| 1975 | | 54 | | | | 24 | 19 | 8 | | | 8 | 53 | | | | | | 8 | 43 | 2 | | | 16 | 235 |
| 1976 | | | 28 | | | | | | | | | | | | | | | | | | | | | 28 |
| 1978 | | | 8 | 24 | | 4 | 40 | | | 10 | 20 | 7 | | 7 | 27 | 1 | | | 10 | 28 | | 8 | 4 | 198 |
| 1979 | | | | | | 1 | 29 | | | 19 | 13 | | | | 17 | 14 | 13 | 12 | 7 | | | | | 125 |
| 1980 | | | | | | | | | | 3 | 26 | | | | | | | | | 30 | | | | 59 |
| 1981 | | 21 | 12 | | | | 31 | 2 | | 2 | | | | 13 | 40 | 12 | | | 20 | 12 | | | | 165 |
| 1982 | | | | | | | | | | | | | 19 | 12 | | | | | | | | | | 31 |
| 1983 | | | | | | | | | | | | | 20 | 12 | | | | | | | | | | 32 |
| 1984 | | | | | 1 | 31 | | | | 15 | 13 | 7 | | | 15 | 16 | | | | 20 | | 13 | | 131 |
| 1985 | | | | | | | | | | 5 | 26 | | | | | | 6 | 20 | 6 | | | | | 63 |
| 1986 | | | | | | 8 | 6 | 2 | 14 | 16 | | | | | | | | 13 | 20 | | | | | 79 |
| 1987 | 16 | | | | | | | | | | 7 | 24 | | | | | 7 | 26 | | | | | | 80 |
| 1988 | 22 | 4 | | | | | 10 | 23 | | | | | | | | | 10 | 21 | | | | | | 90 |
| 1989 | | | | | | | 7 | 26 | | | | | | | | 21 | 12 | | | | | | | 66 |
| 1990 | | | | | | | | | | | 2 | 20 | 12 | | | 20 | 10 | | | | | | | 64 |
| 1991 | | | | | | 14 | 20 | | | | 15 | 16 | | | | | | | | | | | | 65 |
| 1992 | | | | | | | | 16 | 16 | | | | | | 7 | 22 | 4 | | | | | | | 65 |
| 1993 | | | | | | 7 | 27 | | | | | | | 9 | 25 | | | | | | | | | 68 |
| 1994 | | | | | | | 7 | 27 | | | | | 7 | 26 | 1 | | | | | | | | | 68 |
| 1995 | | | | | | 21 | 12 | | | | | | | | 22 | 9 | | | | | | | | 64 |
| 1996 | | | | | | | | 10 | 24 | | | | | | | 20 | 11 | | | | | | | 65 |
| 1997 | | | | | | | | 14 | 20 | | | | | 7 | 15 | 8 | | | | | | | | 64 |
| 1998 | | | 7 | | | | 7 | 17 | 8 | | | 7 | 1 | 7 | 22 | 5 | | | 8 | | | 12 | | 101 |
| 1999 | 11 | | 8 | 2 | | 10 | 23 | | | | | | | 7 | 26 | | | | | | | | | 87 |
| 2000 | | | | | | 14 | 20 | | | | | | | | 20 | 14 | | | | | | | 7 | 75 |
| 2001 | | | | | | 15 | 16 | | | | | | | | 22 | 12 | | | | | | | | 65 |
| 2002 | | | | | | | 3 | 20 | 10 | | | | | 21 | 12 | | | | | | | | | 66 |
| 2003 | 13 | | | | | | | 9 | 23 | 1 | | | | 2 | 21 | 11 | | | | | | | | 80 |
| 2004 | | | | | | 22 | 11 | | | | | | 7 | 25 | 1 | | | | | | | | | 66 |
| 2005 | | | | | 2 | 19 | 10 | | | | | | | | | 22 | 14 | | | | | | | 67 |
| 2006 | 1 | | | | | | | 4 | 21 | 9 | | | | 7 | 29 | | | | | | | | | 71 |
| 2007 | | | | | | 7 | 20 | 9 | | | | | | 7 | 22 | | | | | | | | 7 | 72 |
| 2008 | | | | | | 17 | 17 | | | | | | | 21 | 5 | | | | | | | | | 60 |
| 2009 | | | | | | 19 | 17 | | | | | 18 | 18 | | | | | | | | | | | 72 |
| 2010 | 8 | | | | | 7 | 14 | 13 | | | | | | | 9 | | 22 | 8 | 3 | | | | | 84 |
| 2011 | | | | | | 7 | 21 | 8 | | | | | | | 7 | 35 | | | | | | | | 78 |
| Total | 147 | 182 | 217 | 49 | 3 | 433 | 581 | 364 | 385 | 219 | 165 | 333 | 189 | 265 | 654 | 439 | 139 | 383 | 194 | 178 | 223 | 242 | 72 | 6056 |

Table 13. Sample sizes associated with intra-year SEASONS and LOCATIONS.

| | Samples | | | | | Positives | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Location | EARLY | MID | LATE | Total | | EARLY | MID | LATE | Total | fracpos |
| 8050 | 97 | 40 | 97 | 234 | | 5 | 3 | 4 | 12 | 5.1% |
| 8055 | 69 | 35 | 83 | 187 | | 6 | 2 | 0 | 8 | 4.3% |
| 8060 | 76 | 36 | 82 | 194 | | 0 | 1 | 1 | 2 | 1.0% |
| 8144 | 45 | 14 | 40 | 99 | | 2 | 0 | 1 | 3 | 3.0% |
| 8342 | 182 | 103 | 216 | 501 | | 7 | 9 | 6 | 22 | 4.4% |
| 8351 | 66 | 34 | 78 | 178 | | 4 | 4 | 5 | 13 | 7.3% |
| 8355 | 59 | 32 | 79 | 170 | | 5 | 3 | 1 | 9 | 5.3% |
| 8360 | 66 | 39 | 82 | 187 | | 1 | 3 | 1 | 5 | 2.7% |
| 8733 | 109 | 56 | 133 | 298 | | 3 | 2 | 1 | 6 | 2.0% |
| 8740 | 63 | 35 | 81 | 179 | | 2 | 4 | 1 | 7 | 3.9% |
| 8745 | 59 | 30 | 77 | 166 | | 3 | 1 | 2 | 6 | 3.6% |
| 8750 | 60 | 33 | 84 | 177 | | 6 | 4 | 8 | 18 | 10.2% |
| 8755 | 60 | 29 | 77 | 166 | | 0 | 0 | 3 | 3 | 1.8% |
| 8760 | 114 | 65 | 183 | 362 | | 1 | 1 | 0 | 2 | 0.6% |
| 9028 | 83 | 41 | 92 | 216 | | 0 | 1 | 2 | 3 | 1.4% |
| 9030 | 82 | 43 | 96 | 221 | | 0 | 3 | 0 | 3 | 1.4% |
| 9037 | 107 | 49 | 119 | 275 | | 2 | 1 | 1 | 4 | 1.5% |
| 9045 | 72 | 39 | 88 | 199 | | 1 | 1 | 0 | 2 | 1.0% |
| 9050 | 86 | 41 | 108 | 235 | | 1 | 1 | 0 | 2 | 0.9% |
| 9060 | 75 | 40 | 88 | 203 | | 0 | 1 | 2 | 3 | 1.5% |
| 9330 | 144 | 69 | 178 | 391 | | 2 | 1 | 4 | 7 | 1.8% |
| 9335 | 55 | 24 | 79 | 158 | | 0 | 1 | 2 | 3 | 1.9% |
| 9340 | 68 | 37 | 87 | 192 | | 0 | 1 | 3 | 4 | 2.1% |
| 9350 | 68 | 36 | 87 | 191 | | 0 | 3 | 3 | 6 | 3.1% |
| 9355 | 113 | 58 | 166 | 337 | | 1 | 0 | 1 | 2 | 0.6% |
| Total | 2078 | 1058 | 2580 | 5716 | | 52 | 51 | 52 | 155 | 2.7% |
| fracpos | 2.5% | 4.8% | 2.0% | 2.7% | | | | | | |

Table 14. Cowcod abundance indexes from CalCOFI surveys.

| Year | Index | Std. Error | CV | log.sd |
|---|---|---|---|---|
| 1953 | 0.0301 | 0.00619 | 0.211 | 0.209 |
| 1958 | 0.0231 | 0.00483 | 0.219 | 0.216 |
| 1963 | 0.0293 | 0.00868 | 0.310 | 0.303 |
| 1968 | 0.0811 | 0.01462 | 0.188 | 0.187 |
| 1974 | 0.0441 | 0.01157 | 0.265 | 0.261 |
| 1986 | 0.0028 | 0.00129 | 0.461 | 0.439 |
| 1999 | 0.0138 | 0.00493 | 0.457 | 0.435 |
| 2004 | 0.0201 | 0.00706 | 0.366 | 0.355 |
| 2009 | 0.0443 | 0.01164 | 0.276 | 0.270 |

Table 15. Number of hauls (a) and number of hauls catching at least one cowcod (b) by shift-year and station for Orange County Sanitation District trawl data that were incorporated into the combined Los Angeles/Orange County Sanitation District index.

a) Number of Hauls

| | Station | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shift-Year | T1 | T2 | T3 | T4 | T5 | T10 | T12 | T14 | Total |
| 1970 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1971 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1972 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1973 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1974 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1975 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1976 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1977 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1978 | 2 | 2 | 2 | 2 | 2 | | | | 10 |
| 1979 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1980 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1981 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1982 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1983 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1984 | 2 | 2 | 2 | 2 | 2 | 2 | | | 12 |
| 1985 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1986 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1987 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1988 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1989 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1990 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1991 | 6 | 4 | 4 | 4 | | 4 | | | 22 |
| 1992 | 6 | 4 | 4 | 4 | | 4 | | | 22 |
| 1993 | 6 | 4 | 4 | 4 | | 4 | | | 22 |
| 1994 | 4 | 4 | 2 | 4 | | 2 | | | 16 |
| 1995 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1996 | 4 | 4 | 4 | 4 | | 4 | | | 20 |
| 1997 | 4 | 4 | 4 | 4 | | 4 | | 2 | 22 |
| 1998 | 5 | 4 | 4 | | | 4 | 5 | 4 | 26 |
| 1999 | 6 | 4 | 4 | 3 | | 4 | 6 | 4 | 31 |
| 2000 | 6 | 4 | 4 | | | 4 | 6 | 4 | 28 |
| 2001 | 6 | 4 | 5 | | | 4 | 6 | 4 | 29 |
| 2002 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2003 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2004 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2005 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2006 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2007 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2008 | 6 | 3 | 6 | | | 3 | 6 | 3 | 27 |
| 2009 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2010 | 6 | 4 | 6 | | | 4 | 6 | 4 | 30 |
| 2011 | 2 | 2 | 2 | | | 2 | 2 | 2 | 12 |
| Total | 167 | 135 | 153 | 85 | 30 | 115 | 79 | 55 | 819 |

b) Number of positive hauls

| | Station | | | | | | | | | Percent |
|---|---|---|---|---|---|---|---|---|---|---|
| Shift-Year | T1 | T2 | T3 | T4 | T5 | T10 | T12 | T14 | Total | Positive |
| 1970 | 0 | 0 | 1 | 1 | 0 | | | | 2 | 20.0% |
| 1971 | 0 | 1 | 1 | 1 | 1 | | | | 4 | 40.0% |
| 1972 | 0 | 0 | 0 | 1 | 1 | | | | 2 | 20.0% |
| 1973 | 1 | 0 | 1 | 0 | 1 | | | | 3 | 30.0% |
| 1974 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0.0% |
| 1975 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0.0% |
| 1976 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0.0% |
| 1977 | 0 | 0 | 1 | 0 | 0 | | | | 1 | 10.0% |
| 1978 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0.0% |
| 1979 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0.0% |
| 1980 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0.0% |
| 1981 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0.0% |
| 1982 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0.0% |
| 1983 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 | 0.0% |
| 1984 | 0 | 0 | 0 | 0 | 0 | 1 | | | 1 | 8.3% |
| 1985 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1986 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1987 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1988 | 0 | 0 | 0 | 0 | | 1 | | | 1 | 5.0% |
| 1989 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1990 | 0 | 0 | 0 | 0 | | 1 | | | 1 | 5.0% |
| 1991 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1992 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1993 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1994 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1995 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1996 | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0.0% |
| 1997 | 0 | 0 | 0 | 0 | | 0 | | 0 | 0 | 0.0% |
| 1998 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0.0% |
| 1999 | 0 | 0 | 0 | 0 | | 1 | 0 | 2 | 3 | 9.7% |
| 2000 | 0 | 0 | 0 | | | 0 | 1 | 2 | 3 | 10.7% |
| 2001 | 0 | 0 | 0 | | | 1 | 0 | 0 | 1 | 3.4% |
| 2002 | 0 | 0 | 0 | | | 2 | 0 | 1 | 3 | 10.0% |
| 2003 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0.0% |
| 2004 | 0 | 0 | 0 | | | 1 | 0 | 0 | 1 | 3.3% |
| 2005 | 0 | 0 | 0 | | | 0 | 0 | 1 | 1 | 3.3% |
| 2006 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0.0% |
| 2007 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0.0% |
| 2008 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0.0% |
| 2009 | 0 | 0 | 0 | | | 1 | 0 | 1 | 2 | 6.7% |
| 2010 | 0 | 0 | 3 | | | 1 | 0 | 1 | 5 | 16.7% |
| 2011 | 0 | 0 | 1 | | | 0 | 0 | 0 | 1 | 8.3% |
| Total | 1 | 1 | 8 | 3 | 3 | 10 | 1 | 8 | 35 | 4.3% |

Table 16. Total hauls per year and number of positive cowcod hauls from the Los Angeles County Sanitation District survey. See text for a list of stations included in the index.

| Year | Total hauls | Positive Hauls | Percent Positive |
|---|---|---|---|
| 1972 | 8 | 3 | 38% |
| 1973 | 8 | 7 | 88% |
| 1974 | 8 | 3 | 38% |
| 1975 | 9 | 8 | 89% |
| 1976 | 8 | 2 | 25% |
| 1977 | 8 | 3 | 38% |
| 1979 | 8 | 2 | 25% |
| 1980 | 8 | 3 | 38% |
| 1981 | 8 | 1 | 13% |
| 1982 | 8 | 1 | 13% |
| 1983 | 8 | 1 | 13% |
| 1984 | 8 | 1 | 13% |
| 1985 | 8 | 0 | 0% |
| 1986 | 8 | 3 | 38% |
| 1987 | 8 | 1 | 13% |
| 1988 | 8 | 2 | 25% |
| 1989 | 8 | 0 | 0% |
| 1990 | 8 | 0 | 0% |
| 1991 | 9 | 0 | 0% |
| 1992 | 9 | 0 | 0% |
| 1993 | 9 | 1 | 11% |
| 1994 | 9 | 2 | 22% |
| 1995 | 9 | 0 | 0% |
| 1996 | 9 | 1 | 11% |
| 1997 | 9 | 0 | 0% |
| 1998 | 9 | 0 | 0% |
| 1999 | 9 | 1 | 11% |
| 2000 | 9 | 2 | 22% |
| 2001 | 9 | 0 | 0% |
| 2002 | 9 | 1 | 11% |
| 2004 | 9 | 0 | 0% |
| 2005 | 9 | 0 | 0% |
| 2006 | 9 | 0 | 0% |
| 2007 | 9 | 0 | 0% |
| 2008 | 9 | 1 | 11% |
| 2009 | 9 | 3 | 33% |
| 2010 | 9 | 6 | 67% |
| 2011 | 9 | 1 | 11% |
| TOTAL | 325 | 60 | 18% |

Table 17. Index of cowcod abundance in L.A. and Orange County Sanitation District trawls. Year is central year in time block.

| Year | GLM.index | binom.CV | log.SD |
|---|---|---|---|
| 1973 | 0.536 | 0.143 | 0.142 |
| 1978 | 0.127 | 0.282 | 0.276 |
| 1983 | 0.031 | 0.437 | 0.418 |
| 1988 | 0.047 | 0.343 | 0.334 |
| 1993 | 0.015 | 0.571 | 0.532 |
| 1998 | 0.045 | 0.307 | 0.300 |
| 2003 | 0.031 | 0.371 | 0.359 |
| 2009 | 0.076 | 0.219 | 0.216 |

Table 18. Frequency of positive tows for cowcod in 2003-2012 NWFSC Trawl Survey by half-degree bins (bin name is southernmost latitude).

| Latitude | Nsamp | Npos | FracPos | |
|---|---|---|---|---|
| 32 | 29 | 0 | | |
| 32.5 | 195 | 5 | 2.6% | |
| 33 | 247 | 4 | 1.6% | |
| 33.5 | 297 | 32 | 10.8% | |
| 34 | 395 | 37 | 9.4% | Conception |
| 34.5 | 224 | 7 | 3.1% | |
| 35 | 262 | 5 | 1.9% | |
| 35.5 | 178 | 3 | 1.7% | |
| 36 | 109 | 4 | 3.7% | |
| 36.5 | 84 | 11 | 13.1% | Monterey |
| 37 | 211 | 16 | 7.6% | |
| 37.5 | 109 | 6 | 5.5% | |
| 38 | 182 | 19 | 10.4% | Pt. Reyes |
| 38.5 | 105 | 7 | 6.7% | |
| 39 | 128 | 3 | 2.3% | |
| 39.5 | 112 | 3 | 2.7% | Mendocino |

Table 19. Number of aged cowcod otoliths and average ages by year and region from the NWFSC combined trawl survey.

| | North of Point Conception | | South of Point Conception | |
|---|---|---|---|---|
| **Year** | **Number of ages** | **Average age** | **Number of ages** | **Average age** |
| 2003 | 5 | 3.2 | 8 | 6.9 |
| 2004 | 21 | 3.7 | 4 | 3.5 |
| 2005 | 14 | 3.9 | 11 | 3.3 |
| 2006 | 6 | 6.2 | 20 | 4.4 |
| 2007 | 4 | 5.8 | 17 | 6.8 |
| 2008 | 5 | 4.6 | 12 | 2.6 |
| 2009 | 14 | 10.7 | 8 | 6.5 |
| 2010 | 17 | 6.5 | 41 | 3.0 |
| 2011 | 17 | 3.4 | 12 | 1.4 |
| 2012 | 33 | 4.5 | 40 | 3.8 |
| **Grand Total** | **136** | **5.1** | **173** | **3.9** |

Table 20. NWFSC trawl survey index of small (<1kg) cowcod abundance in southern California waters. Sampling years are 2003-2012. The index is shifted by 4 years (average age of catch) to represent spawning biomass four years earlier.

| year | index | log.sigma |
|---|---|---|
| 1999 | 0.207 | 0.531 |
| 2000 | 0.285 | 0.403 |
| 2001 | 0.310 | 0.369 |
| 2002 | 0.212 | 0.406 |
| 2003 | 0.230 | 0.357 |
| 2004 | 0.271 | 0.334 |
| 2005 | 0.166 | 0.370 |
| 2006 | 0.434 | 0.230 |
| 2007 | 0.219 | 0.359 |
| 2008 | 0.323 | 0.284 |

Table 21. Sampling coverage (number of drops) for the NWFSC hook-and-line survey sites that have encountered cowcod since 2004.

| Site Number | 2004 | 2005 | 2006 | 2007 | Year 2008 | 2009 | 2010 | 2011 | 2012 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 6 | 5 | | 5 | | 5 | 5 | 5 | 5 | 5 | 35 |
| 15 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 17 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 40 |
| 18 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 40 |
| 21 | | | 5 | 5 | 5 | 5 | 5 | | 5 | 30 |
| 24 | | | 5 | 5 | 5 | 5 | 5 | | 5 | 30 |
| 29 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 40 |
| 31 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 40 |
| 33 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 36 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 43 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 52 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 77 | 5 | | | | 5 | 5 | 5 | 5 | 5 | 30 |
| 79 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 137 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 139 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 147 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 149 | 5 | | | | 5 | 5 | 5 | 5 | 5 | 30 |
| 151 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 154 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 168 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 181 | | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | 35 |
| 182 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 186 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 200 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 205 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 209 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 231 | 5 | | | | 5 | 5 | 5 | 5 | 5 | 30 |
| 232 | 5 | | | | 5 | 5 | 5 | 5 | 5 | 30 |
| 243 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 342 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 346 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 350 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 |
| 352 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 45 |
| 377 | | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 35 |
| 385 | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 35 |
| 414 | | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 37 |
| 418 | | | | | 5 | 5 | 5 | 5 | 5 | 25 |
| Grand Total | 130 | 147 | 150 | 165 | 195 | 195 | 195 | 160 | 195 | 1532 |

Table 22. Catch in weight (kg) for the NWFSC hook-and-line survey sites that have encountered cowcod since 2004.

| Site Number | 2004 | 2005 | 2006 | 2007 | Year 2008 | 2009 | 2010 | 2011 | 2012 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0 | 0 | 2.78 | 3.24 | 0 | 0 | 0 | 0 | 3.24 | 9.26 |
| 6 | 0 | | 3.18 | | 3.32 | 8.32 | 0 | 0 | 0 | 14.82 |
| 15 | | 0 | 0 | 0 | 0 | 2.48 | 1.76 | 0 | 0 | 4.24 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 7.42 | 7.42 |
| 18 | 0 | 1.66 | 4.96 | 0 | 0 | 0 | 0 | | 0 | 6.62 |
| 21 | | | 0 | 0 | 0 | 0 | 4.98 | | 0 | 4.98 |
| 24 | | | 0 | 4.28 | 0 | 0 | 0 | | 0 | 4.28 |
| 29 | 0 | 0 | 0 | 0 | 4.92 | 0 | 0 | | 0 | 4.92 |
| 31 | 0 | 0 | 0 | 4.58 | 0 | 6.8 | 0 | | 0 | 11.38 |
| 33 | 0 | 0 | 0 | 1.8 | 1.04 | 0 | 0 | 0 | 0.1 | 2.94 |
| 36 | 0 | 2.82 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.82 |
| 43 | 0 | 2.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.02 |
| 52 | 0 | 0 | 0 | 9.24 | 0 | 3.36 | 0 | 0 | 0 | 12.6 |
| 77 | 0 | | | | 0 | 0 | 0 | 0 | 2.36 | 2.36 |
| 79 | 0 | 3.64 | 2.2 | 0 | 1.92 | 4.54 | 0 | 0 | 0 | 12.3 |
| 137 | 4.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.12 |
| 139 | 0 | 0 | | 0 | 0 | 0 | 4.12 | 0 | 9.74 | 13.86 |
| 147 | 0 | 0 | 0 | 0 | 0 | 0 | 2.74 | 0 | 0 | 2.74 |
| 149 | 0 | | | | 0 | 0 | 0 | 0 | 1.55 | 1.55 |
| 151 | 0 | 0 | 0 | 0 | 0 | 4.22 | 0 | 1.46 | 0 | 5.68 |
| 154 | 0 | 0 | 0 | 0 | 0 | 0 | 3.8 | 0 | 0 | 3.8 |
| 168 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.92 | 2.92 |
| 181 | | 0 | | 0 | 0 | 4.06 | 0 | 0 | 0 | 4.06 |
| 182 | 0 | 0 | | 3.18 | 4.66 | 0 | 0 | 0 | 0 | 7.84 |
| 186 | 0 | 0 | | 3.04 | 0 | 0 | 0 | 0 | 0 | 3.04 |
| 200 | | 4.92 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.92 |
| 205 | 0 | 0 | 0 | 4.16 | 0 | 0 | 0 | 0 | 0 | 4.16 |
| 209 | | 0 | 4.34 | 0 | 0 | 6.68 | 0 | 0 | 0 | 11.02 |
| 231 | 2.35 | | | | 13.24 | 11.5 | 0 | 3.96 | 9.03 | 40.08 |
| 232 | 0 | | | | 11.34 | 5 | 0 | 50.98 | 25.88 | 93.2 |
| 243 | 0 | 0 | 0 | 0 | 1.68 | 0 | 0 | 2.62 | 0 | 4.3 |
| 342 | | 3.38 | 13.42 | 5.1 | 0 | 9.38 | 3.56 | 0 | 7.72 | 42.56 |
| 346 | 11.58 | 17.76 | 0 | 19.62 | 2.8 | 17.4 | 15.52 | 37.32 | 21.92 | 143.92 |
| 350 | | 15.79 | 3.86 | 5.48 | 0 | 5.3 | 16.28 | 22.82 | 6.77 | 76.3 |
| 352 | 7.25 | 5.2 | 0 | 1.46 | 6.34 | 7.9 | 0 | 5.22 | 18.8 | 52.17 |
| 377 | | 0 | 0 | 0 | 0 | 7.22 | 5.55 | | 0 | 12.77 |
| 385 | | | 5.9 | 0 | 5.26 | 0 | 0 | 0 | 6.98 | 18.14 |
| 414 | | 19.26 | 0 | 20.84 | 24.22 | 16.46 | 34.42 | 0 | 32.4 | 147.6 |
| 418 | | | | | 0 | 18.16 | 0 | 14.76 | 0 | 32.92 |
| Grand Total | 25.3 | 76.45 | 40.64 | 86.02 | 80.74 | 138.78 | 92.73 | 139.14 | 156.83 | 836.63 |

Table 23. NWFSC hook-and-line survey delta-GLM index

| year | index | CV |
|---|---|---|
| 2004 | 0.144 | 0.608 |
| 2005 | 0.486 | 0.327 |
| 2006 | 0.335 | 0.433 |
| 2007 | 0.550 | 0.335 |
| 2008 | 0.400 | 0.297 |
| 2009 | 0.798 | 0.282 |
| 2010 | 0.301 | 0.349 |
| 2011 | 0.603 | 0.310 |
| 2012 | 0.706 | 0.252 |

Table 24. Number of cowcod ages, by year, from the NWFSC hook-and-line survey. Age estimates for 2008 are pending.

| Year | Number of ages |
|---|---|
| 2003 | 1 |
| 2004 | 6 |
| 2005 | 17 |
| 2006 | 11 |
| 2007 | 23 |
| 2008 | |
| 2009 | 30 |
| 2010 | 21 |
| 2011 | 24 |
| 2012 | 36 |

Table 25. Cowcod observed in the SWFSC annual rockfish recruitment and ecosystem assessment survey.

| | | Core Area | | Core + Expanded Area | |
|---|---|---|---|---|---|
| CRUISE | YEAR | SUM | MEAN COWCOD PER HAUL | SUM | MEAN COWCOD PER HAUL |
| 8303 | 1983 | 0 | 0.000 | | |
| 8406 | 1984 | 0 | 0.000 | | |
| 8505 | 1985 | 2 | 0.031 | | |
| 8608 | 1986 | 1 | 0.011 | | |
| 8705 | 1987 | 17 | 0.160 | | |
| 8806 | 1988 | 1 | 0.010 | | |
| 8904 | 1989 | 1 | 0.010 | | |
| 9005 | 1990 | 0 | 0.000 | | |
| 9105 | 1991 | 0 | 0.000 | | |
| 9206 | 1992 | 5 | 0.053 | | |
| 9307 | 1993 | 5 | 0.050 | | |
| 9406 | 1994 | 0 | 0.000 | | |
| 9506 | 1995 | 0 | 0.000 | | |
| 9606 | 1996 | 0 | 0.000 | | |
| 9707 | 1997 | 0 | 0.000 | | |
| 9807 | 1998 | 0 | 0.000 | | |
| 9903 | 1999 | 0 | 0.000 | | |
| 0002 | 2000 | 1 | 0.010 | | |
| 0103 | 2001 | 3 | 0.033 | | |
| 0205 | 2002 | 2 | 0.026 | | |
| 0304 | 2003 | 1 | 0.010 | | |
| 0403 | 2004 | 1 | 0.011 | 5 | 0.035 |
| 0504 | 2005 | 0 | 0.000 | 7 | 0.047 |
| 0603 | 2006 | 0 | 0.000 | 2 | 0.013 |
| 0703 | 2007 | 0 | 0.000 | 3 | 0.018 |
| 0803 | 2008 | 0 | 0.000 | 2 | 0.020 |
| 0902 | 2009 | 1 | 0.012 | 2 | 0.015 |
| 1002 | 2010 | 5 | 0.058 | 8 | 0.060 |
| 1101 | 2011 | 3 | 0.057 | 3 | 0.048 |
| 1203 | 2012 | 1 | 0.015 | 10 | 0.106 |
| 1305 | 2013 | 99 | 1.456 | 101 | 0.706 |

Table 26. Trip-based CPUE index from CPFV logbook records.

| year | index | log.SD |
|---|---|---|
| 1980 | 0.0523 | 0.1061 |
| 1981 | 0.0435 | 0.0906 |
| 1982 | 0.0469 | 0.1000 |
| 1983 | 0.0426 | 0.1684 |
| 1984 | 0.0326 | 0.1202 |
| 1985 | 0.0387 | 0.1196 |
| 1986 | 0.0309 | 0.1500 |
| 1987 | 0.0241 | 0.1347 |
| 1988 | 0.0315 | 0.3413 |
| 1989 | 0.0496 | 0.1878 |
| 1990 | 0.0229 | 0.2095 |
| 1991 | 0.0216 | 0.1230 |
| 1992 | 0.0361 | 0.1542 |
| 1993 | 0.0258 | 0.1517 |
| 1994 | 0.0378 | 0.2124 |
| 1995 | 0.0317 | 0.1433 |
| 1996 | 0.0298 | 0.1836 |
| 1997 | 0.0340 | 0.1636 |
| 1998 | 0.0290 | 0.2967 |
| 1999 | 0.0301 | 0.3255 |

Table 27. Number of cowcod (kept and returned) reported by onboard CPFV observers, 1999-2011.

| Region / Year | Kept | Returned |
|---|---|---|
| Central_CA | | |
| 1999 | 2 | 0 |
| 2001 | 1 | 1 |
| 2002 | 4 | 1 |
| 2005 | 0 | 1 |
| 2007 | 0 | 2 |
| 2009 | 0 | 2 |
| Southern_CA | | |
| 1999 | 10 | 0 |
| 2000 | 3 | 0 |
| 2002 | 5 | 3 |
| 2004 | 1 | 6 |
| 2005 | 0 | 6 |
| 2006 | 0 | 6 |
| 2007 | 0 | 1 |
| 2008 | 1 | 5 |
| 2009 | 4 | 4 |
| 2010 | 0 | 5 |
| 2011 | 0 | 20 |
| **Grand Total** | **31** | **63** |

Table 28. Estimated medians from the STAR Panel's requested runs 1 through 7 (not all requests required model runs). Pre-STAR panel base model medians are included for reference.

| Quantity | Base Model | Request 1 Uniform_Delta | Request 2a Unif_Fmsy/M | Request 2b 2x Sigma Fmsy/M | Request 2c Scorp. Fmsy/M | Request 3 D-M Bmsy/B0 | Request 7a Sub q = 1.5 | Request 7b Visual q = 0.375 |
|---|---|---|---|---|---|---|---|---|
| Imp.logQ, CPFV | -10.372 | -10.421 | -10.364 | -10.430 | -10.435 | -10.413 | -10.193 | -10.550 |
| Imp.logQ, NW Trawl | -8.385 | -8.398 | -8.369 | -8.388 | -8.376 | -8.418 | -8.174 | -8.559 |
| Imp.logQ, San. Dist. | -9.937 | -9.970 | -9.922 | -9.977 | -9.969 | -9.953 | -9.724 | -10.087 |
| Imp.logQ, NW Hook | -7.896 | -7.903 | -7.871 | -7.873 | -7.877 | -7.934 | -7.687 | -8.045 |
| Imp.logQ, CalCOFI | -11.261 | -11.278 | -11.235 | -11.283 | -11.277 | -11.283 | -11.096 | -11.390 |
| logQ, Visual Survey | -0.699 | -0.656 | -0.688 | -0.676 | -0.732 | -0.731 | -0.412 | -1.020 |
| Log(a), CPFV | -4.205 | -4.109 | -4.098 | -4.233 | -4.305 | -4.197 | -4.222 | -4.226 |
| Log(a), NW Trawl | -3.951 | -3.890 | -3.715 | -3.760 | -3.778 | -3.803 | -3.839 | -3.784 |
| Log(a), San. Dist. | -0.446 | -0.590 | -0.337 | -0.409 | -0.518 | -0.639 | -0.893 | -0.515 |
| Log(a), NW Hook | -3.437 | -3.378 | -3.573 | -3.300 | -3.426 | -3.519 | -3.587 | -3.528 |
| Log(a), CalCOFI | -0.917 | -0.878 | -0.932 | -0.819 | -0.736 | -0.917 | -0.615 | -0.818 |
| M | 0.041 | 0.042 | 0.047 | 0.044 | 0.045 | 0.039 | 0.049 | 0.036 |
| Fmsy/M | 0.728 | 0.721 | 0.665 | 0.466 | 0.533 | 0.695 | 0.612 | 0.734 |
| Delta | 0.750 | 0.759 | 0.761 | 0.763 | 0.763 | 0.759 | 0.776 | 0.741 |
| Bmsy/B0 | 0.456 | 0.417 | 0.452 | 0.512 | 0.483 | 0.384 | 0.640 | 0.412 |
| Fmsy | 0.031 | 0.029 | 0.027 | 0.021 | 0.025 | 0.028 | 0.029 | 0.026 |
| Emsy | 0.030 | 0.029 | 0.026 | 0.020 | 0.024 | 0.027 | 0.028 | 0.025 |
| MSY | 53.1 | 52.5 | 51.1 | 43.7 | 45.7 | 49.6 | 47.9 | 49.8 |
| Bmsy | 1933.5 | 1885.1 | 1994.8 | 2234.7 | 2139.3 | 1840.0 | 2123.5 | 2104.7 |
| B1900 | 4567.4 | 4701.7 | 4662.9 | 4792.0 | 4760.2 | 4808.7 | 3845.9 | 5005.3 |
| B2013 | 1450.3 | 1439.1 | 1406.2 | 1395.7 | 1409.9 | 1520.5 | 1176.6 | 1632.2 |
| OFL2013 | 40.3 | 39.9 | 38.4 | 28.2 | 32.2 | 41.1 | 31.9 | 39.6 |
| OFL2014 | 41.1 | 40.7 | 39.1 | 28.6 | 32.7 | 42.0 | 32.6 | 40.4 |
| OFL2015 | 41.9 | 41.6 | 39.8 | 29.1 | 33.2 | 42.9 | 33.2 | 41.2 |
| OFL2016 | 42.9 | 42.3 | 40.5 | 29.5 | 33.7 | 43.7 | 33.9 | 42.0 |
| SB2013/SB0 | 0.326 | 0.322 | 0.309 | 0.289 | 0.293 | 0.315 | 0.280 | 0.335 |
| F2012/Fmsy | 0.052 | 0.055 | 0.059 | 0.077 | 0.065 | 0.056 | 0.060 | 0.059 |
| B40% | 1827.0 | 1880.7 | 1865.2 | 1916.8 | 1904.1 | 1923.5 | 1538.4 | 2002.1 |
| Emsy(B40% proxy) | 0.024 | 0.025 | 0.022 | 0.019 | 0.020 | 0.025 | 0.024 | 0.022 |
| MSY(B40% proxy) | 42.2 | 41.9 | 36.3 | 34.8 | 35.9 | 45.3 | 38.3 | 43.4 |

Table 29. Estimated medians from the STAR Panel's requested runs 1 through 7 (not all requests required model runs), expressed as a percentage change relative to the median, pre-STAR base model results (i.e. 100% x (sensitivity-base)/base). Blue and red horizontal bars indicate positive and negative differences, respectively.

| Quantity | Base Model | Request 1 Uniform_Delta | Request 2a Unif_Fmsy/M | Request 2b 2x Sigma Fmsy/M | Request 2c Scorp. Fmsy/M | Request 3 D-M Bmsy/B0 | Request 7a Sub q = 1.5 | Request 7b Visual q = 0.375 |
|---|---|---|---|---|---|---|---|---|
| Imp.logQ, CPFV | 0% | 0% | 0% | 1% | 1% | 0% | -2% | 2% |
| Imp.logQ, NW Trawl | 0% | 0% | 0% | 0% | 0% | 0% | -3% | 2% |
| Imp.logQ, San. Dist. | 0% | 0% | 0% | 0% | 0% | 0% | -2% | 2% |
| Imp.logQ, NW Hook | 0% | 0% | 0% | 0% | 0% | 0% | -3% | 2% |
| Imp.logQ, CalCOFI | 0% | 0% | 0% | 0% | 0% | 0% | -1% | 1% |
| logQ, Visual Survey | 0% | -6% | -2% | -3% | 5% | 5% | -41% | 46% |
| Log(a), CPFV | 0% | -2% | -3% | 1% | 2% | 0% | 0% | 0% |
| Log(a), NW Trawl | 0% | -2% | -6% | -5% | -4% | -4% | -3% | -4% |
| Log(a), San. Dist. | 0% | 33% | -24% | -8% | 16% | 43% | 100% | 16% |
| Log(a), NW Hook | 0% | -2% | 4% | -4% | 0% | 2% | 4% | 3% |
| Log(a), CalCOFI | 0% | -4% | 2% | -11% | -20% | 0% | -33% | -11% |
| M | 0% | 1% | 15% | 6% | 9% | -4% | 20% | -11% |
| Fmsy/M | 0% | -1% | -9% | -36% | -27% | -4% | -16% | 1% |
| Delta | 0% | 1% | 1% | 2% | 2% | 1% | 3% | -1% |
| Bmsy/B0 | 0% | -9% | -1% | 12% | 6% | -16% | 40% | -10% |
| Fmsy | 0% | -4% | -11% | -32% | -19% | -8% | -4% | -14% |
| Emsy | 0% | -3% | -11% | -32% | -20% | -8% | -4% | -14% |
| MSY | 0% | -1% | -4% | -18% | -14% | -7% | -10% | -6% |
| Bmsy | 0% | -3% | 3% | 16% | 11% | -5% | 10% | 9% |
| B1900 | 0% | 3% | 2% | 5% | 4% | 5% | -16% | 10% |
| B2013 | 0% | -1% | -3% | -4% | -3% | 5% | -19% | 13% |
| OFL2013 | 0% | -1% | -5% | -30% | -20% | 2% | -21% | -2% |
| OFL2014 | 0% | -1% | -5% | -30% | -21% | 2% | -21% | -2% |
| OFL2015 | 0% | -1% | -5% | -31% | -21% | 2% | -21% | -2% |
| OFL2016 | 0% | -1% | -6% | -31% | -21% | 2% | -21% | -2% |
| SB2013/SB0 | 0% | -1% | -5% | -11% | -10% | -3% | -14% | 3% |
| F2012/Fmsy | 0% | 4% | 13% | 46% | 24% | 6% | 15% | 12% |
| B40% | 0% | 3% | 2% | 5% | 4% | 5% | -16% | 10% |
| Emsy(B40% proxy) | 0% | 5% | -8% | -21% | -19% | 3% | 1% | -10% |
| MSY(B40% proxy) | 0% | -1% | -14% | -18% | -15% | 7% | -9% | 3% |

Table 30. Estimated medians from the STAR Panel's requested runs 8 through 11 (not all requests required model runs). Pre-STAR panel base model medians are included for reference.

| Quantity | Base Model | Request 8a 1/2 catch | Request 8b 2x catch | *Base Model no CPFV* | Request 8c 1/2 catch, no CPFV | Request 8d 2x catch, no CPFV | Request 11a Amat = 8 | Request 11b Amat = 14 |
|---|---|---|---|---|---|---|---|---|
| Imp.logQ, CPFV | -10.372 | -10.472 | -10.315 | -- | -- | -- | -10.319 | -10.518 |
| Imp.logQ, NW Trawl | -8.385 | -8.473 | -8.277 | -7.931 | -7.886 | -7.922 | -8.377 | -8.493 |
| Imp.logQ, San. Dist. | -9.937 | -10.005 | -9.850 | -9.358 | -9.309 | -9.295 | -9.890 | -10.067 |
| Imp.logQ, NW Hook | -7.896 | -7.980 | -7.789 | -7.542 | -7.496 | -7.540 | -7.914 | -7.970 |
| Imp.logQ, CalCOFI | -11.261 | -11.290 | -11.291 | -10.808 | -10.780 | -10.785 | -11.224 | -11.376 |
| logQ, Visual Survey | -0.699 | -0.803 | -0.611 | -0.293 | -0.274 | -0.301 | -0.667 | -0.796 |
| Log(a), CPFV | -4.205 | -4.117 | -4.168 | -- | -- | -- | -4.196 | -4.224 |
| Log(a), NW Trawl | -3.951 | -4.033 | -4.000 | -3.945 | -3.881 | -3.870 | -3.704 | -3.730 |
| Log(a), San. Dist. | -0.446 | -0.467 | -0.527 | -0.669 | -0.601 | -0.677 | -0.520 | -0.589 |
| Log(a), NW Hook | -3.437 | -3.423 | -3.345 | -3.569 | -3.635 | -3.505 | -3.383 | -3.606 |
| Log(a), CalCOFI | -0.917 | -0.668 | -0.836 | -1.132 | -1.149 | -1.139 | -0.926 | -0.799 |
| M | 0.041 | 0.046 | 0.037 | 0.056 | 0.059 | 0.057 | 0.049 | 0.033 |
| Fmsy/M | 0.728 | 0.766 | 0.714 | 1.060 | 1.135 | 1.086 | 0.777 | 0.701 |
| Delta | 0.750 | 0.677 | 0.846 | 0.802 | 0.765 | 0.860 | 0.732 | 0.748 |
| Bmsy/B0 | 0.456 | 0.392 | 0.603 | 0.417 | 0.413 | 0.465 | 0.526 | 0.340 |
| Fmsy | 0.031 | 0.031 | 0.027 | 0.058 | 0.064 | 0.061 | 0.040 | 0.023 |
| Emsy | 0.030 | 0.030 | 0.026 | 0.055 | 0.060 | 0.058 | 0.038 | 0.022 |
| MSY | 53.1 | 45.3 | 88.0 | 69.0 | 61.0 | 108.7 | 64.7 | 38.3 |
| Bmsy | 1933.5 | 1567.5 | 3511.4 | 1259.4 | 1022.6 | 1795.9 | 1835.1 | 2054.4 |
| B1900 | 4567.4 | 3681.4 | 6546.2 | 3110.5 | 2523.3 | 4327.8 | 3816.1 | 5176.8 |
| B2013 | 1450.3 | 1546.9 | 1308.9 | 1074.7 | 1023.7 | 1122.5 | 1508.7 | 1512.1 |
| OFL2013 | 40.3 | 46.4 | 35.5 | 57.4 | 62.8 | 63.8 | 52.8 | 34.0 |
| OFL2014 | 41.1 | 47.4 | 36.1 | 59.0 | 64.9 | 65.9 | 54.4 | 34.5 |
| OFL2015 | 41.9 | 48.3 | 36.8 | 61.2 | 67.0 | 68.4 | 55.7 | 34.9 |
| OFL2016 | 42.9 | 49.3 | 37.5 | 63.2 | 68.9 | 71.0 | 57.3 | 35.4 |
| SB2013/SB0 | 0.326 | 0.411 | 0.202 | 0.339 | 0.402 | 0.261 | 0.388 | 0.293 |
| F2012/Fmsy | 0.052 | 0.050 | 0.058 | 0.032 | 0.028 | 0.029 | 0.041 | 0.070 |
| B40% | 1827.0 | 1472.6 | 2618.5 | 1244.2 | 1009.3 | 1731.1 | 1526.5 | 2070.7 |
| Emsy(B40% proxy) | 0.024 | 0.025 | 0.025 | 0.051 | 0.056 | 0.055 | 0.037 | 0.015 |
| MSY(B40% proxy) | 42.2 | 37.8 | 62.0 | 63.2 | 55.9 | 95.7 | 56.0 | 32.0 |

Table 31. Estimated medians from the STAR Panel's requested runs 8 through 11 (not all requests required model runs), expressed as a percentage change relative to the median, pre-STAR base model results (i.e. 100% x (sensitivity-base)/base). Blue and red horizontal bars indicate positive and negative differences, respectively.

| Quantity | Base Model | Request 8a 1/2 catch | Request 8b 2x catch | *Base Model no CPFV* | Request 8c 1/2 catch, no CPFV | Request 8d 2x catch, no CPFV | Request 11a Amat = 8 | Request 11b Amat = 14 |
|---|---|---|---|---|---|---|---|---|
| Imp.logQ, CPFV | 0% | 1% | -1% | -- | -- | -- | -1% | 1% |
| Imp.logQ, NW Trawl | 0% | 1% | -1% | -5% | -6% | -6% | 0% | 1% |
| Imp.logQ, San. Dist. | 0% | 1% | -1% | -6% | -6% | -6% | 0% | 1% |
| Imp.logQ, NW Hook | 0% | 1% | -1% | -4% | -5% | -5% | 0% | 1% |
| Imp.logQ, CalCOFI | 0% | 0% | 0% | -4% | -4% | -4% | 0% | 1% |
| logQ, Visual Survey | 0% | 15% | -13% | -58% | -61% | -57% | -5% | 14% |
| Log(a), CPFV | 0% | -2% | -1% | -- | -- | -- | 0% | 0% |
| Log(a), NW Trawl | 0% | 2% | 1% | 0% | -2% | -2% | -6% | -6% |
| Log(a), San. Dist. | 0% | 5% | 18% | 50% | 35% | 52% | 17% | 32% |
| Log(a), NW Hook | 0% | 0% | -3% | 4% | 6% | 2% | -2% | 5% |
| Log(a), CalCOFI | 0% | -27% | -9% | 23% | 25% | 24% | 1% | -13% |
| M | 0% | 12% | -9% | 36% | 44% | 38% | 19% | -20% |
| Fmsy/M | 0% | 5% | -2% | 46% | 56% | 49% | 7% | -4% |
| Delta | 0% | -10% | 13% | 7% | 2% | 15% | -2% | 0% |
| Bmsy/B0 | 0% | -14% | 32% | -9% | -9% | 2% | 15% | -25% |
| Fmsy | 0% | 2% | -11% | 91% | 108% | 99% | 30% | -26% |
| Emsy | 0% | 2% | -11% | 86% | 103% | 95% | 29% | -25% |
| MSY | 0% | -15% | 66% | 30% | 15% | 105% | 22% | -28% |
| Bmsy | 0% | -19% | 82% | -35% | -47% | -7% | -5% | 6% |
| B1900 | 0% | -19% | 43% | -32% | -45% | -5% | -16% | 13% |
| B2013 | 0% | 7% | -10% | -26% | -29% | -23% | 4% | 4% |
| OFL2013 | 0% | 15% | -12% | 42% | 56% | 58% | 31% | -16% |
| OFL2014 | 0% | 15% | -12% | 43% | 58% | 60% | 32% | -16% |
| OFL2015 | 0% | 15% | -12% | 46% | 60% | 63% | 33% | -17% |
| OFL2016 | 0% | 15% | -13% | 47% | 61% | 66% | 33% | -17% |
| SB2013/SB0 | 0% | 26% | -38% | 4% | 23% | -20% | 19% | -10% |
| F2012/Fmsy | 0% | -5% | 11% | -40% | -46% | -44% | -21% | 33% |
| B40% | 0% | -19% | 43% | -32% | -45% | -5% | -16% | 13% |
| Emsy(B40% proxy) | 0% | 4% | 3% | 111% | 130% | 126% | 52% | -38% |
| MSY(B40% proxy) | 0% | -10% | 47% | 50% | 32% | 127% | 33% | -24% |

Table 32. (Response to STAR Panel Request 2) Alternative prior distributions for Fmsy/M. Parameters of the lognormal distributions are the arithmetic mean and log-scale standard deviation.

| Description | Distribution |
|---|---|
| Zhou Teleost (base model) | Lognormal(mean=0.97, logSD=0.46) |
| Twice Sigma | Lognormal(mean=0.97, logSD=0.92) |
| Uniform | Uniform(0,4) |
| Zhou Scorpaenid | Lognormal(mean=0.813, logSD=0.625) |

Table 33. (Response to STAR Panel Request 3) Alternative prior distributions for Bmsy/B0. Parameters are the mean and standard deviation of the standard beta distribution.

| Description | Distribution |
|---|---|
| Base | Bounded beta (mean=0.5, SD=0.285) |
| Data-Moderate | Bounded beta (mean=0.4, SD=0.15) |

Table 34. (Response to STAR Panel Request 6) Frequency of Nlarvae in southern California CalCOFI samples. The underlying data set has not been reduced to the selected stations used in the cowcod index, and contains 165 positive tows as compared with the 155 positive tows in the index data set. The additional positives come from stations that were not sampled regularly.

| | | Number of larvae in tow | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Years | Nsamps | 0 | pos | 1 | 2 | 3 | 4 | 5 | 9 | 13 |
| 1953 | 1324 | 1293 | 31 | 27 | 3 | 0 | 1 | 0 | 0 | 0 |
| 1958 | 1426 | 1401 | 25 | 22 | 3 | 0 | 0 | 0 | 0 | 0 |
| 1963 | 736 | 724 | 12 | 11 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1968 | 672 | 634 | 38 | 28 | 5 | 2 | 1 | 0 | 1 | 1 |
| 1974 | 577 | 558 | 19 | 15 | 2 | 0 | 1 | 1 | 0 | 0 |
| 1986 | 2595 | 2589 | 6 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| 1999 | 695 | 689 | 6 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 705 | 695 | 10 | 8 | 0 | 1 | 1 | 0 | 0 | 0 |
| 2009 | 787 | 769 | 18 | 12 | 4 | 2 | 0 | 0 | 0 | 0 |
| all years | 9517 | 9352 | 165 | 131 | 21 | 5 | 5 | 1 | 1 | 1 |
| fracpos | | | | 79.4% | 12.7% | 3.0% | 3.0% | 0.6% | 0.6% | 0.6% |

Table 35. (Response to STAR Panel Request 6) Positive stations used in the CalCOFI index, summarized by location and time period.

| Npositive | | | | | | | | | | | Nsamples | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sta\Year | 1953 | 1958 | 1963 | 1968 | 1974 | 1986 | 1999 | 2004 | 2009 | Total | 1953 | 1958 | 1963 | 1968 | 1974 | 1986 | 1999 | 2004 | 2009 | Total | | fracpos |
| 8050 | 1 | 1 | 1 | 5 | 2 | 1 | 0 | 1 | 0 | 12 | 27 | 31 | 25 | 28 | 20 | 55 | 9 | 19 | 20 | 234 | | 5.1% |
| 8055 | 0 | 1 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 8 | 32 | 36 | 14 | 13 | 9 | 51 | 9 | 12 | 11 | 187 | | 4.3% |
| 8060 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 33 | 36 | 15 | 14 | 9 | 52 | 9 | 14 | 12 | 194 | | 1.0% |
| 8144 | 0 | | 0 | | 1 | 1 | 0 | 0 | 1 | 3 | 2 | | 9 | | 20 | 25 | 10 | 13 | 20 | 99 | | 3.0% |
| 8246 | 1 | 2 | 1 | 0 | 0 | 0 | | | | 4 | 9 | 34 | 12 | 13 | 3 | 23 | | | | 94 | | 4.3% |
| 8340 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 17 | 33 | 14 | 14 | 6 | 49 | 14 | 14 | 13 | 174 | | 1.7% |
| 8342 | 2 | 2 | 0 | 3 | 3 | 0 | 0 | 1 | 1 | 12 | 26 | 37 | 12 | 14 | 10 | 52 | 15 | 14 | 13 | 193 | | 6.2% |
| 8344 | 2 | 0 | 0 | | 1 | 0 | | | | 3 | 17 | 1 | 3 | | 16 | 3 | | | | 40 | | 7.5% |
| 8351 | 1 | 4 | 1 | 5 | 1 | 0 | 0 | 0 | 1 | 13 | 22 | 35 | 13 | 14 | 7 | 49 | 14 | 13 | 11 | 178 | | 7.3% |
| 8355 | 1 | 0 | 1 | 4 | 2 | 1 | 0 | 0 | 0 | 9 | 24 | 26 | 13 | 14 | 7 | 49 | 12 | 14 | 11 | 170 | | 5.3% |
| 8360 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 5 | 29 | 35 | 13 | 14 | 7 | 53 | 12 | 13 | 11 | 187 | | 2.7% |
| 8733 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 6 | 32 | 24 | 23 | 27 | 17 | 103 | 20 | 26 | 26 | 298 | | 2.0% |
| 8740 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 7 | 30 | 37 | 11 | 14 | 7 | 44 | 10 | 13 | 13 | 179 | | 3.9% |
| 8745 | 1 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 6 | 19 | 28 | 11 | 14 | 7 | 54 | 9 | 13 | 11 | 166 | | 3.6% |
| 8750 | 5 | 3 | 0 | 3 | 1 | 0 | 2 | 0 | 4 | 18 | 26 | 35 | 10 | 13 | 7 | 53 | 9 | 12 | 12 | 177 | | 10.2% |
| 8755 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 20 | 27 | 11 | 14 | 7 | 52 | 9 | 13 | 13 | 166 | | 1.8% |
| 8760 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 43 | 71 | 33 | 33 | 12 | 103 | 17 | 25 | 25 | 362 | | 0.6% |
| 9028 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 28 | 36 | 16 | 13 | 13 | 53 | 16 | 18 | 23 | 216 | | 1.4% |
| 9030 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 37 | 36 | 11 | 13 | 21 | 61 | 16 | 13 | 13 | 221 | | 1.4% |
| 9037 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 4 | 38 | 36 | 11 | 13 | 10 | 83 | 32 | 26 | 26 | 275 | | 1.5% |
| 9045 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 36 | 36 | 11 | 14 | 10 | 52 | 16 | 13 | 11 | 199 | | 1.0% |
| 9050 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 43 | 64 | 11 | 15 | 10 | 51 | 15 | 13 | 13 | 235 | | 0.9% |
| 9060 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 36 | 37 | 11 | 14 | 10 | 55 | 14 | 13 | 13 | 203 | | 1.5% |
| 9327 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 5 | 27 | 35 | 17 | 26 | 11 | 45 | 11 | 13 | 13 | 198 | | 2.5% |
| 9330 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 35 | 35 | 11 | 14 | 8 | 53 | 11 | 13 | 13 | 193 | | 1.0% |
| 9335 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 28 | 11 | 13 | 8 | 52 | 11 | 12 | 13 | 158 | | 1.9% |
| 9340 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 33 | 36 | 11 | 14 | 8 | 53 | 11 | 13 | 13 | 192 | | 2.1% |
| 9350 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 34 | 36 | 11 | 14 | 7 | 52 | 11 | 13 | 13 | 191 | | 3.1% |
| 9355 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 35 | 59 | 22 | 27 | 16 | 107 | 20 | 26 | 25 | 337 | | 0.6% |
| Total | 27 | 26 | 12 | 37 | 17 | 5 | 5 | 9 | 17 | 155 | 800 | 1000 | 396 | 443 | 303 | 1587 | 362 | 414 | 411 | 5716 | | 2.7% |

Table 36. Estimated parameters in the base model.

| | Prior Distribution | | | | Posterior Percentiles | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter Description** | **Density Function** | **mean** | **std. dev.** | **bounds** | **5%** | **25%** | **50%** | **75%** | **95%** |
| Natural mortality, M | lognormal | 0.055 | 0.4 | (0,Inf) | 0.030 | 0.043 | 0.054 | 0.069 | 0.099 |
| Fmsy / M | lognormal | 0.97 | 0.46 | (0,Inf) | 0.522 | 0.803 | 1.051 | 1.372 | 2.029 |
| Delta (Δ) in year 2000 | beta | 0.7 | 0.2 | (0.01,0.99) | 0.657 | 0.749 | 0.801 | 0.847 | 0.894 |
| Bmsy / Bo | beta | 0.5 | 0.285 | (0.05,0.95) | 0.156 | 0.303 | 0.422 | 0.545 | 0.708 |
| log catchability for visual survey | normal | -0.2863 | 0.5 | (-Inf, Inf) | -0.878 | -0.523 | -0.293 | -0.058 | 0.284 |
| Additive variance (log scale) | | | | | | | | | |
| NWFSC Trawl Survey | log-uniform | | | (-5.3, 0.18*) | -5.165 | -4.566 | -3.854 | -3.059 | -1.964 |
| Sanitation District Trawl Survey | log-uniform | | | (-5.3, 1.39*) | -1.803 | -1.138 | -0.674 | -0.169 | 0.546 |
| NWFSC Hook-and-Line Survey | log-uniform | | | (-5.3, 0.18*) | -5.144 | -4.465 | -3.595 | -2.681 | -1.543 |
| CalCOFI Ichthyoplankton Survey | log-uniform | | | (-5.3, 1.5*) | -2.324 | -1.607 | -1.126 | -0.639 | 0.088 |

* upper bounds of log-uniform priors are chosen to avoid restricting the posterior distribution, based on trial runs

Table 37. Reference points from the base model for cowcod in the SCB. Estimates are posterior medians and do not represent a single population trajectory.

| Quantity | 2.5th percentile | Median | 97.5th percentile |
|---|---|---|---|
| Unfished Spawning Biomass ($SB_0$, mt) | 990 | 1549 | 2684 |
| Unfished age 11+ biomass (mt) | 1981 | 3099 | 5368 |
| Spawning Biomass in 2013 | 273 | 524 | 924 |
| Depletion in 2013 (% of $SB_0$) | 15.0% | 33.9% | 65.6% |
| ***Reference points based on estimated MSY*** | | | |
| Spawning biomass at *MSY* ($SB_{MSY}$) | 256 | 629 | 1162 |
| $SB_{MSY} / SB_0$ | 0.121 | 0.422 | 0.745 |
| Exploitation rate corresponding to *MSY* | 0.022 | 0.055 | 0.126 |
| *MSY* (mt) | 30.0 | 68.9 | 103.1 |
| ***Reference points based on $SB_{40\%}$ proxy MSY harvest rate*** | | | |
| Proxy SB at MSY ($B_{40\%}$) | 396 | 620 | 1074 |
| Exploitation rate resulting in $B_{40\%}$ | 0.012 | 0.050 | 0.113 |
| Yield from $B_{40\%}$ proxy harvest rate at $B_{40\%}$ (mt) | 24.6 | 62.2 | 98.4 |

Table 38. Time series of catch, age 11+ biomass, spawning biomass, depletion, exploitation rate (catch / vulnerable biomass), and exploitation rate relative to the estimated MSY rate.

| Year | Catch | Biomass, Age 11+ | SSB | Depletion | Exp. Rate (C/B) | E / Emsy |
|---|---|---|---|---|---|---|
| 1900 | 0 | 4564.5 | 2282.3 | 1 | 0 | 0 |
| 1901 | 5.3 | 4564.5 | 2282.3 | 1 | 0.001 | 0.046 |
| 1902 | 10.7 | 4559.2 | 2279.6 | 0.999 | 0.002 | 0.093 |
| 1903 | 16 | 4548.7 | 2274.4 | 0.997 | 0.004 | 0.14 |
| 1904 | 21.4 | 4533.4 | 2266.7 | 0.993 | 0.005 | 0.187 |
| 1905 | 26.7 | 4513.4 | 2256.7 | 0.989 | 0.006 | 0.235 |
| 1906 | 32 | 4489 | 2244.5 | 0.983 | 0.007 | 0.285 |
| 1907 | 37.4 | 4460.2 | 2230.1 | 0.977 | 0.008 | 0.335 |
| 1908 | 42.7 | 4427.4 | 2213.7 | 0.97 | 0.01 | 0.385 |
| 1909 | 48 | 4391.5 | 2195.7 | 0.962 | 0.011 | 0.438 |
| 1910 | 53.4 | 4350.3 | 2175.2 | 0.953 | 0.012 | 0.492 |
| 1911 | 58.7 | 4306.3 | 2153.2 | 0.943 | 0.014 | 0.547 |
| 1912 | 64 | 4258.5 | 2129.2 | 0.933 | 0.015 | 0.603 |
| 1913 | 69.3 | 4208.2 | 2104.1 | 0.922 | 0.016 | 0.665 |
| 1914 | 74.7 | 4154.3 | 2077.1 | 0.91 | 0.018 | 0.728 |
| 1915 | 80 | 4096.5 | 2048.3 | 0.898 | 0.02 | 0.792 |
| 1916 | 85.4 | 4036.7 | 2018.4 | 0.884 | 0.021 | 0.856 |
| 1917 | 137.7 | 3974.5 | 1987.2 | 0.871 | 0.035 | 1.405 |
| 1918 | 125.6 | 3859.7 | 1929.8 | 0.846 | 0.033 | 1.326 |
| 1919 | 75.1 | 3765.6 | 1882.8 | 0.826 | 0.02 | 0.814 |
| 1920 | 81.6 | 3725.1 | 1862.6 | 0.817 | 0.022 | 0.894 |
| 1921 | 71.3 | 3679.3 | 1839.6 | 0.807 | 0.019 | 0.793 |
| 1922 | 70.1 | 3648.4 | 1824.2 | 0.799 | 0.019 | 0.787 |
| 1923 | 93.9 | 3617.3 | 1808.6 | 0.794 | 0.026 | 1.062 |
| 1924 | 125.9 | 3569.2 | 1784.6 | 0.783 | 0.035 | 1.443 |
| 1925 | 138.2 | 3484.4 | 1742.2 | 0.765 | 0.04 | 1.62 |
| 1926 | 171.5 | 3390.4 | 1695.2 | 0.745 | 0.051 | 2.073 |
| 1927 | 142.3 | 3261.6 | 1630.8 | 0.718 | 0.044 | 1.796 |
| 1928 | 111.3 | 3170 | 1585 | 0.699 | 0.035 | 1.445 |
| 1929 | 102.6 | 3115.1 | 1557.6 | 0.688 | 0.033 | 1.355 |
| 1930 | 126.9 | 3067.5 | 1533.8 | 0.678 | 0.041 | 1.7 |
| 1931 | 161 | 2998.5 | 1499.2 | 0.663 | 0.054 | 2.207 |
| 1932 | 109.5 | 2893.1 | 1446.6 | 0.64 | 0.038 | 1.557 |
| 1933 | 82 | 2845.7 | 1422.8 | 0.629 | 0.029 | 1.184 |
| 1934 | 70.7 | 2827.4 | 1413.7 | 0.626 | 0.025 | 1.024 |
| 1935 | 53 | 2820.9 | 1410.4 | 0.625 | 0.019 | 0.766 |
| 1936 | 20.6 | 2834 | 1417 | 0.628 | 0.007 | 0.296 |
| 1937 | 24.9 | 2876.3 | 1438.2 | 0.638 | 0.009 | 0.351 |
| 1938 | 18.7 | 2909 | 1454.5 | 0.646 | 0.006 | 0.259 |
| 1939 | 22 | 2941.8 | 1470.9 | 0.655 | 0.007 | 0.3 |
| 1940 | 23.7 | 2966.7 | 1483.4 | 0.661 | 0.008 | 0.319 |
| 1941 | 29.5 | 2990.7 | 1495.3 | 0.665 | 0.01 | 0.392 |
| 1942 | 10.6 | 3012.2 | 1506.1 | 0.667 | 0.004 | 0.14 |
| 1943 | 12.4 | 3049.5 | 1524.8 | 0.673 | 0.004 | 0.161 |
| 1944 | 2 | 3072.2 | 1536.1 | 0.678 | 0.001 | 0.026 |
| 1945 | 4.6 | 3107.3 | 1553.7 | 0.684 | 0.001 | 0.058 |
| 1946 | 11.7 | 3140.7 | 1570.3 | 0.689 | 0.004 | 0.145 |
| 1947 | 18.8 | 3158.9 | 1579.5 | 0.692 | 0.006 | 0.231 |
| 1948 | 29.9 | 3169.5 | 1584.8 | 0.694 | 0.009 | 0.366 |
| 1949 | 38.7 | 3168.2 | 1584.1 | 0.694 | 0.012 | 0.47 |
| 1950 | 44 | 3162 | 1581 | 0.692 | 0.014 | 0.533 |
| 1951 | 49.2 | 3157.1 | 1578.6 | 0.689 | 0.016 | 0.598 |
| 1952 | 36.7 | 3147.6 | 1573.8 | 0.685 | 0.012 | 0.446 |
| 1953 | 31.2 | 3146.7 | 1573.4 | 0.686 | 0.01 | 0.379 |
| 1954 | 46.8 | 3150.7 | 1575.4 | 0.686 | 0.015 | 0.568 |
| 1955 | 52 | 3139 | 1569.5 | 0.684 | 0.017 | 0.63 |
| 1956 | 65.2 | 3121.8 | 1560.9 | 0.682 | 0.021 | 0.79 |
| 1957 | 55.7 | 3093.3 | 1546.7 | 0.676 | 0.018 | 0.678 |

(Cont.) Results in shaded area based on status quo catch of 0.8 mt.

| Year | Catch | Biomass, Age 11+ | SSB | Depletion | Exp. Rate (C/B) | E / Emsy |
|---|---|---|---|---|---|---|
| 1958 | 56.4 | 3079.7 | 1539.8 | 0.673 | 0.018 | 0.688 |
| 1959 | 52.3 | 3065.2 | 1532.6 | 0.67 | 0.017 | 0.639 |
| 1960 | 57 | 3055.1 | 1527.5 | 0.668 | 0.019 | 0.698 |
| 1961 | 60 | 3037.2 | 1518.6 | 0.665 | 0.02 | 0.737 |
| 1962 | 48 | 3022.1 | 1511 | 0.662 | 0.016 | 0.592 |
| 1963 | 57.3 | 3019 | 1509.5 | 0.661 | 0.019 | 0.705 |
| 1964 | 51.9 | 3003.8 | 1501.9 | 0.659 | 0.017 | 0.639 |
| 1965 | 70.1 | 2996.1 | 1498 | 0.658 | 0.023 | 0.863 |
| 1966 | 76.6 | 2971.7 | 1485.8 | 0.652 | 0.026 | 0.948 |
| 1967 | 102.4 | 2938 | 1469 | 0.645 | 0.035 | 1.277 |
| 1968 | 105 | 2884.8 | 1442.4 | 0.634 | 0.036 | 1.331 |
| 1969 | 125.1 | 2832.6 | 1416.3 | 0.621 | 0.044 | 1.613 |
| 1970 | 95.8 | 2761.7 | 1380.8 | 0.605 | 0.035 | 1.268 |
| 1971 | 106.1 | 2720 | 1360 | 0.596 | 0.039 | 1.419 |
| 1972 | 152.6 | 2669 | 1334.5 | 0.585 | 0.057 | 2.074 |
| 1973 | 171.8 | 2573.2 | 1286.6 | 0.565 | 0.067 | 2.422 |
| 1974 | 183.7 | 2460.5 | 1230.2 | 0.542 | 0.075 | 2.704 |
| 1975 | 182.6 | 2341.3 | 1170.7 | 0.516 | 0.078 | 2.828 |
| 1976 | 189.3 | 2230.9 | 1115.5 | 0.492 | 0.085 | 3.088 |
| 1977 | 191.2 | 2113.6 | 1056.8 | 0.467 | 0.09 | 3.293 |
| 1978 | 203.2 | 1999.6 | 999.8 | 0.443 | 0.102 | 3.699 |
| 1979 | 262.1 | 1877.8 | 938.9 | 0.416 | 0.14 | 5.089 |
| 1980 | 223.6 | 1699.9 | 850 | 0.379 | 0.132 | 4.821 |
| 1981 | 216 | 1564.6 | 782.3 | 0.35 | 0.138 | 5.076 |
| 1982 | 327.5 | 1439.8 | 719.9 | 0.324 | 0.227 | 8.359 |
| 1983 | 177.1 | 1211.5 | 605.7 | 0.273 | 0.146 | 5.436 |
| 1984 | 227.9 | 1139.5 | 569.7 | 0.256 | 0.2 | 7.452 |
| 1985 | 208.1 | 1014.2 | 507.1 | 0.228 | 0.205 | 7.639 |
| 1986 | 194.4 | 905.8 | 452.9 | 0.205 | 0.215 | 8.003 |
| 1987 | 105.8 | 813.2 | 406.6 | 0.184 | 0.13 | 4.88 |
| 1988 | 100.5 | 807.8 | 403.9 | 0.183 | 0.124 | 4.627 |
| 1989 | 38.7 | 803.7 | 401.8 | 0.182 | 0.048 | 1.781 |
| 1990 | 30.5 | 853.3 | 426.6 | 0.193 | 0.036 | 1.304 |
| 1991 | 26.4 | 902.3 | 451.1 | 0.204 | 0.029 | 1.071 |
| 1992 | 35.8 | 946.3 | 473.2 | 0.214 | 0.038 | 1.375 |
| 1993 | 24.5 | 970.9 | 485.4 | 0.22 | 0.025 | 0.915 |
| 1994 | 39.6 | 994.5 | 497.2 | 0.225 | 0.04 | 1.444 |
| 1995 | 25.1 | 995.7 | 497.9 | 0.225 | 0.025 | 0.91 |
| 1996 | 29.9 | 1005.3 | 502.7 | 0.228 | 0.03 | 1.078 |
| 1997 | 9.2 | 1002.7 | 501.4 | 0.227 | 0.009 | 0.331 |
| 1998 | 4 | 1014.5 | 507.2 | 0.23 | 0.004 | 0.144 |
| 1999 | 7.2 | 1031.4 | 515.7 | 0.233 | 0.007 | 0.254 |
| 2000 | 4.9 | 1047.8 | 523.9 | 0.236 | 0.005 | 0.171 |
| 2001 | 0.6 | 1070.2 | 535.1 | 0.24 | 0.001 | 0.02 |
| 2002 | 0.6 | 1095.7 | 547.9 | 0.246 | 0.001 | 0.019 |
| 2003 | 0.5 | 1122.1 | 561.1 | 0.252 | 0 | 0.015 |
| 2004 | 0.9 | 1152.5 | 576.2 | 0.257 | 0.001 | 0.027 |
| 2005 | 0.2 | 1178.9 | 589.4 | 0.263 | 0 | 0.005 |
| 2006 | 0.1 | 1204.5 | 602.2 | 0.269 | 0 | 0.002 |
| 2007 | 0.2 | 1231.5 | 615.7 | 0.275 | 0 | 0.006 |
| 2008 | 0.2 | 1258.9 | 629.5 | 0.28 | 0 | 0.007 |
| 2009 | 0.2 | 1281.8 | 640.9 | 0.286 | 0 | 0.006 |
| 2010 | 0.2 | 1308 | 654 | 0.291 | 0 | 0.005 |
| 2011 | 0.8 | 1330.4 | 665.2 | 0.296 | 0.001 | 0.022 |
| 2012 | 0.8 | 1352.1 | 676 | 0.3 | 0.001 | 0.022 |
| 2013 | 0.8 | 1374.4 | 687.2 | 0.306 | 0.001 | 0.022 |
| 2014 | 0.8 | 1398.8 | 699.4 | 0.311 | 0.001 | 0.021 |
| 2015 | | 1423.6 | 711.8 | 0.317 | | |

# 10 Figures


Figure 1. Assumed stock boundary (U.S. waters off California, south of 34° 27′ N. latitude) for the cowcod base model, showing INPFC areas.

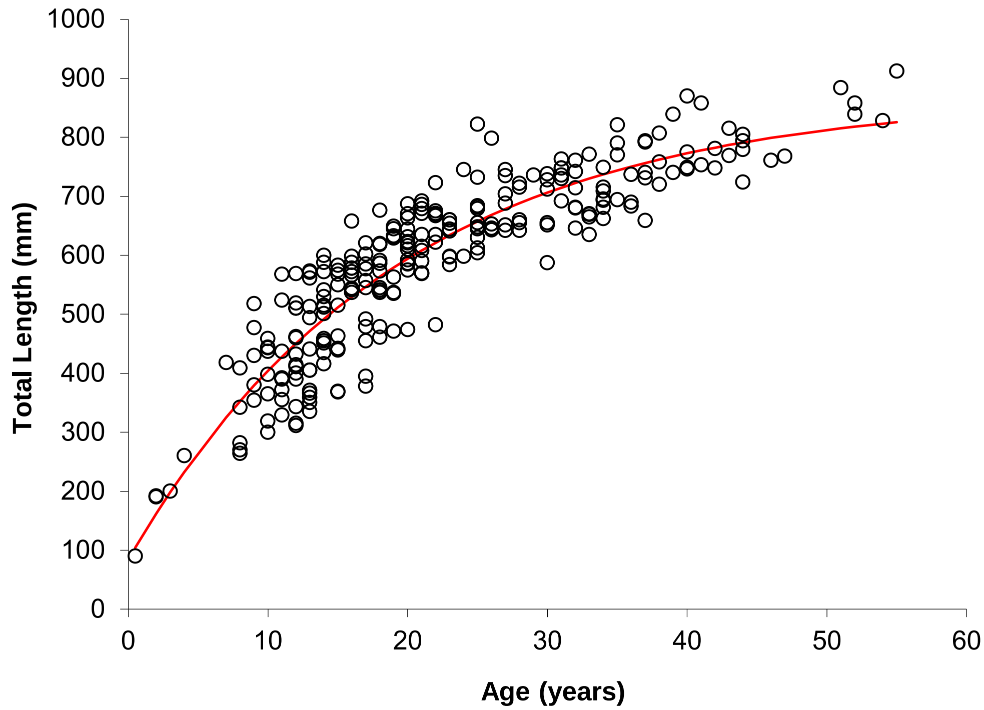


Figure 2. Fit of von Bertalanffy growth curve to length-at-age data, sexes combined (Dick et al. 2007).

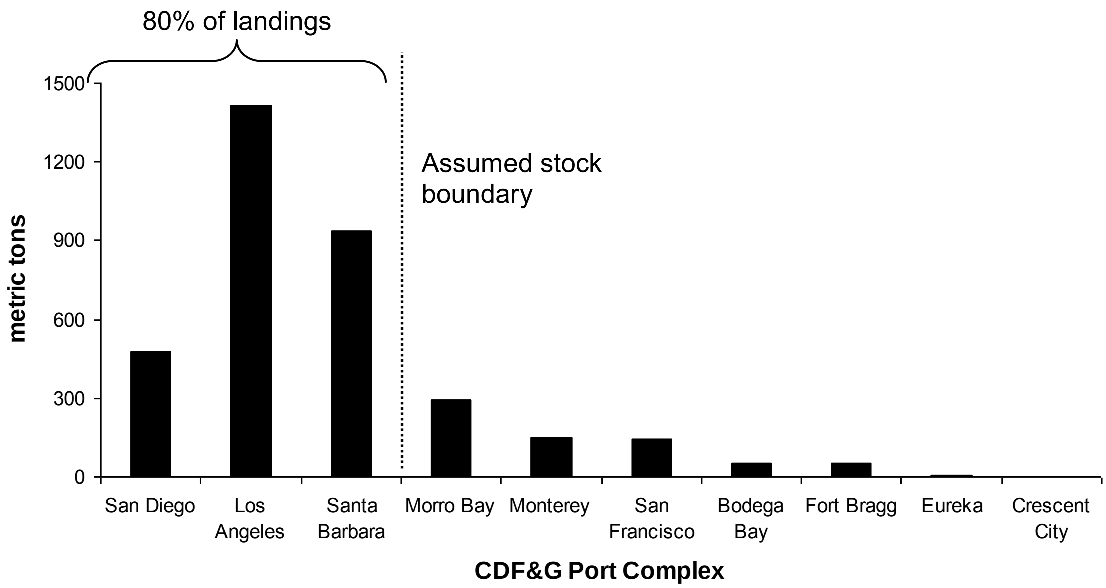


Figure 3. Cowcod landings by port complex, 1969-2005. Source: CALCOM.

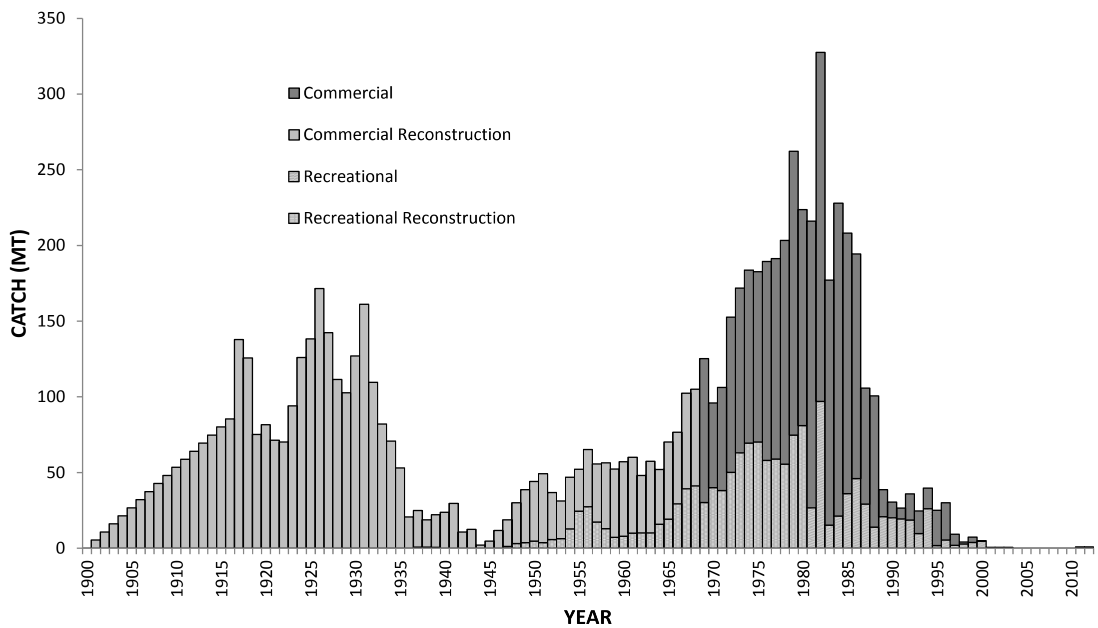


Figure 4. Estimated commercial and recreational removals of cowcod in the Southern California Bight, 1900-2012.

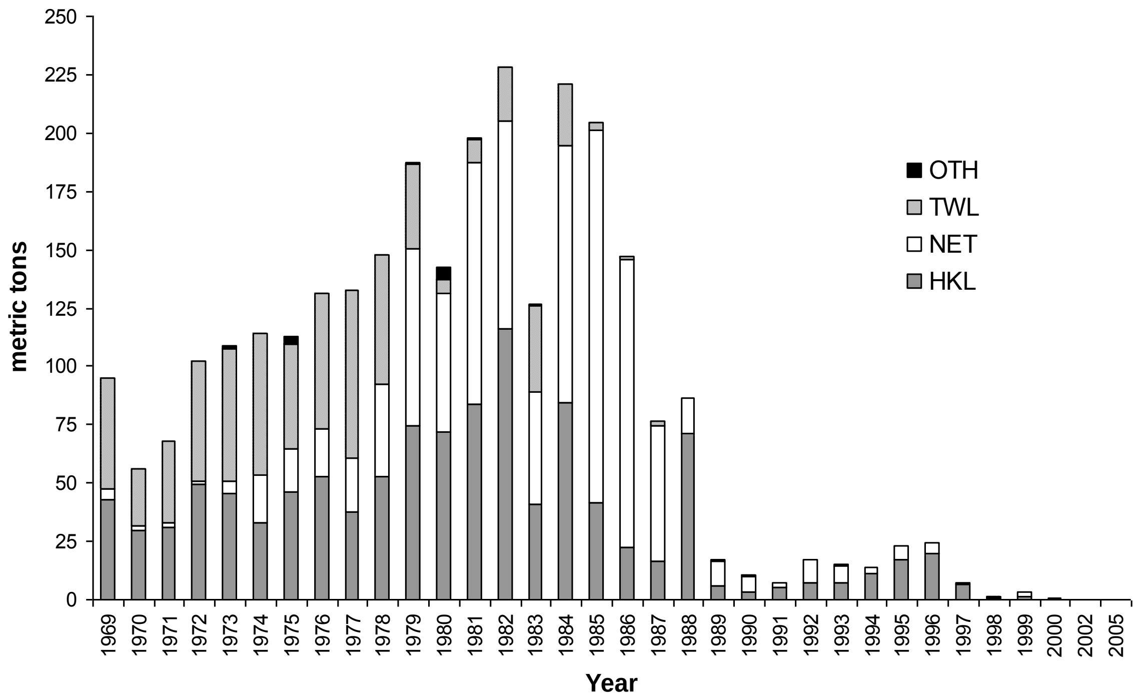


Figure 5. Commercial catches of cowcod by gear type (CALCOM, 2007). Gear groups are hook & line (HKL), trawl (TWL), net (NET), and other (OTH).

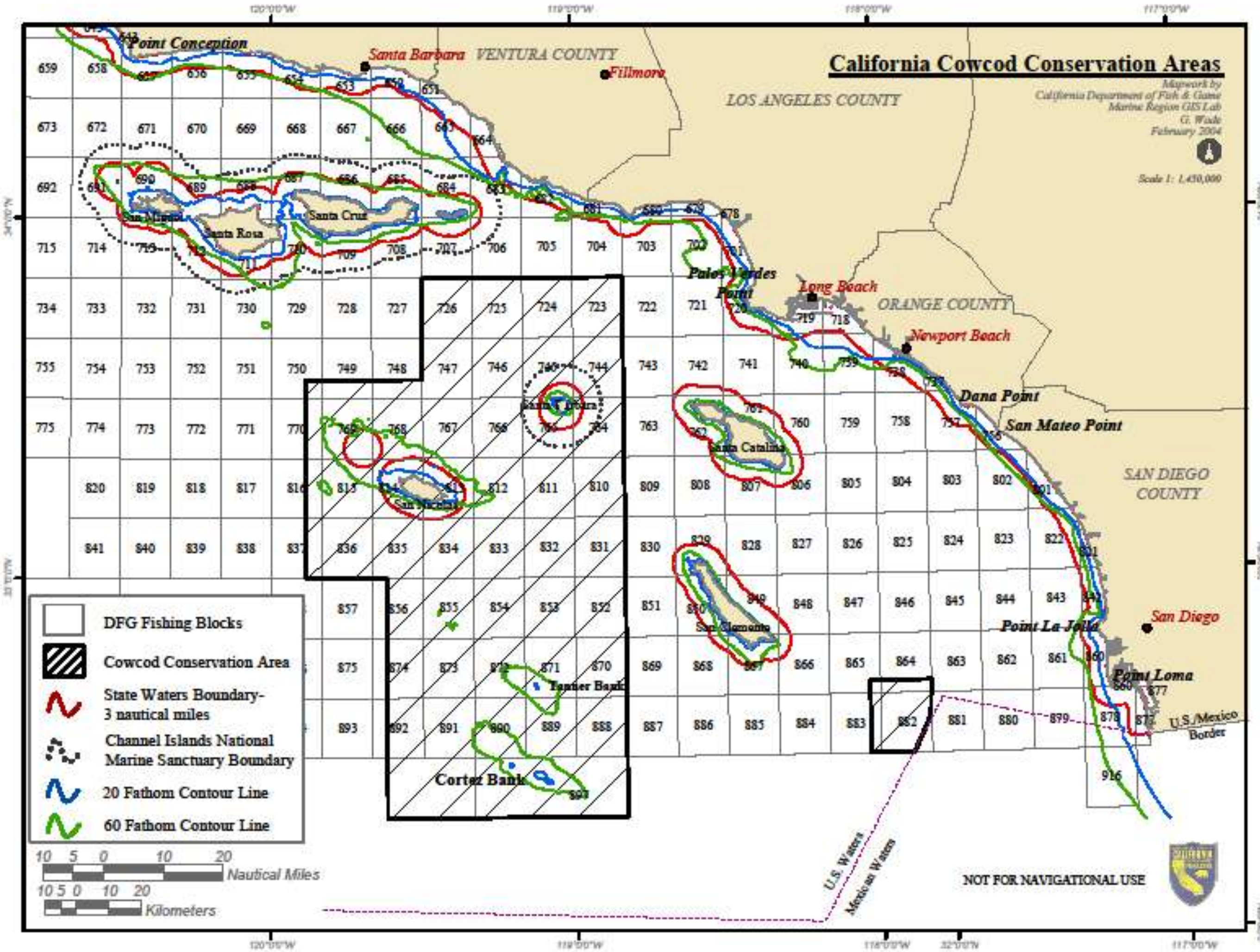


Figure 6. Cowcod Conservation Areas in the Southern California Bight. Source: CDFW (http://www.dfg.ca.gov/marine/cowcod.asp)

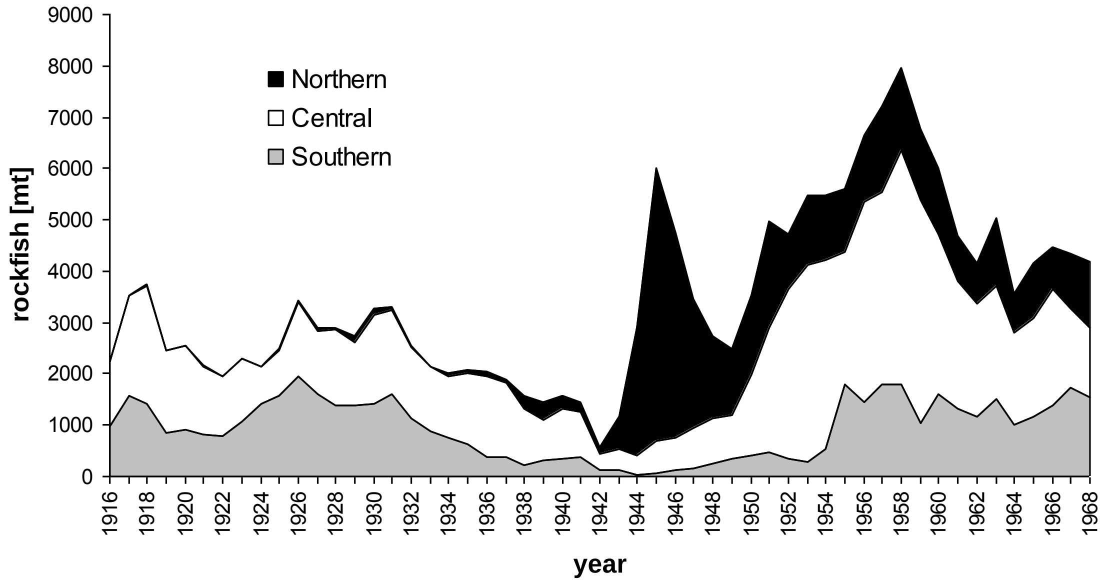


Figure 7: Total commercial rockfish landings by area in California, 1916-1968. See text for definition of regions. Data from 1916-1927 are from CDF&G Fish Bulletin No. 105 (1958), and data after 1927 are from the NMFS SWFSC ERD Live-Access Server.

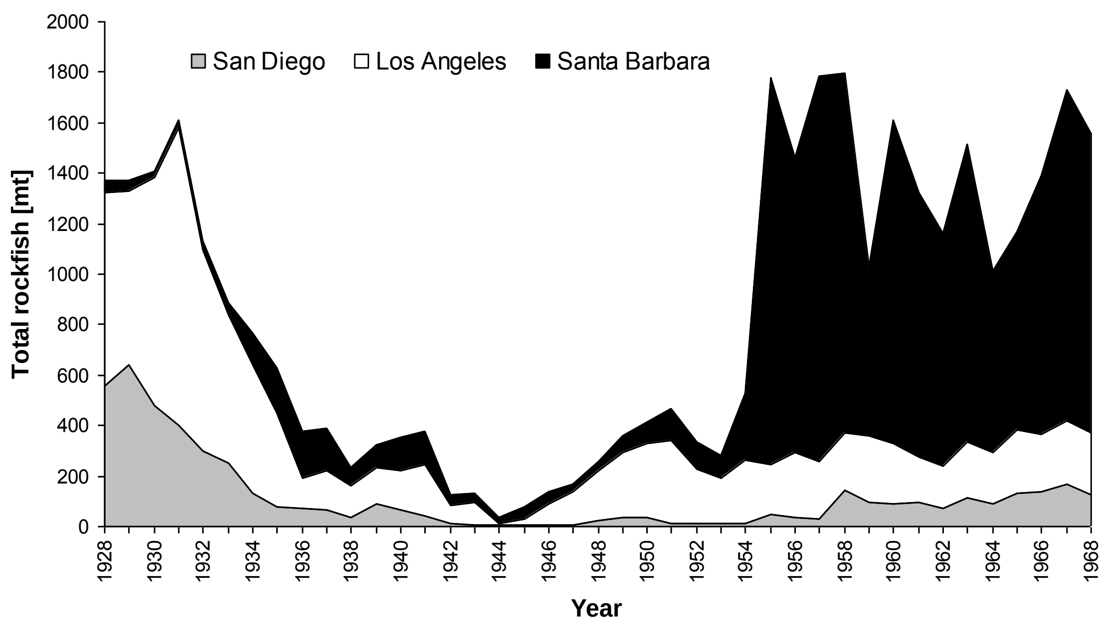


Figure 8. Total commercial rockfish landings in Southern California, 1928-1968, from the ERD database. Landings include thornyheads (genus *Sebastolobus*) and exclude foreign catch. Increased catch in the Santa Barbara region (1954+) is largely due to landings at Morro Bay and Avila.

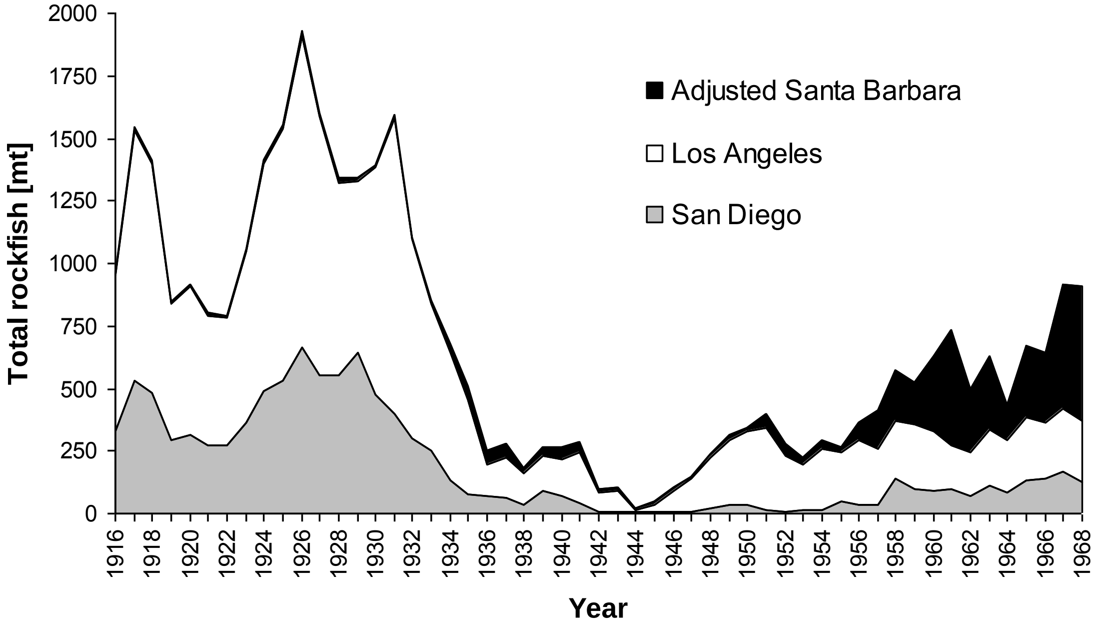


Figure 9. Total commercial rockfish landings in Southern California by region, 1916-1968. Catch in the Santa Barbara region has been adjusted to exclude landings at Morro Bay and Avila

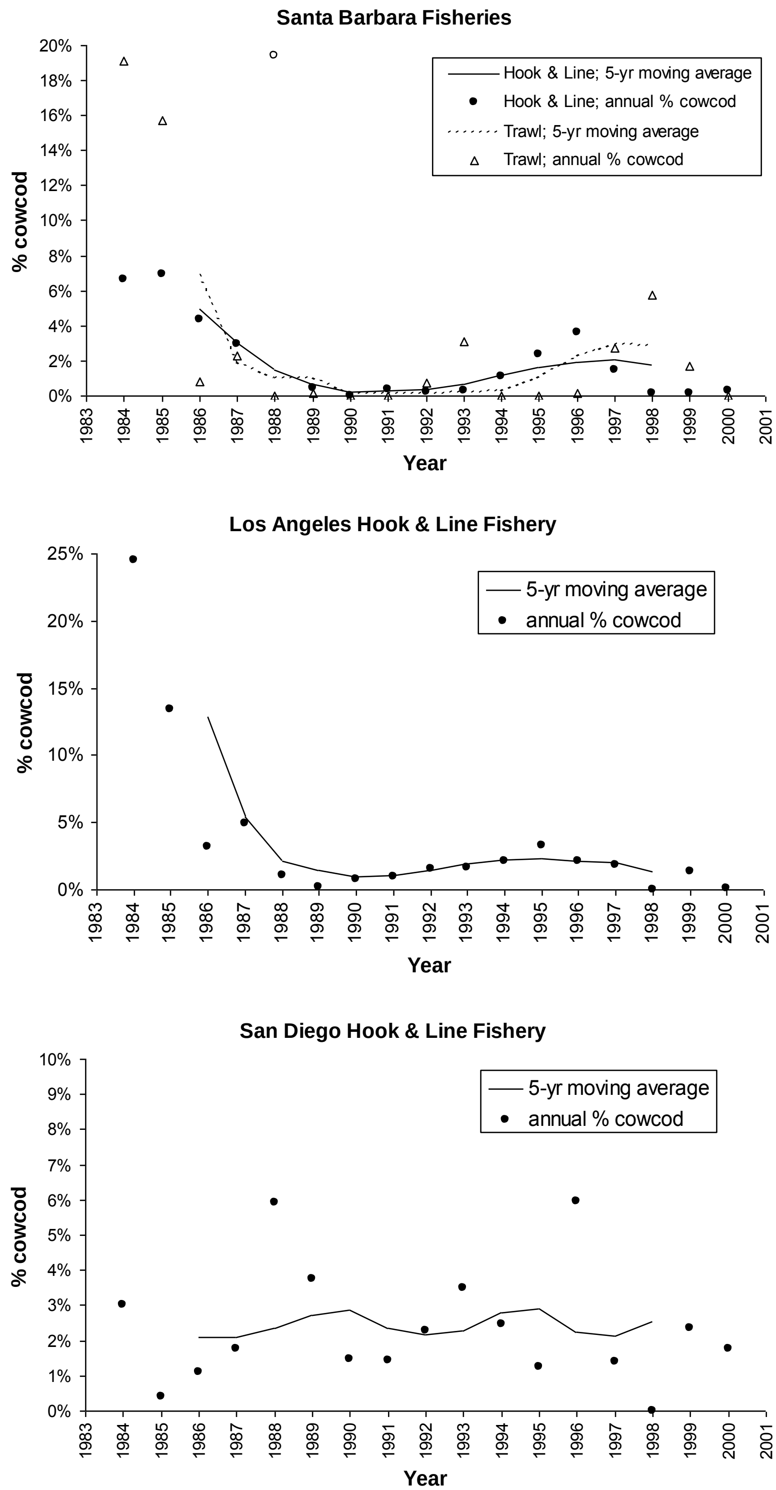


Figure 10. Percent cowcod in rockfish landings, 1984-2000, by year, port, and gear. Moving averages for the Santa Barbara hook & line fishery do not include data from 1988 (open circle).

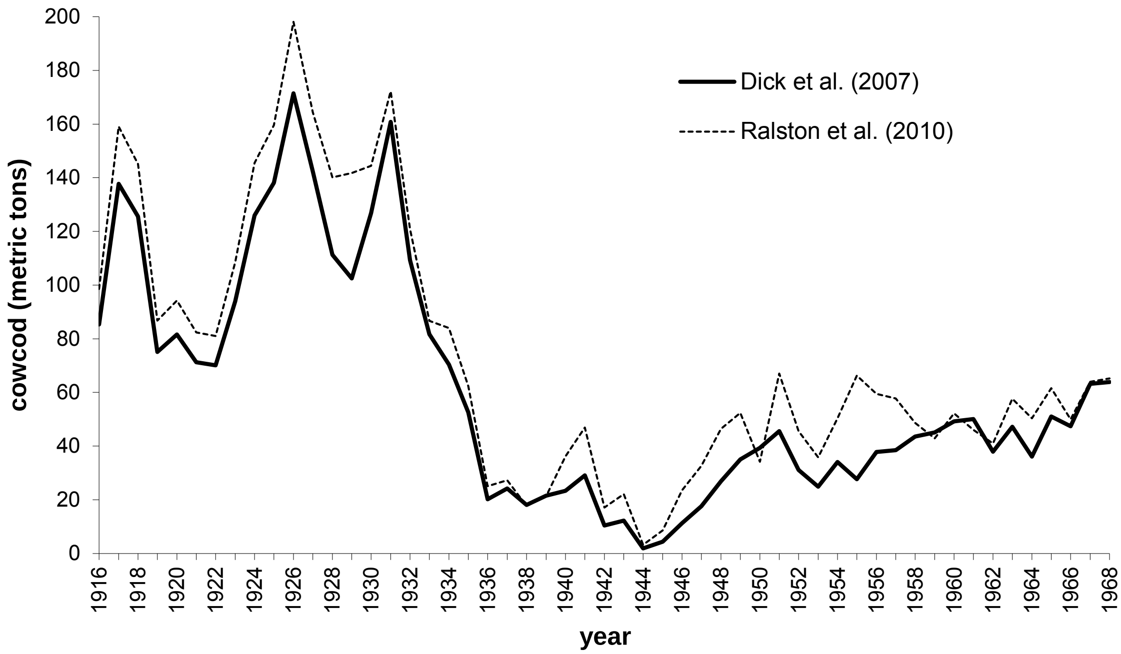


Figure 11. Comparison of historical commercial catch reconstructions for cowcod. Estimates by Ralston et al. (2010) represent catch in the Conception INPFC area. Dick et al. (2007) estimated cowcod catches for U.S. waters south of Point Conception.

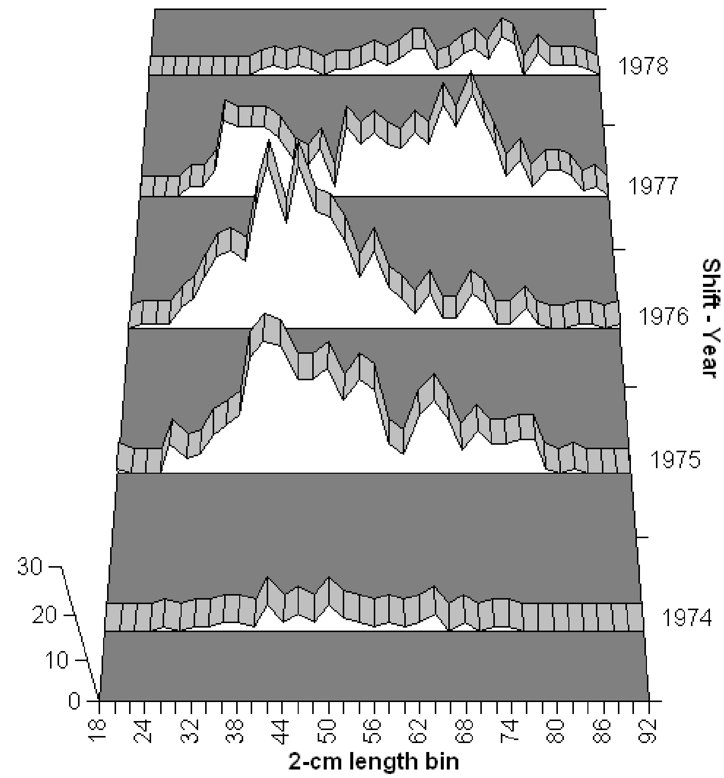


Figure 12. Cowcod length compositions from onboard CPFV sampling in Southern California, 1974-1978.

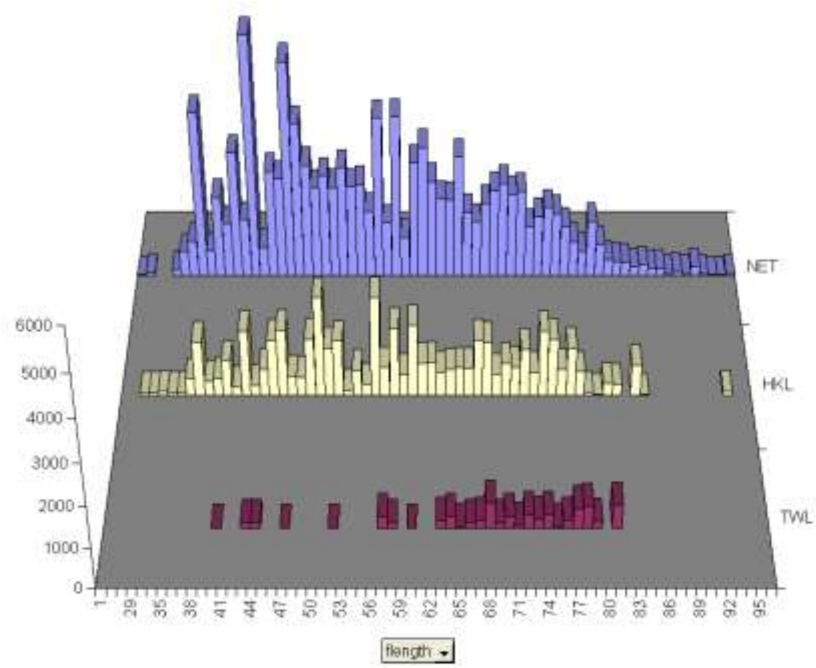


Figure 13. Frequency distributions of cowcod lengths from the commercial fishery, by gear group (all years combined).

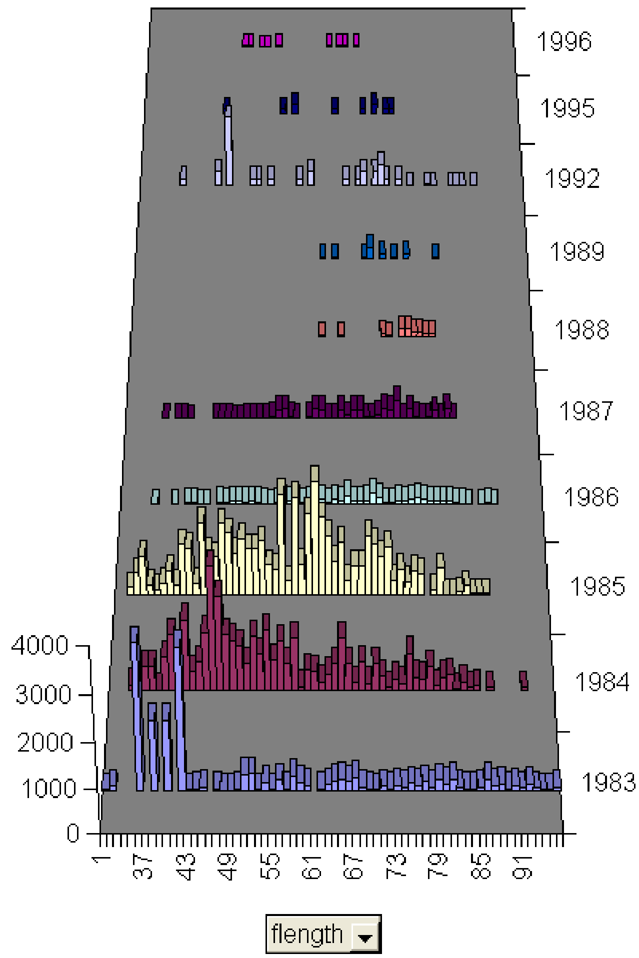


Figure 14. Frequency distributions of cowcod lengths, by year, for the net fishery in Southern California.

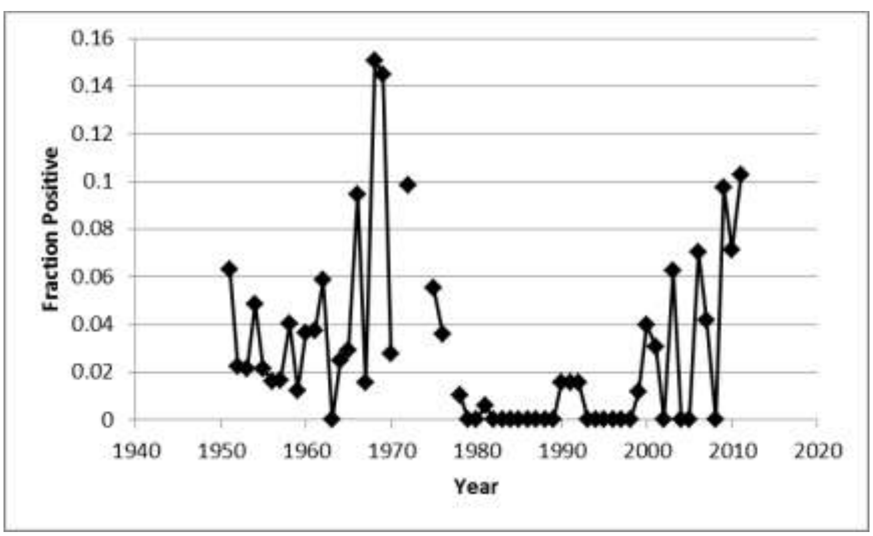


Figure 15. Fraction of southern California CalCOFI samples positive for cowcod.

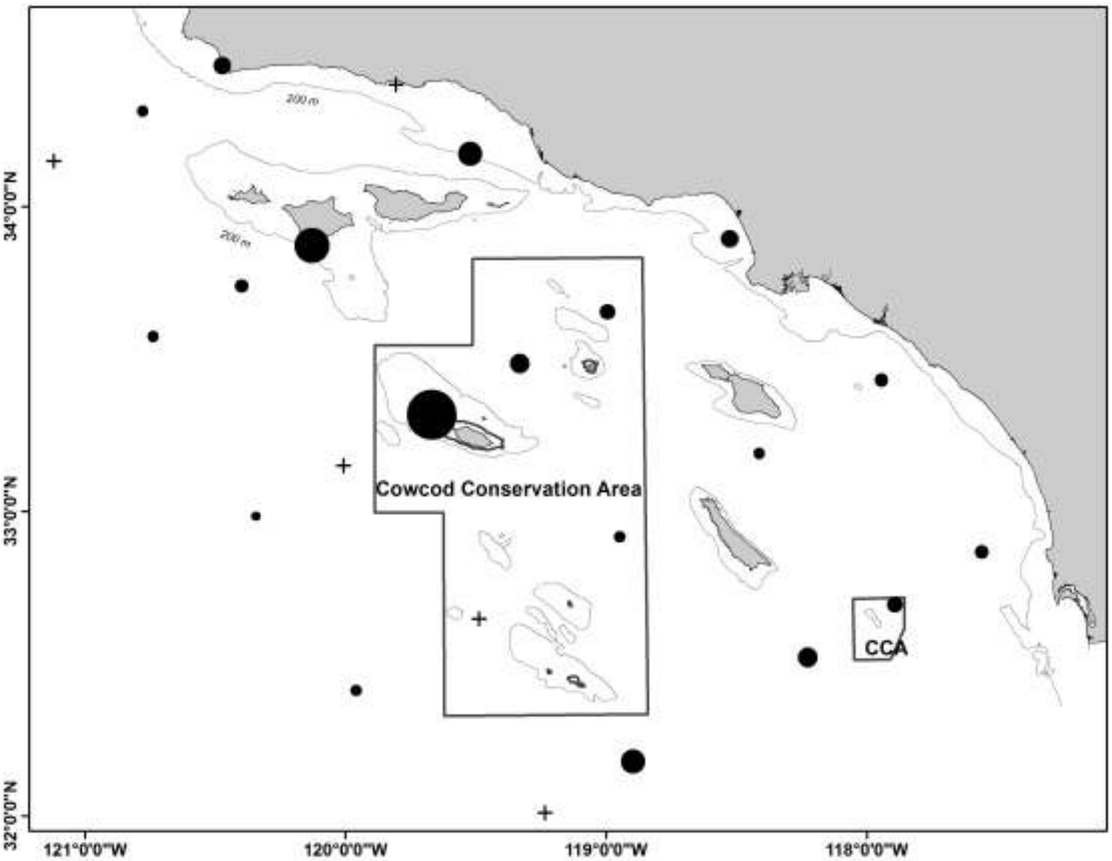


Figure 16. Fraction of tows positive for cowcod (1951-60) at CalCOFI stations. Circle size is proportional to the fraction of positive tows (maximum size = 0.131). Plus signs indicate stations that did not observe cowcod.

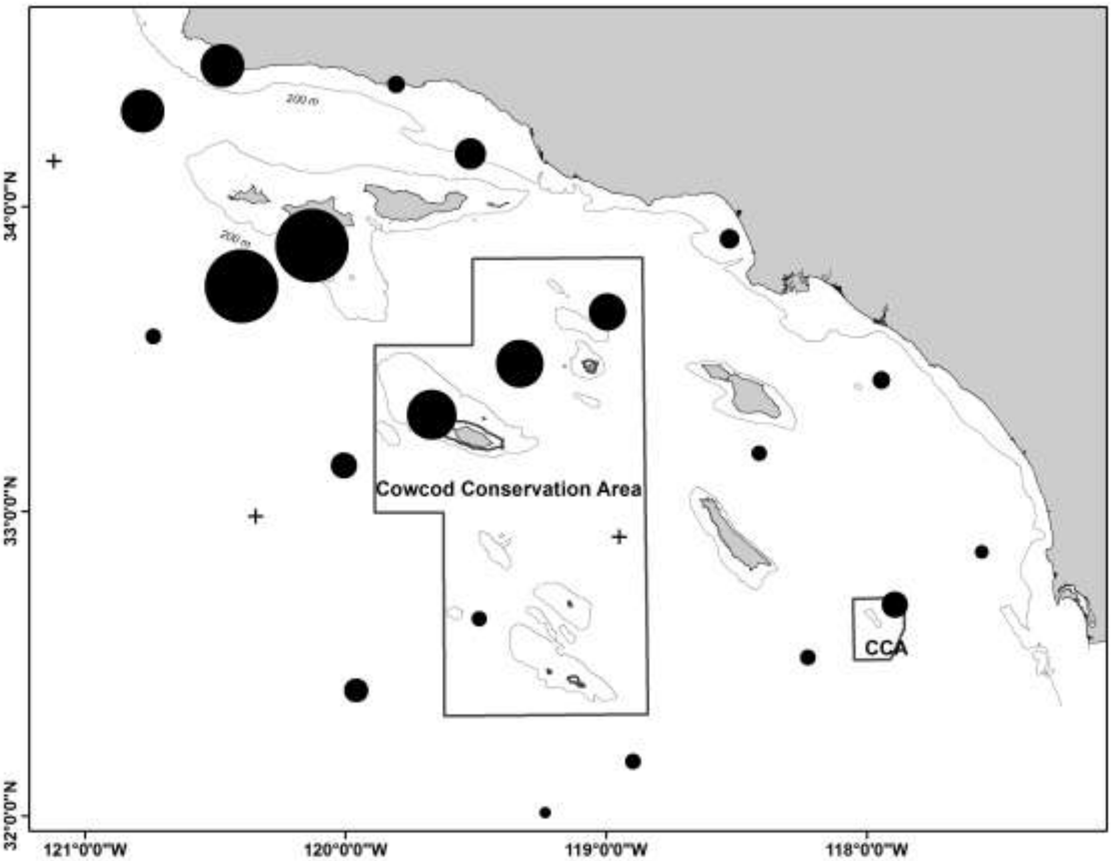


Figure 17. Fraction of tows positive for cowcod (1961-75) at CalCOFI stations. Circle size is proportional to the fraction of positive tows (maximum size = 0.206). Plus signs indicate stations that did not observe cowcod.

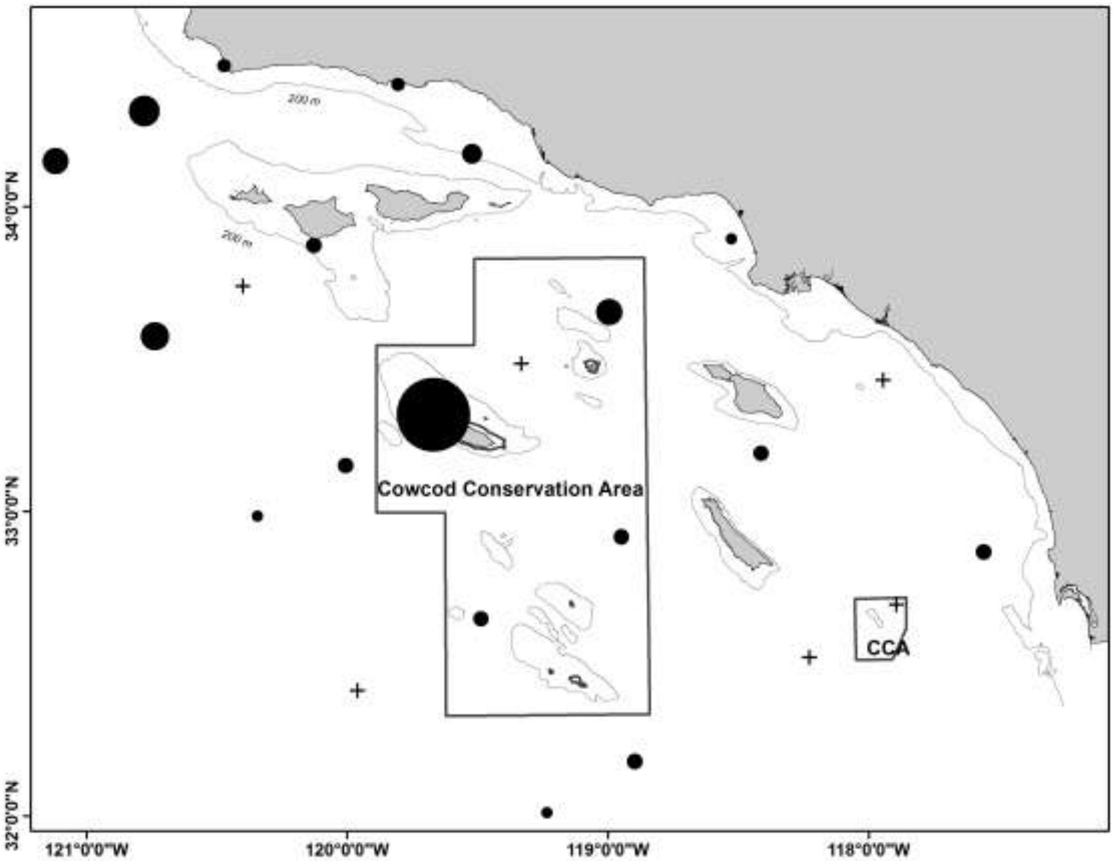


Figure 18. Fraction of tows positive for cowcod (1999-2011) at CalCOFI stations. Circle size is proportional to the fraction of positive tows (maximum size = 0.2). Plus signs indicate stations that did not observe cowcod.

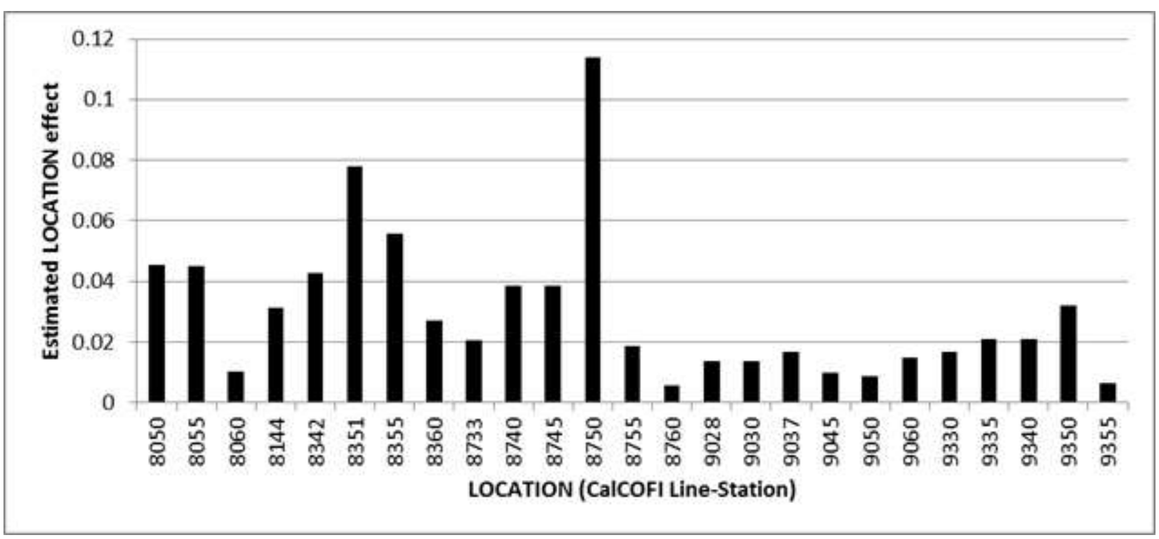


Figure 19. Estimated LOCATION effects from binomial GLM.

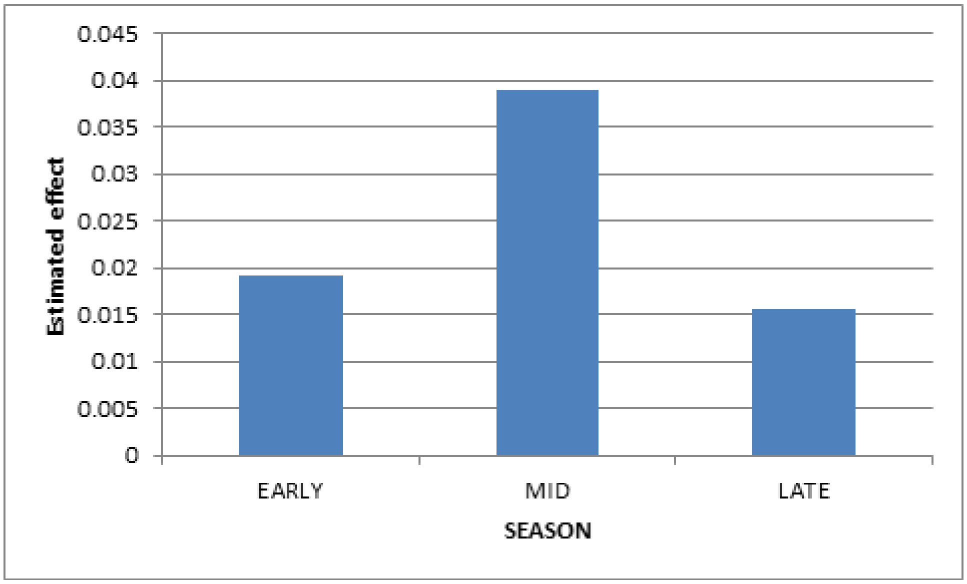


Figure 20. Estimated SEASON effects from binomial GLM. EARLY is 1 Nov to 5 Feb; MID is 6 Feb to 17 March; LATE is 18 March to May.

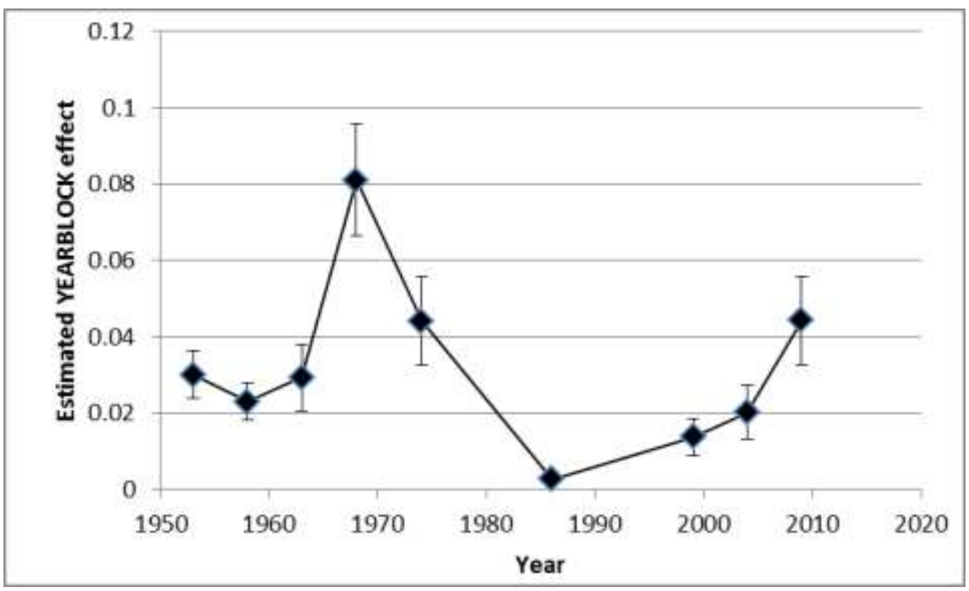


Figure 21. CalCOFI index of larval abundance , using time blocks. Error bars are 1 standard error.

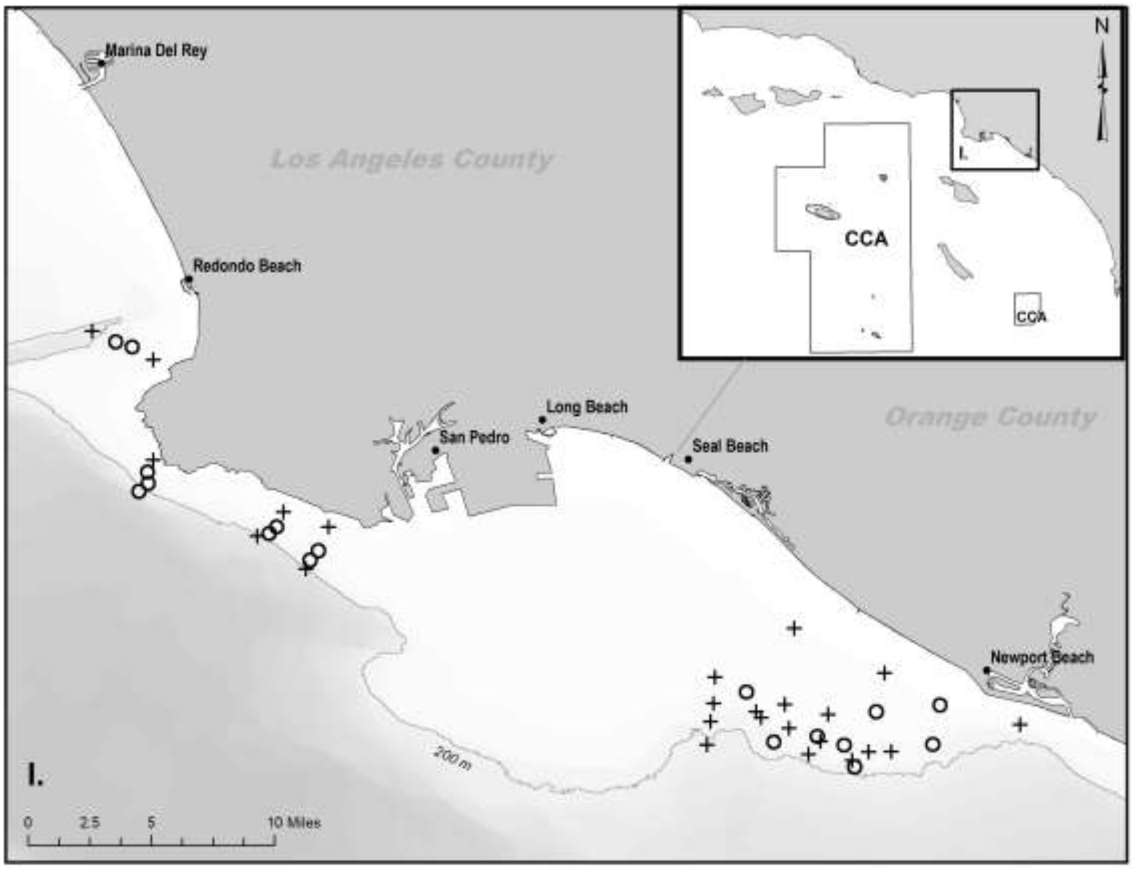


Figure 22. Location of trawls conducted by the Los Angeles and Orange County Sanitation Districts. Circles indicate stations where cowcod have been taken, plus signs indicate stations where cowcod have not been taken.

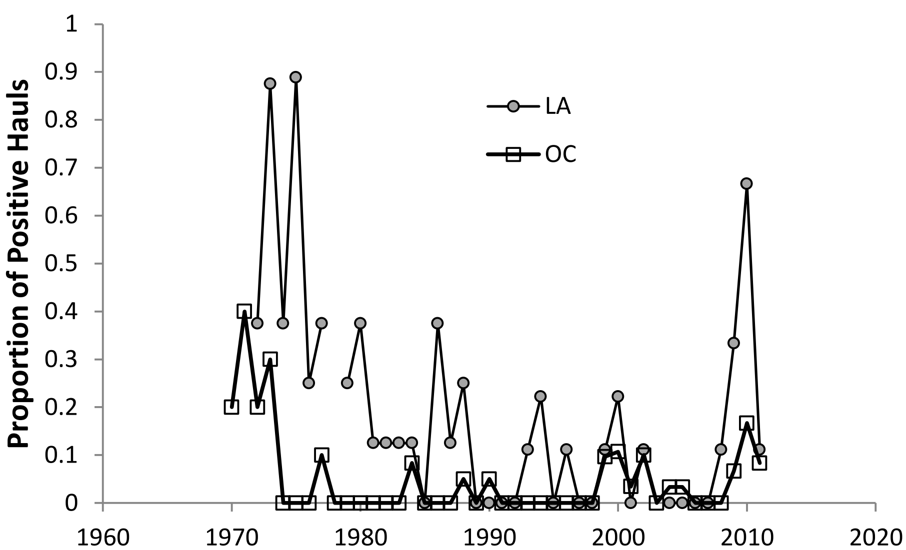


Figure 23. Proportion of hauls positive for cowcod by year and survey in the Los Angeles County (LA) and Orange County (OC) Sanitation District surveys.

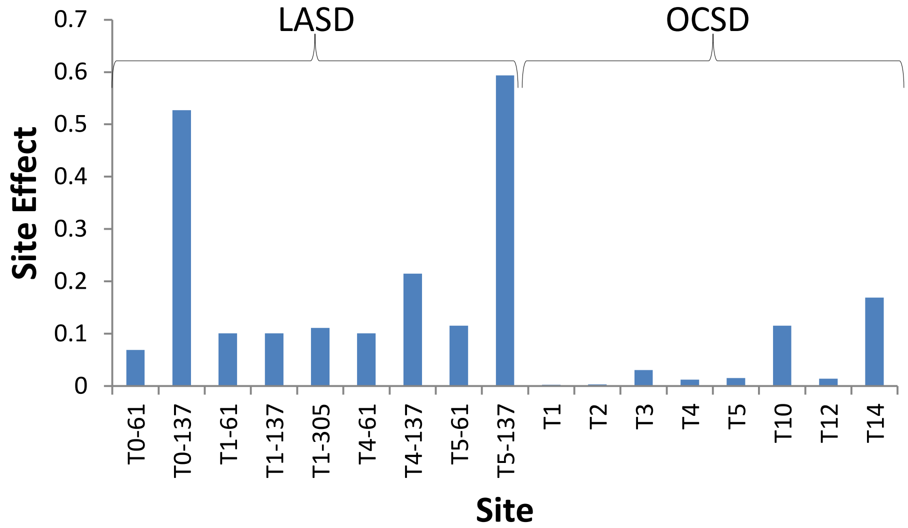


Figure 24. Site effects from the combined Sanitation District index.

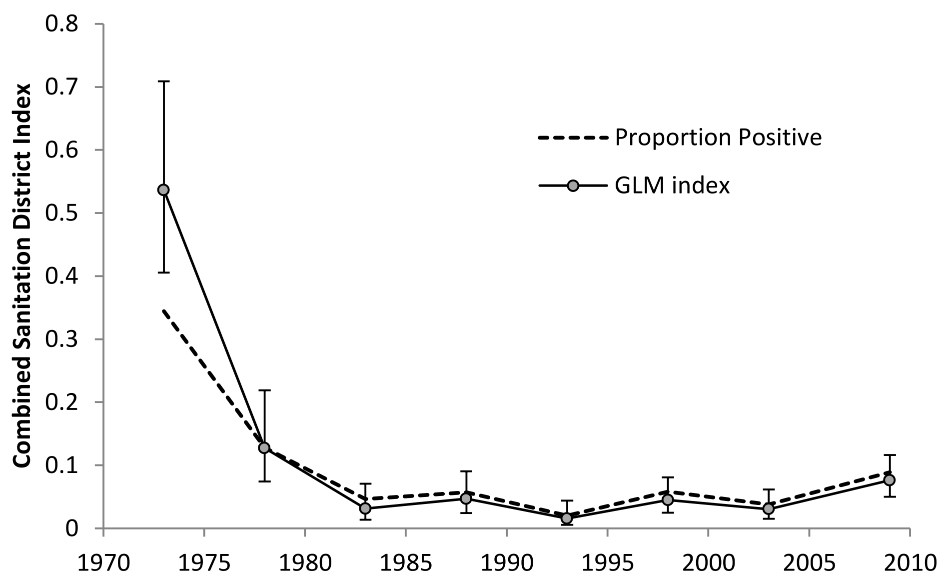


Figure 25. Comparison of the combined LA/OC Sanitation District GLM index (with station and quarter effects) to the proportion of positive hauls in a given year (not accounting for station or quarter effects). Error bars are 95% lognormal confidence intervals.

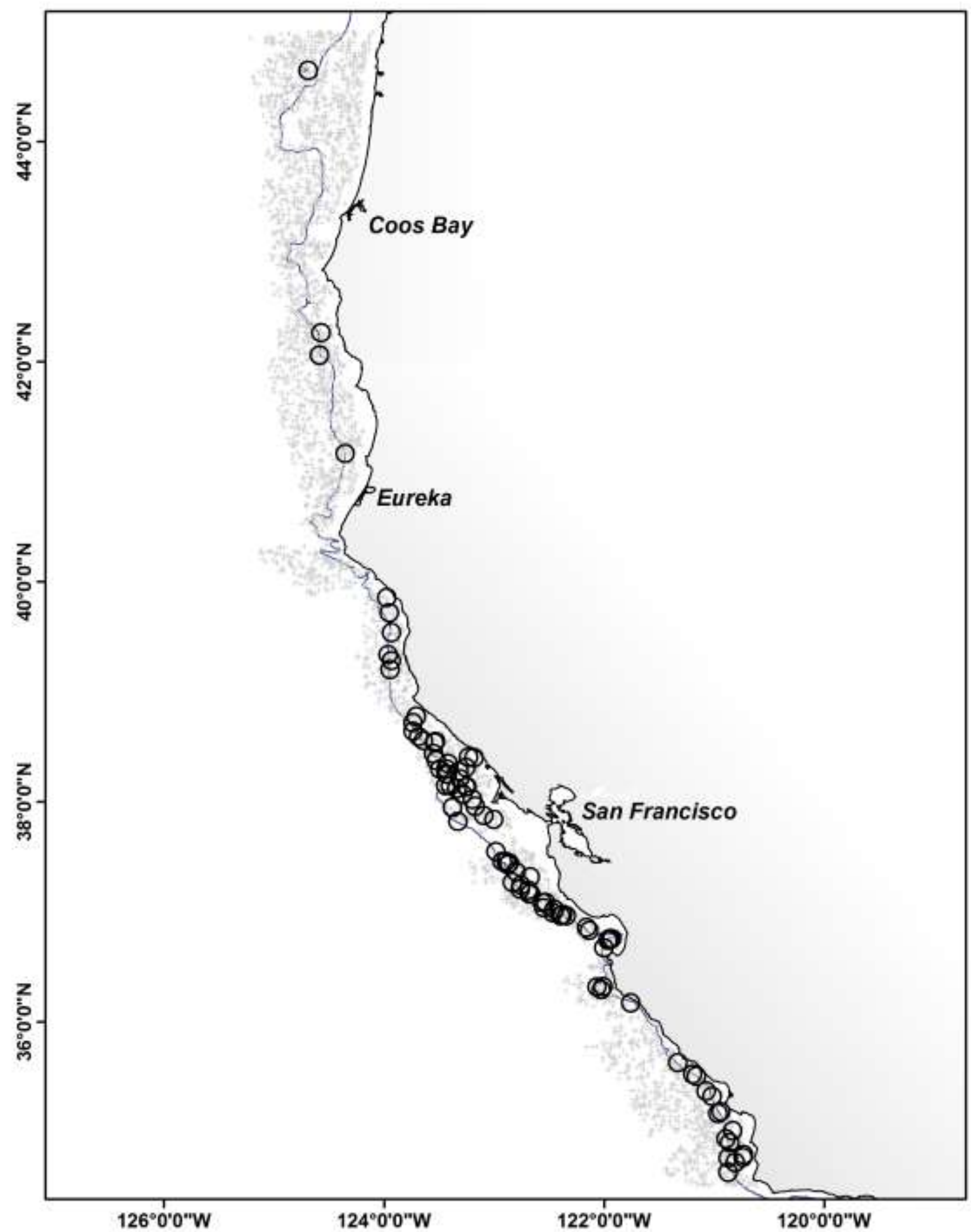


Figure 26. NWFSC combined trawl survey effort (plus signs) and positive hauls for cowcod (circles), north of Point Conception.

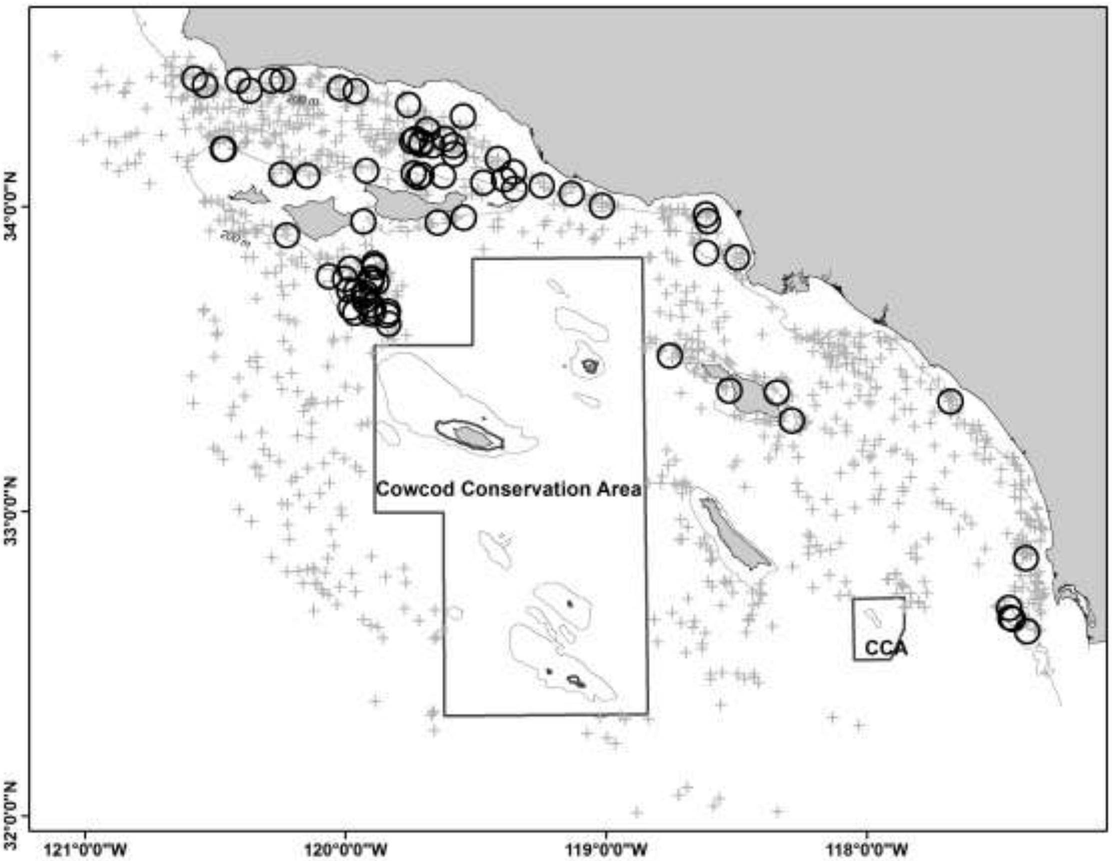


Figure 27. NWFSC combined trawl survey effort (plus signs) and positive hauls for cowcod (circles), south of Point Conception.

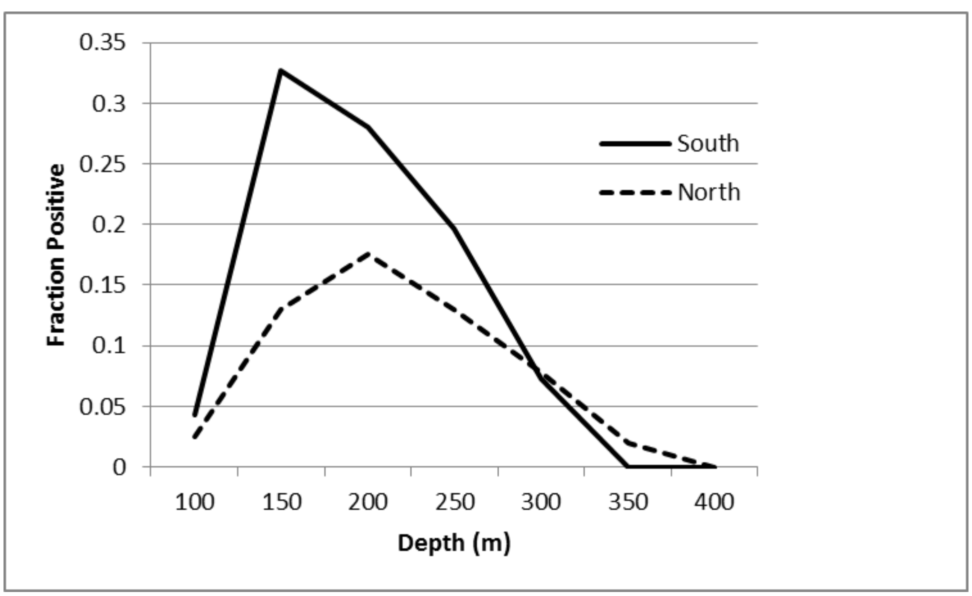


Figure 28. Fraction of hauls positive for cowcod by 50-meter depth bin in the NWFSC combined trawl survey, north and south of Point Conception.

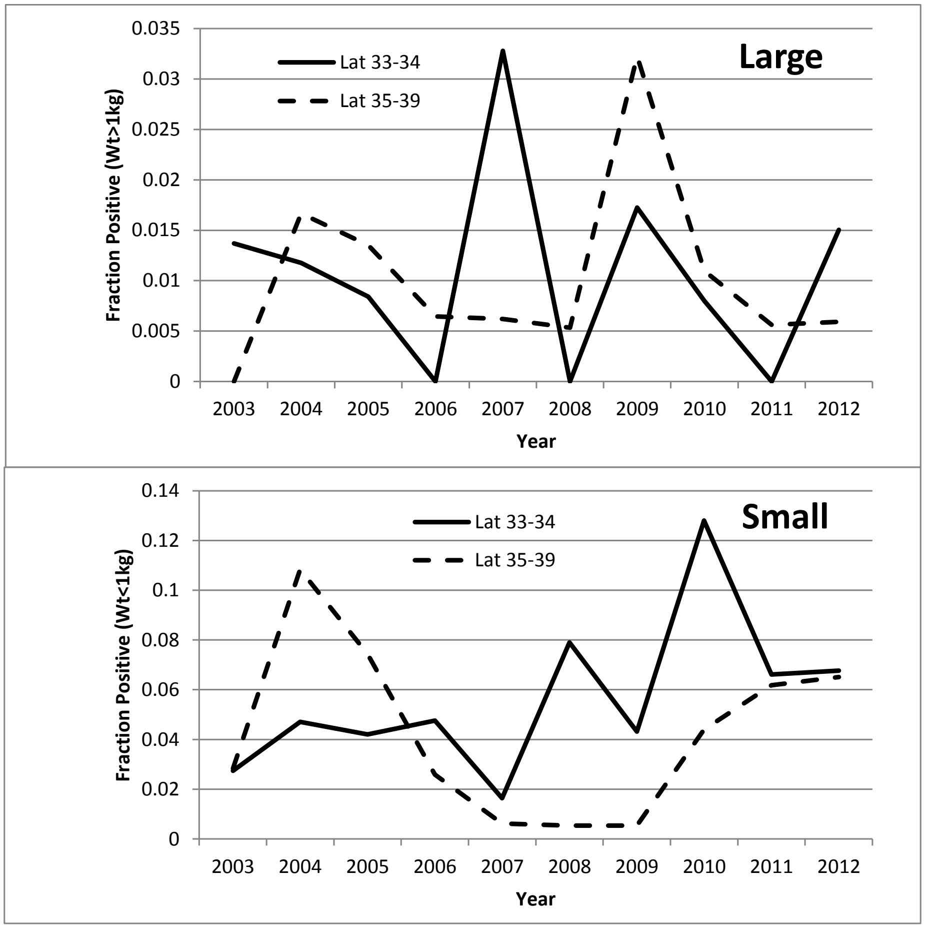


Figure 29. Comparison of trends in large (>1 kg) and small (<1 kg) cowcod from the NWFSC trawl survey, north and south of Point Conception.

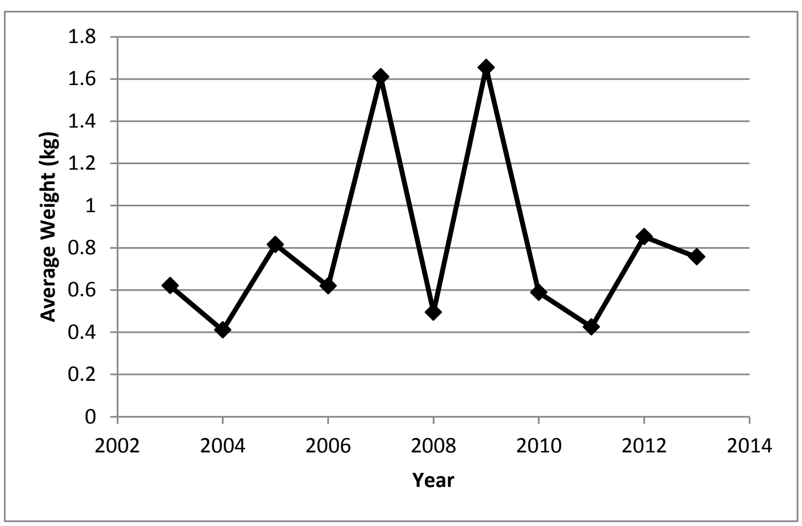


Figure 30. Average weight by year of cowcod in the NWFSC trawl survey.

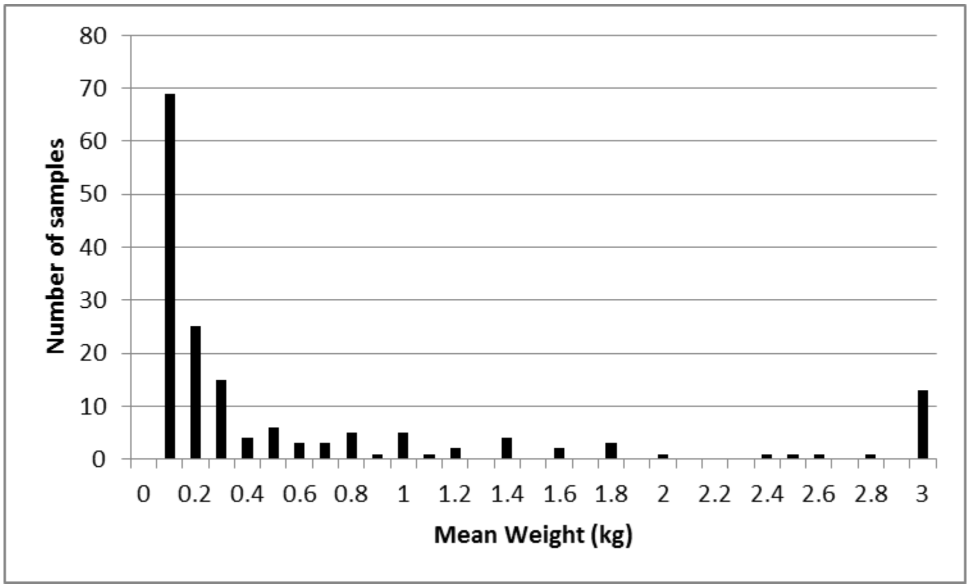


Figure 31. Frequency distribution of mean weight of cowcod caught in trawl surveys. The 3-kilogram size includes all larger values.

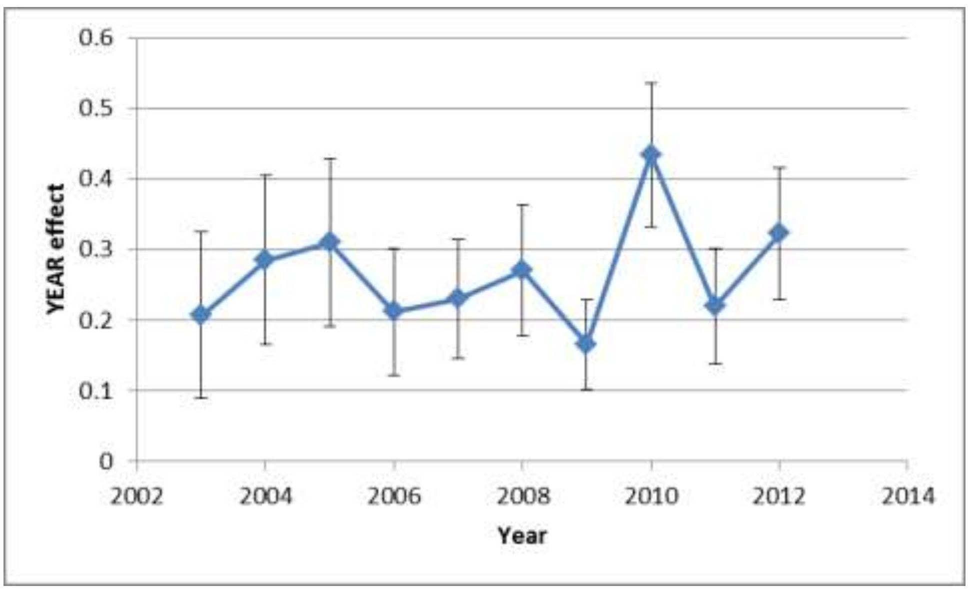


Figure 32. NWFSC trawl survey index of small (<1kg) cowcod abundance in southern California waters. Error bars are 1 SE.

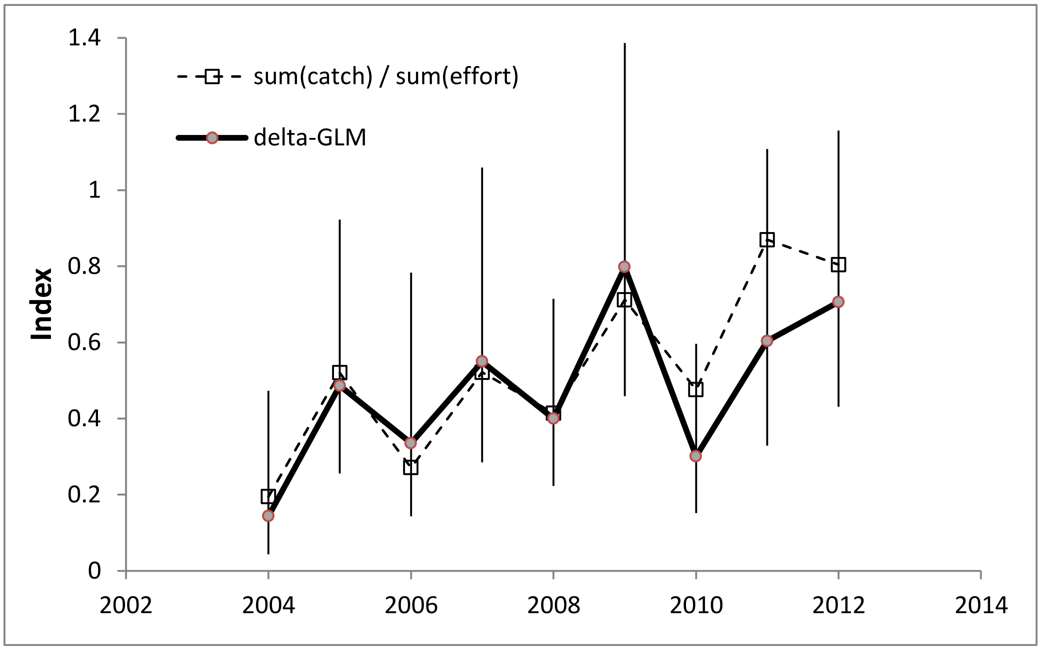


Figure 33. Raw CPUE (catch per drop) and delta-GLM index for the NWFSC hook-and-line survey. Bars are 95% jackknifed confidence intervals assuming a lognormal error structure.

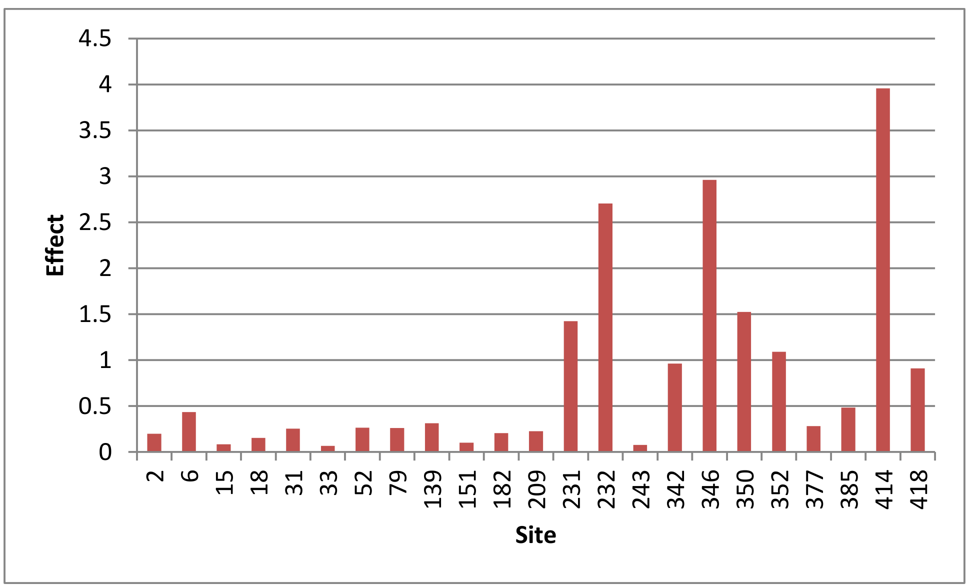


Figure 34. Site effects for NWFSC delta-GLM index for cowcod.

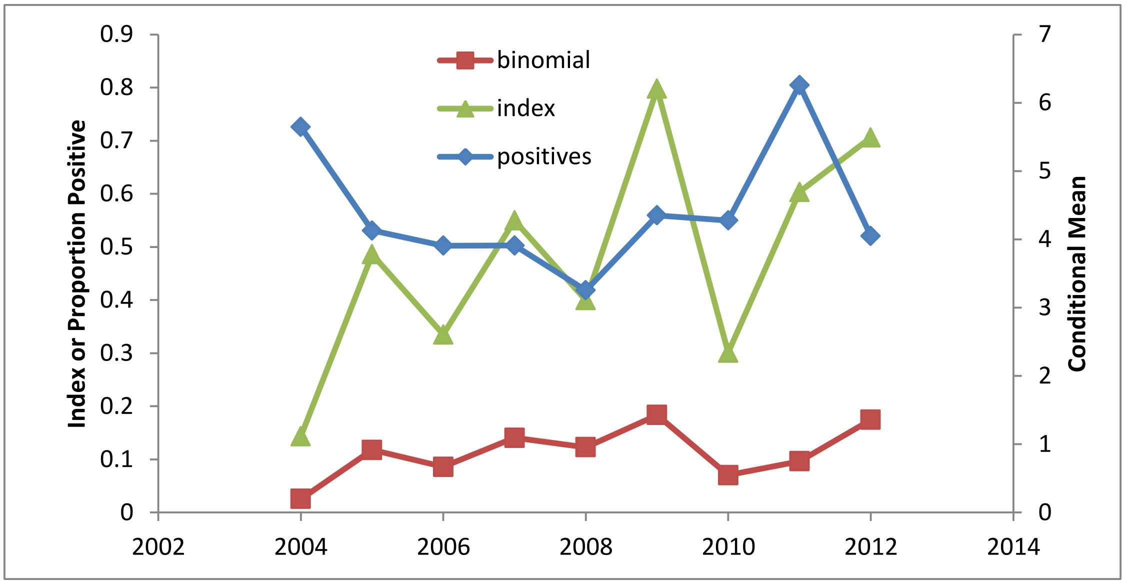


Figure 35. Binomial and positive (conditional mean) components of the NWFSC hook-and-line index for cowcod, compared to the final index (product of the two components).

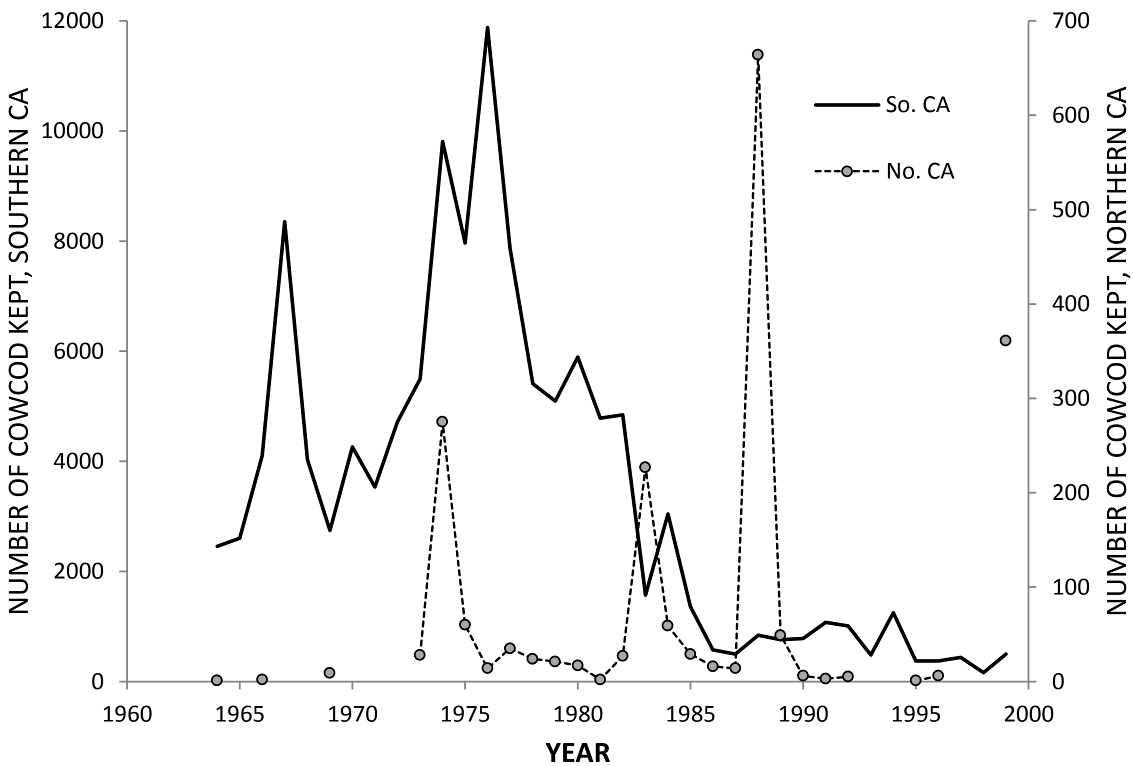


Figure 36. Number of cowcod recorded as kept in the California CPFV logbook database, by region. "Southern CA" = CDFW statistical blocks 651 and greater, "Northern CA" = block numbers less than 651.

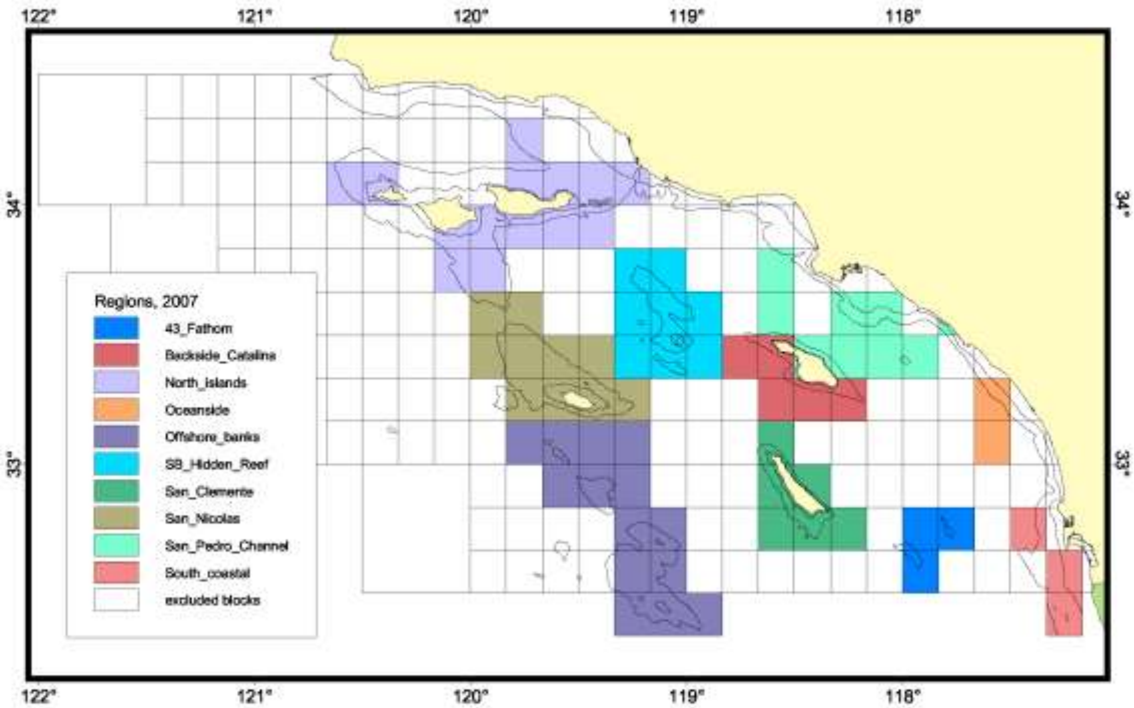


Figure 37. Spatial stratification of CDFW fishing blocks for the monthly aggregated CPFV logbook index, as used in the 2007 and 2009 cowcod assessments (Dick et al. 2007).

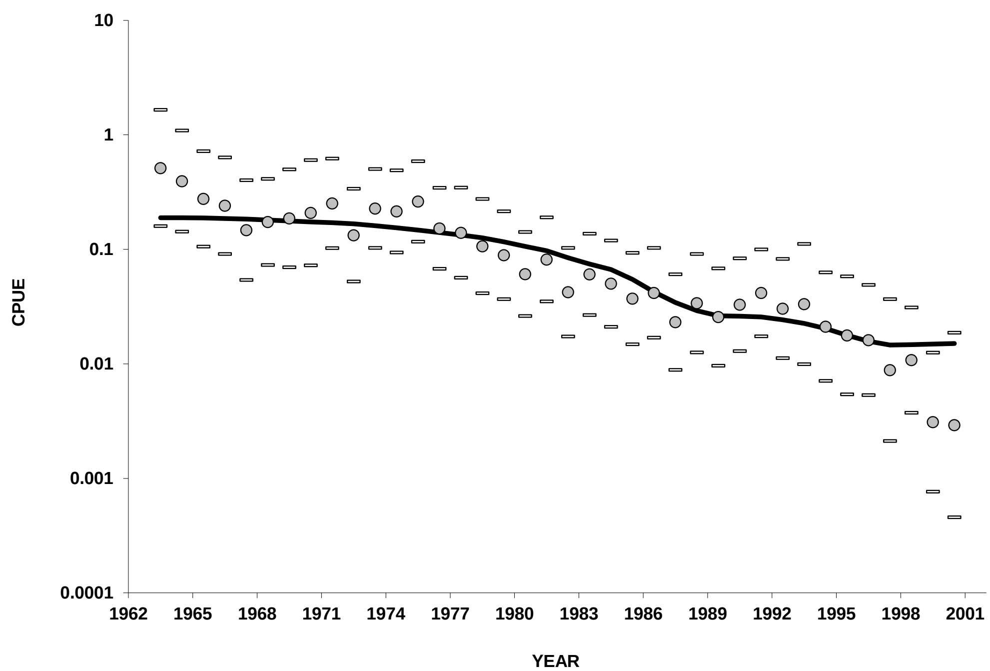


Figure 38. Base model fit to the (log-scale) CPFV logbook index in the 2009 cowcod assessment (Dick et al. 2009), showing hyperdepletion pattern.

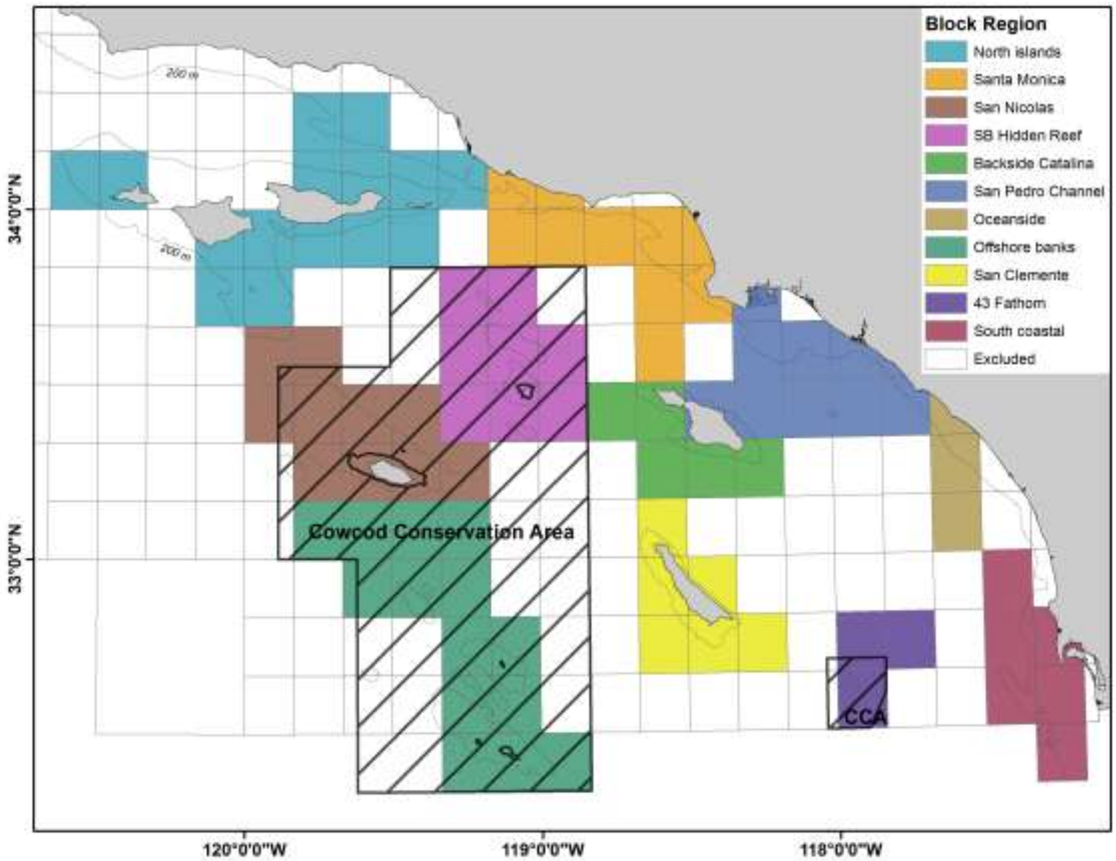


Figure 39. Spatial stratification of CDFW fishing blocks for the trip-based CPFV logbook index.

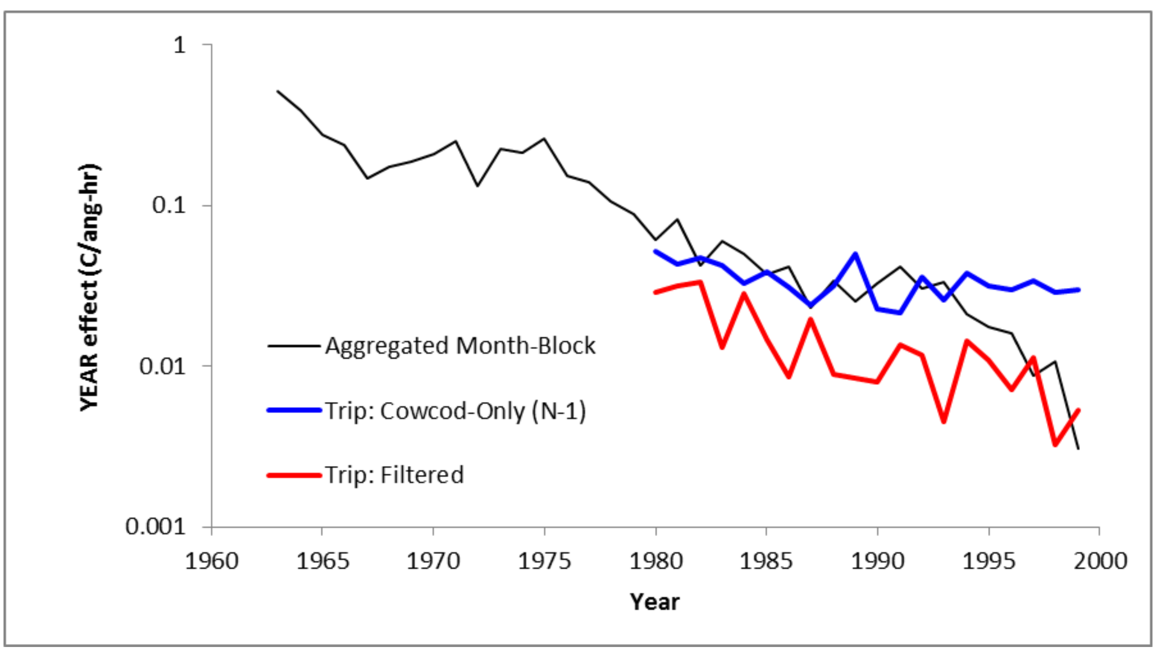


Figure 40. Comparison of three cowcod CPUE indices derived from CPFV logbook data.

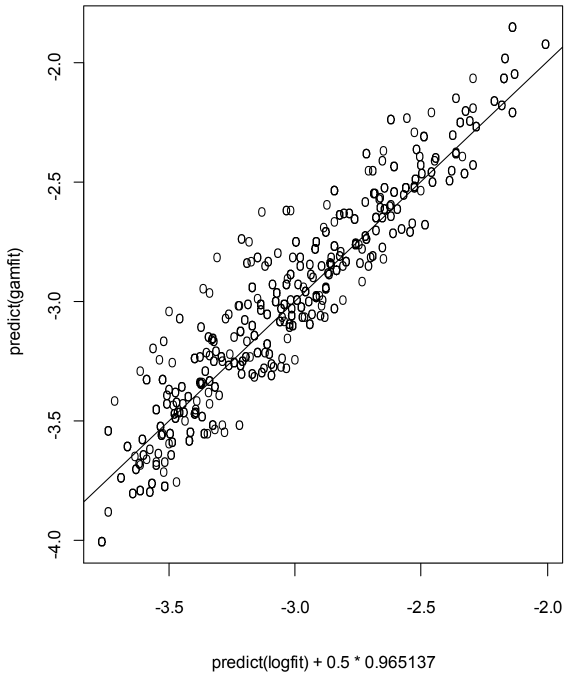


Figure 41. Comparison of predicted values for positive CPFV logbook data, specifically a (bias-adjusted) Gaussian model for log(CPUE) and a Gamma model with a log link function.

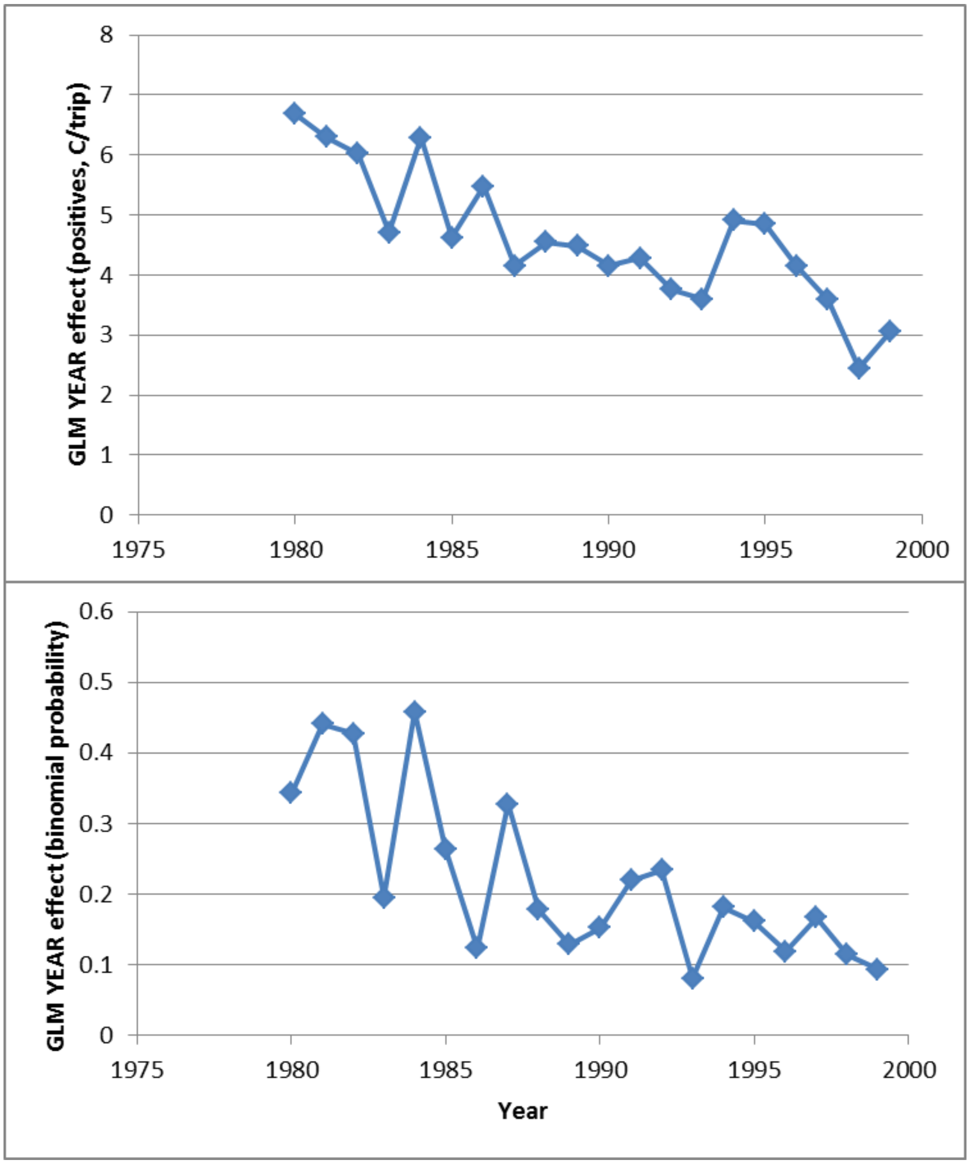


Figure 42. Time series of YEAR effects from the two portions of a delta-lognormal model of cowcod catch per trip using Rockfish-Trips Only logs.

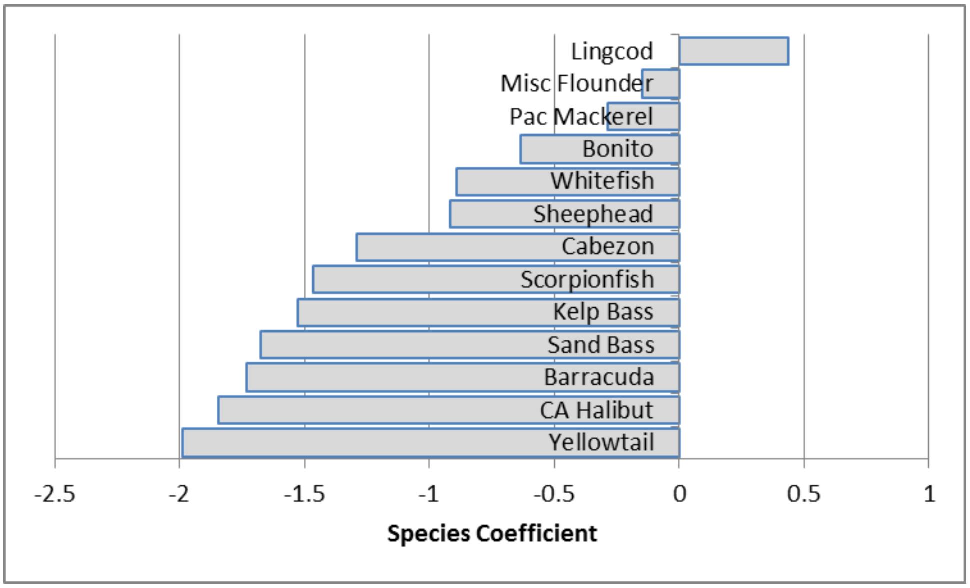


Figure 43. Logistic regression coefficients of species presence used to filter the CPFV logbook data ("Rockfish-Trip" subset).

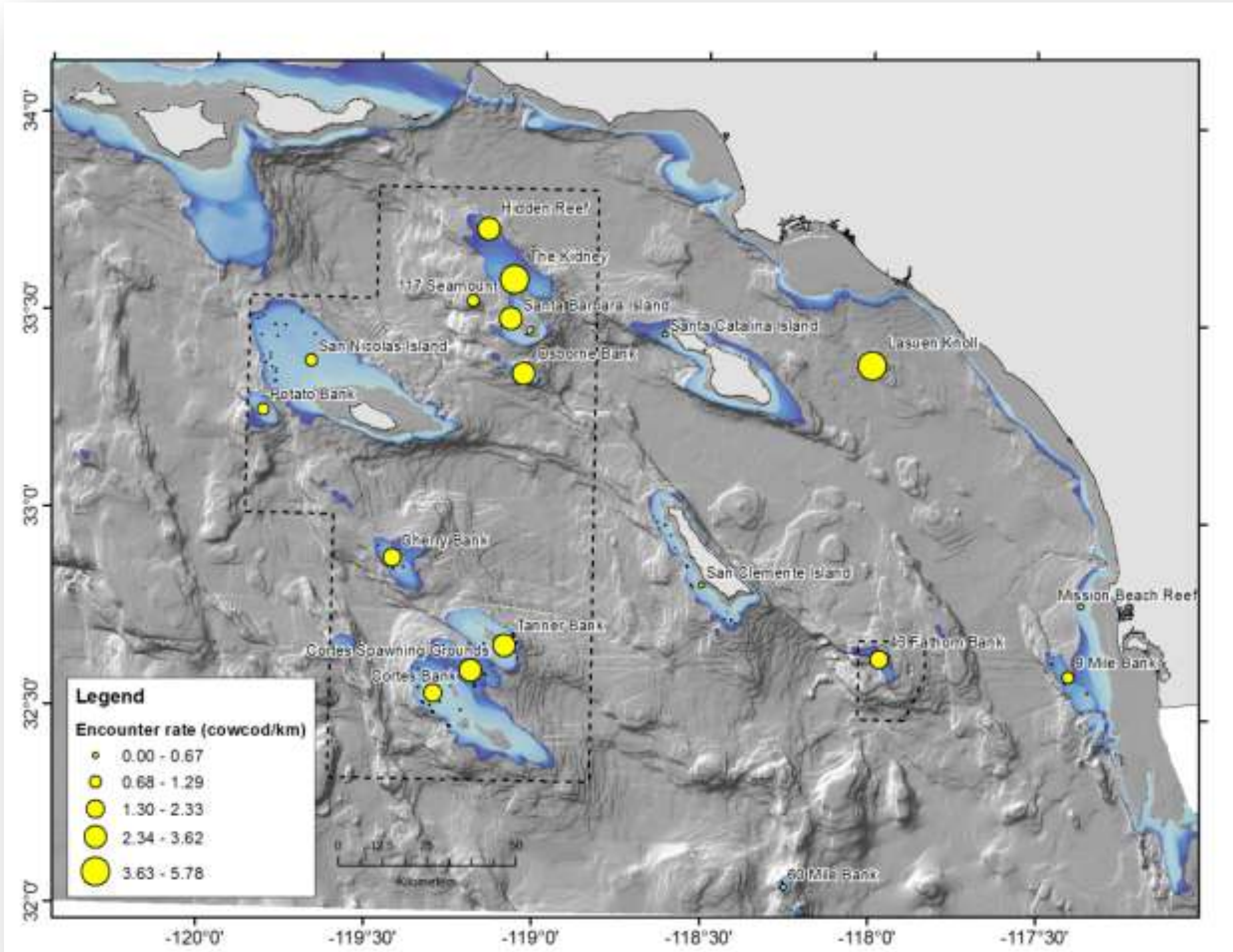


Figure 44. Encounter rates of cowcod from the 2012 Southern California Bight Cowcod Assessment Survey. 167 transects were surveyed by remotely operated vehicle at 18 sites. Estimates of cowcod abundance and biomass from the survey are pending. Figure courtesy of K. Steirhoff, NMFS SWFSC.

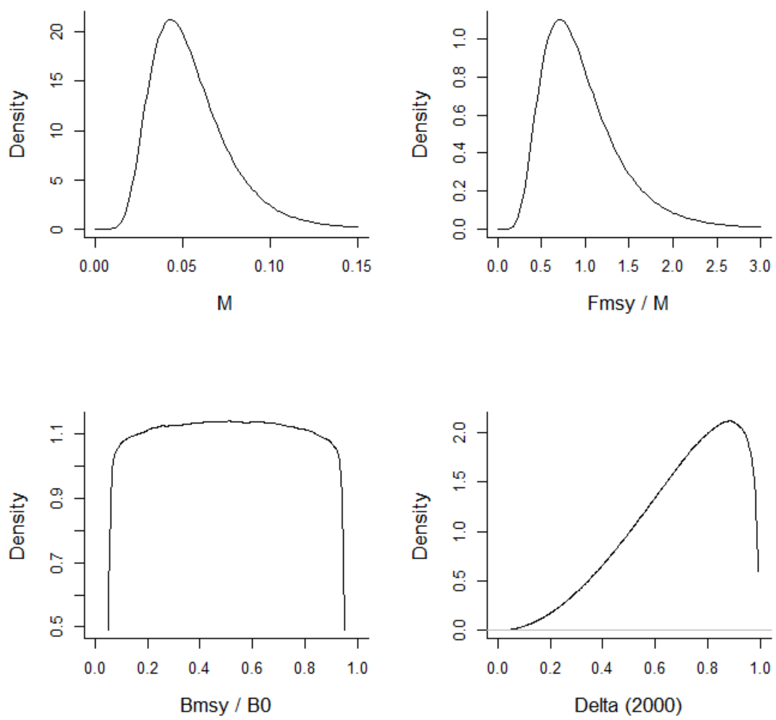


Figure 45. Prior distributions for population dynamics parameters in the cowcod base model.

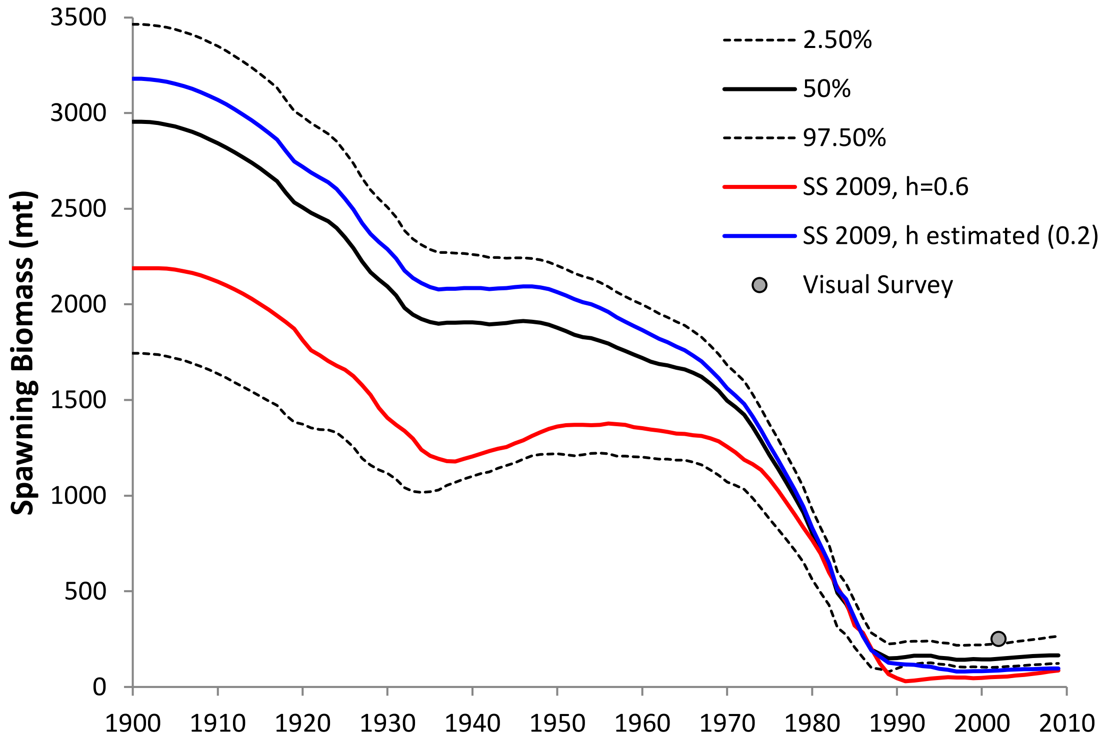


Figure 46. Spawning biomass estimates from three models fit to the data from the 2009 cowcod assessment. The red solid line is the 2009 base case model, with steepness (h) fixed at 0.6. The blue solid line is the same model with steepness estimated (h=0.2). The black solid line is median biomass from the XDB-SRA model, all parameters estimated, with 2.5% and 97.5% quantiles (black dashed lines).

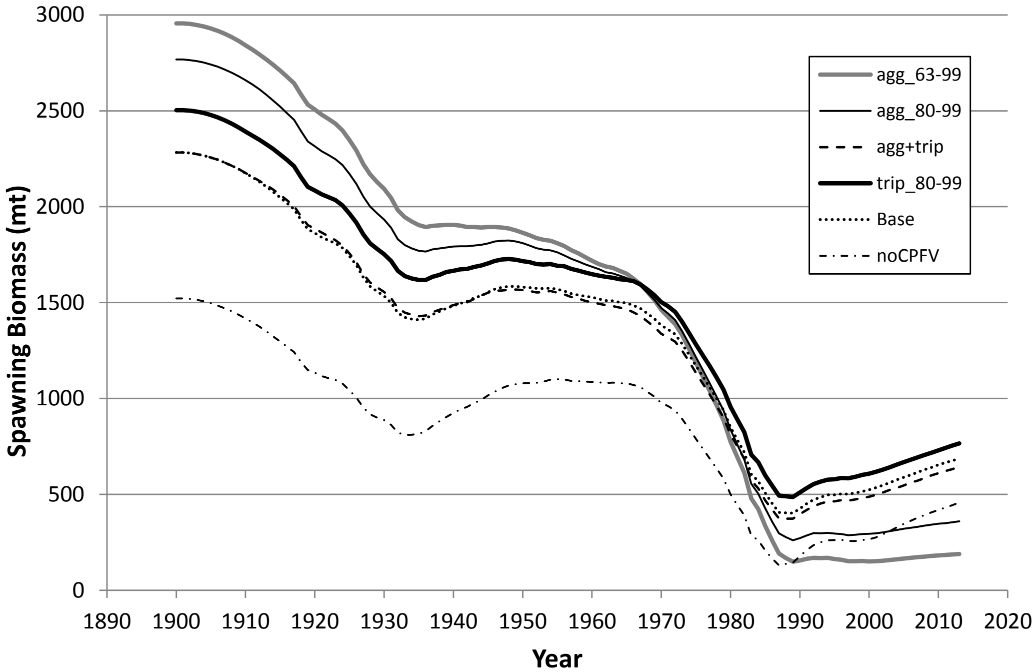


Figure 47. Effect of alternative CPFV logbook treatments on median spawning biomass trajectories. Base model included for reference.

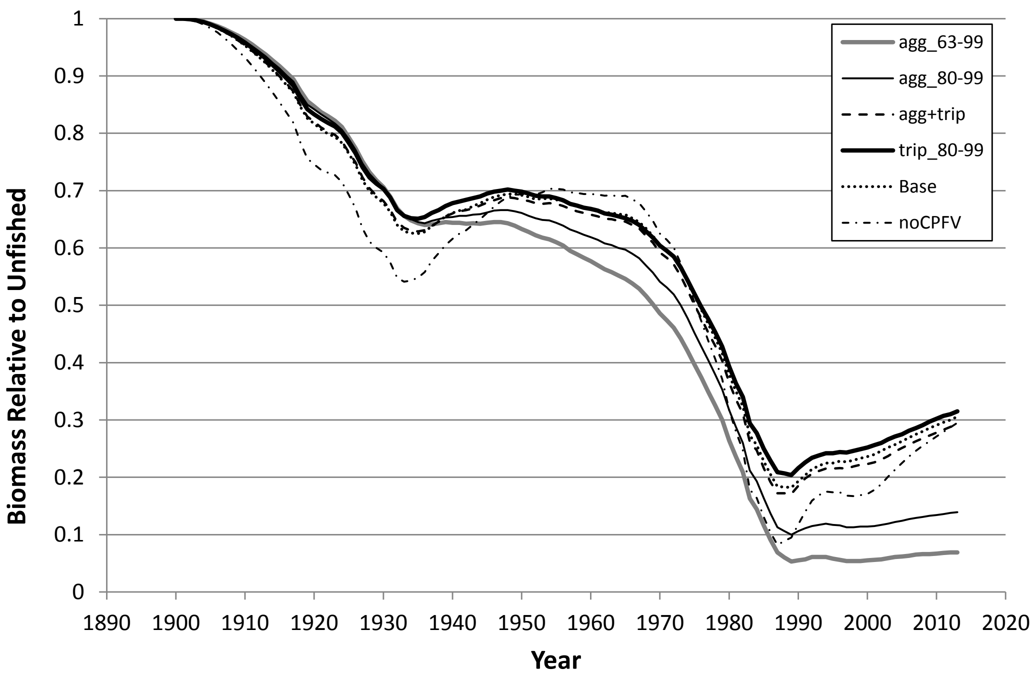


Figure 48. Effect of alternative CPFV logbook treatments on relative spawning biomass trajectories. Base model included for reference.

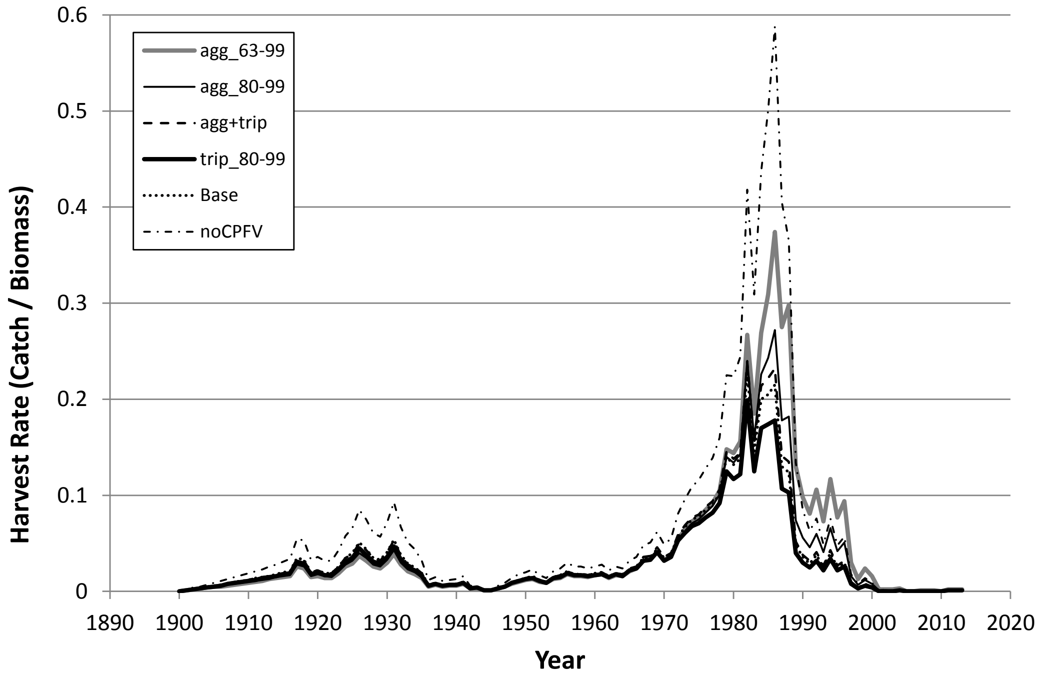


Figure 49. Effect of alternative CPFV logbook treatments on annual harvest rates. Base model included for reference.

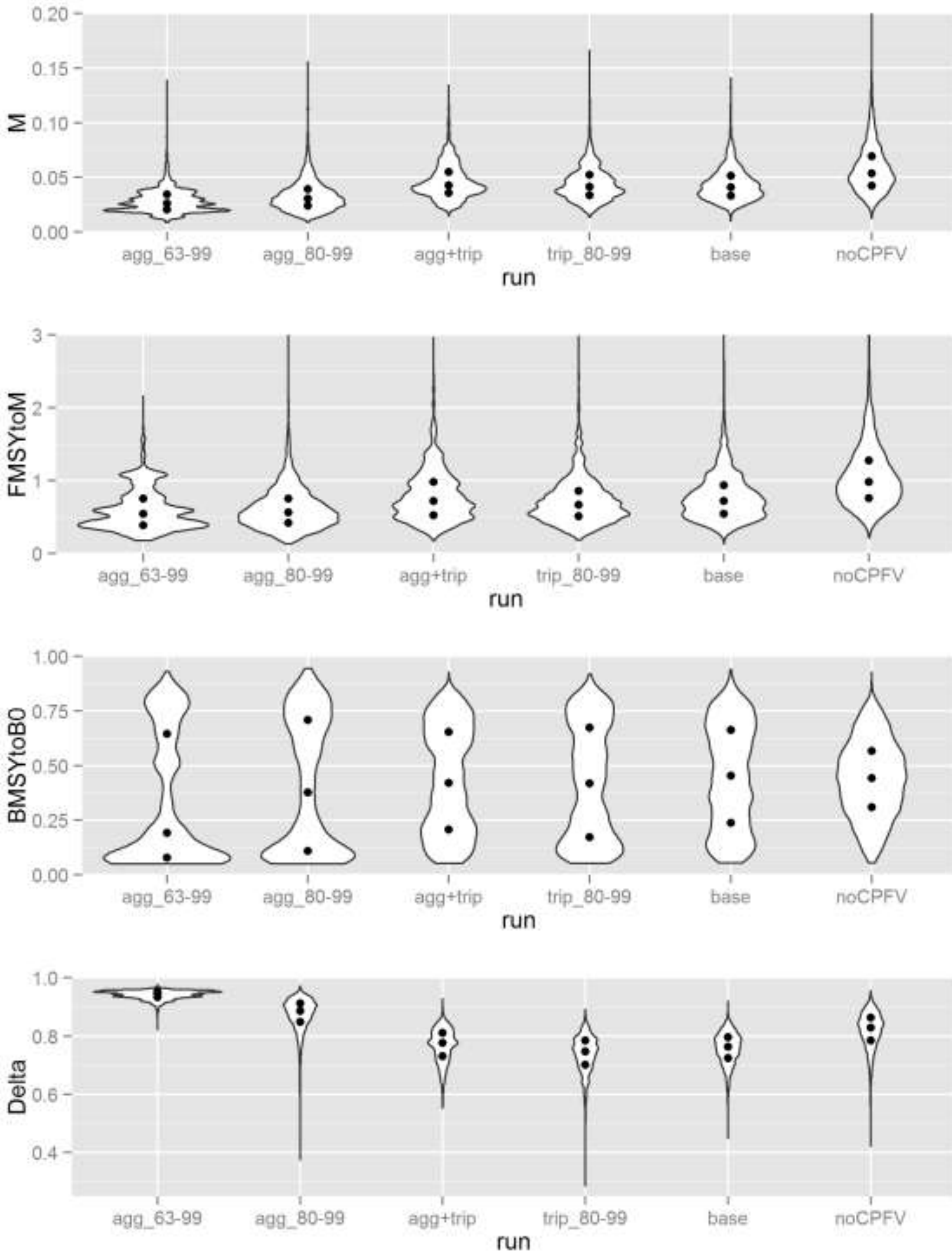


Figure 50. Comparison of posterior parameter distributions for models fit to alternative treatments of CPFV logbook data. Points inside 'violin' plots represent the median and interquartile range, and violins for each parameter are scaled to have equal areas. Base model included for reference.

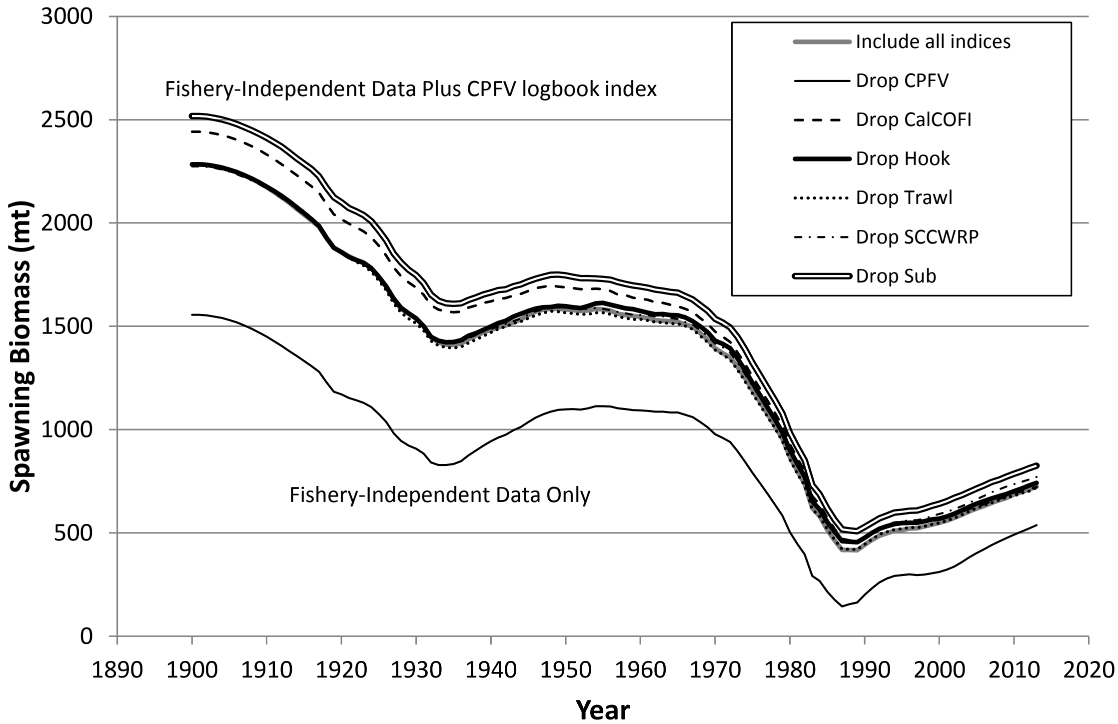


Figure 51. Effect of removing individual indices on median spawning biomass trajectories. A model fit to all six indices (including CPFV logbook) is included for reference. All models fit to the CPFV logbook index estimate a larger stock, relative to the model fit only to fishery-independent data sets.

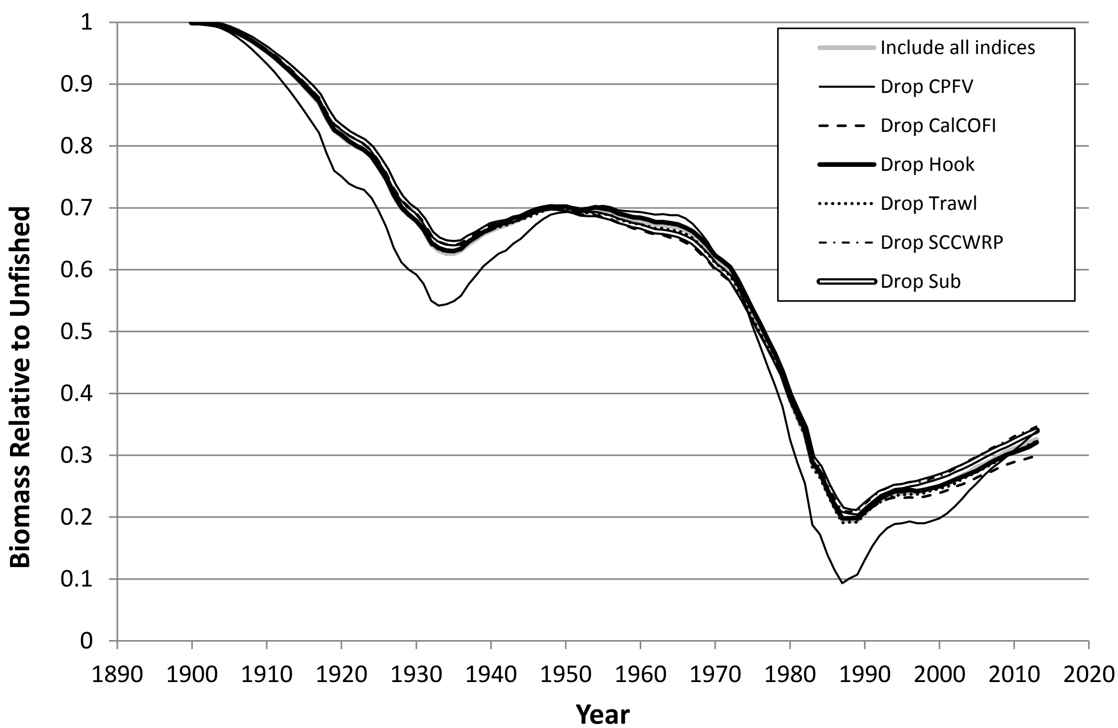


Figure 52. Effect of removing individual indices on median “depletion” (relative spawning biomass).

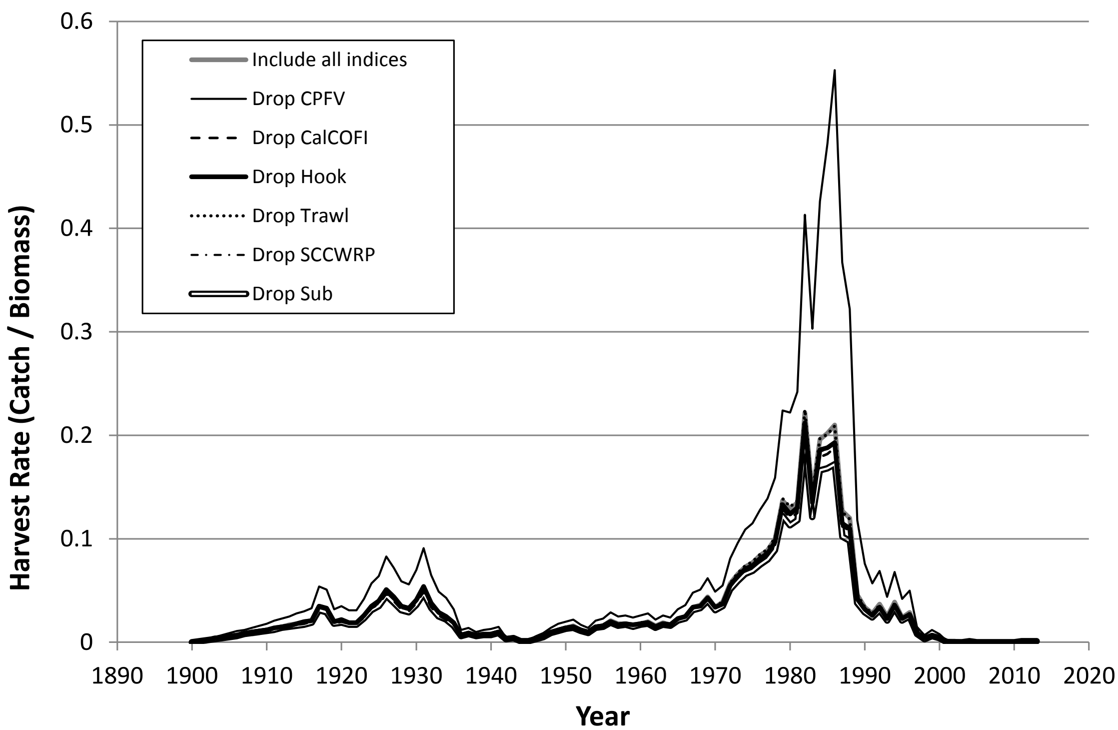


Figure 53. Effect of removing individual indices on estimates of annual harvest rates (catch divided by age 11+ biomass).

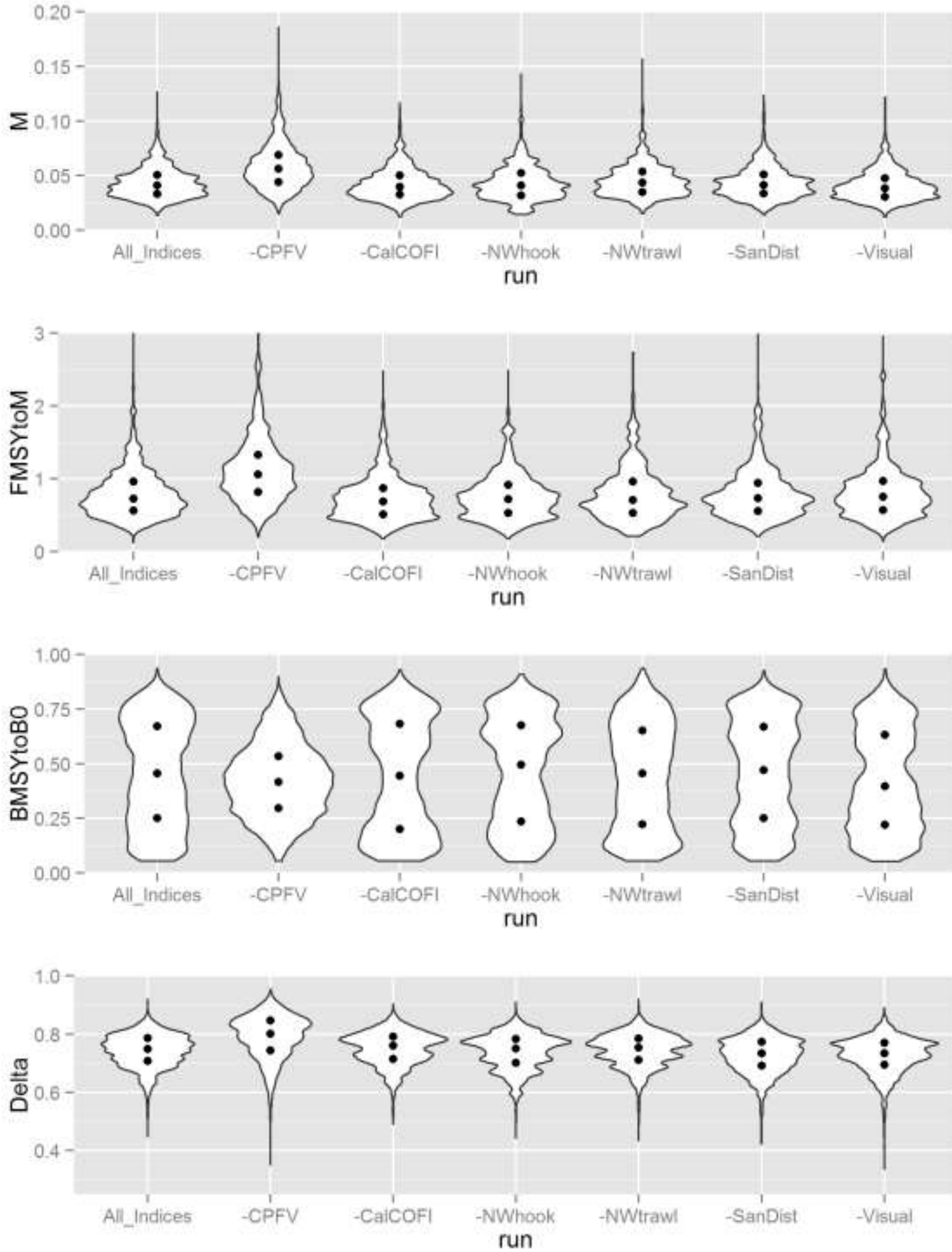


Figure 54. Comparison of posterior parameter distributions for models with individual indices removed "-[index name]." Model fit to all indices included for reference. Points inside 'violin' plots represent the median and interquartile range, and violins for each parameter are scaled to have equal areas.

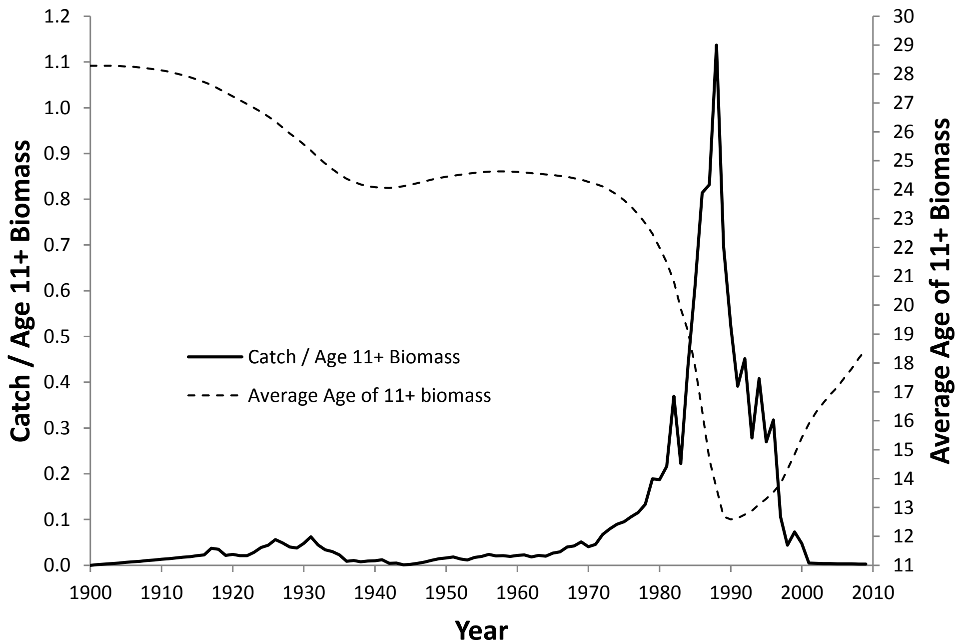


Figure 55. Harvest rates (catch divided by age 11+ biomass) from the 2009 cowcod assessment. The 2007 cowcod assessment had similar harvest rates (see Dick et al. 2007; their Figure 28).

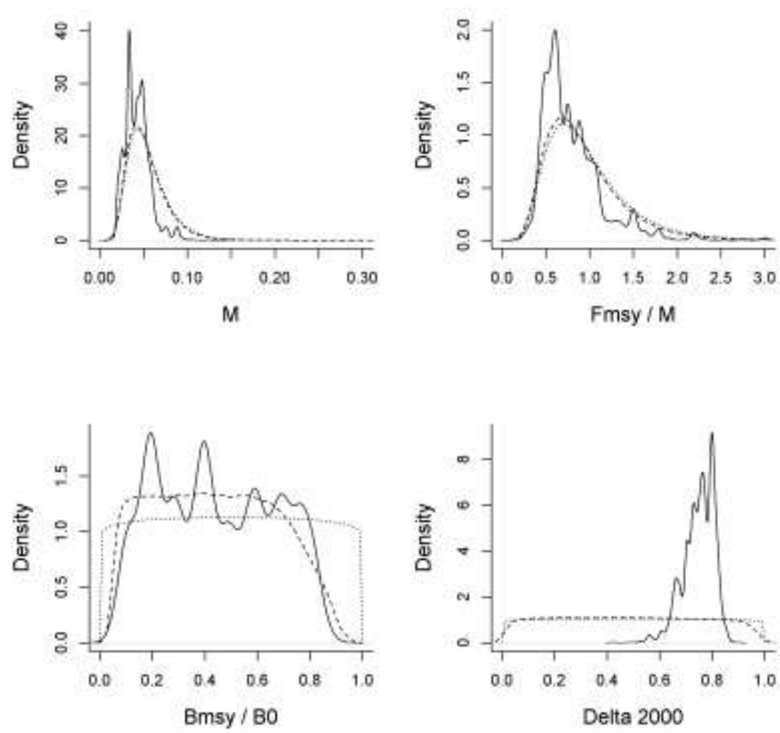


Figure 56. (Response to STAR Panel Request 1) Prior (dotted lines), post-model pre-data (dashed lines), and posterior (solid lines) distributions of population parameters for the model with a diffuse prior on relative biomass reduction (delta) in the year 2000.

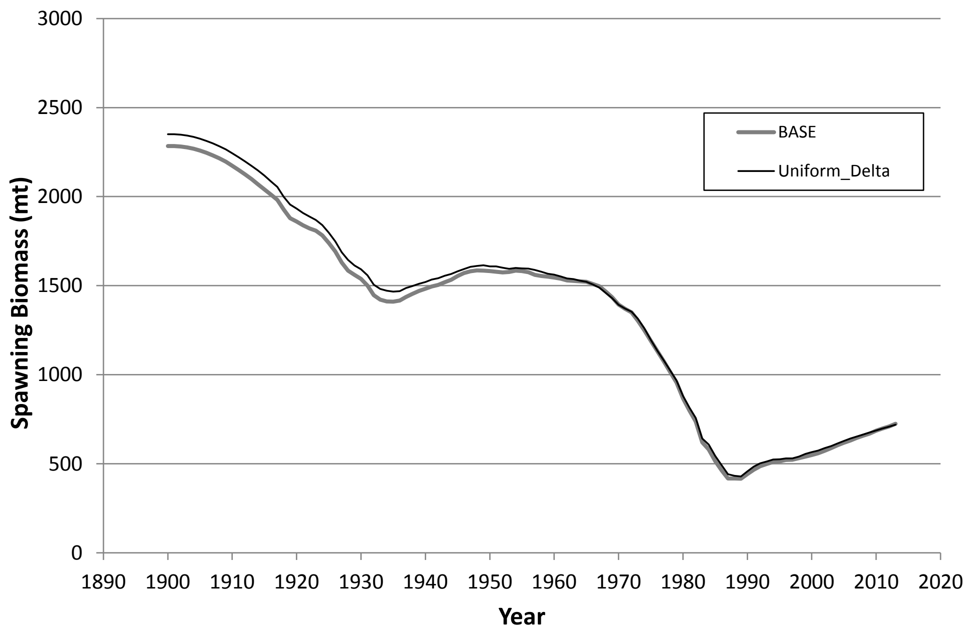


Figure 57. (Response to STAR Panel Request 1) Median spawning biomass estimates by year, comparing results from the delta prior used in the pre-STAR panel base model ("Base," including CPFV logbook data) to a nearly uniform prior distribution over the interval 0.01 to 0.99.

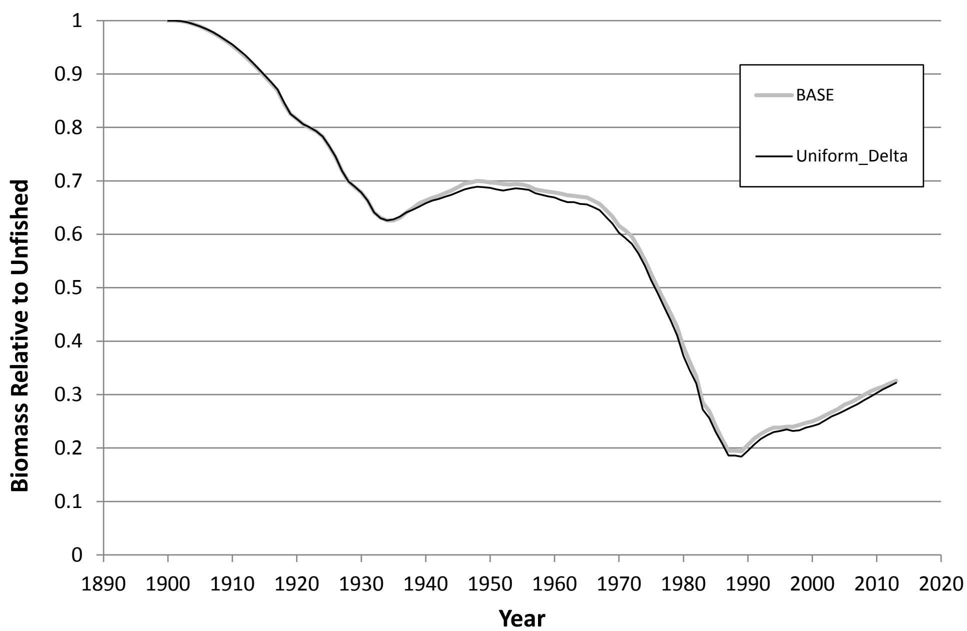


Figure 58. (Response to STAR Panel Request 1) Median relative biomass (B/B0) estimates by year, comparing results from the delta prior used in the pre-STAR panel base model ("Base," including CPFV logbook data) to a nearly uniform prior distribution over the interval 0.01 to 0.99.

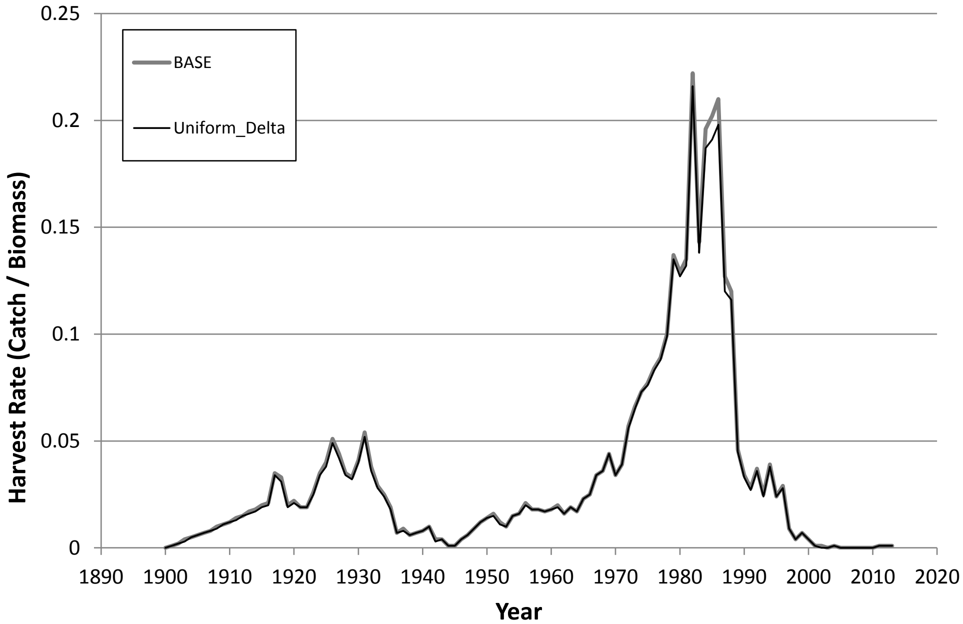


Figure 59. (Response to STAR Panel Request 1) Median harvest rate (catch/biomass) estimates by year, comparing results from the delta prior used in the pre-STAR panel base model ("Base," including CPFV logbook data) to a nearly uniform prior distribution over the interval 0.01 to 0.99.

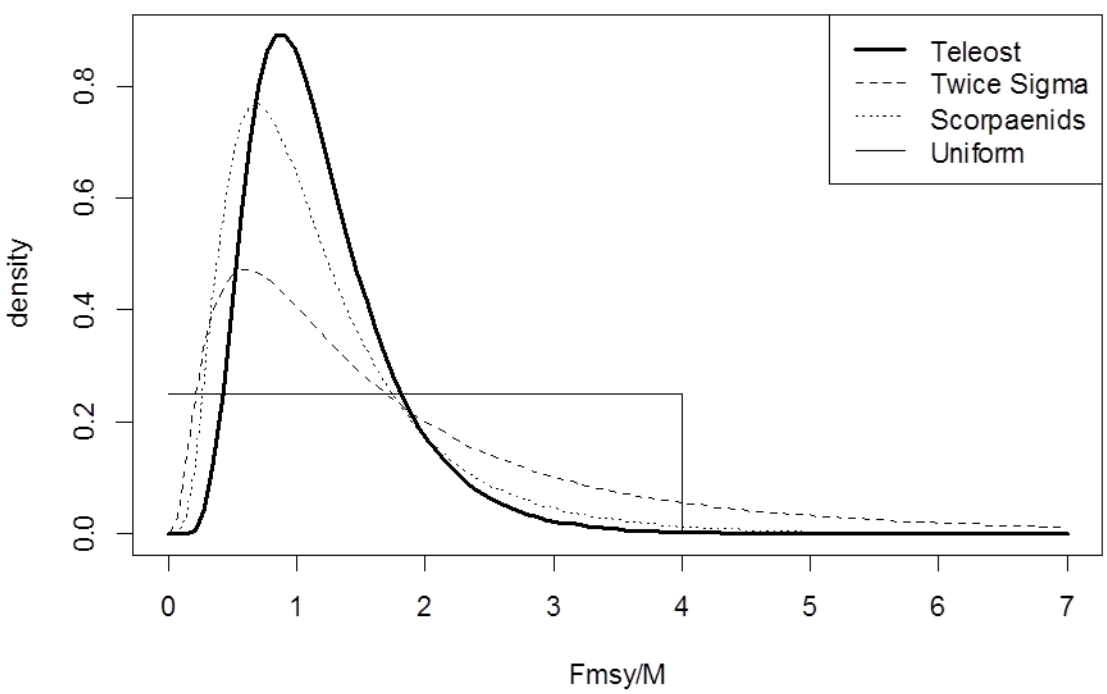


Figure 60. (Response to STAR Panel Request 2) Alternative prior distributions for Fmsy/M.

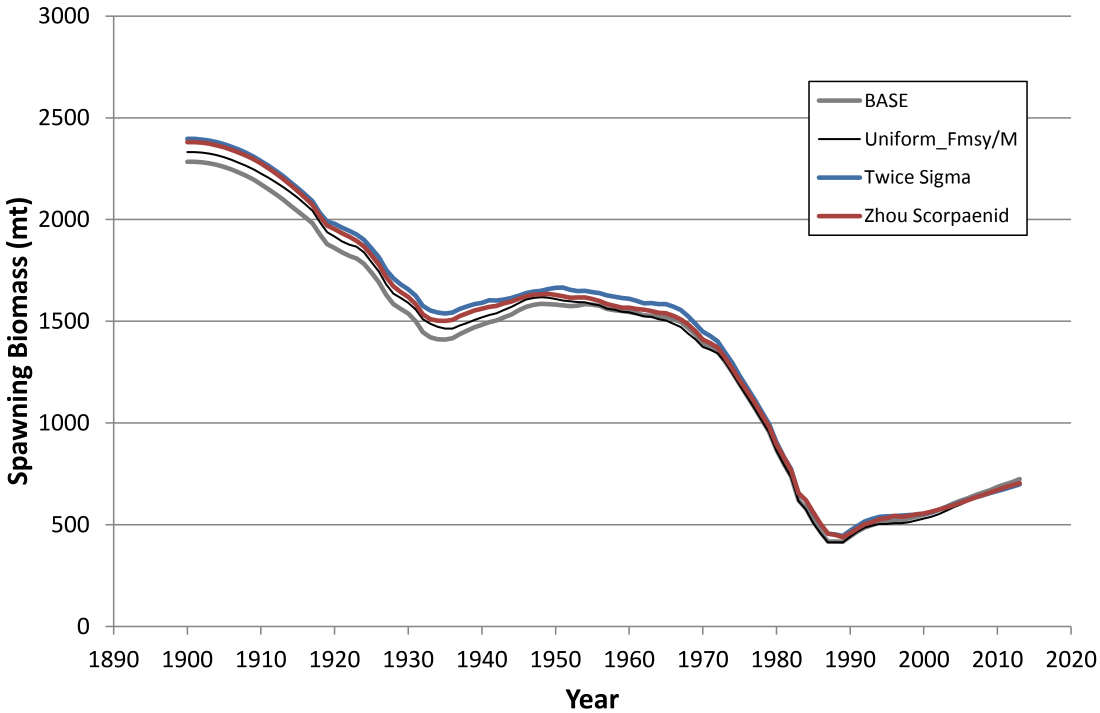


Figure 61. (Response to STAR Panel Request 2) Median spawning biomass trajectories under alternative priors for Fmsy/M. "Base" refers to the pre-STAR panel base model (including CPFV index).

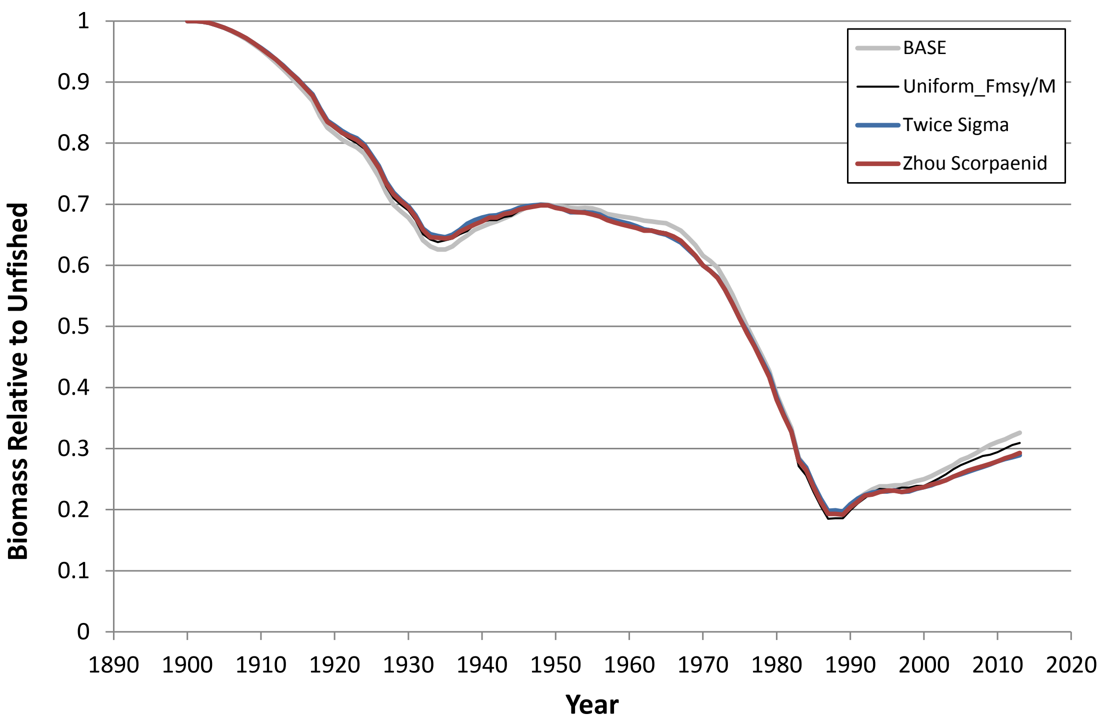


Figure 62. (Response to STAR Panel Request 2) Median depletion (relative biomass) trajectories under alternative priors for Fmsy/M. "Base" refers to the pre-STAR panel base model (including CPFV index).

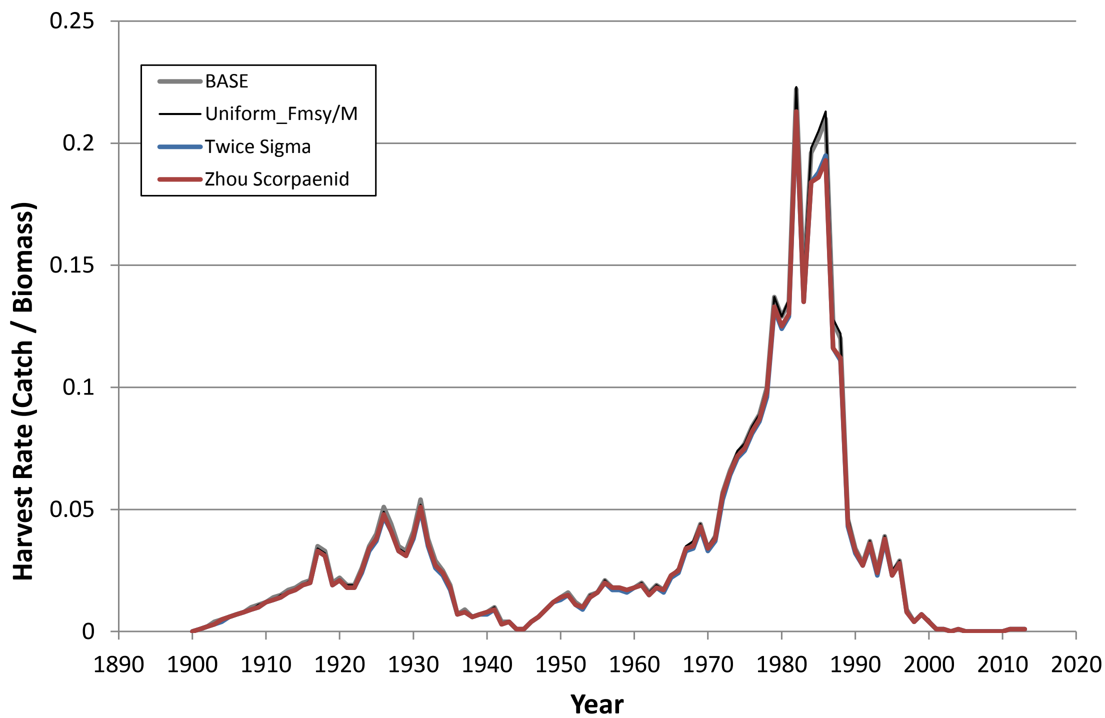


Figure 63. (Response to STAR Panel Request 2) Median harvest rates (catch / age 11+ biomass) under alternative priors for Fmsy/M. “Base” refers to the pre-STAR panel base model (including CPFV index).

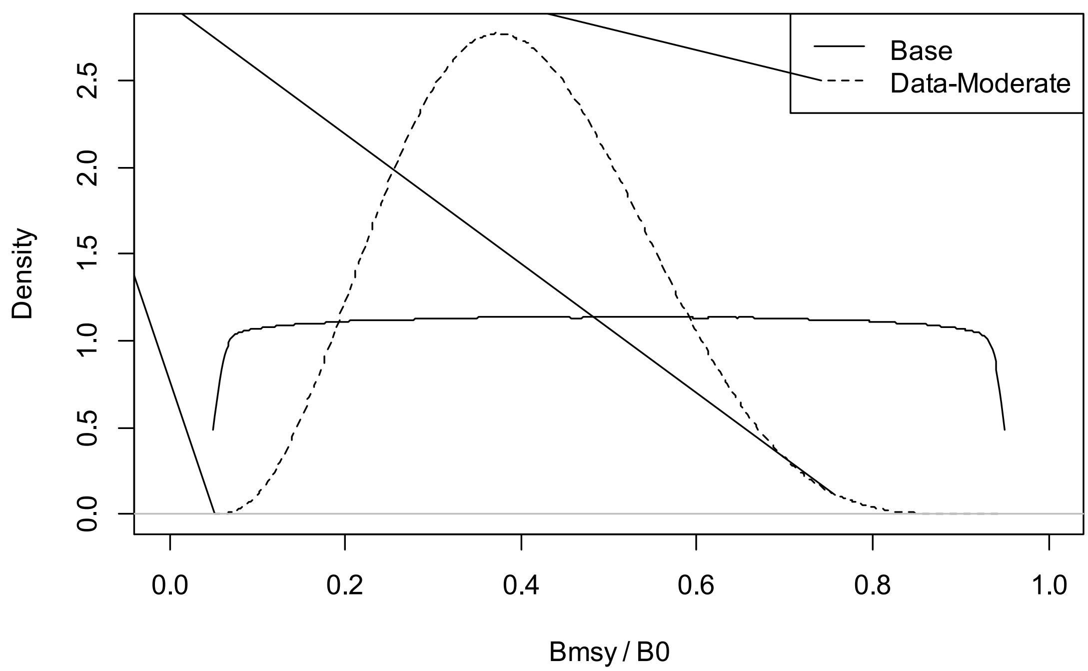


Figure 64. (Response to STAR Panel Request 3) Alternative prior distributions for Bmsy/B0.

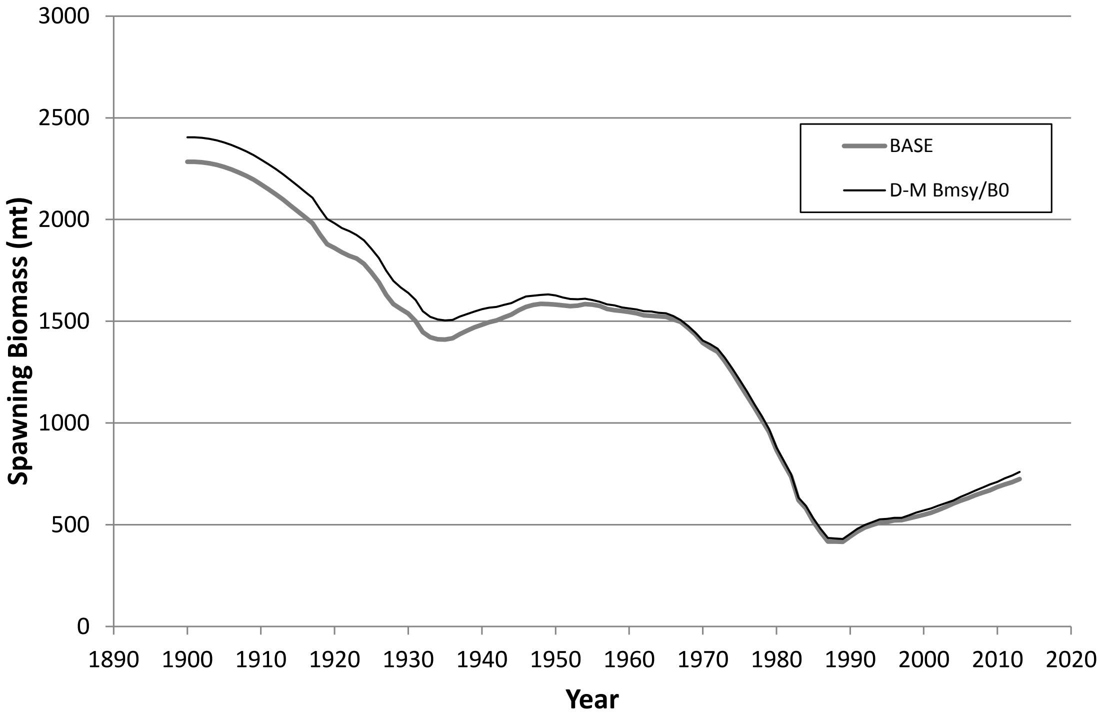


Figure 65. (Response to STAR Panel Request 3) Median spawning biomass trajectories under alternative priors for Bmsy/B0. "Base" refers to the pre-STAR panel base model (including CPFV index).

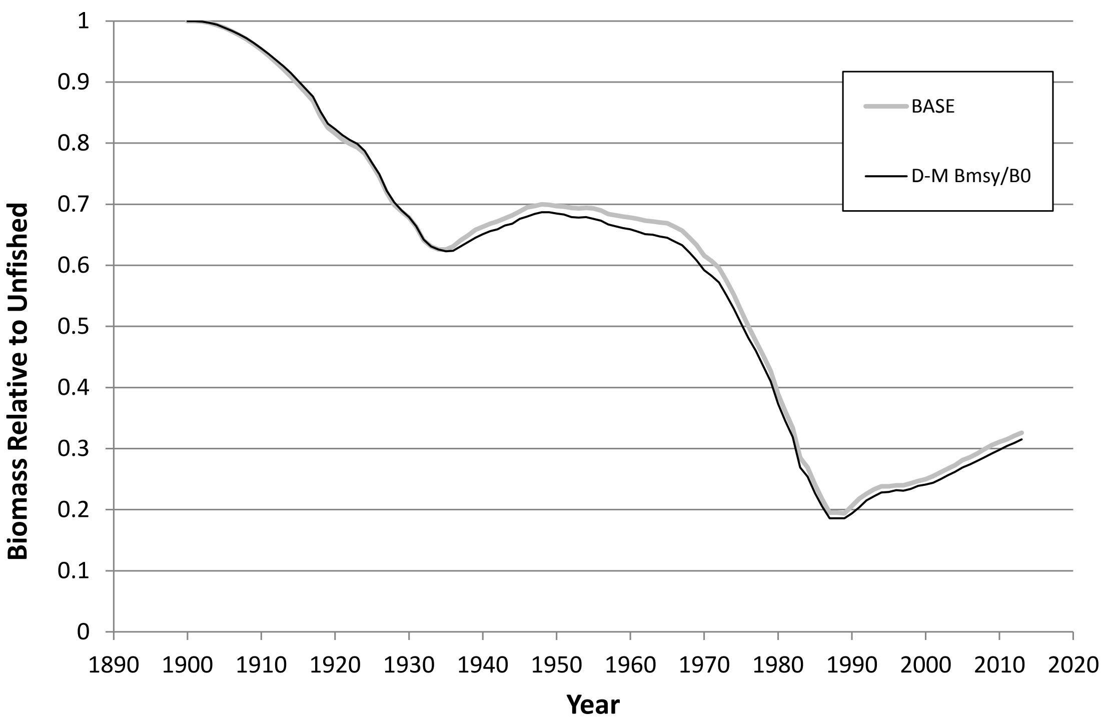


Figure 66. (Response to STAR Panel Request 3) Median relative biomass trajectories under alternative priors for Bmsy/B0. "Base" refers to the pre-STAR panel base model (including CPFV index).

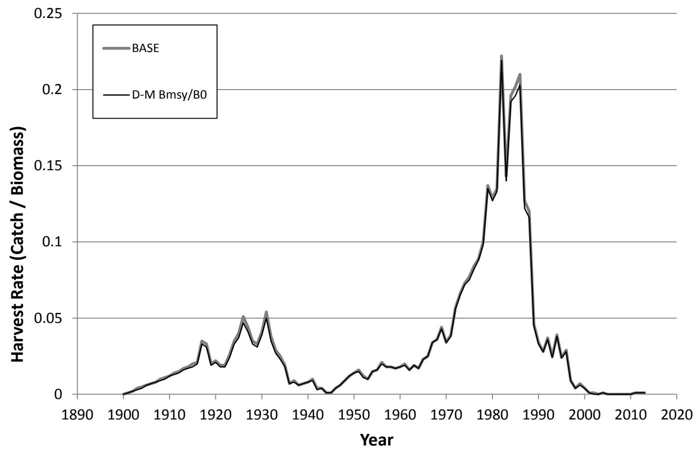


Figure 67. (Response to STAR Panel Request 3) Median harvest rates under alternative priors for Bmsy/B0. "Base" refers to the pre-STAR panel base model (including CPFV index).

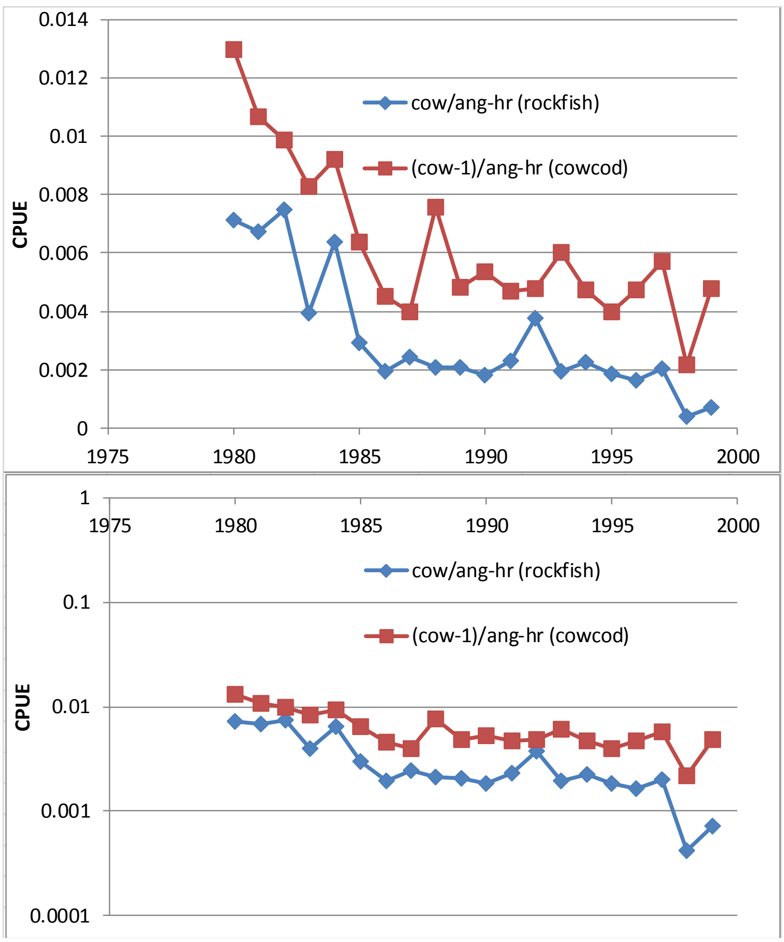


Figure 68. (Response to STAR Panel Request 4) CPUE time series derived from trip-based CPFV logbook data using alternative methods for identifying relevant trips (effective effort for cowcod).

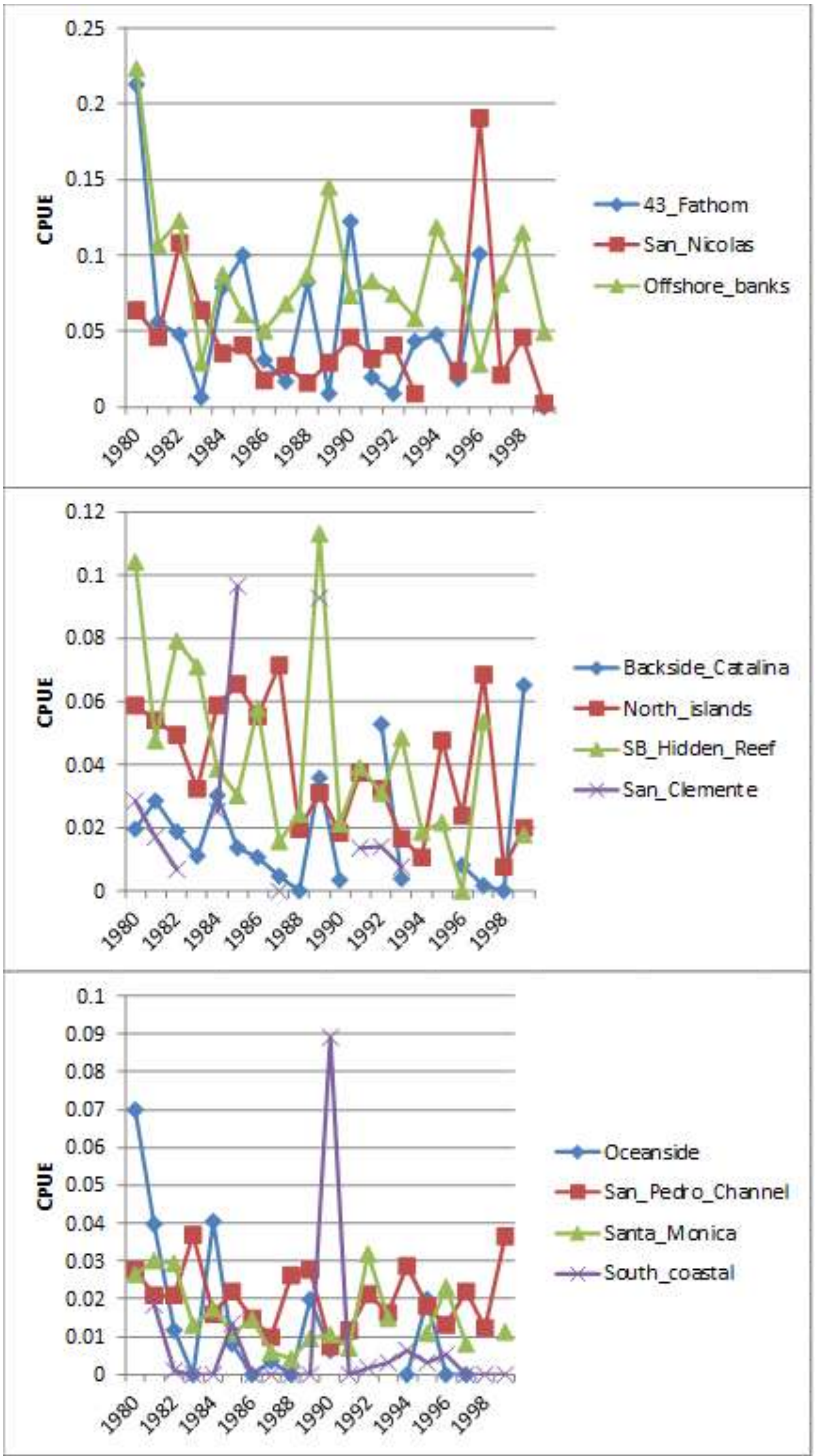


Figure 69. (Response to STAR Panel Request 5) Average CPUE (N-1 per ang-hr) from the trip-based CPFV logbook database, by year and region.

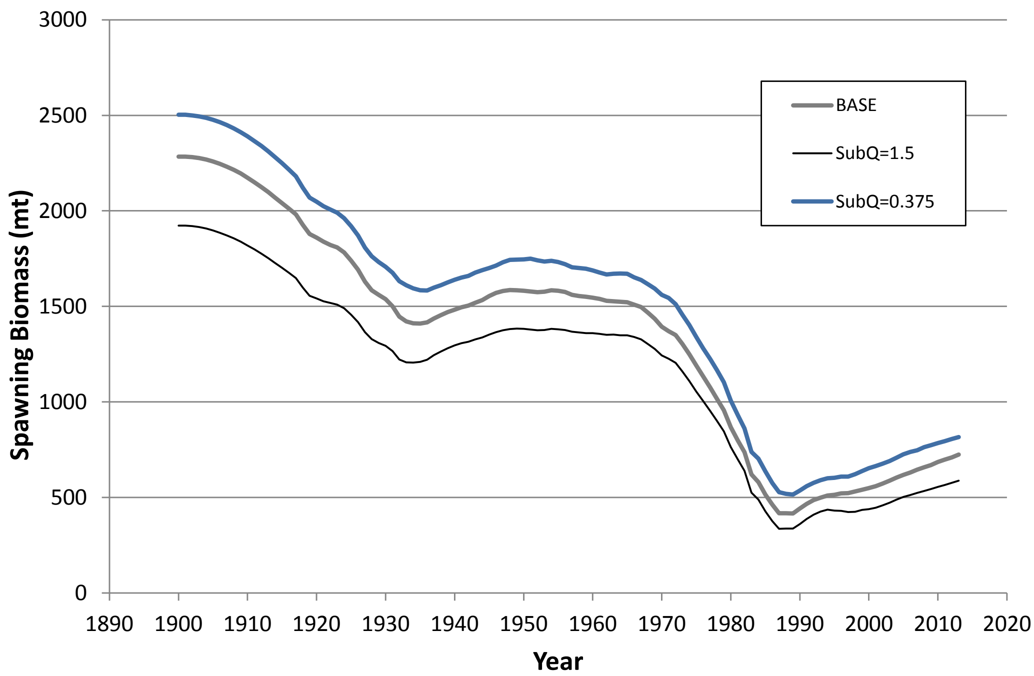


Figure 70. (Response to STAR Panel Request 7) Median spawning biomass trajectories under alternative priors for catchability of the visual survey. “Base” refers to the pre-STAR panel base model (including CPFV index).

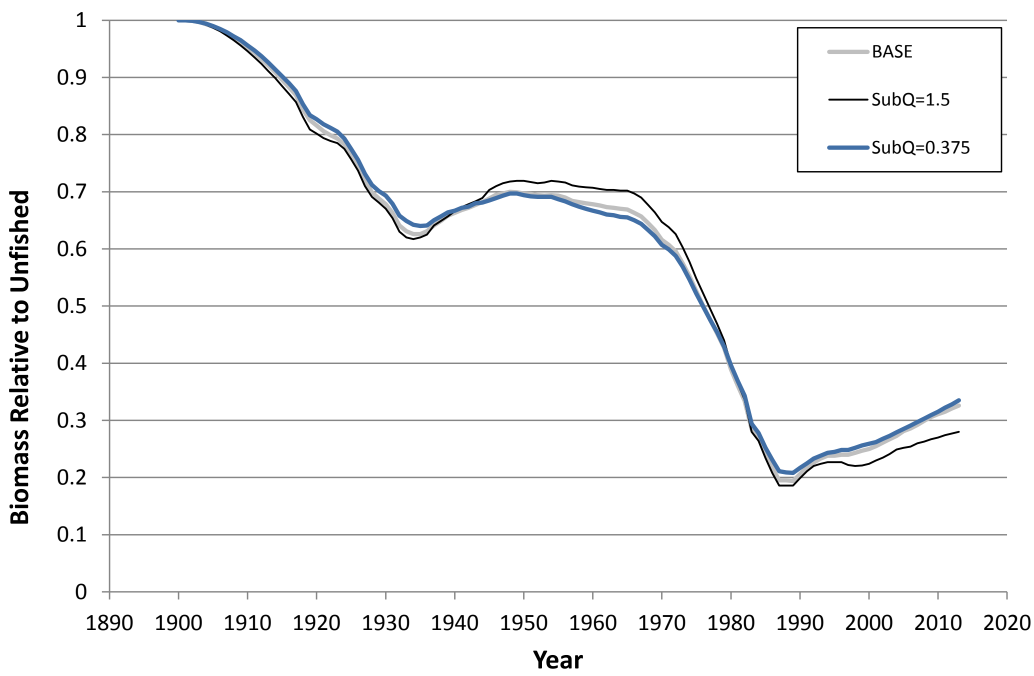


Figure 71. (Response to STAR Panel Request 7) Median relative biomass trajectories under alternative priors for catchability of the visual survey. “Base” refers to the pre-STAR panel base model (including CPFV index).

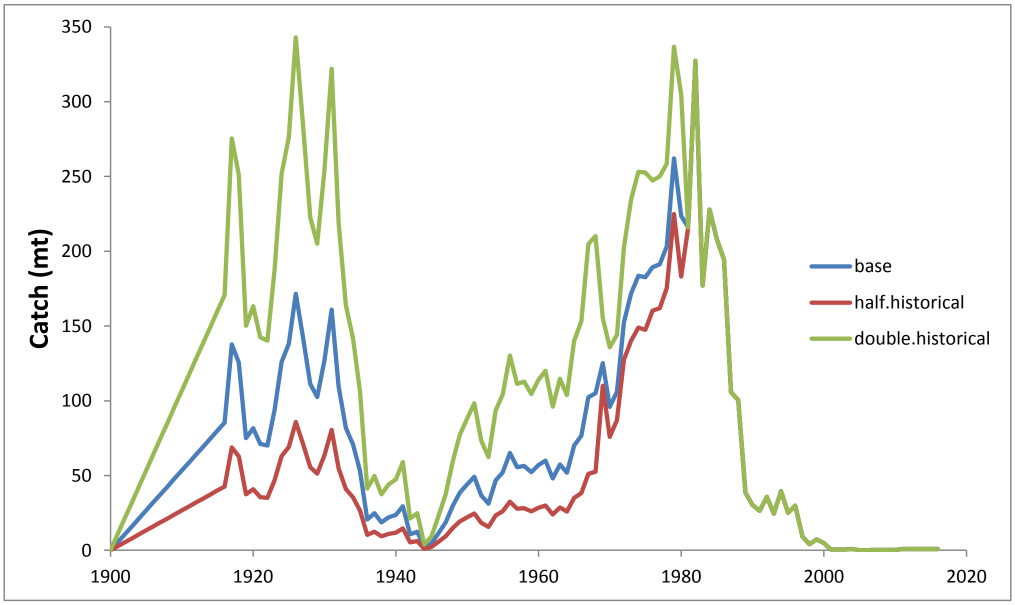


Figure 72. (Response to STAR Panel Request 8) Alternative historical catch time series (half/double base catches).

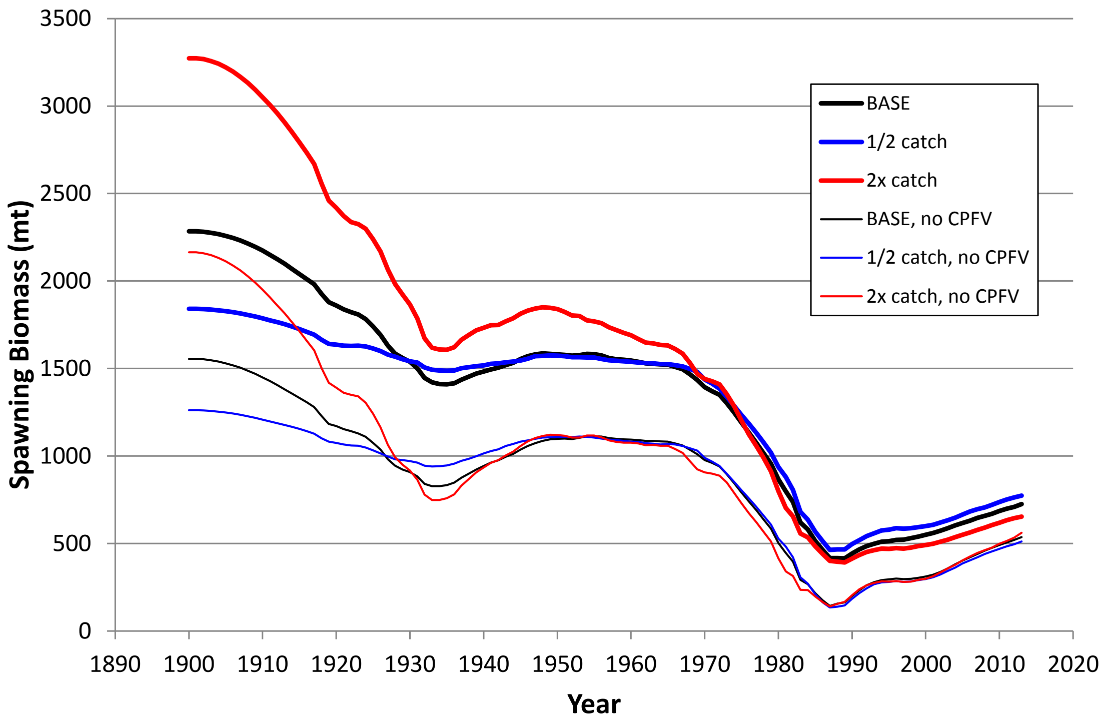


Figure 73. (Response to STAR Panel Request 8) Median spawning biomass trajectories under alternative historical catch levels, with and without the CPFV logbook index. "Base" refers to the pre-STAR panel base model (including CPFV index).

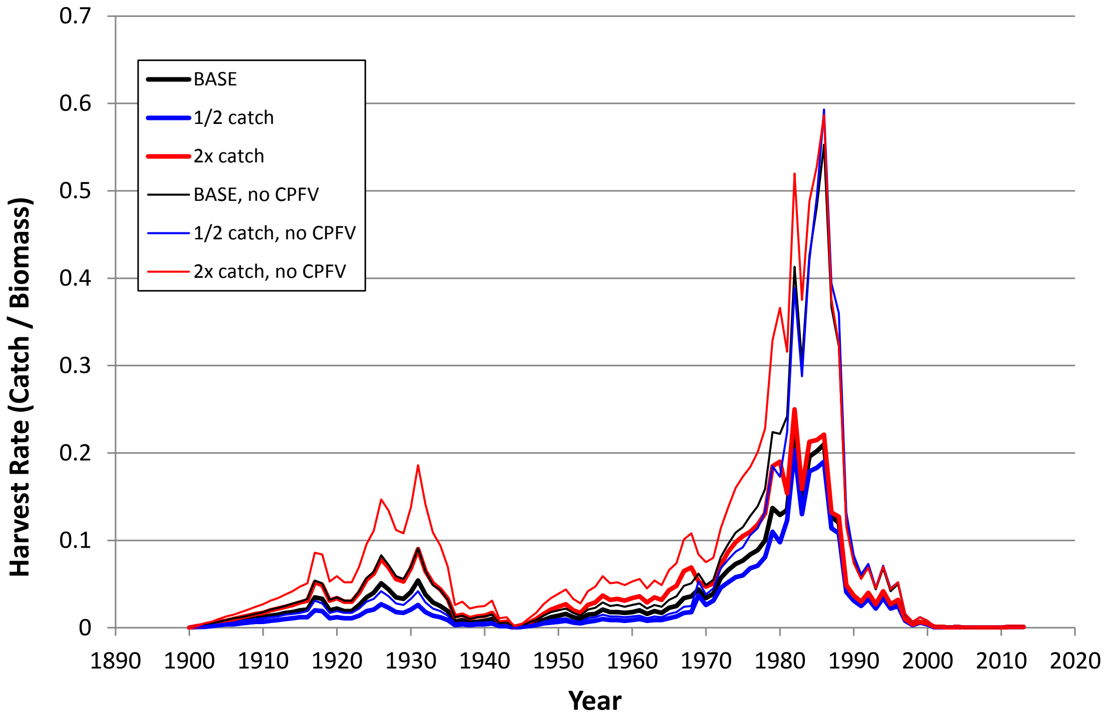


Figure 74. (Response to STAR Panel Request 8) Median harvest rates under alternative historical catch levels, with and without the CPFV logbook index. "Base" refers to the pre-STAR panel base model (including CPFV index).

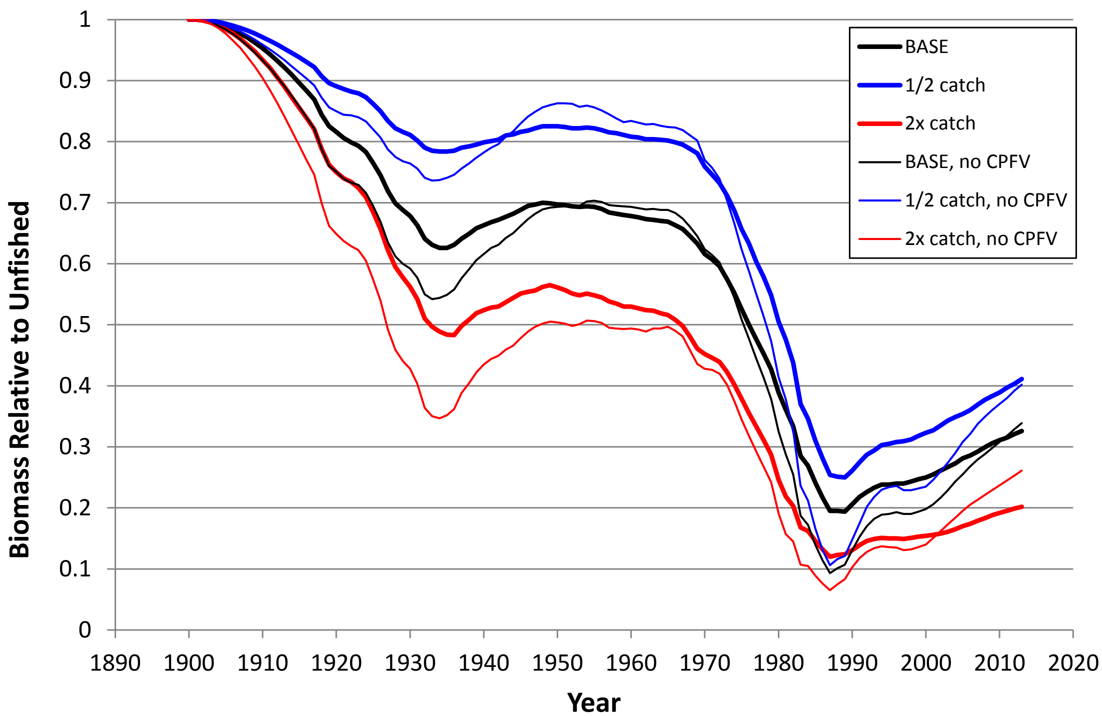


Figure 75. (Response to STAR Panel Request 8) Median relative biomass trajectories under alternative historical catch levels, with and without the CPFV logbook index. "Base" refers to the pre-STAR panel base model (including CPFV index).

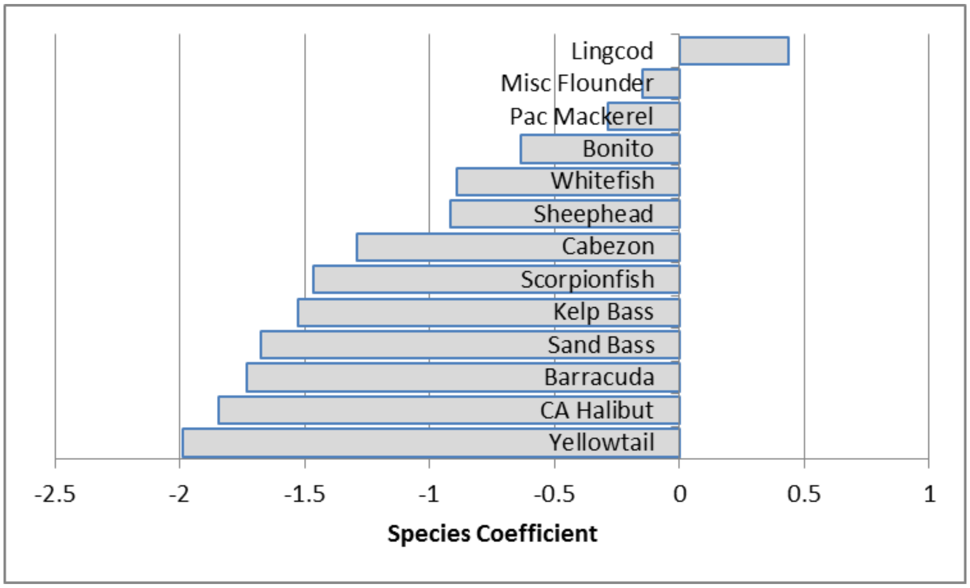


Figure 76. (Response to STAR Panel Request 9) Coefficients from the Stephens-MacCall species filter (binomial GLM). All indicator species were counter-indicators for cowcod except lingcod.

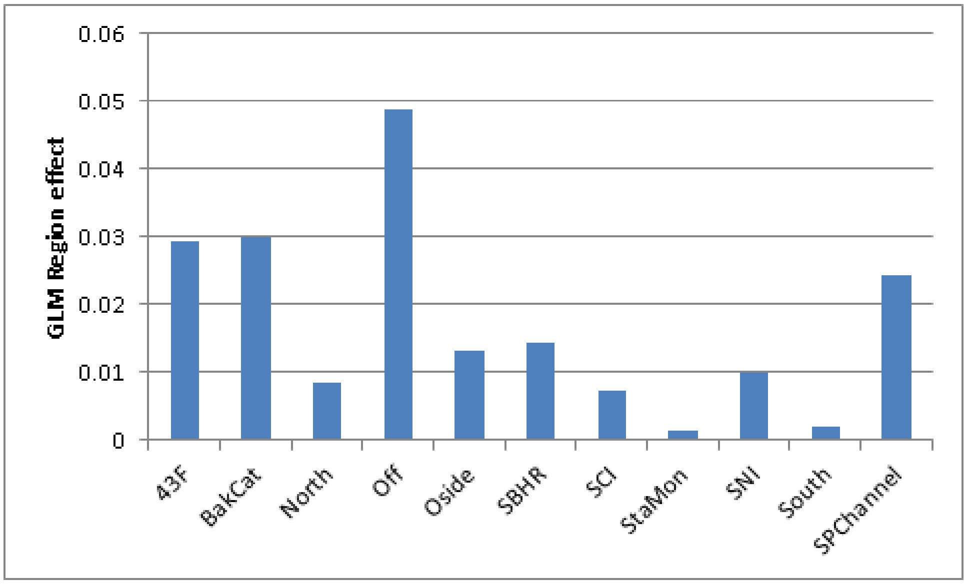


Figure 77. (Response to STAR Panel Request 9) Region effects from the delta-GLM model for CPFV logbook CPUE data, after Stephens-MacCall filter was applied.

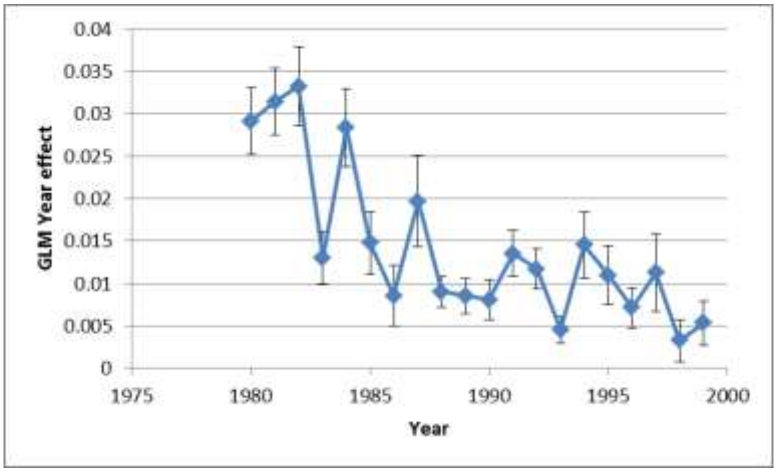


Figure 78. (Response to STAR Panel Request 9) Year effects from the delta-GLM model for CPFV logbook CPUE data, after Stephens-MacCall filter was applied.

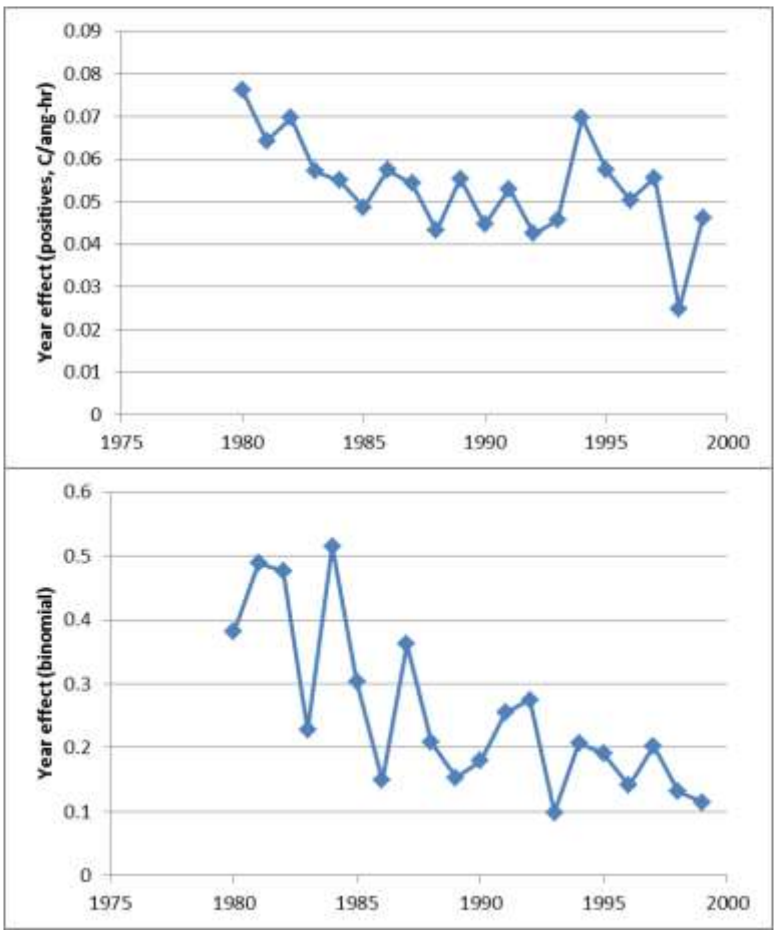


Figure 79. (Response to STAR Panel Request 9) Year effects from the two components (binomial and conditional mean) of the delta-GLM model for CPFV logbook CPUE data, after Stephens-MacCall filter was applied.

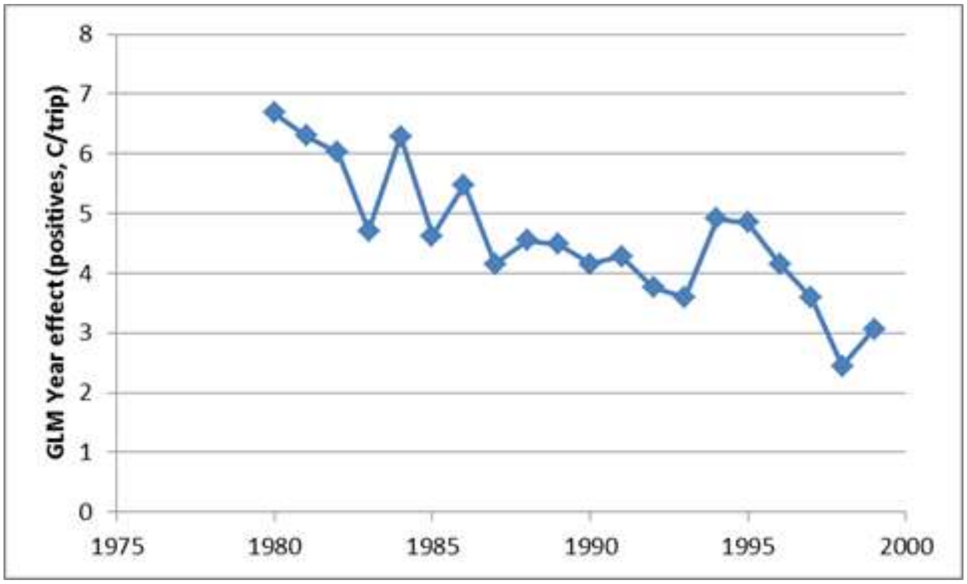


Figure 80. (Response to STAR Panel Request 9) Number of cowcod caught per trip (positive trips only).

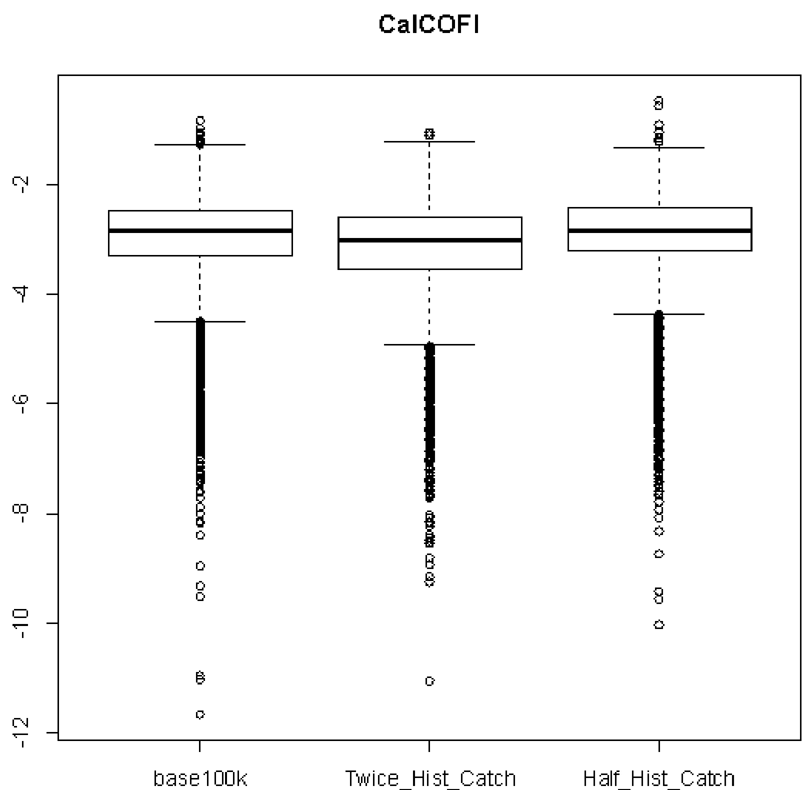


Figure 81. (Response to STAR Panel Request 10) Log-likelihood distributions for the CalCOFI index under alternative catch histories.

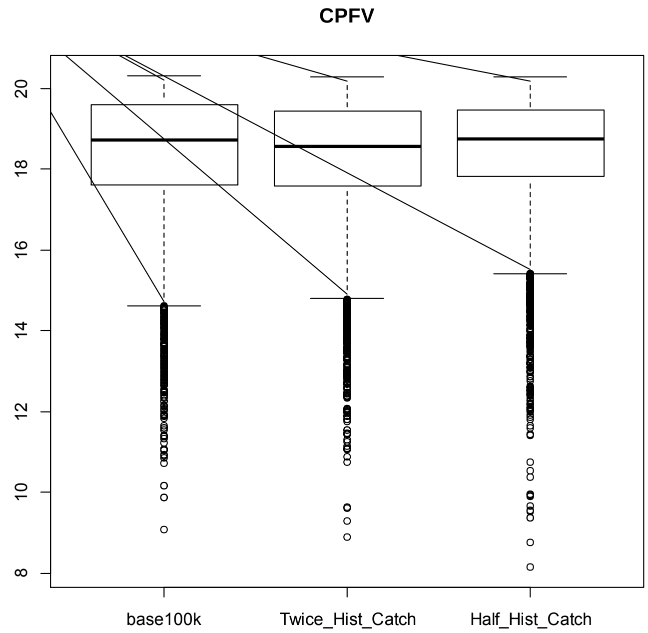


Figure 82. (Response to STAR Panel Request 10) Log-likelihood distributions for the CPFV logbook index under alternative catch histories.

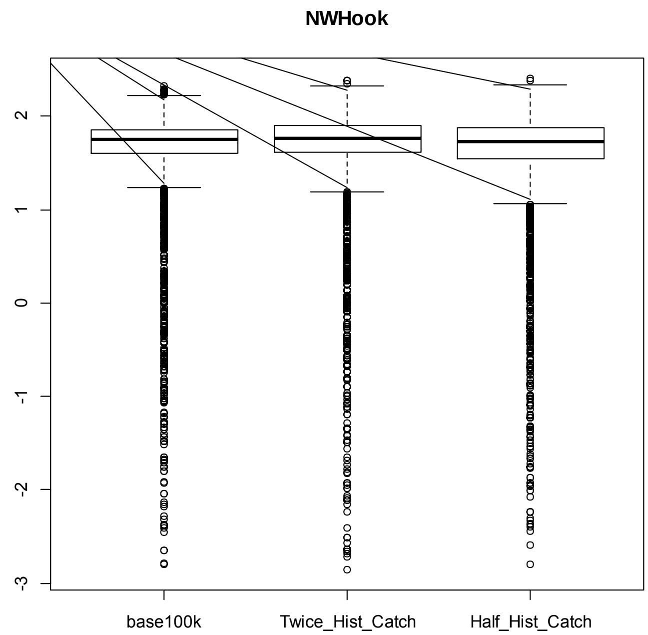


Figure 83. (Response to STAR Panel Request 10) Log-likelihood distributions for the NWFSC Hook-and-Line Survey index under alternative catch histories.

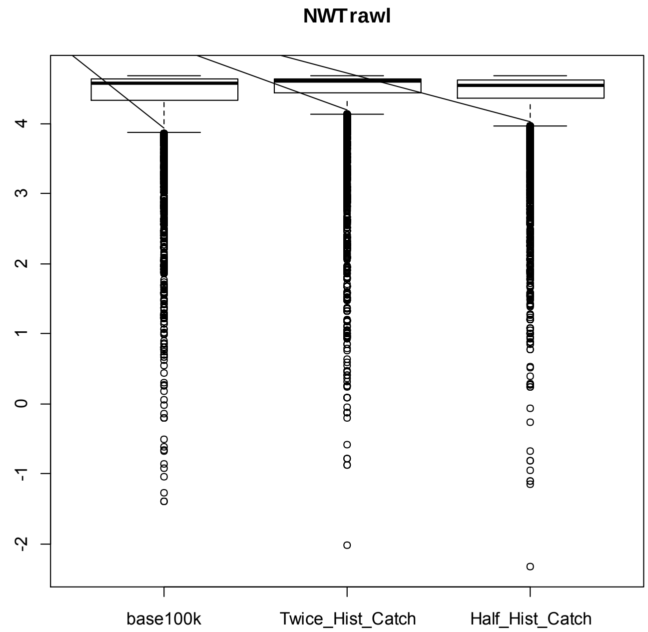


Figure 84. (Response to STAR Panel Request 10) Log-likelihood distributions for the NWFSC Trawl Survey index under alternative catch histories.

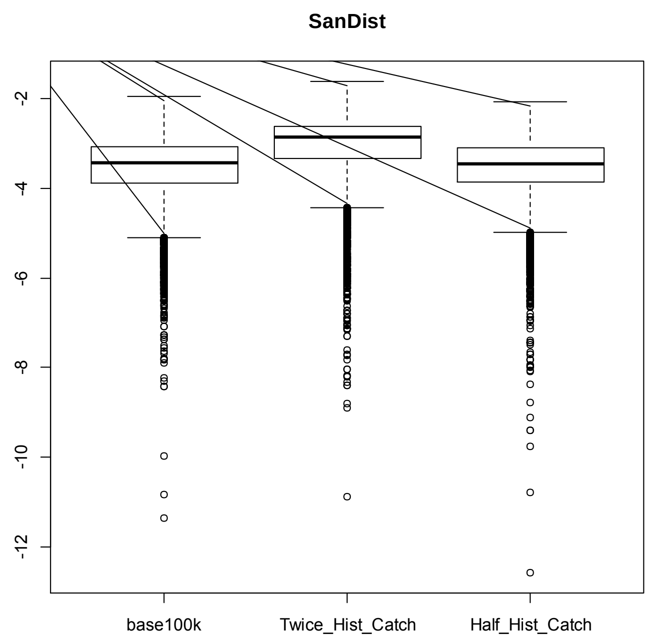


Figure 85. (Response to STAR Panel Request 10) Log-likelihood distributions for the Sanitation District index under alternative catch histories.

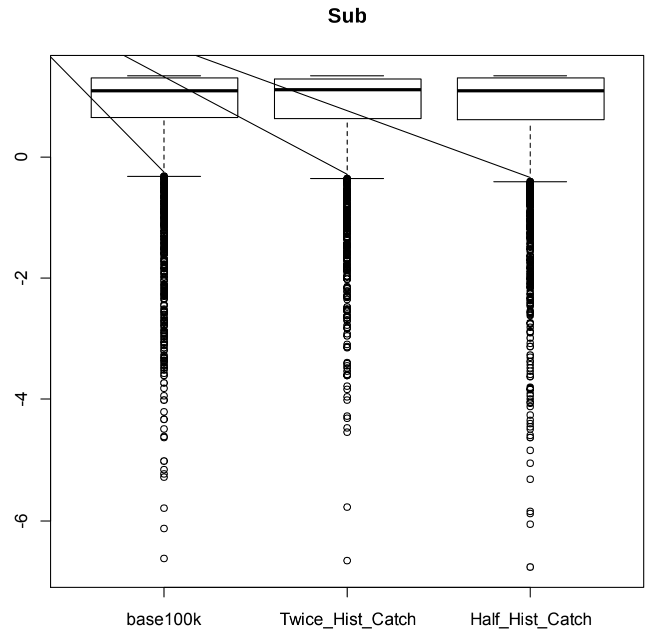


Figure 86. (Response to STAR Panel Request 10) Log-likelihood distributions for the Visual (Sub) Survey index under alternative catch histories.

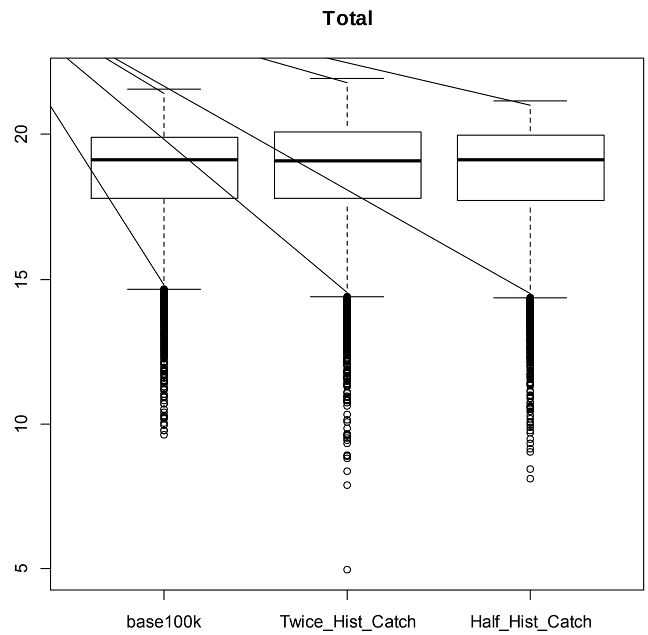


Figure 87. (Response to STAR Panel Request 10) Total Log-likelihood distributions under alternative catch histories.

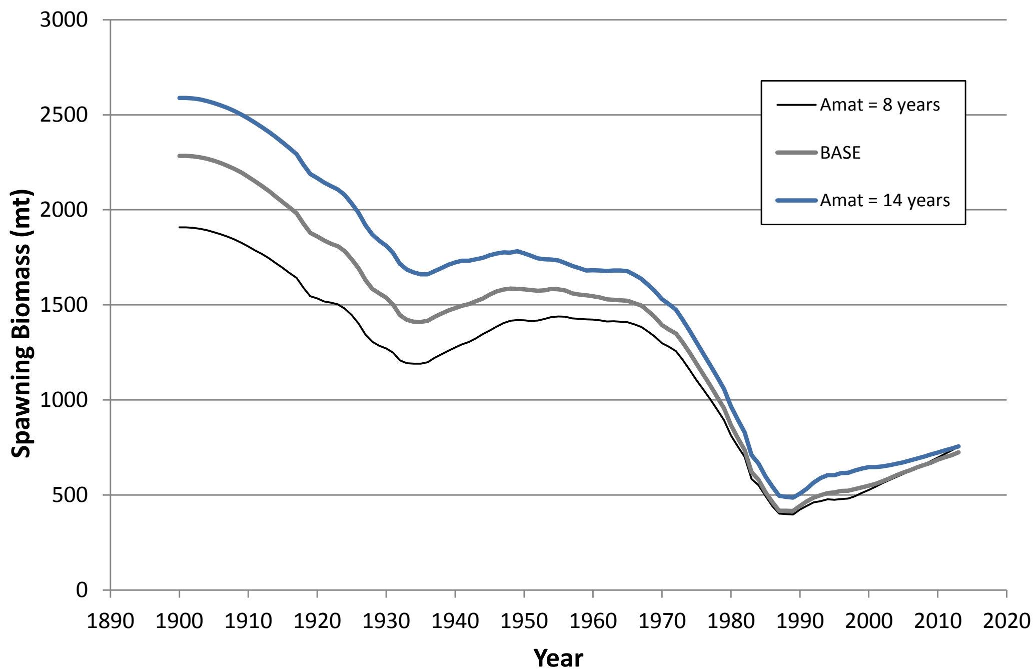


Figure 88. (Response to STAR Panel Request 11) Median spawning biomass trajectories under alternative time lag assumptions (+/- 3 years from age 11 assumption in base case). “Base” refers to the pre-STAR panel base model (including CPFV index).

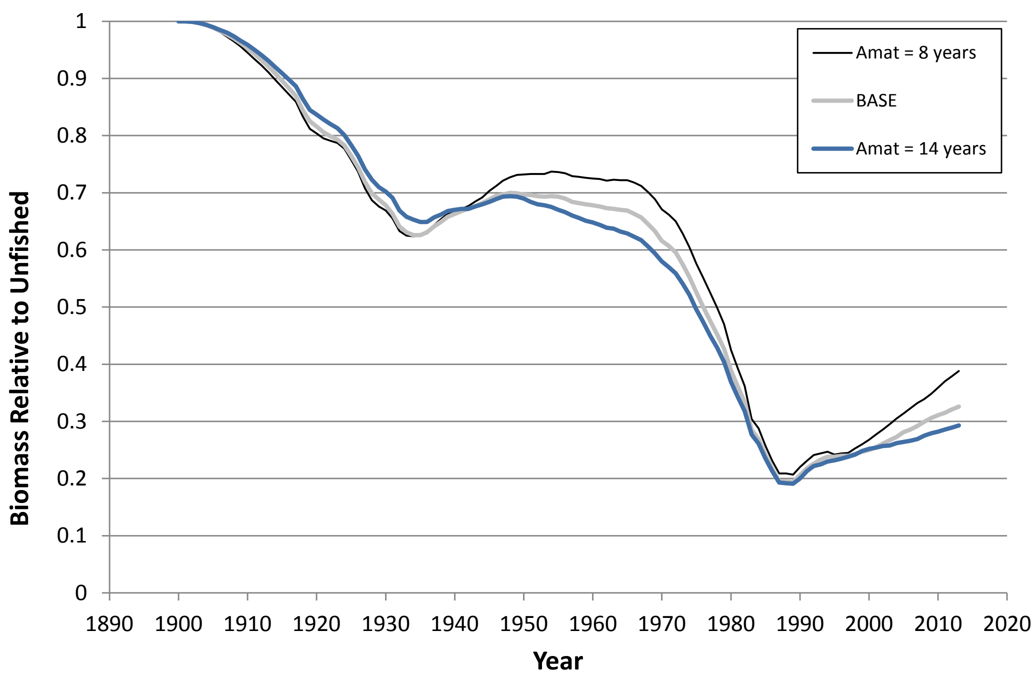


Figure 89. (Response to STAR Panel Request 11) Median relative biomass (“depletion) trajectories under alternative time lag assumptions (+/- 3 years from age 11 assumption in base case). “Base” refers to the pre-STAR panel base model (including CPFV index).

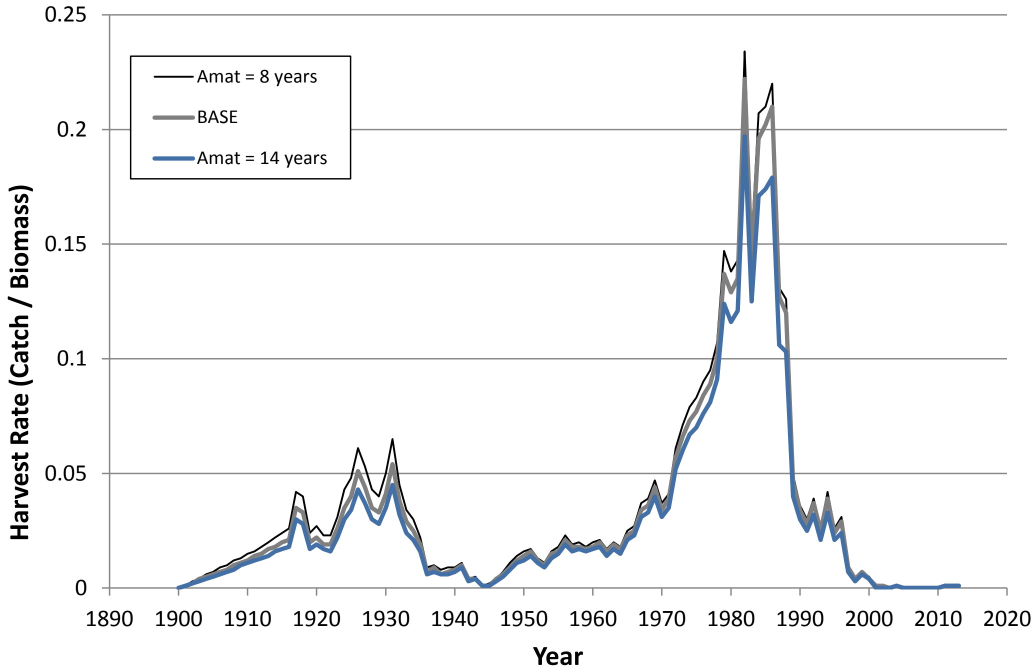


Figure 90. (Response to STAR Panel Request 11) Median harvest rates under alternative time lag assumptions (+/- 3 years from age 11 assumption in base case). "Base" refers to the pre-STAR panel base model (including CPFV index).

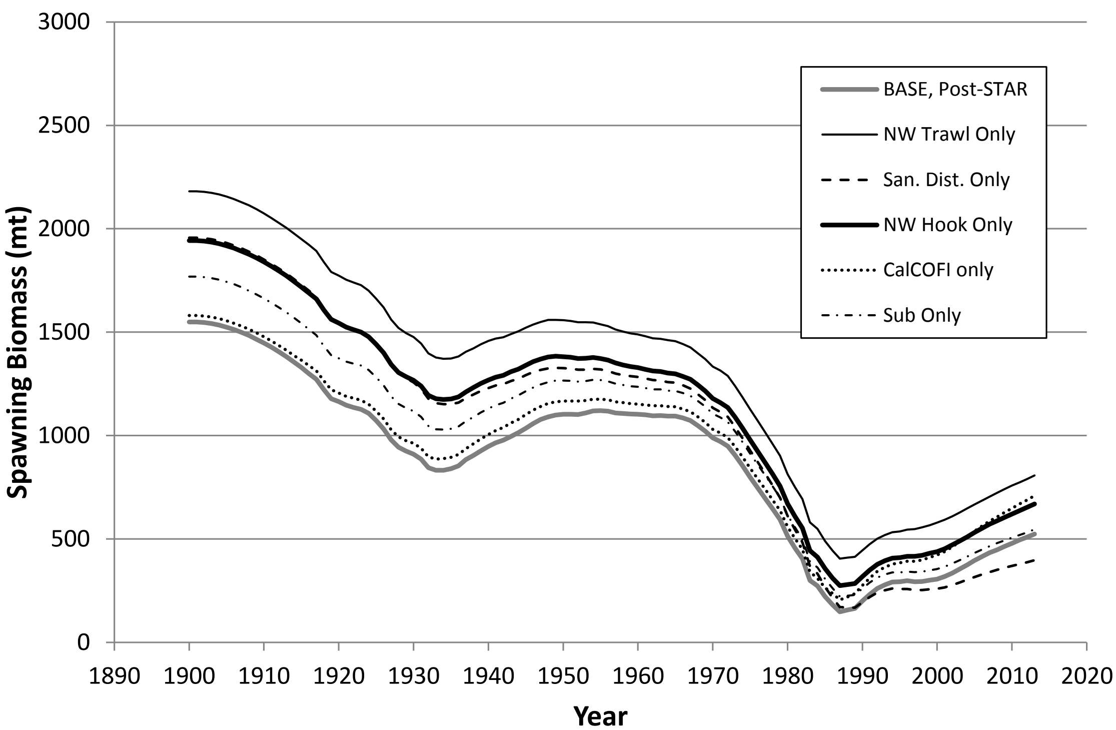


Figure 91. (Response to STAR Panel Request 12) Median spawning biomass trajectories from the Post-STAR Panel base model, compared to fits to single indices.

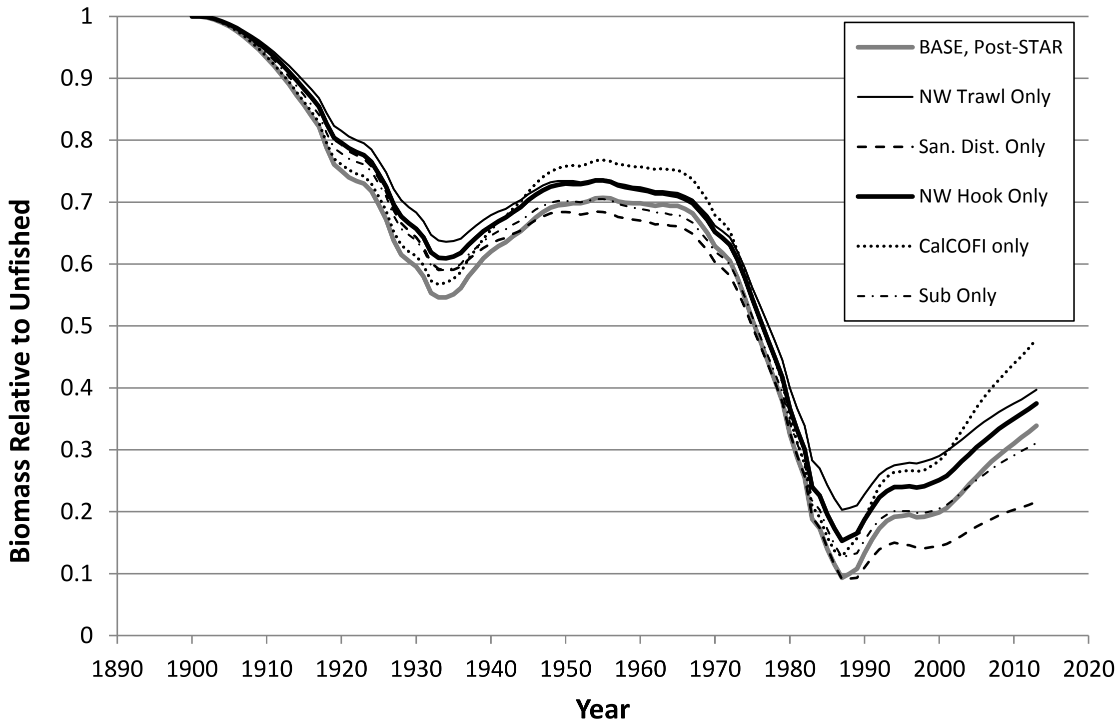


Figure 92. (Response to STAR Panel Request 12) Median relative biomass trajectories from the Post-STAR Panel base model, compared to fits to single indices.

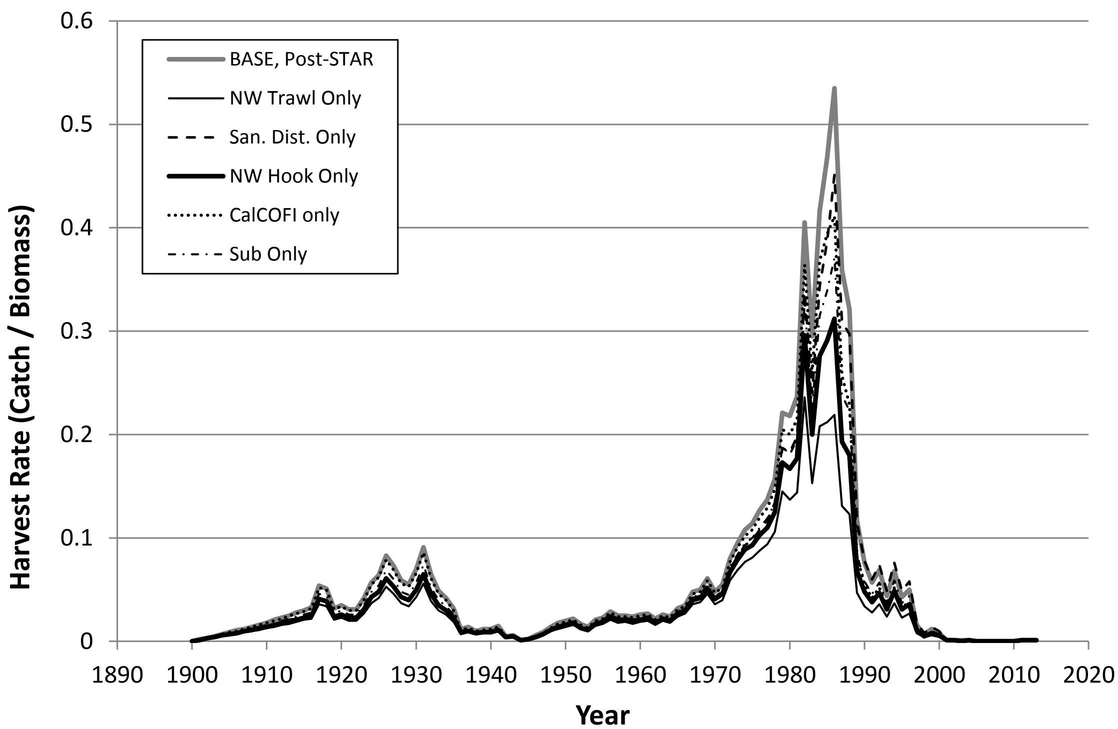


Figure 93. (Response to STAR Panel Request 12) Median harvest rates from the Post-STAR Panel base model, compared to fits to single indices.

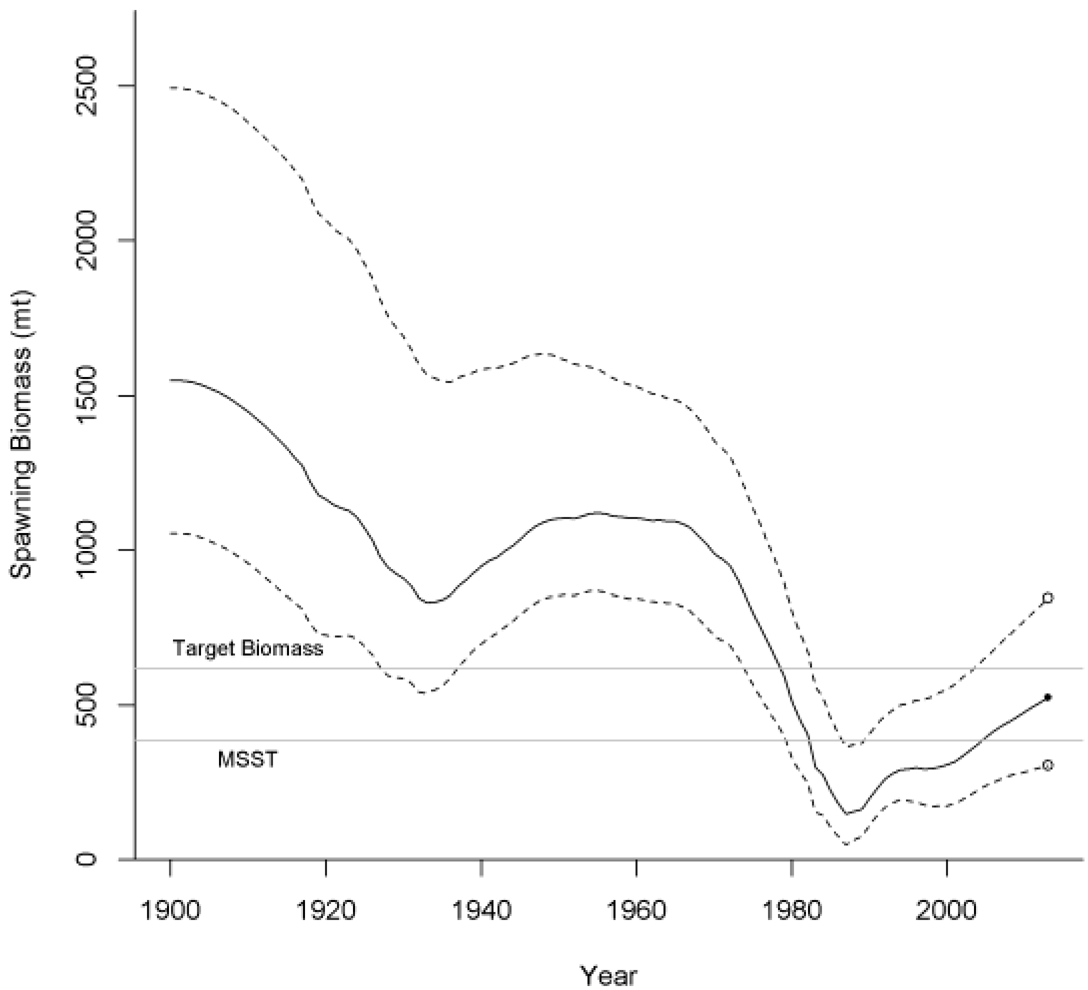


Figure 94. Distribution of spawning biomass trajectories from the base model (median = solid line, 5th and 95th percentile = dashed lines), relative to Target Biomass (40% of unfished biomass) and the Minimum Stock Size Threshold (MSST, 25% of unfished biomass). Circles indicate values in 2013.

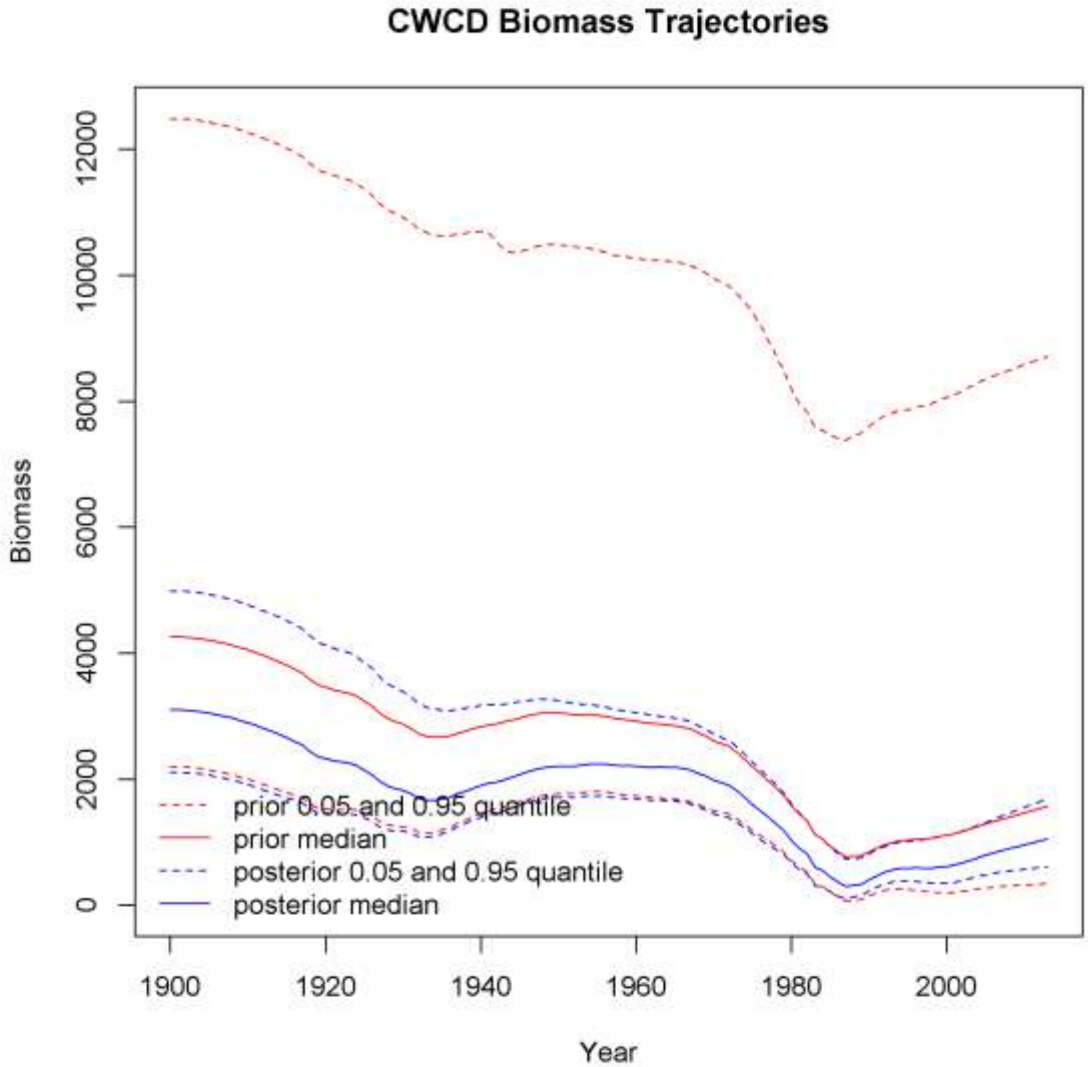


Figure 95. Total mature biomass from the prior predictive distribution (DB-SRA, in red) and the posterior distribution (XDB-SRA, in blue). Median = (solid lines) and 5th and 95th quantiles = (dashed lines).

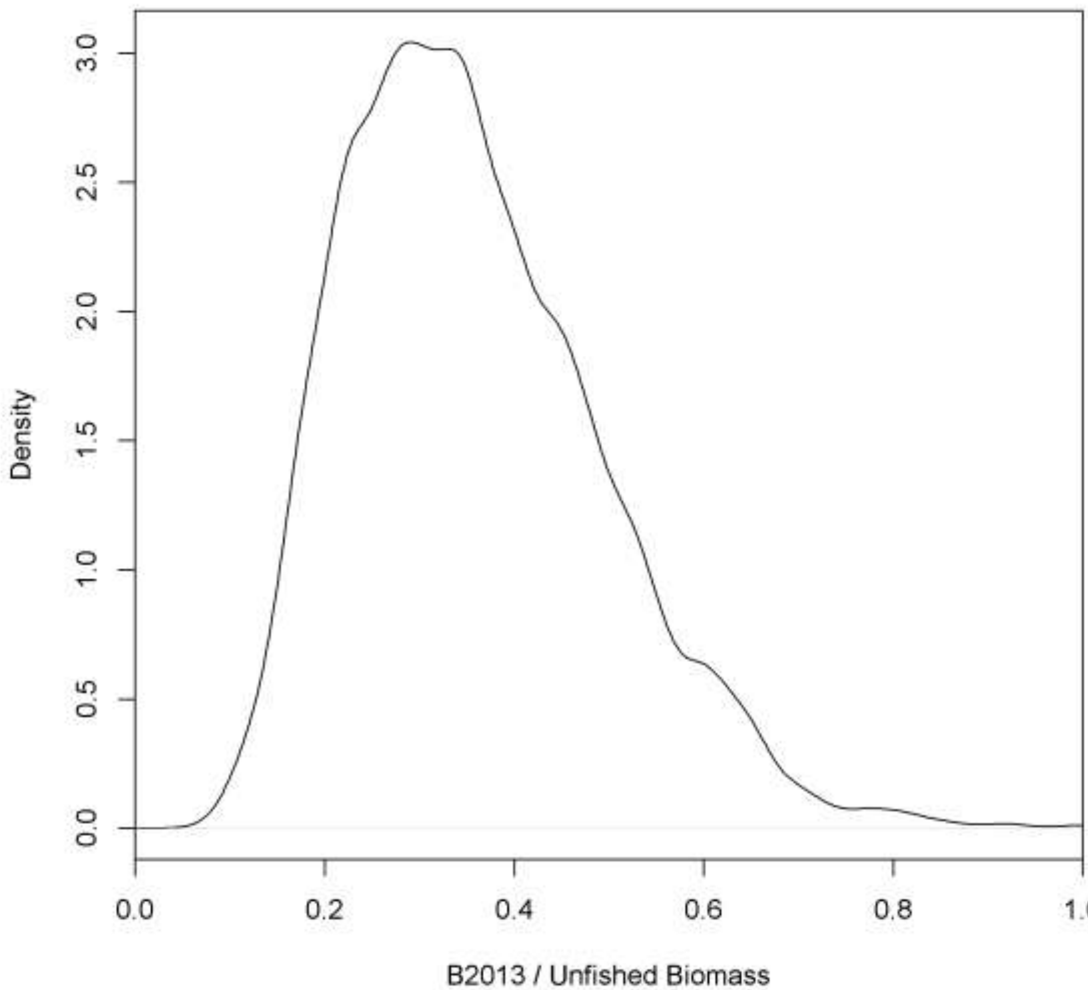


Figure 96. Posterior density of “depletion” (biomass in 2013 relative to unfished biomass) for the cowcod base model.

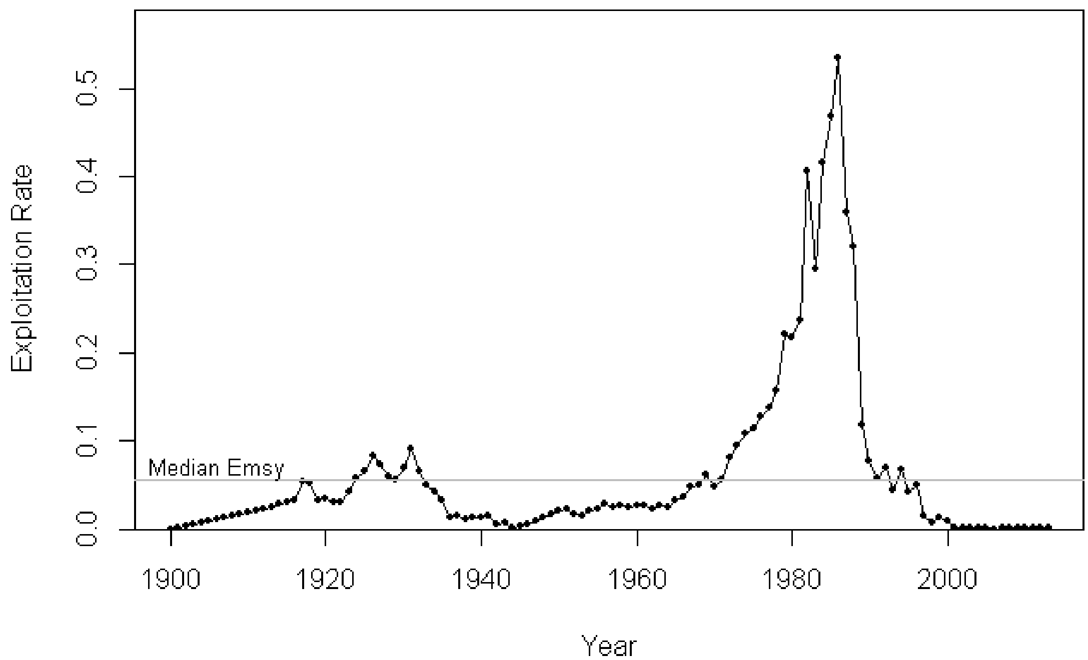


Figure 97. Median exploitation rate (exploitation rate = catch / vulnerable biomass) time series for the cowcod base model. Median exploitation rate producing long-term MSY ($E_{MSY}$) shown for reference.

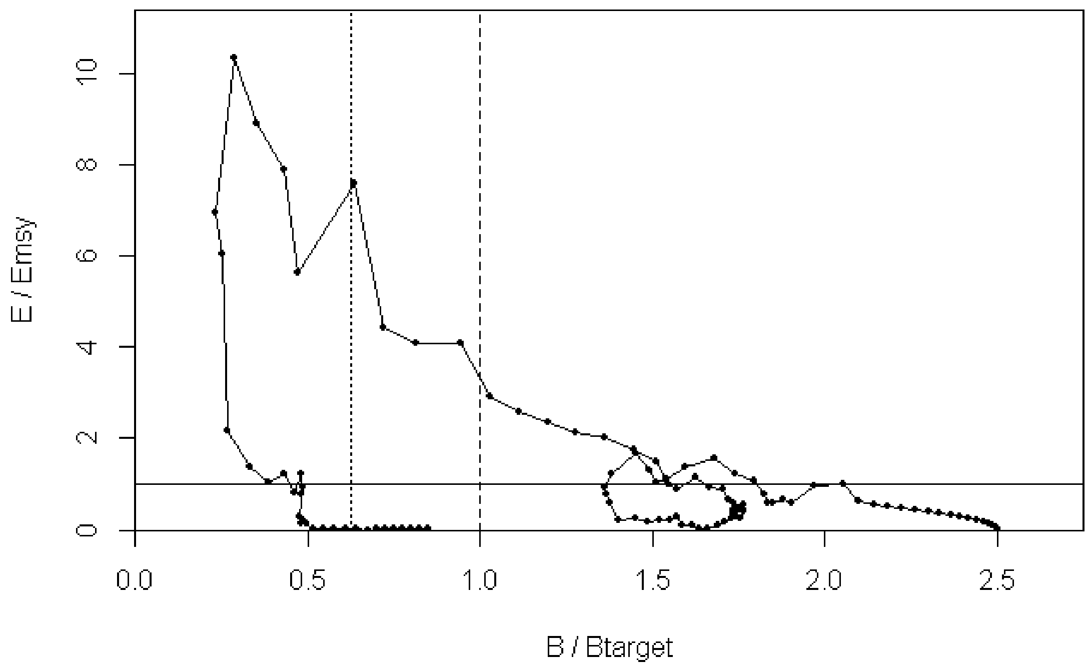


Figure 98. Phase plot of median annual harvest rates divided by the median MSY harvest rate vs. median spawning biomass divided by the target spawning biomass (40% of unfished spawning biomass) for the base case model. Target and limit reference points are shown for Emsy (solid horizontal line), target biomass (dashed vertical line), and the minimum stock size threshold for biomass (dotted vertical line).

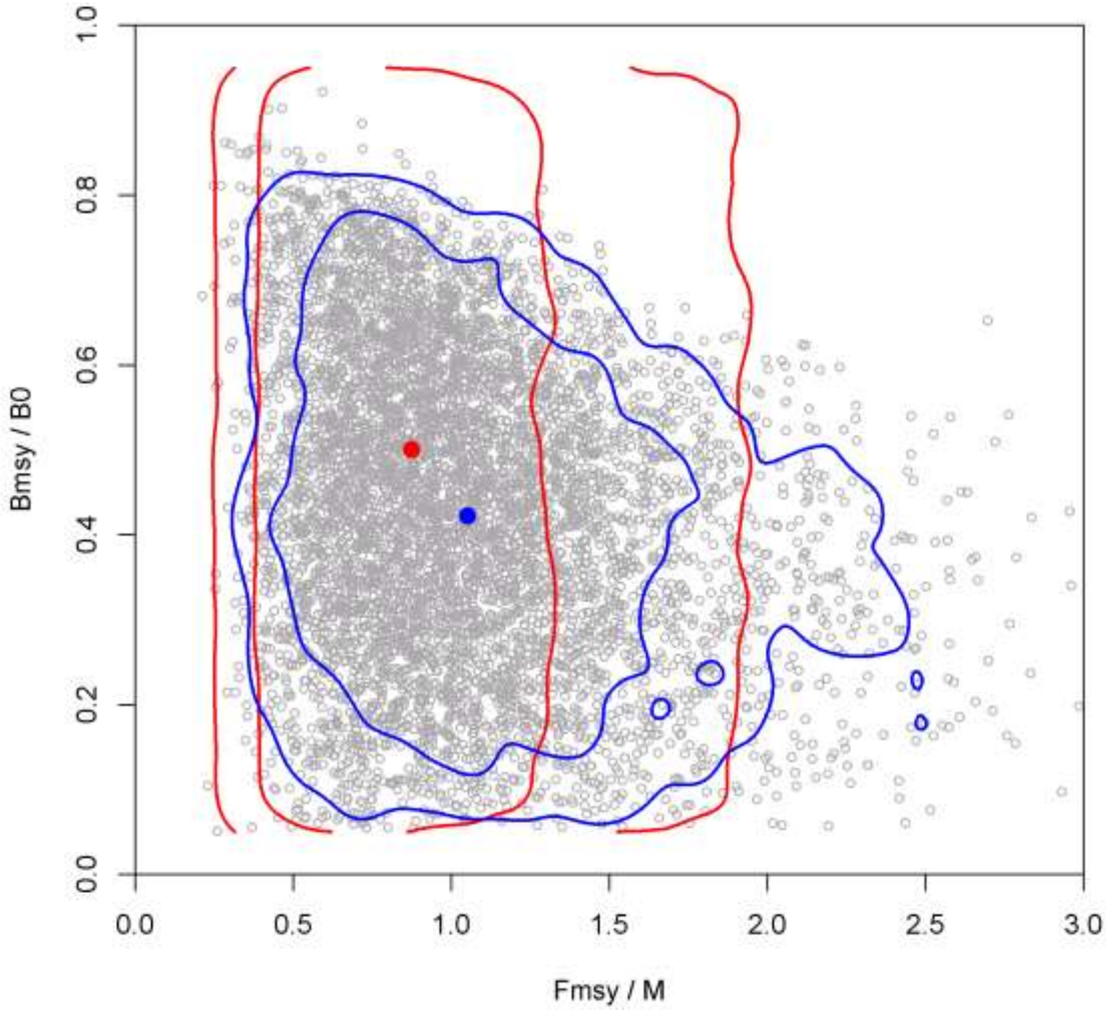


Figure 99. Bivariate prior and posterior distributions for Fmsy/M and Bmsy/B0 from the base model. Red lines are 75% and 95% contours of the prior, blue lines are updated posterior contours. Grey circles are posterior draws, large solid circles are centroids (medians) of the prior and posterior (red and blue, respectively).

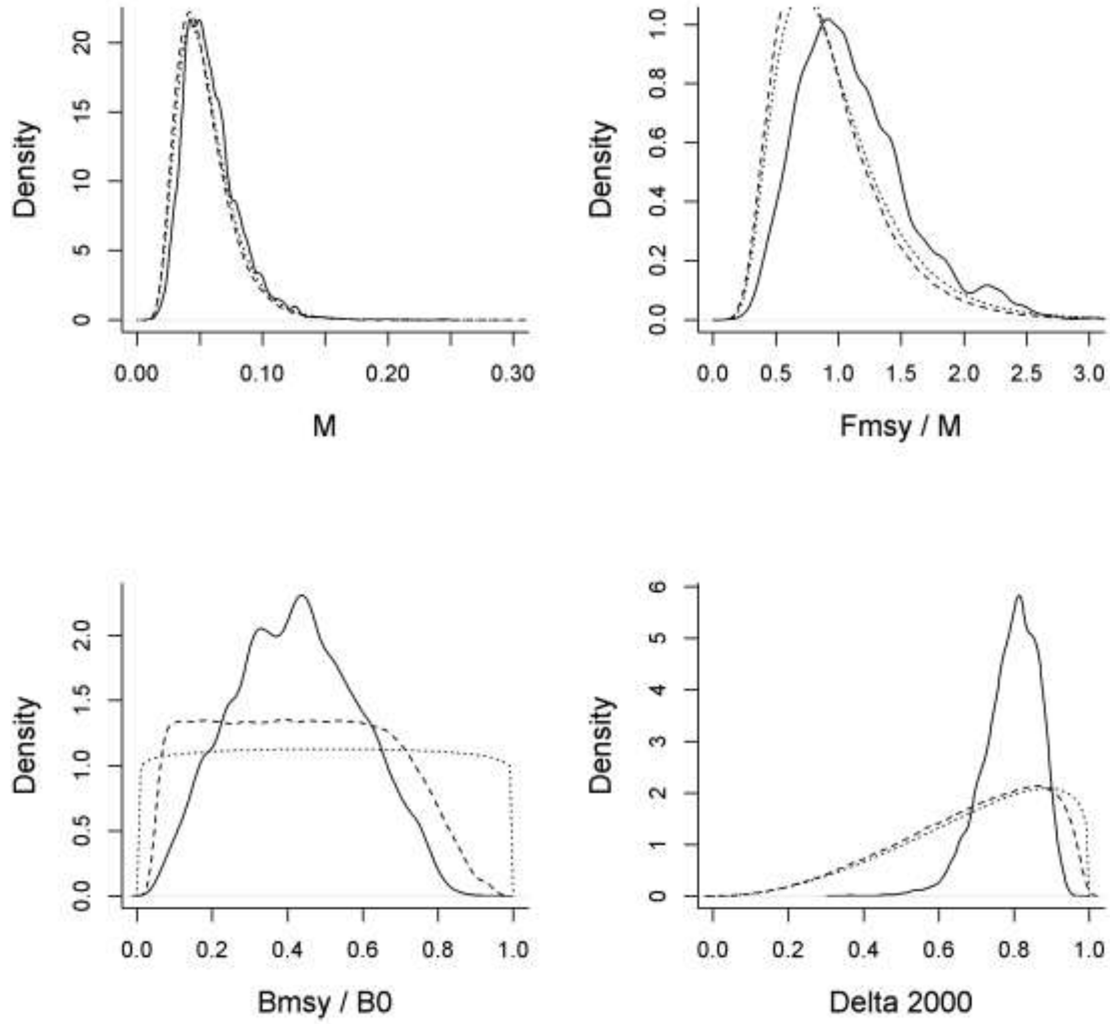


Figure 100. Distributions for XDB-SRA population dynamics parameters. Prior (dotted), post-model pre-data (dashed), and posterior (solid) distributions.

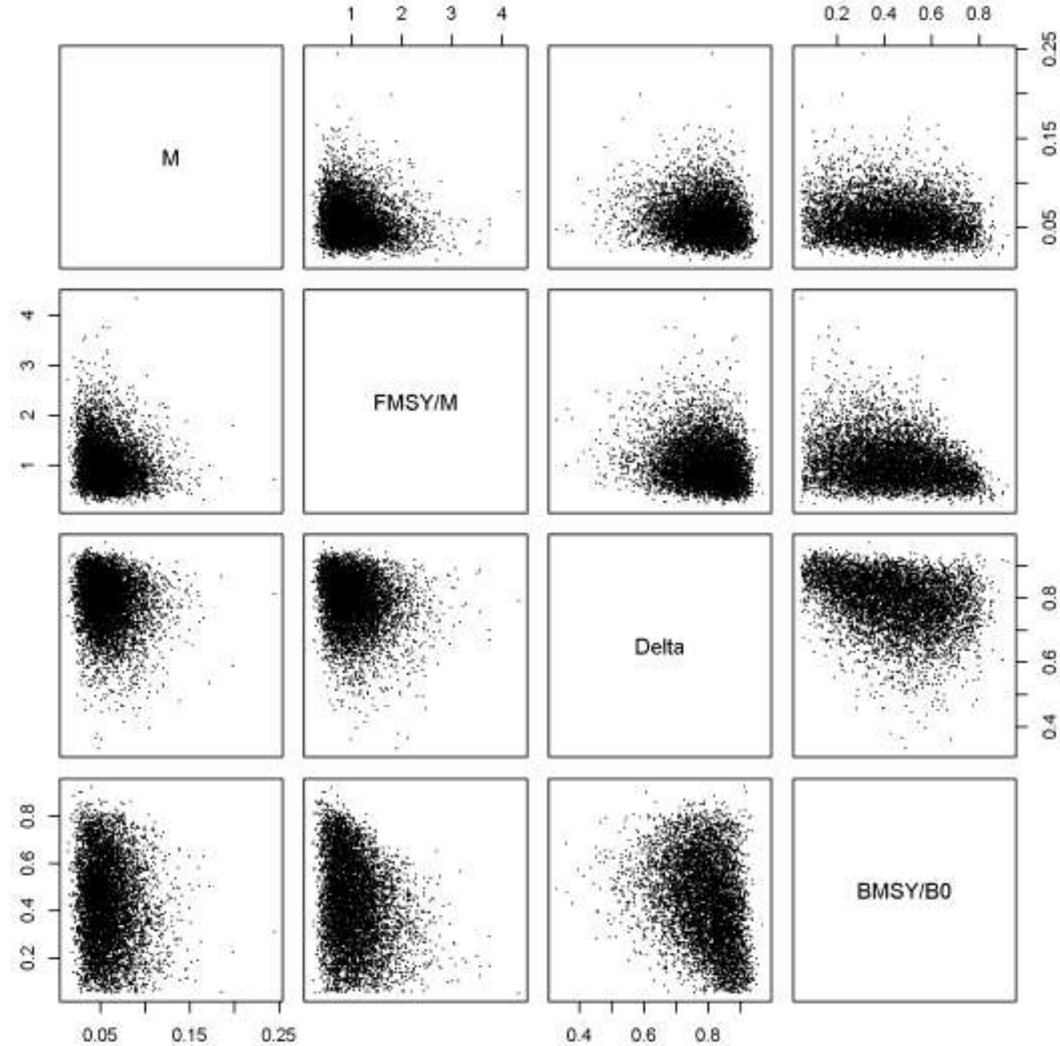


Figure 101. Pairwise scatterplots of population dynamics parameters in base model.

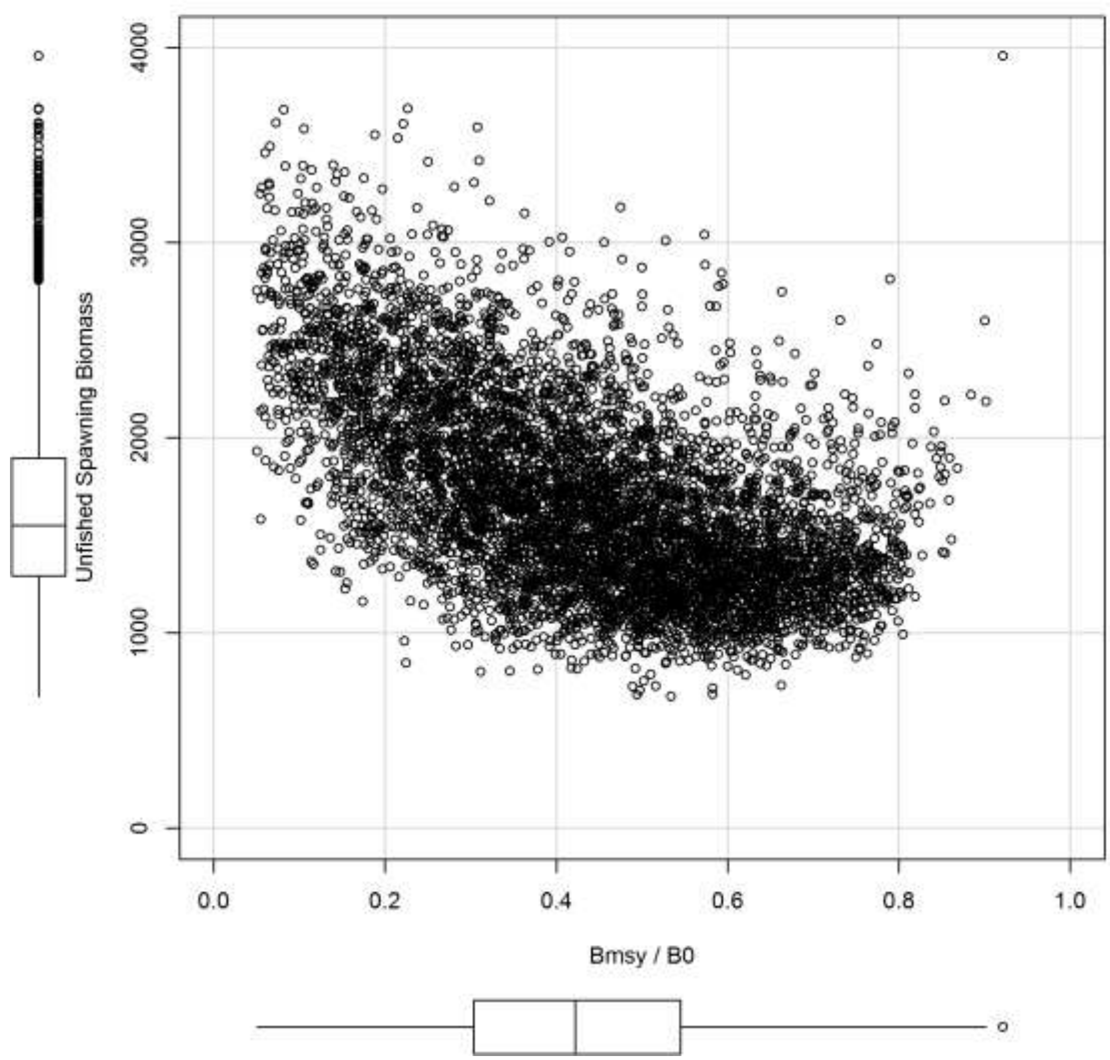


Figure 102. Relationship between unfished spawning biomass and $B_{MSY}/B_0$ in base model.

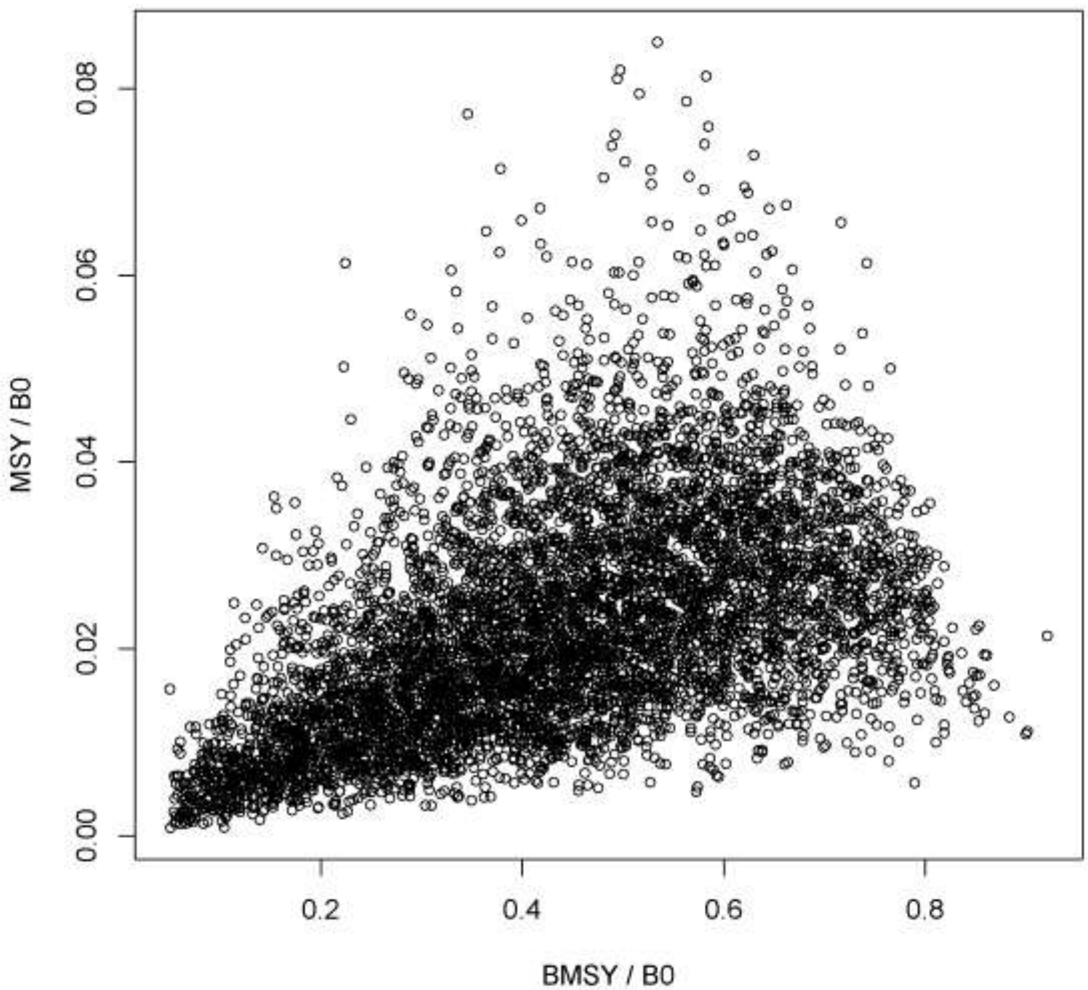


Figure 103. Relationship between MSY and $B_{MSY}$, relative to $B_0$. Each point represents the peak of a yield curve, in units of $B_0$.

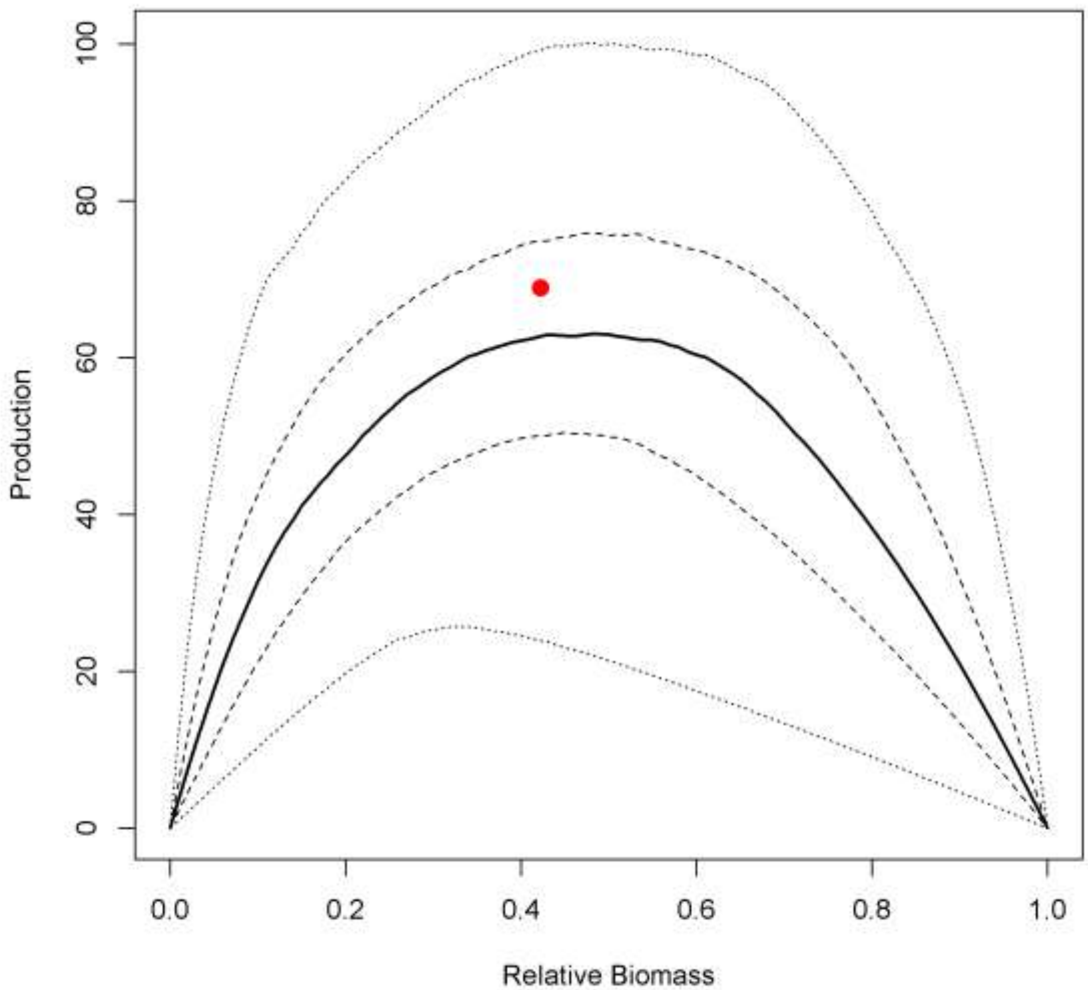


Figure 104. Distribution of yield curves from the base model. The solid, dashed, and dotted lines are median, interquartile, and 95th percentiles of production, respectively, given relative biomass. The red circle represents the marginal medians of $B_{MSY}/B_0$ and MSY.

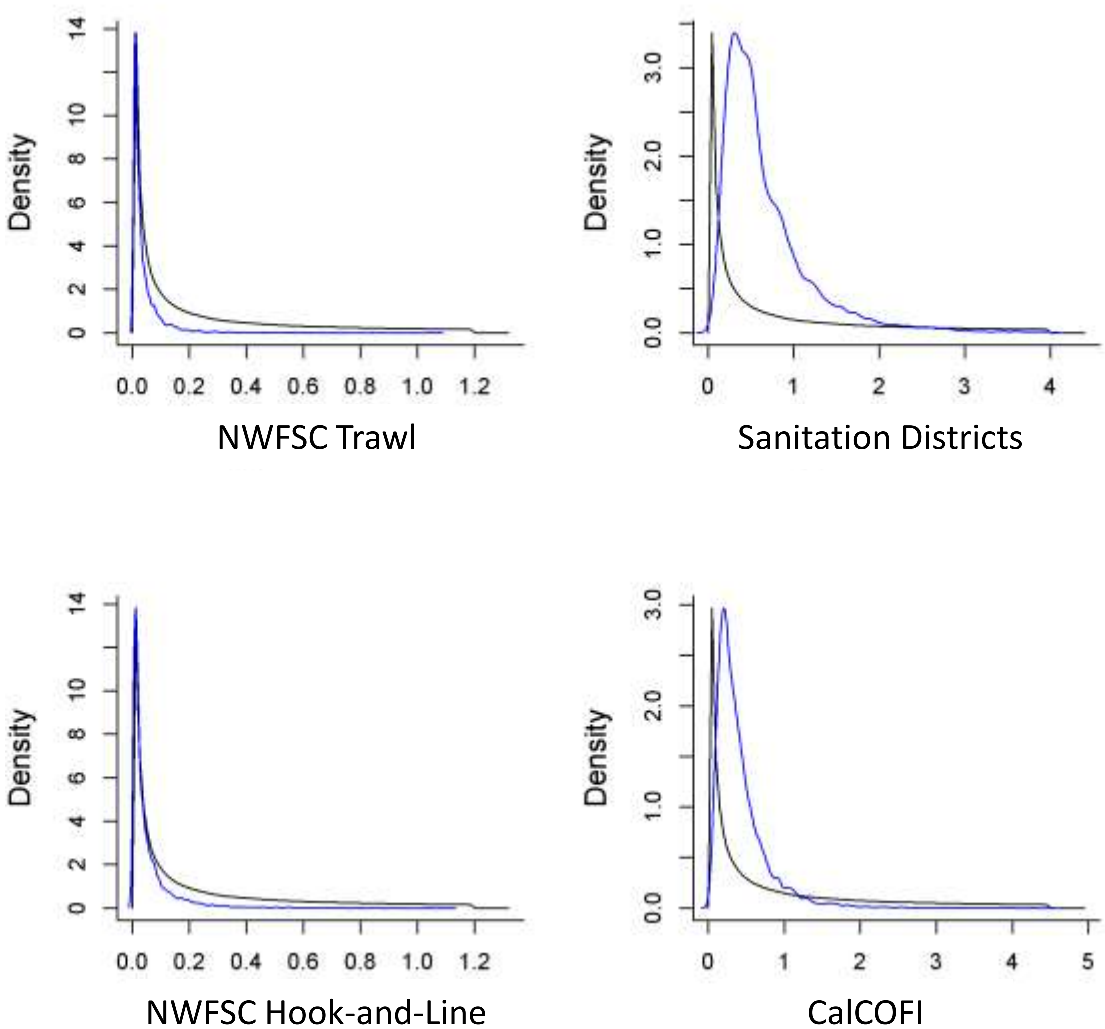


Figure 105. Additive variance parameters for the 4 time series in the base model. Solid black line is the log-uniform prior, blue line is the posterior distribution.

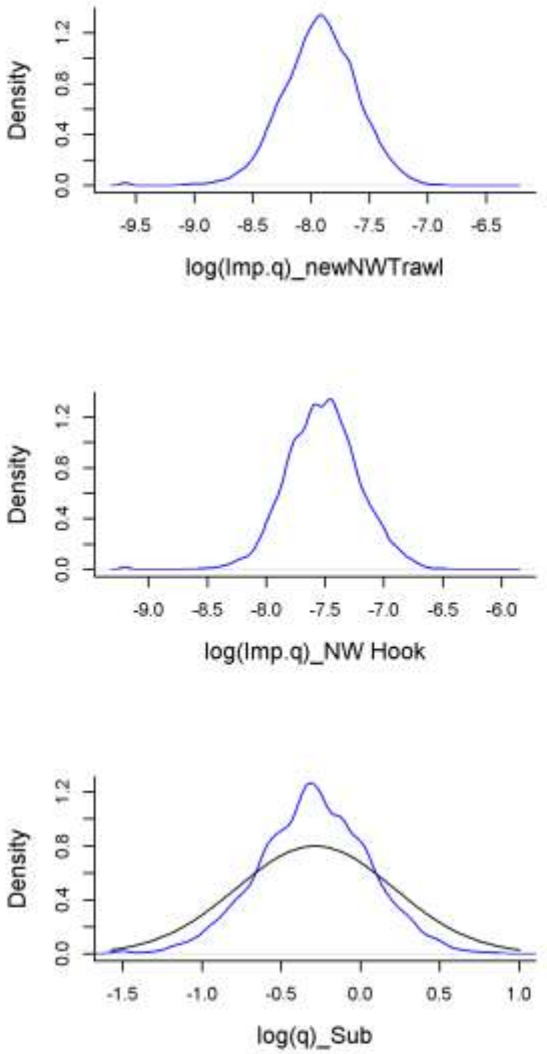


Figure 106. Catchability coefficients (q) in the base model (log scale). The posterior visual survey q (blue density, bottom left) is shown relative to the prior distribution (black).

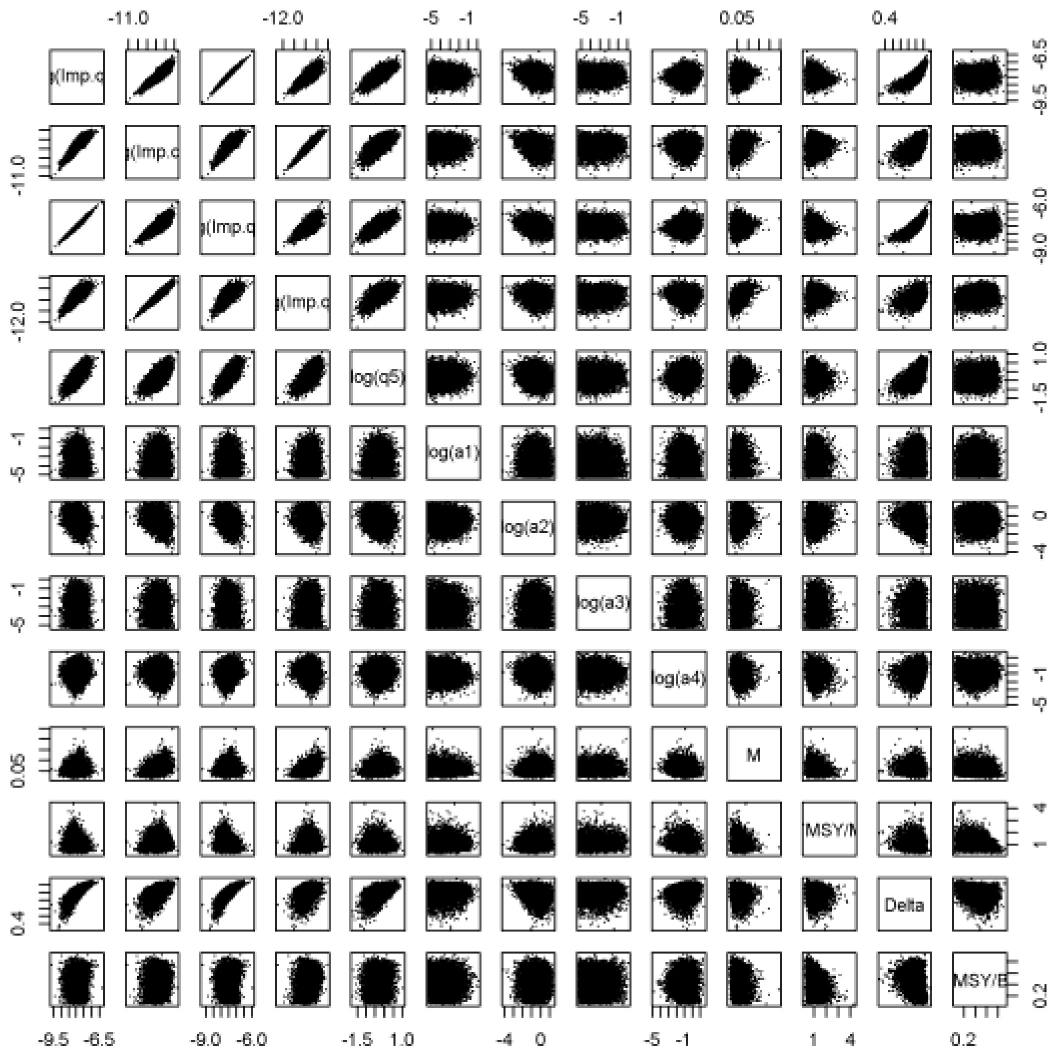

Figure 107. Pairwise scatterplot of all estimated model parameters in the base model (plus 5 calculated q's for survey time series, in the upper left 5x5 matrix).

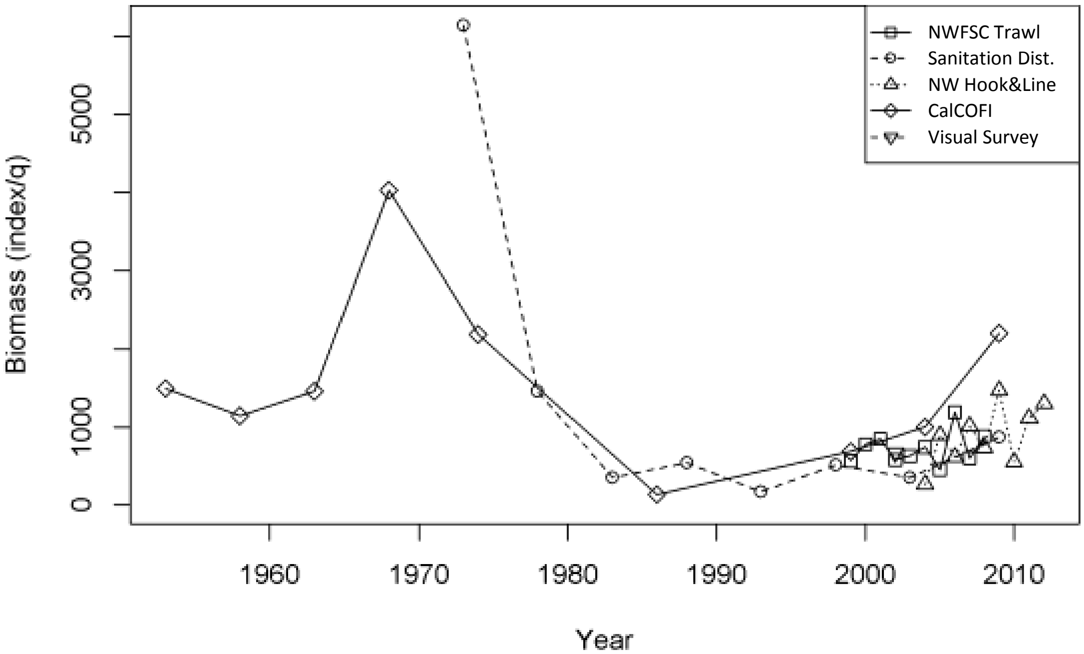


Figure 108. Indices of abundance, rescaled to units of biomass (dividing each index by its median q).

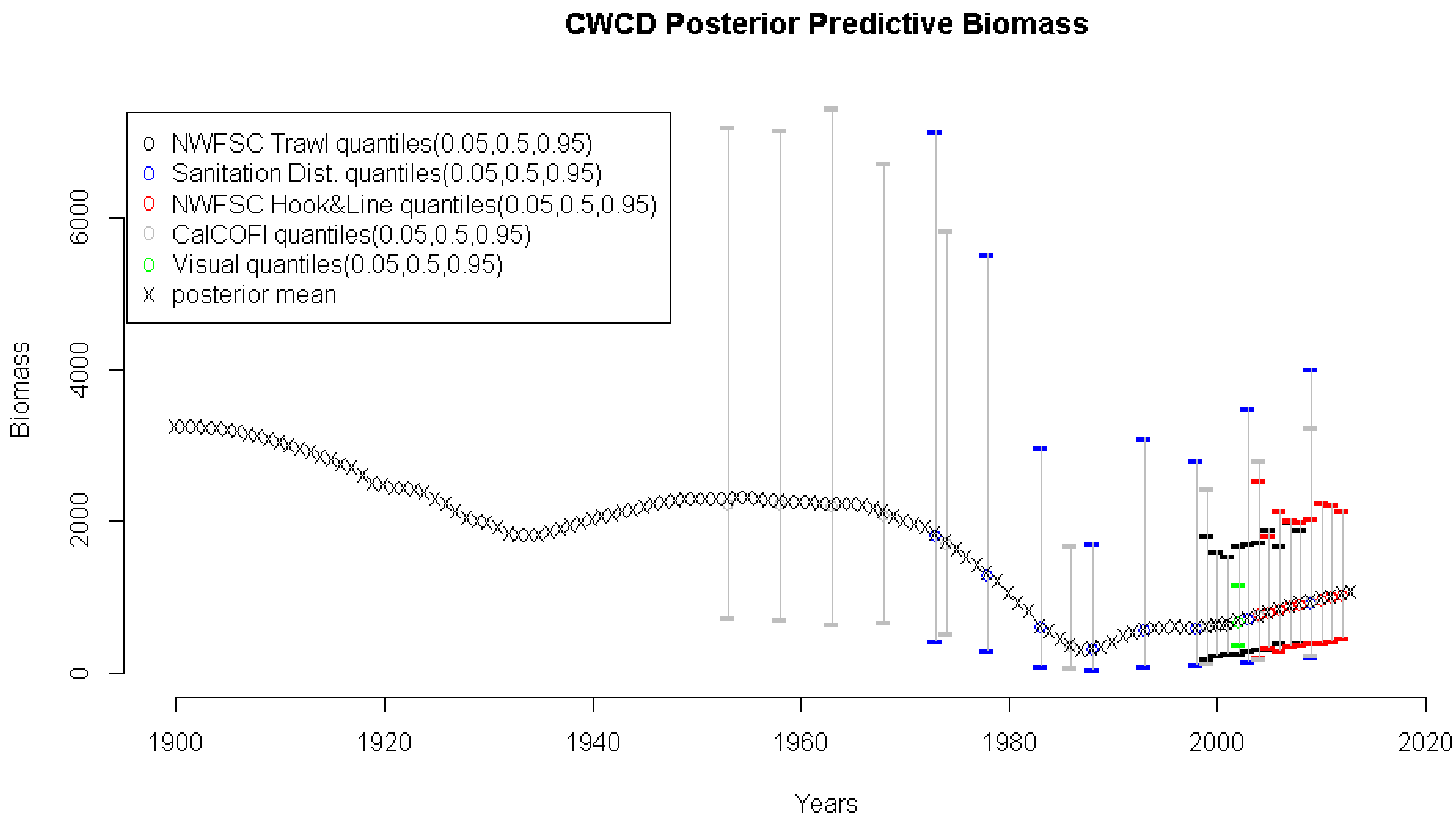


Figure 109. Posterior predictive intervals (5th and 95th percentiles) of vulnerable biomass for all indices in the base model, and the posterior mean of vulnerable biomass (X's).

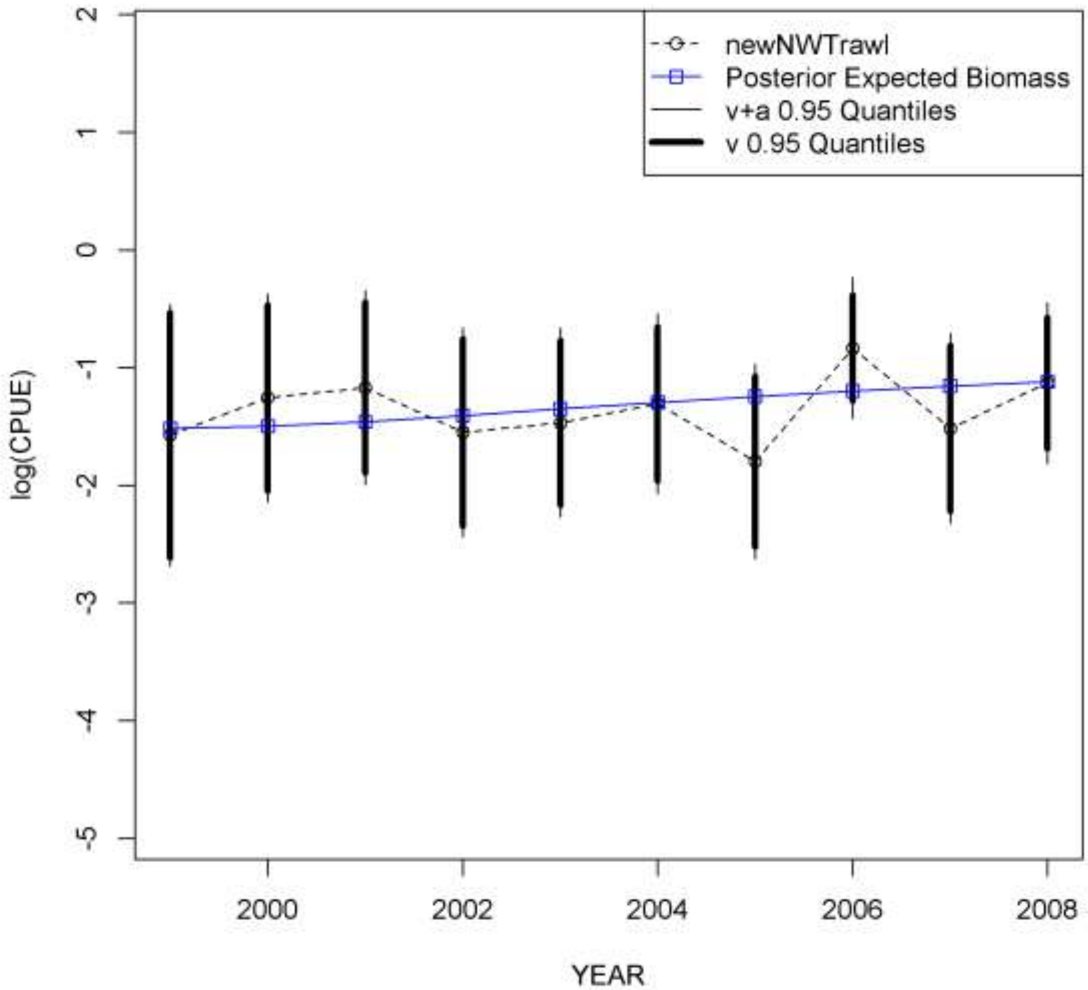


Figure 110. Log-scale fit of the NWFSC Trawl Survey index (2003-2012, with 4-year lag) to vulnerable biomass (1999-2008). Dashed line with circles is the index, blue line with squares is the posterior expected biomass, thick vertical lines are the 95% intervals from the input (fixed) variances, and the thin vertical lines are the 95% intervals with estimated added variance.

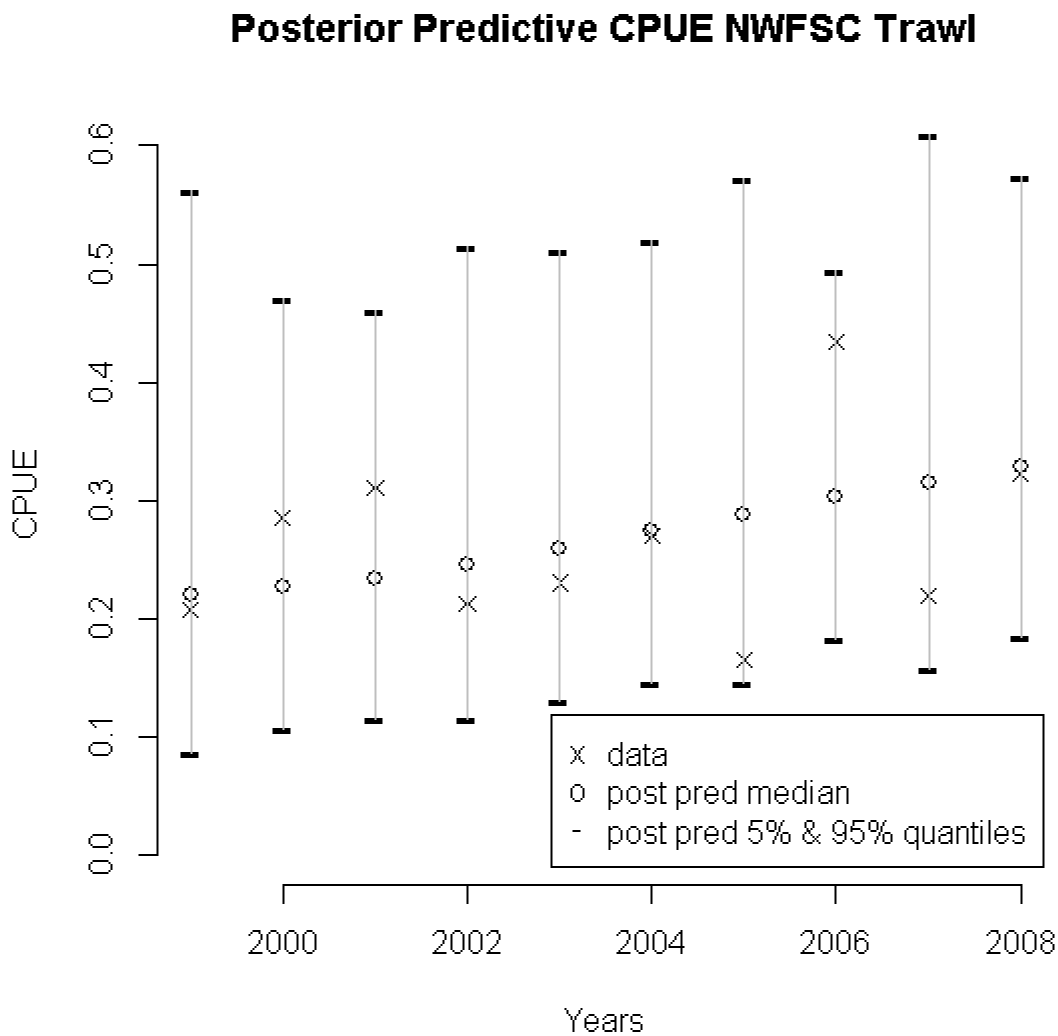


Figure 111. Posterior predictive intervals (5th and 95th quantiles) and median values, relative to observed data (X's) from the NWFSC Trawl Survey index (2003-2012, with 4-year lag).

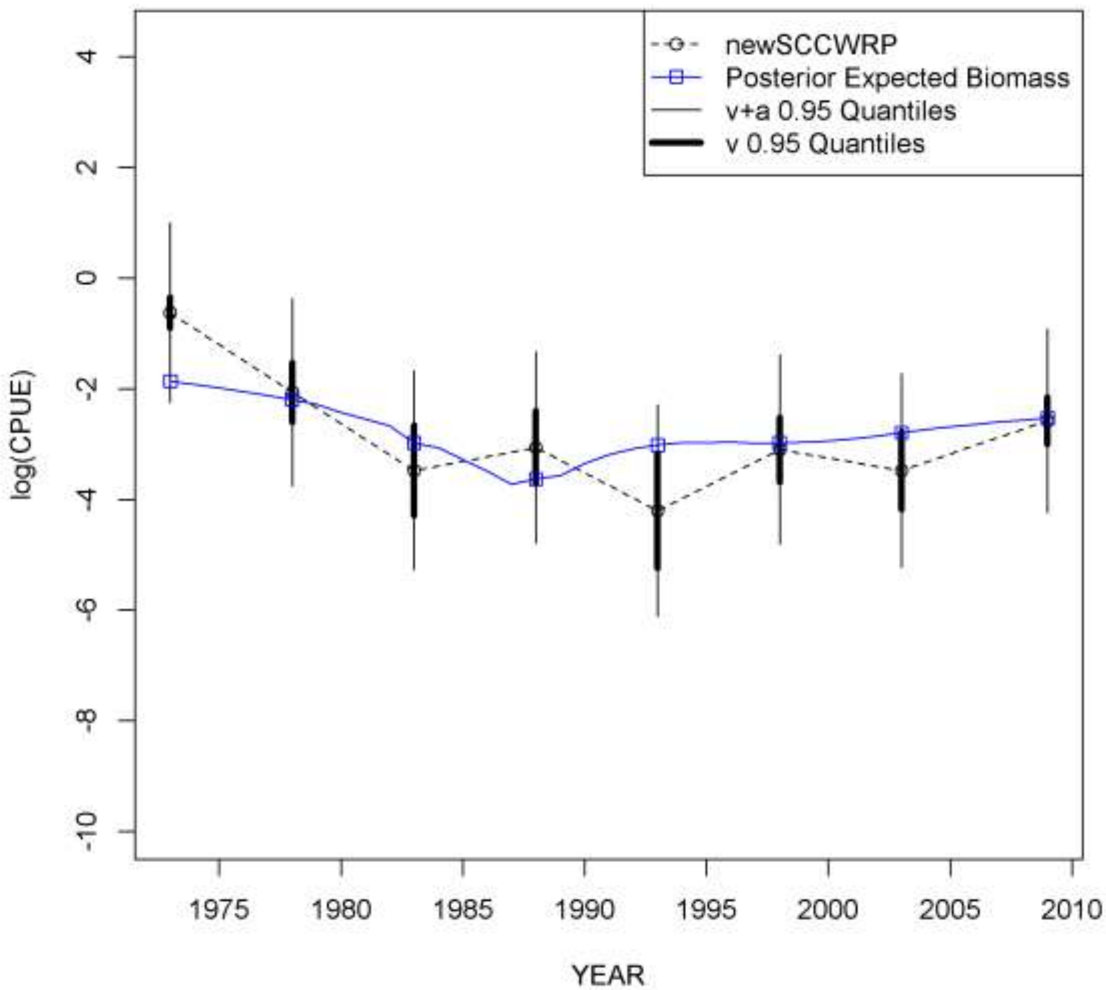


Figure 112. Log-scale fit of the Sanitation District Trawl Survey index. Dashed line with circles is the index, blue line with squares is the posterior expected biomass, thick vertical lines are the 95% intervals from the input (fixed) variances, and the thin vertical lines are the 95% intervals with estimated added variance

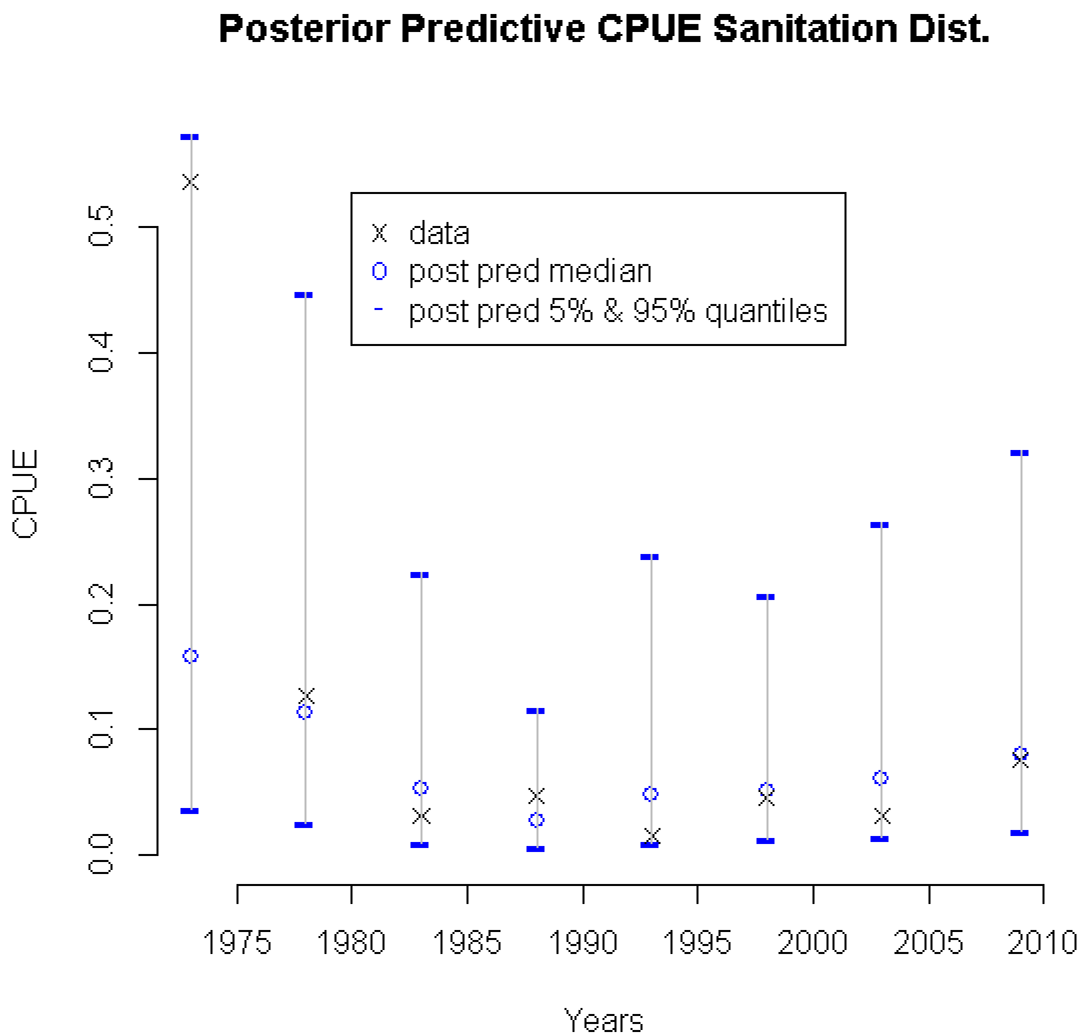


Figure 113. Posterior predictive intervals (5th and 95th quantiles) and median values (circles), relative to observed data (X's) from the Sanitation District Trawl Survey index.

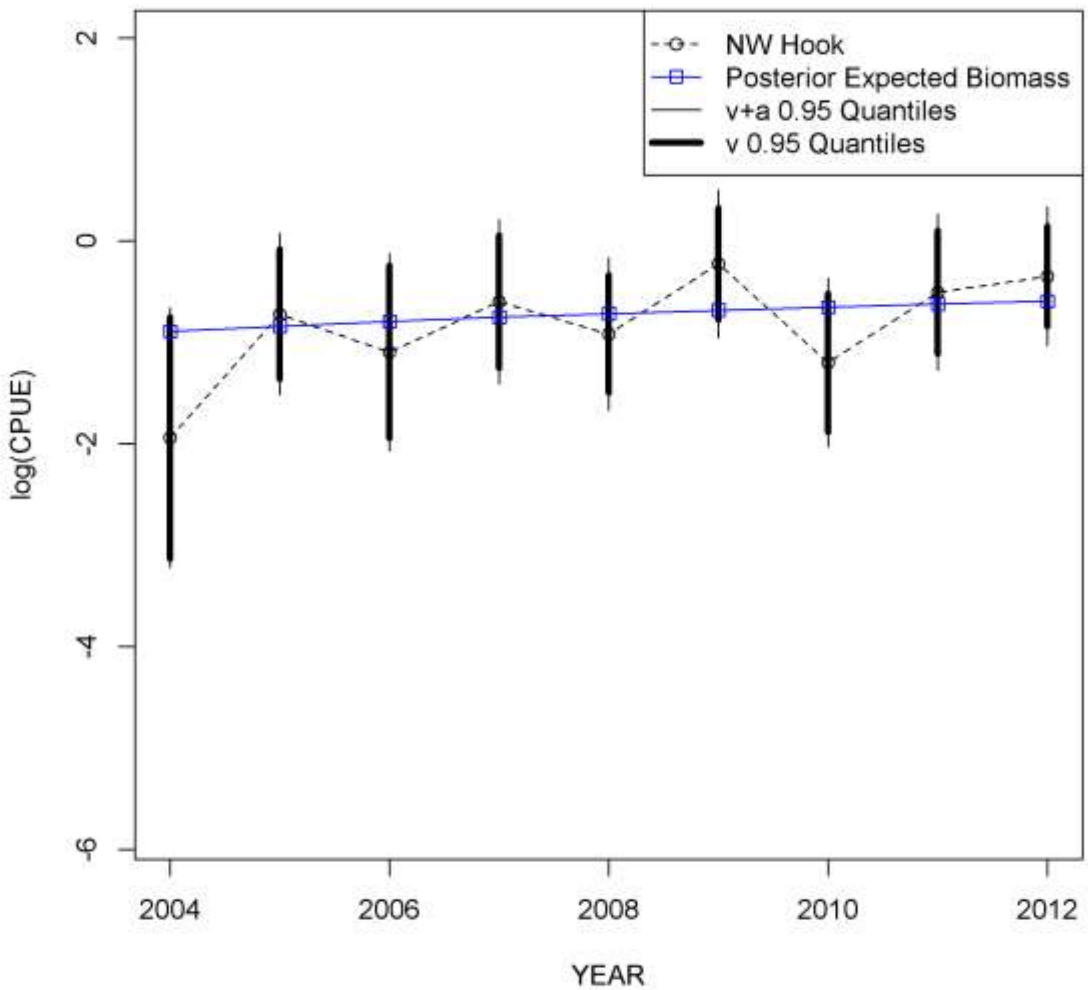


Figure 114. Log-scale fit of the NWFSC Hook-and-Line Survey index (2004-2012) to vulnerable biomass. Dashed line with circles is the index, blue line with squares is the posterior expected biomass, thick vertical lines are the 95% intervals from the input (fixed) variances, and the thin vertical lines are the 95% intervals with estimated added variance.

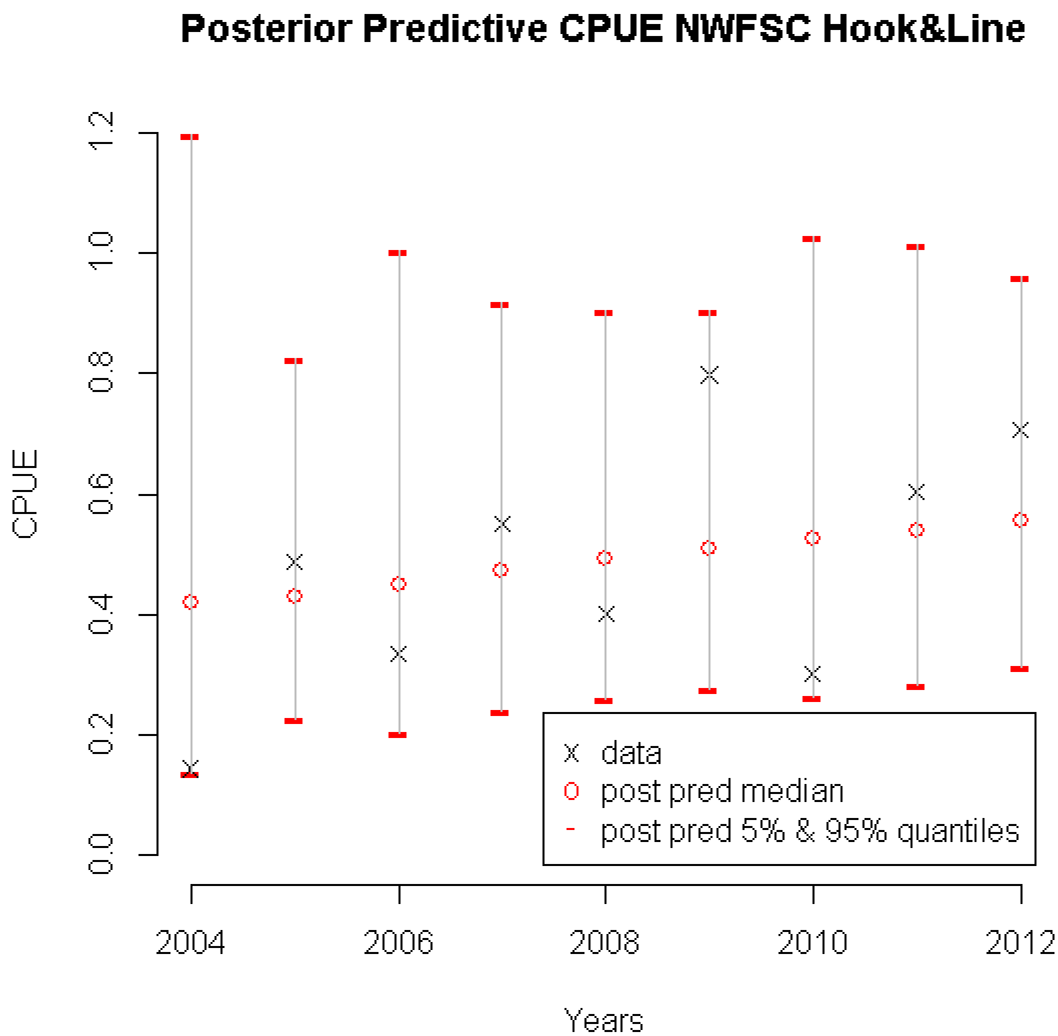


Figure 115. Posterior predictive intervals (5th and 95th quantiles) and median values, relative to observed data (X's) from the NWFSC Hook-and-Line Survey index.

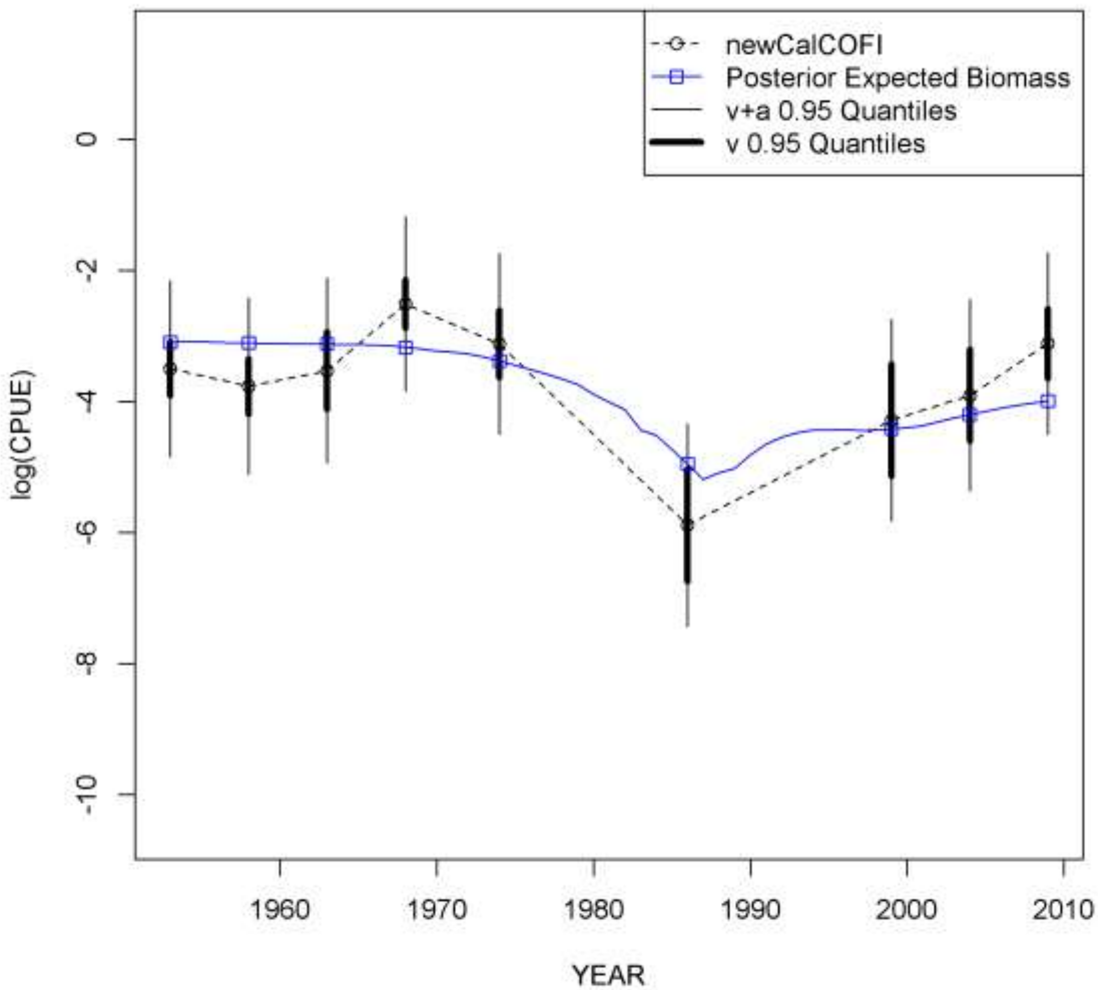


Figure 116. Log-scale fit of the CalCOFI Ichthyoplankton Survey index. Dashed line with circles is the index, blue line with squares is the posterior expected biomass, thick vertical lines are the 95% intervals from the input (fixed) variances, and the thin vertical lines are the 95% intervals with estimated added variance.

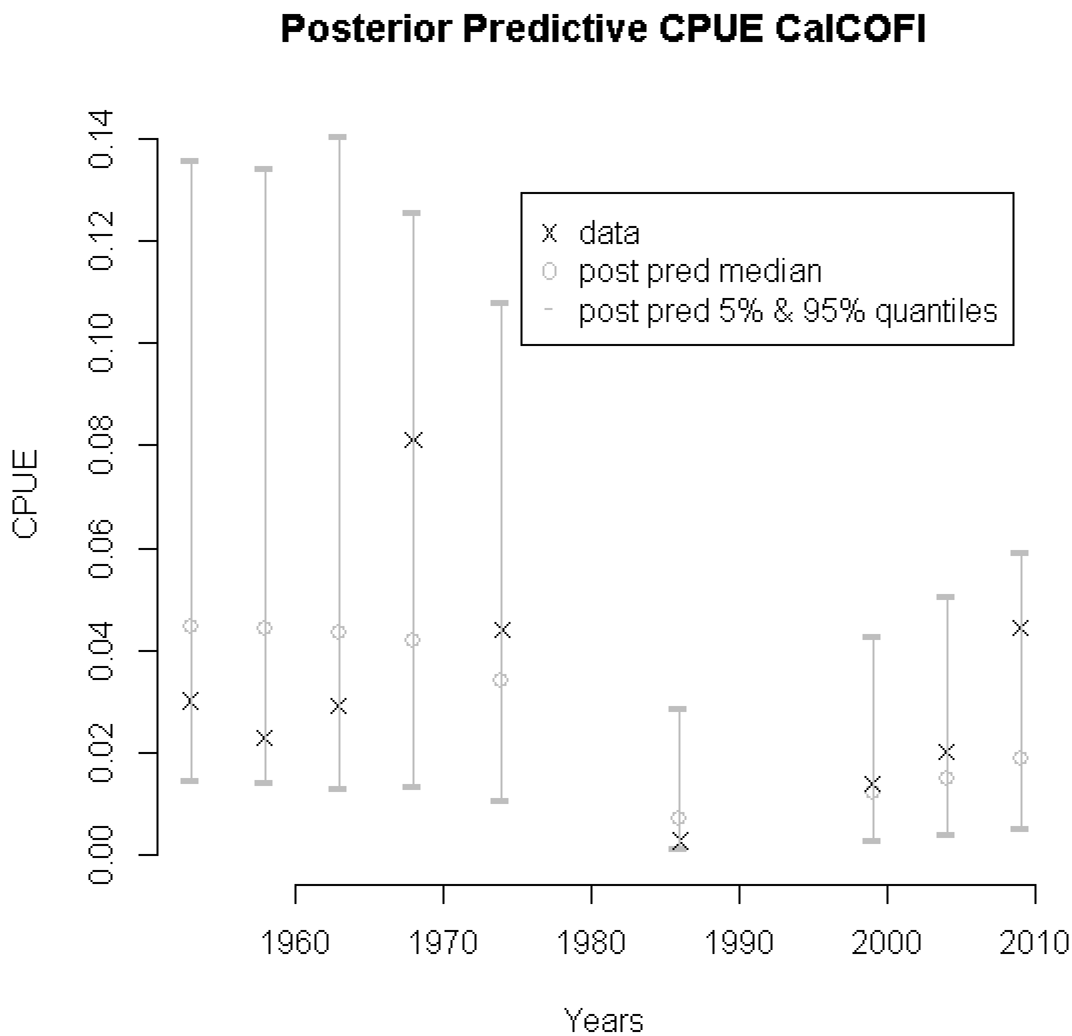


Figure 117. Posterior predictive intervals (5th and 95th quantiles) and median values (circles), relative to observed data (X's) from the CalCOFI Ichthyoplankton Survey index.

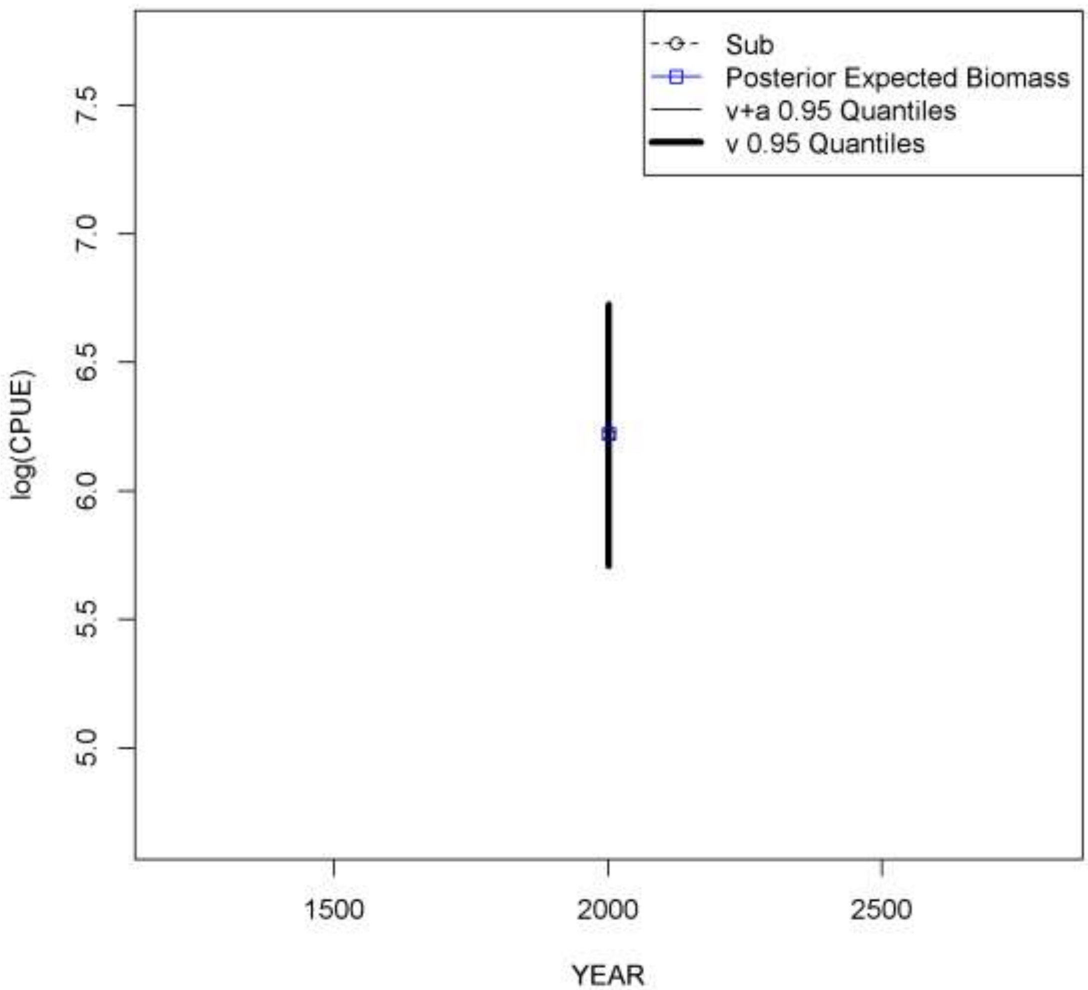


Figure 118. Log-scale fit of the 2002 Visual (Submersible) Transect Survey index. Dashed line with circles is the index, blue line with squares is the posterior expected biomass, thick vertical lines are the 95% intervals from the input (fixed) variances, and the thin vertical lines are the 95% intervals with estimated added variance.

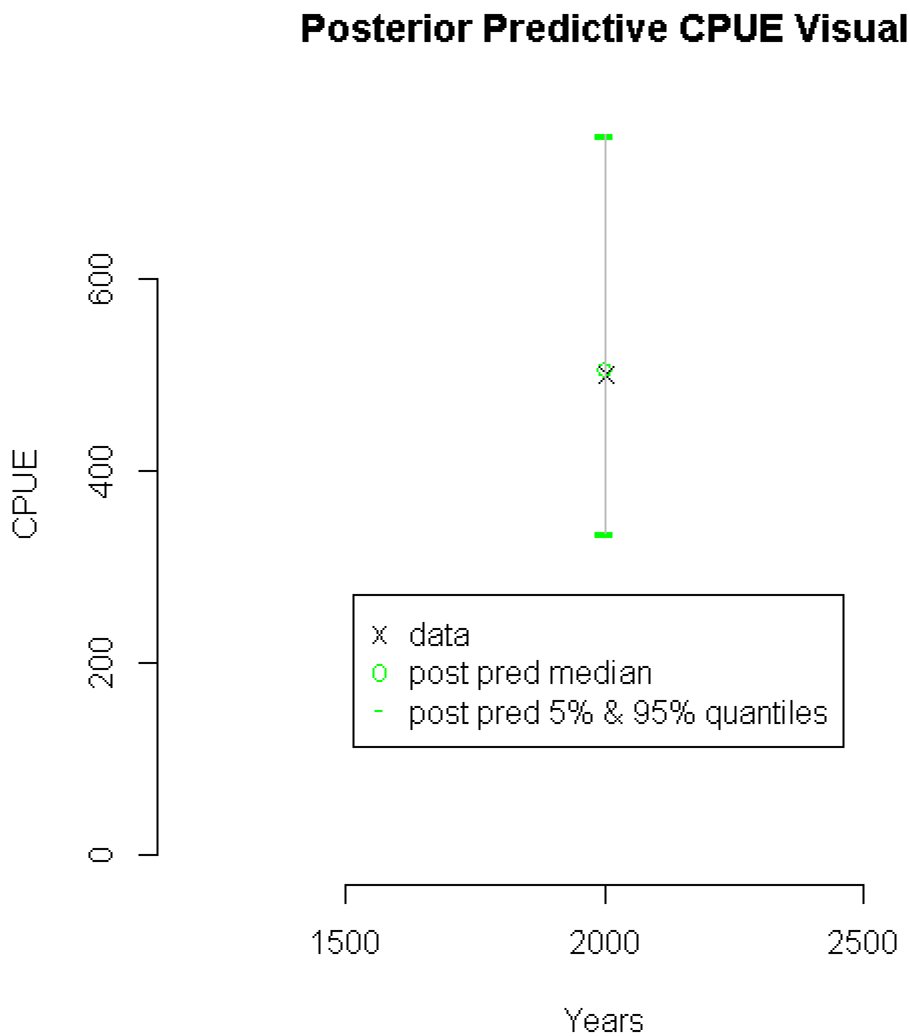


Figure 119. Posterior predictive intervals (5th and 95th quantiles) and median value (circle), relative to observed datum (X) from the 2002 Visual (Submersible) Transect Survey.

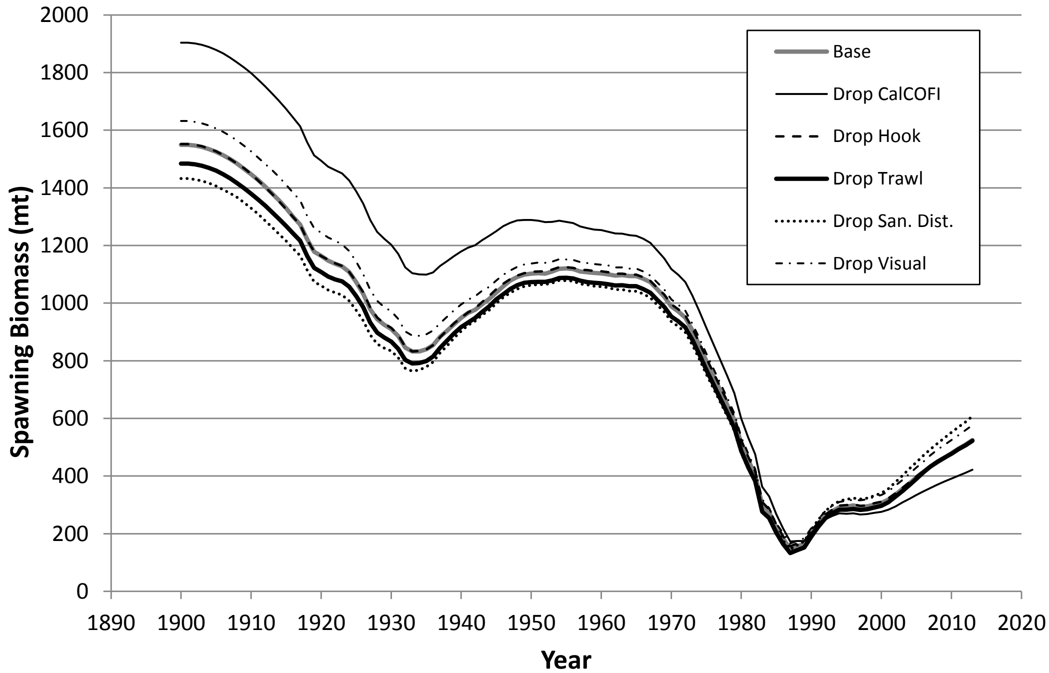


Figure 120. Median spawning biomass trajectories from the Post-STAR Panel base model, compared to models with individual indices removed.

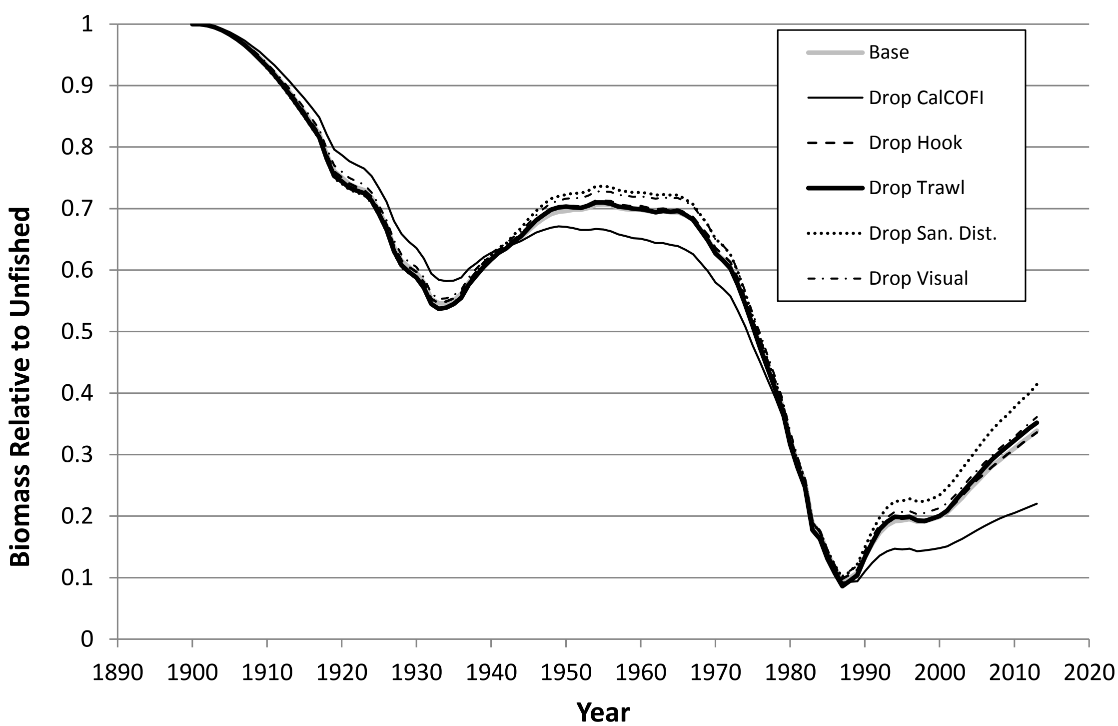


Figure 121. Median relative biomass trajectories from the Post-STAR Panel base model, compared to models with individual indices removed

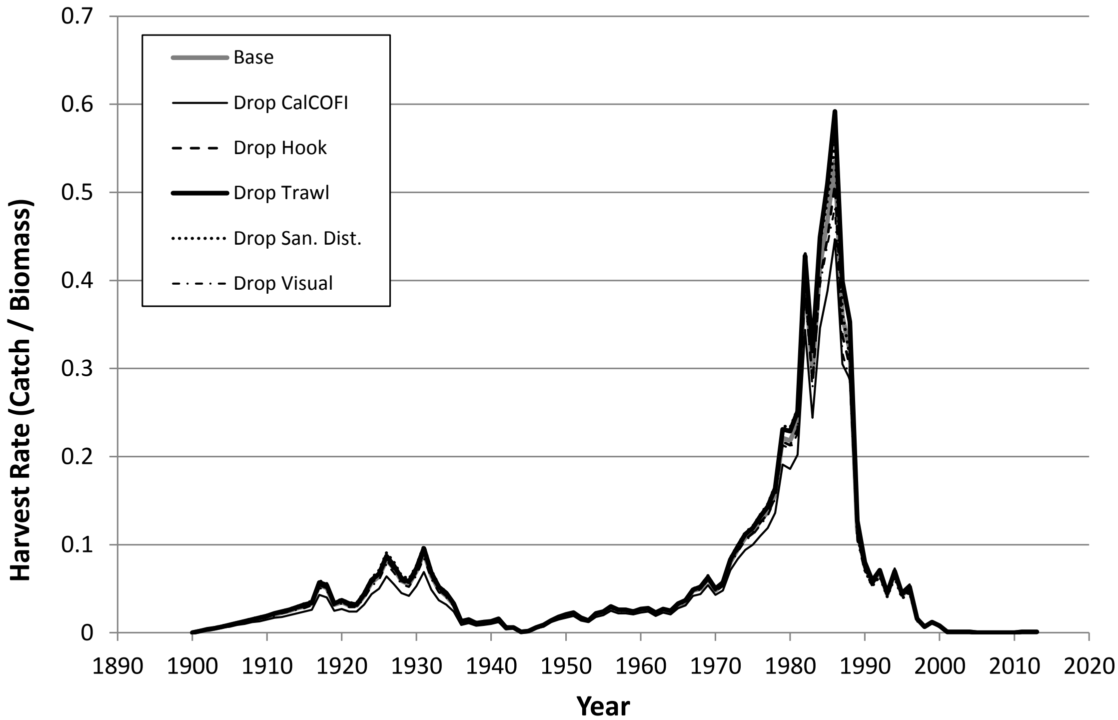


Figure 122. Median harvest rates from the Post-STAR Panel base model, compared to models with individual indices removed

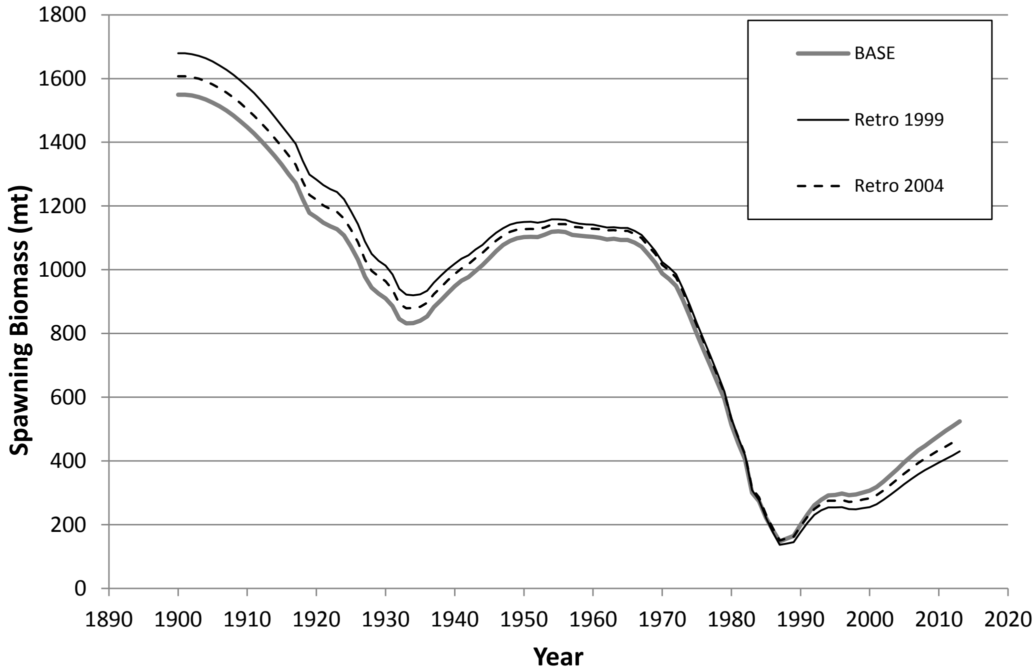


Figure 123. Median spawning biomass trajectories from retrospective analyses, truncating abundance indices to 2007, 2002, and 1998. Base model included for reference.

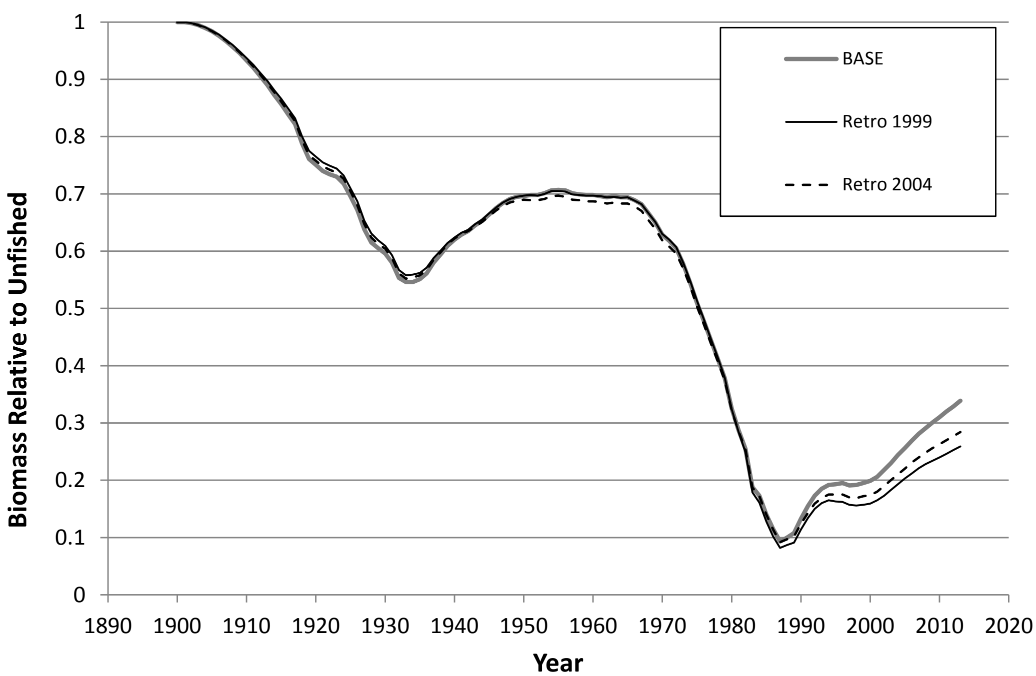


Figure 124. Median relative spawning biomass trajectories from retrospective analyses, truncating abundance indices to 2007, 2002, and 1998. Base model included for reference.

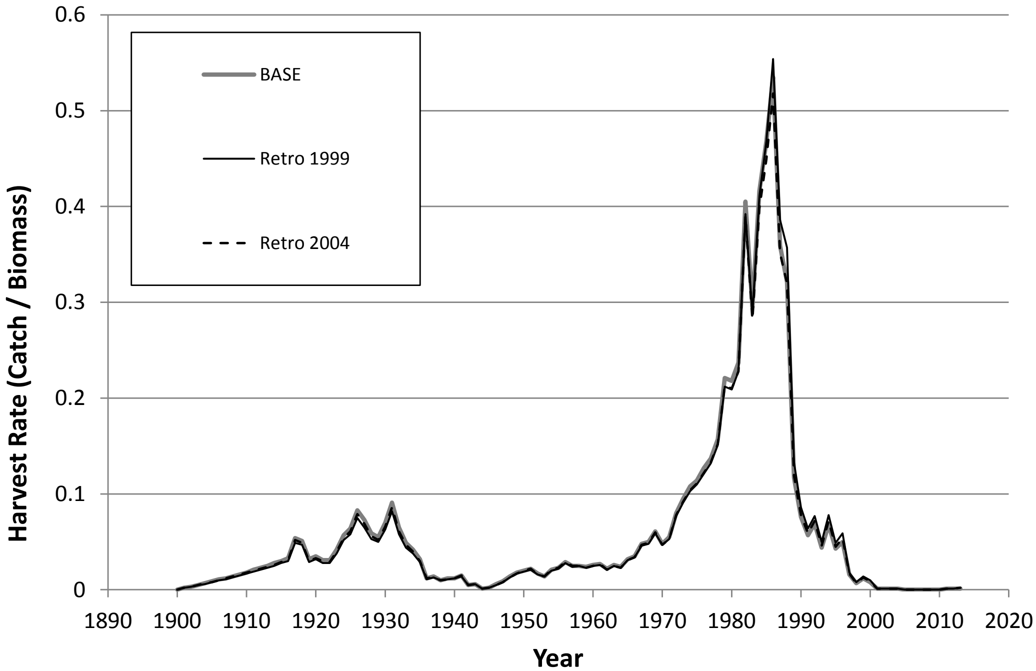


Figure 125. Median annual harvest rates from retrospective analyses, truncating abundance indices to 2007, 2002, and 1998. Base model included for reference.

# Appendix A. XDB-SRA data files

## Appendix A.1. Catch

| catch.mt | year |
|---|---|
| 0.01 | 1900 |
| 5.34 | 1901 |
| 10.68 | 1902 |
| 16.01 | 1903 |
| 21.35 | 1904 |
| 26.68 | 1905 |
| 32.02 | 1906 |
| 37.35 | 1907 |
| 42.68 | 1908 |
| 48.02 | 1909 |
| 53.35 | 1910 |
| 58.69 | 1911 |
| 64.02 | 1912 |
| 69.35 | 1913 |
| 74.69 | 1914 |
| 80.02 | 1915 |
| 85.36 | 1916 |
| 137.73 | 1917 |
| 125.59 | 1918 |
| 75.1 | 1919 |
| 81.57 | 1920 |
| 71.26 | 1921 |
| 70.11 | 1922 |
| 93.94 | 1923 |
| 125.94 | 1924 |
| 138.15 | 1925 |
| 171.48 | 1926 |
| 142.3 | 1927 |
| 111.35 | 1928 |
| 102.59 | 1929 |
| 126.94 | 1930 |
| 161.02 | 1931 |
| 109.54 | 1932 |
| 81.97 | 1933 |
| 70.74 | 1934 |
| 53 | 1935 |
| 20.63 | 1936 |
| 24.88 | 1937 |
| 18.71 | 1938 |
| 22.01 | 1939 |
| 23.69 | 1940 |
| 29.48 | 1941 |
| 10.6 | 1942 |
| 12.37 | 1943 |
| 1.99 | 1944 |

| | |
|---|---|
| 4.59 | 1945 |
| 11.66 | 1946 |
| 18.76 | 1947 |
| 29.92 | 1948 |
| 38.68 | 1949 |
| 44 | 1950 |
| 49.19 | 1951 |
| 36.67 | 1952 |
| 31.21 | 1953 |
| 46.81 | 1954 |
| 52.05 | 1955 |
| 65.17 | 1956 |
| 55.68 | 1957 |
| 56.36 | 1958 |
| 52.3 | 1959 |
| 57.05 | 1960 |
| 60.04 | 1961 |
| 48.03 | 1962 |
| 57.34 | 1963 |
| 51.89 | 1964 |
| 70.08 | 1965 |
| 76.63 | 1966 |
| 102.37 | 1967 |
| 105.02 | 1968 |
| 125.13 | 1969 |
| 95.85 | 1970 |
| 106.1 | 1971 |
| 152.62 | 1972 |
| 171.79 | 1973 |
| 183.66 | 1974 |
| 182.55 | 1975 |
| 189.35 | 1976 |
| 191.23 | 1977 |
| 203.18 | 1978 |
| 262.15 | 1979 |
| 223.63 | 1980 |
| 215.97 | 1981 |
| 327.51 | 1982 |
| 177.05 | 1983 |
| 227.88 | 1984 |
| 208.11 | 1985 |
| 194.36 | 1986 |
| 105.78 | 1987 |
| 100.53 | 1988 |
| 38.66 | 1989 |
| 30.46 | 1990 |
| 26.42 | 1991 |
| 35.8 | 1992 |
| 24.54 | 1993 |
| 39.65 | 1994 |
| 25.05 | 1995 |

| | |
|---|---|
| 29.93 | 1996 |
| 9.15 | 1997 |
| 4.03 | 1998 |
| 7.24 | 1999 |
| 4.94 | 2000 |
| 0.58 | 2001 |
| 0.58 | 2002 |
| 0.48 | 2003 |
| 0.86 | 2004 |
| 0.15 | 2005 |
| 0.07 | 2006 |
| 0.21 | 2007 |
| 0.25 | 2008 |
| 0.21 | 2009 |
| 0.17 | 2010 |
| 0.83 | 2011 |
| 0.82 | 2012 |
| 0.83 | 2013 # avg. of 2011-12 |
| 0.83 | 2014 # avg. of 2011-12 |
| 0.83 | 2015 # avg. of 2011-12 |
| 0.83 | 2016 # avg. of 2011-12 |

## Appendix A.2. NWFSC trawl survey index (4-year offset)

| year | index | sigma.lnX. |
|---|---|---|
| 1999 | 0.2071543 | 0.530952416 |
| 2000 | 0.2849131 | 0.403054854 |
| 2001 | 0.3102929 | 0.369174727 |
| 2002 | 0.2122672 | 0.405874285 |
| 2003 | 0.2302692 | 0.356999726 |
| 2004 | 0.2706166 | 0.333752622 |
| 2005 | 0.1656464 | 0.369851176 |
| 2006 | 0.4342021 | 0.229552796 |
| 2007 | 0.2194043 | 0.358962276 |
| 2008 | 0.3225766 | 0.284433887 |

## Appendix A.3. Sanitation District trawl survey index (5-year time blocks)

| year | index | sigma.lnX. |
|---|---|---|
| 1973 | 0.536 | 0.142 |
| 1978 | 0.127 | 0.276 |
| 1983 | 0.031 | 0.418 |
| 1988 | 0.047 | 0.334 |
| 1993 | 0.015 | 0.532 |
| 1998 | 0.045 | 0.3 |
| 2003 | 0.031 | 0.359 |
| 2009 | 0.076 | 0.216 |

## Appendix A.4. NWFSC hook-and-line survey index

| year | index | sigma.lnX. |
|---|---|---|
| 2004 | 0.1436499 | 0.608389277 |
| 2005 | 0.4860135 | 0.326935435 |
| 2006 | 0.3349771 | 0.433438755 |
| 2007 | 0.5496947 | 0.334772558 |
| 2008 | 0.3995499 | 0.29677224 |
| 2009 | 0.7977309 | 0.281920339 |
| 2010 | 0.3008201 | 0.34878955 |
| 2011 | 0.6034886 | 0.310088658 |
| 2012 | 0.7059486 | 0.251883863 |

### Appendix A.5. CalCOFI Ichthyoplankton (5-year time blocks)

| year | index | sigma.lnX. |
|---|---|---|
| 1953 | 0.030125162 | 0.208548835 |
| 1958 | 0.023079926 | 0.215986688 |
| 1963 | 0.029334458 | 0.302708783 |
| 1968 | 0.081053264 | 0.186543613 |
| 1974 | 0.044052331 | 0.260923856 |
| 1986 | 0.002778817 | 0.438692569 |
| 1999 | 0.013798416 | 0.435306873 |
| 2004 | 0.020138975 | 0.354579933 |
| 2009 | 0.044280336 | 0.270490437 |

### Appendix A.6. Visual survey of CCAs

| year | index | sigma.lnX. |
|---|---|---|
| 2002 | 500.7 | 0.26 |

## Appendix B. XDB-SRA control file

| | |
|---|---|
| sci.name | Sebastes levis |
| common.name | Cowcod |
| species.code | CWCD |
| age.mat | 11 |
| delta.yr | 2000 |
| DBSRA.OFL.yr | 2016 |
| M.est | 0.055 |
| SD.lnM | 0.4 |
| FMSYtoMratio | 0.97 |
| SD.FMSYtoMratio | 0.46 |
| Delta | 0.7 |
| SD.Delta | 0.2 |
| DeltaLowerBound | 0.01 |
| DeltaUpperBound | 0.99 |
| BMSYtoB0ratio | 0.5 |
| SD.BMSYtoB0ratio | 0.285 |
| BMSYtoB0LowerBound | 0.05 |
| BMSYtoB0UpperBound | 0.95 |
| random.seed | 4989 |

Agenda Item G.3.a
Attachment 10
September 2013

# Cowcod

# Stock Assessment Review (STAR) Panel Report

**NO**AA Fisheries, Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, California, 95060

**August 5-9, 2013**

## STAR Panel Members

Tom Jagielo, Scientific and Statistical Committee, (Panel Chair)
Kevin Piner, NMFS Southwest Fisheries Science Center
Beatriz Roel, Center of Independent Experts
Yan Jiao, Center of Independent Experts

## Pacific Fishery Management Council (PFMC) Advisors

Bob Leos, California Department of Fish and Wildlife, GMT
Gerry Richter, Point Conception Groundfishermen's Association, GAP
John DeVore, Pacific Fishery Management Council

## Stock Assessment Team (STAT)

E.J. Dick, NMFS Southwest Fisheries Science Center
Alec MacCall, NMFS Southwest Fisheries Science Center

**Overview**

The Cowcod STAR Panel (Panel) met in Santa Cruz, California during 5-9 August 2013 to review a draft stock assessment of cowcod (*Sebastes levis*) in the Southern California Bight (SCB), prepared by the cowcod stock assessment team (STAT). Tom Jagielo (Panel Chair) welcomed participants, reviewed the Pacific Fishery Management Council's (PFMC) *Terms of Reference for the Groundfish Stock Assessment and Review Process*, and discussed logistics for the Panel meeting. Dr. Kevin Piner agreed to serve as rapporteur.

The draft assessment document and extensive background material (previous assessments, previous STAR Panel reports, etc.) were provided (via the PFMC FTP site) to the Panel two weeks in advance of the Panel meeting. The FTP site was also used for common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Dr. E.J. Dick led the presentation of the draft assessment document, and together with Dr. Alec MacCall presented subsequent analyses carried out during the week. For this assessment the modeled stock was restricted to the SCB as was assumed in previous assessments. Full stock assessments of cowcod were conducted in 1998 (Butler et. al. 1999), 2005 (Piner et. al. 2005), and 2007 (Dick et. al. 2007), with an update in 2009 (Dick et. al. 2009). Cowcod has been classified as an overfished stock since 2000 and has been subject to PFMC rebuilding plans since that time.

The 2013 stock assessment uses Extended Depletion-Based Stock Reduction Analysis (XDB-SRA) to estimate stock status, scale, and productivity; a Bayesian extension of DB-SRA (Dick and MacCall 2011) with all model parameters estimated in a fully Bayesian framework. The base model is fit to four time series of relative abundance (CalCOFI larval abundance survey, Sanitation District trawl surveys, NWFSC trawl survey, and NWFSC hook-and-line survey), and a single visual survey estimate of absolute abundance. A trip-based CPUE time series derived from Commercial Passenger Fishing Vessel logbook records was also evaluated but not included in the final base model.

The cowcod stock status, as indicated by the spawning stock biomass depletion ratio ($SSB_{2013}/SSB_0 = 0.34$), is more optimistic than that reported in the 2009 assessment update ($SSB_{2009}/SSB_0 = 0.045$). The principal reason for this difference in stock status is driven primarily by inclusion of fishery-independent surveys suggesting increases in stock abundance and exclusion of a fishery-dependent index (CPFV logbook) with a strong pattern of hyperdepletion.

A cowcod decision table, based on the posterior of the model and 12.5%, 50% and 87.5 % of the 2013 estimates, was recommended to represent states of nature.

The Panel concluded that this cowcod assessment was based on the best available data; the new assessment results constitute the best available information on stock status, and are suitable to serve as the basis for fishery management decisions and stock status determinations.

The Panel commends the STAT for their excellent presentations, well-written and complete documentation, their willingness to respond to the Panel's requests for additional analyses, and their dedication in finding possible solutions to difficult assessment problems. The SWFSC and PFMC staffs are thanked for arranging the meeting facilities, hotel accommodations, and the FTP site containing the background materials.

## Discussion and Additional Analyses Requested by the STAR Panel

**Request 1**: Investigate the influence of the delta model parameter prior on the model results by modeling a non-informative prior.

Rationale: To examine the influence of the delta model parameter prior.

Response: The STAT team presented models with the delta prior changed to an approximately uniform distribution. Results of the model indicated that the median of the new posterior is similar to that generated by the base model with little change in estimated dynamics. It was concluded that the prior had little effect on SSB and depletion. The STAT team proposed keeping the original prior and the STAR panel agreed.

**Request 2**: Investigate the $F_{MSY}/M$ model parameter prior by 1) using a non-informative prior, and 2) using the prior based only on Sebastes data.

Rationale: To examine the influence of the $F_{MSY}/M$ model parameter prior.

Response: The STAT team presented results of models that used 3 alternative priors: 2 versions of an uninformative prior (a uniform prior and a lognormal prior with a larger sigma) and a *Scorpaenid*-based lognormal prior. The lognormal priors allowed for smaller values but constrained the higher values of $F_{MSY}/M$ than the base prior. The uniform prior did not result in a large shift. The central tendency of the *Scorpaenid*-based prior was shifted to smaller value of $F_{MSY}/M$. Model results using all priors were slightly more depleted stock with a higher estimated M. The STAT preferred to keep the original prior and the STAR Panel agreed.

**Request 3**: Investigate the use of a more informative prior for the model parameter $B_{MSY}/B_0$ based on the life history of cowcod by modeling the data-moderate panel prior.

Rationale: To examine the impact of a more informative $B_{MSY}/B_0$ prior.

Response: The STAT team presented results of a model that changed base prior from a mean=0.5, sd=285; to a mean=0.4, sd=0.15. Results using the new prior showed that median spawning biomass and depletion levels were not greatly affected but uncertainty may be somewhat reduced. STAT team indicated that the original uniformed prior better represents our true understanding of uncertainty in productivity. STAR Panel agreed.

**Request 4**: Plot the proportion positive in the CPFV index (in log and arithmetic space), by region and year (trips with rockfish present), to see if there are spatial changes over time.

Rationale: To investigate possible hyperstability.

Response: The STAT team presented CPUE results that included only trips that caught more rockfish than all other taxa as a rocky habitat proxy (~70,000 trips). Results of standardizing the 1) n-1 cowcod filtering and 2) rockfish trips filtering is similar with a bit more hyperstability in the n-1cowcod data. STAT team also noted an unreliable drop in CPUE in 1998 and 1999 due to changing fishery behaviors. (See Request 9). The STAR Panel agreed that dropping 1998 and 1999 may be reasonable pending a new standardization.

**Request 5**: Plot the proportion positive (for the n-1 dataset) in log and arithmetic space of the cowcod-only trips in CPFV regions using the dataset in the base model index.

Rationale: To investigate possible hyperstability.

Response: The STAT provided plots of CPUE. The CPUE estimates show serial depletion based on distance from shore. The presence of serial depletion may be indicative of hyperstability in the cowcod only trips.

**Request 6**: Plot the number of CalCOFI larvae by tow and the number of tows by station using the five-year time block stratification.

Rationale: To better understand the quality of the data behind the binomial model and validate the binomial model used to represent abundance.

Response: The STAT team presented the number of larvae captured and the proportion positive by station and year. 80% of the positive stations are 1 larva and 13% are 2 larvae. The proportion of stations with positive observations are also quite low (average 1.8% positive).

**Request 7**: Profile on the q prior (range from 0.375-1.5) for the visual survey.

Rationale: To determine the influence of the estimated q for the visual survey, as a sensitivity analysis.

Response: The STAT team provided results based on alternative priors for q. When the q prior is large (i.e. 1.5), the data prefer a smaller q. When the q prior is small (i.e. 0.375), the prior and posterior are similar. The q prior affects population scale and increasing the median of q affects the model results. This was sensitivity analysis request, and did not provide a motivation to change from the historical base model prior.

**Request 8**: Provide sensitivity runs of historical catch uncertainty (recreational: pre 1981; commercial: pre 1969) by doubling and halving the catches in these years. Do these runs with and without the CPFV index included.

Rationale: To determine how historical catch uncertainty influences the production model.

Response: The STAT team provided the results of model runs that altered historical catch and either used or dropped the CPFV index. Use of the CPFV index in the model affected the scale of the population. Higher historical catches leads to higher levels of B0 and higher depletion in 2013. The converse is true for low historical catches. Changing the historical catch did not greatly affect estimates of current biomass. Use of the CPFV index has influence on depletion for higher historical catch likely due to the rejection of implausible runs at very low biomasses. It is evident that the model is sensitive to assumptions about historical catch (and inclusion of the CPFV index). These results led to Request 10 (below).

**Request 9**: Based on the findings of Request 4, continue filtering the data informing the CPFV index based on rockfish trips only (with further filtering criteria explored by the STAT) and including regions and seasons in the CPFV dataset to produce new delta GLM estimates of CPUE.

Rationale: To explore a potentially more representative CPUE dataset for cowcod.

Response: The STAT team filtered the CPFV trip logs by 1) rockfish trips (>50% rockfish), 2) the number of rockfish per angler, and 3) no-groundfish catch; to produce a new candidate dataset of rockfish trips.  The data were further subdivided by non-rockfish species thought to co-occur with cowcod (~59,000 trips). Only trips with lingcod were consistently caught with cowcod, which further reduced the number of observations (5,270 trips). This resulted in only 1088 positive cowcod trips, which was only a small fraction of the trips taking cowcod. The STAT team presented the results from a delta-GLM using the reduced dataset. The binomial portion of the index indicated a decline in the number of locations taking cowcod through time. The CPUE of the positive observations were relatively stable for the dataset. The STAT team concluded that using positive cowcod only trips likely produced a hyper-stable index. The STAT team recommends not using the CPFV index in the assessment model due to the difficulty of getting a representative subset of CPFV observations. The STAR Panel accepted this decision.

**Request 10**: Provide a table of all likelihood components for alternative historical catch scenarios.

Rationale: To get a better understanding of model fits to these alternative catch scenarios.

Response: The STAT team presented the distribution of total and component likelihoods for models fit, assuming the base level of historical catch and 0.5x and 2x levels of catch. There were essentially no differences in the fit to the data for each of the catch series indicating that the trends estimated by the model are not sensitive to the magnitude of historical catches.

**Request 11**: Examine the sensitivity to the assumption of time-lagged (i.e., knife-edge at age 11) maturity and selectivity in the base model, by using 8-year and 14-year time lags.

Rationale: To explore the sensitivity to a reasonable range of time lag assumptions.

Response: The STAT team presented SSB and depletion from models with alternative time-lagged maturity and found it did make a difference. A shorter time lag resulted in SSB that was smaller and less depleted, and the converse was true for the longer time-lag. Depletion was 39%, 33%, and 29%; for the 8 year, 11year (base), and 14 year age-at-maturity assumptions, respectively.  The STAT team recognized that the model results are sensitive to this assumption but noted that the current assumption is consistent with the available data. The STAR Panel agreed with keeping this assumption for the base model.

**Discussion**

The STAT and STAR panel discussed 1) the results presented in the draft 2013 assessment document, and 2) those that followed from the series of analyses requested (above). The STAT team recommended, and the STAR Panel agreed to, a base model that was the same as the original model except for the removal of the CPFV index. The final base model includes the following likelihood components:

1. Visual (submersible) Survey of Cowcod Conservation Area (CCA)
2. CalCOFI larval abundance index
3. NWFSC Trawl, fraction positive index.
4. NWFSC Hook and Line Survey
5. Sanitation District Trawl survey

**Request 12**: Present the new base model with a 10-year projection, assuming an annual catch of 3 mt. Provide the full diagnostics, especially the fit to the indices. Present a series of sensitivity runs with each index included as the only index in the model.

Response: The STAT team presented the runs requested. The model results appear to best fit 1) the NWFSC Trawl and 2) the NWFSC Hook and Line survey indices. Model fits to individual time series resulted in different final depletions, ranging from <25% to >40%. The catch time series appeared to determine trends prior to the 1990s.

**Description of Base Model and Alternative Models Used to Bracket Uncertainty**

The new base model for cowcod represents a move from a Stock Synthesis (SS)-based age-structured production model (Methot and Wetzel 2013) to an Extended DB-SRA (XDB-SRA) model (Dick and MacCall 2011). The STAT team reported the results of several analyses designed to provide a bridge between the previous model and the new modeling platform. The STAT team preferred the XDB-SRA modeling platform because they thought it better characterized uncertainty in productivity given the assumption of deterministic recruitment. It was the STAT team's opinion that the assumption of the Beverton-Holt spawner-recruit curve in the previous assessment overly constrained the shape of the production function. Further, the STAT team indicated there was not enough information in the compositional data to estimate year-class strength. The STAR panel had no particular preference for a modeling platform, but felt that the XDB-SRA platform was a reasonable approach given the available data.

In the new 2013 base model, the values assumed for biological parameters, and the historical catch time series (with minor changes in the recent period) were the same as those used in the 2009 stock assessment update.

<u>Indices of abundance.</u>

1. Submersible Survey of the CCA (2002). This is the same index used in the 2009 update assessment (altered to be biomass of spawners (>40cm)) which reduced the biomass estimate by 23 tons. This treatment is needed for the way the assessment treats fishable biomass (knife-edge at age 11). This is a short (one year) index.
2. CalCOFI larval abundance index (1951-2011). This was not included in the 2009 update assessment, but was included in cowcod assessments prior to the 2007 full assessment.

This is a percent positive index. This is a long time series index, but data are binned into groups of years to create positive observations in each time block.

3. NWFSC Trawl, fraction positive index (2003-2012). This is a new index for this assessment. The STAT team removed data from shallower than 100 m and deeper than 250 m and stratified into large and small size groups. Only the small fish series was included in this index. This series was lagged four years (1999-2008).
4. NWFSC Hook and Line Survey (2004-2012). This is a new index for this assessment.
5. Sanitation District Trawl survey (1972-2012). This index was not included in the 2009 update assessment, but was included in cowcod assessments prior to the 2007 full assessment. This is a proportion-positive index with a relatively long time series. Observations were binned into groups of years due to low sample sizes. Only the fourth quarter samples were used to construct the index for the LA district data.

Previous assessments of cowcod have incorporated a CPFV CPUE index. A new trip-based CPFV index was prepared and extensively evaluated in the present assessment, but was ultimately not included in the final base model. The proposed CPFV index was derived using only trips that caught cowcod as the sample frame. As an attempt to evaluate potential hyperdepletion in the previous CPFV CPUE index, the STAT team constructed several CPUE indices with alternative filtering of the input data. The STAT team identified properties of hyperstability in the new index, which were investigated by alternative data filtering to refine the definition of effective cowcod effort. The STAT team ultimately rejected this index since they were unable to resolve this concern. Model comparisons were made to examine the effect of using/omitting the CPFV index from the base model. The model was most sensitive to the inclusion of this index. The STAR Panel agreed with the STAT recommendation to remove this index.

**Comments on the Technical Merits of the Assessment**

The STAR Panel appreciated the extensive exploration of data sources and the analyses presented by the STAT team.

The original base model presented to the STAR Panel could not estimate $B_{MSY}/B_0$ well; however, the final base model resulted in a much better estimate of this parameter.

The XDB-SRA model is fully Bayesian. Given the relatively sparse data informing this assessment, a Bayesian approach allows incorporation of other sources of data in a statistically defensible framework. This approach also allows a fuller characterization of uncertainty, which was particularly useful.

**Areas of Disagreement**

There were no areas of disagreement between the STAT team and members of the STAR panel.

**Unsolved Problems and Major Uncertainties**

The major uncertainty in the stock assessment was the quality of the data used. Historically, the most influential and internally consistent index was the CPFV CPUE index, which was removed from this assessment during the course of STAR panel deliberations.

Among the remaining indices, the CalCOFI index was the most influential in the estimated rate of rebuilding, abundance, and depletion. However, this index was based on relatively few positive tows with generally one cowcod larva per tow.

The CalCOFI and sanitation survey indices had large estimated additional variances.

The base model assumed knife-edge age-at-maturity at 11 years. The model was sensitive to this assumption.

The full consequences of the time-block data binning in the base model could not be fully evaluated during the STAR panel.

Historical catch uncertainty was high and the model estimates of virgin biomass were sensitive to assumptions used in reconstructing these catches.

The abundance and dynamics of the population of cowcod outside the SCB are uncertain. This portion of the population remains unassessed.

**Concerns Raised by the GMT and GAP Advisors During the Meeting**

There were no concerns raised by the GAP advisor during the meeting.

The GMT advisor raised a concern relative to not assessing the population north of 34º27’ N lat. The GMT advisor and STAT discussed this concern to the satisfaction of the GMT advisor.

**Prioritized Research Recommendations**

1. Investigate the stock structure of cowcod in adjacent areas, especially the population in waters off Mexico.
2. Re-investigate the CPFV data to attempt to produce a CPUE time series to be used as an index of relative abundance. The CPFV data have a historical basis for inclusion and produce a time-series that has a smaller interannual variability than other indices.
3. Age-at-maturity and other life history parameters are inherently uncertain for cowcod and require further investigation. Future assessments should consider incorporating the uncertainty associated with age at 50% maturity.
4. Investigate methods to include uncertainty in historical catches in the modeling.
5. Evaluate the methods used to reconstruct historical catches of cowcod and other rockfish.
6. The STAT team expressed the most confidence in the NWFSC Hook-and-Line and visual surveys. The STAT team and STAR Panel recommend continuing these indices into the future and extending the NWFSC Hook-and-Line survey into the CCAs.
7. Priors for model parameters, based on rockfish, should be developed.

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Agenda Item G.3.a
Attachment 11 (Full Version, Electronic Only)
September 2013

# Draft

## Status of the U.S. Pacific Sanddab Resource in 2013

by

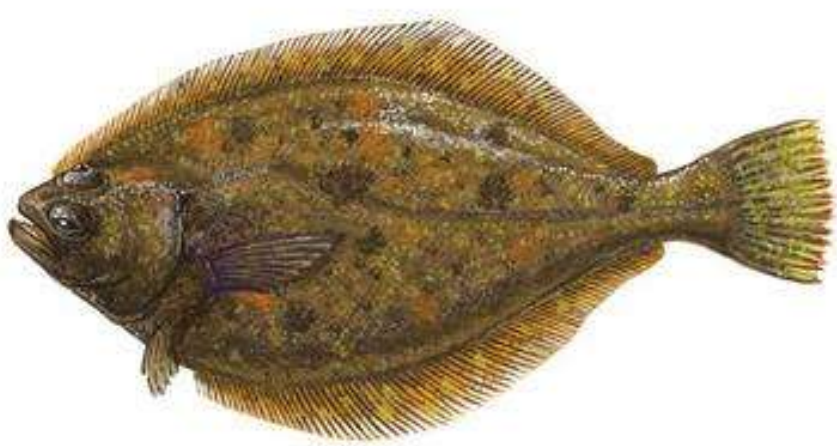
Xi He[1], Donald E. Pearson[1], John C. Field[1], Lyndsey Lefebvre[1] and Meisha Key[2]

August 2013

[1]Fisheries Ecology Division
Southwest Fisheries Science Center
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
110 Shaffer Road
Santa Cruz, CA 95060

xi.he@noaa.gov

[2]Meisha Key
California Department of Fish and Wildlife
c/o[1]



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# Table of Contents

# Executive Summary

## Stock

Pacific sanddab (*Citharichthys sordidus*) is a left-eyed flounder of the family Paralichthyidae and is widely distributed along the Pacific west coast from the Bering Sea to Cabo San Lucas, at the tip of Baja California. This assessment reports the stock status off the coast of California, Oregon, and Washington, and it is the first time that the stock is being assessed. The stock is considered a single stock as there are no genetic studies or other evidences of stock structure along the U.S. coast.

## Catches

Although Pacific sanddab has not historically been a primary target in commercial fisheries, it has been commonly caught, mostly by bottom trawl gears. The earliest reported catch was recorded in 1892. Total landings were close to 1,200mt in the late 1910s (Figure a). Landings were at relative low levels (~400mt) between the late 1930s and the early 1970s, with an increasing trend from the early 1970s to the late 1990s. Since then, landings have been declining and total landings in recent years were around 200 mt (Table a). Discards of Pacific sanddab were generally high, primarily due to its small size, but larger sanddabs are highly prized by the commercial and recreational fisheries for their excellent edibility.

Recreational landings, mostly taken by hook and line, were at the highest levels in the early 1980s (just over 20 0mt), ranging between 20 mt and 80 mt in recent years. Recreational landings averaged about 7% of total landings between 1981 and 2012, but increased to 30% in recent years (2010 to 2012 average).

**Table a. Annual total landed catches (mt) of Pacific sanddab from 2003 to 2012.**

| Year | Total landings (mt) |
|---|---|
| 2003 | 650.6 |
| 2004 | 523.2 |
| 2005 | 398.3 |
| 2006 | 440.6 |
| 2007 | 315.3 |
| 2008 | 229.1 |
| 2009 | 326.7 |
| 2010 | 198.0 |
| 2011 | 235.7 |
| 2012 | 221.8 |

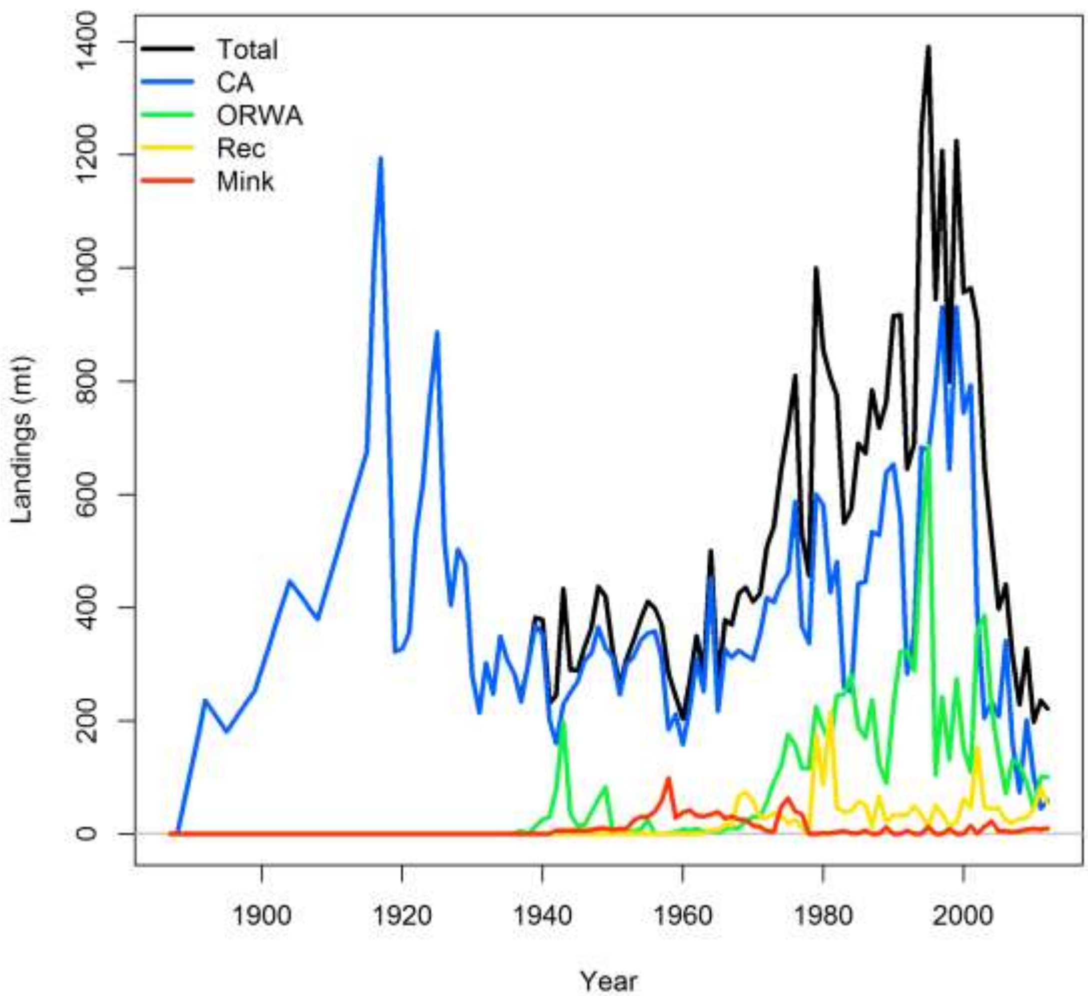


**Figure a: Time series of total landings and landings by four fleets catching Pacific sanddab from 1888 to 2012.**

## Data and assessment

This is the first time that the Pacific sanddab stock has been being assessed on the U.S. West Coast. To our knowledge, no assessments have even been conducted in Alaska, Canada and Mexico. Catch data for Pacific sanddab by various fleets were assembled from a variety of sources, including published historical catch reports, the Pacific Fisheries Information Network (PacFIN), the Recreational Fisheries Information Network (RecFIN), and most recently, from the West Coast Groundfish Observer Program (WCGOP) total mortality estimates. Survey and index data included the NWFS triennial bottom trawl survey, the NWFSC bottom trawl survey, and the California Commercial Passenger Fishing Vessels (CA CPFV) fishery CPUE index. Over 12,590 otoliths from variety of sources were aged, most of which were from the NWFSC survey, which was the most comprehensive data source for estimates of growth and relative stock abundances in recent years. Length composition data were available from all surveys and from a range of years for the two commercial trawl fisheries and the recreational fishery. Estimates of fishery discards were provided by the Pikitch study in the late 1980s, and by the WCGOP observer program in recent years.

The base case assessment model assumed the stock was in an unfished condition in 1888, and subject to exploitation by the four fisheries modeled in this assessment: two commercial trawl fisheries, one recreational fishery, and one trawl fishery for mink food. Two sexes were used in the model given evidence of sexually dimorphic growth. Key parameters, including stock-recruit steepness, virgin recruitment, growth, and natural mortality, were internally estimated. Selectivity functions for all surveys and fisheries were assumed to be asymptotic and sex-specific where size composition data were available by sex.

The assessment was conducted using the most recent version of Stock Synthesis (SS, version 3.24O, April 2013). The survey indices were derived from using R programs developed by scientists from the NWFSC and SWFSC. Graphic outputs were produced using the r4ss R programs developed by the NWFSC.

## Stock biomass

The time series of estimated spawning biomass from the base case assessment model is plotted in Figure b, along with approximate asymptotic 95% intervals. The recent trend in spawning biomass and stock depletion is presented in Table b. The stock was relatively stable until the mid-1990s, and then declined continuously through the mid-2000s, primarily due to low recruitments during the period (Figure c). The stock has been continuously increasing in recent years.

**Table b: Recent trend in beginning of the year biomass and depletion (%).**

| Year | Spawning biomass (mt) | ~95% confidence interval | Estimated Depletion (%) | ~95% confidence interval |
|---|---|---|---|---|
| 2004 | 3719 | 541-6897 | 41.5 | 24.7-58.4 |
| 2005 | 3319 | 357-6281 | 37.1 | 37.1-53.5 |
| 2006 | 3210 | 181-6239 | 35.9 | 18.2-53.5 |
| 2007 | 3281 | 0-6657 | 36.6 | 15.5-57.7 |
| 2008 | 3832 | 0-8048 | 42.8 | 15.1-70.5 |
| 2009 | 4654 | 0-9834 | 52.0 | 17.7-86.3 |
| 2010 | 5362 | 0-11286 | 59.9 | 20.8-99.0 |
| 2011 | 6277 | 0-12933 | 70.1 | 27.3-112.9 |
| 2012 | 7568 | 0-15412 | 84.5 | 34.7-134.4 |
| 2013 | 8554 | 128-16980 | 95.5 | 43.7-147.3 |

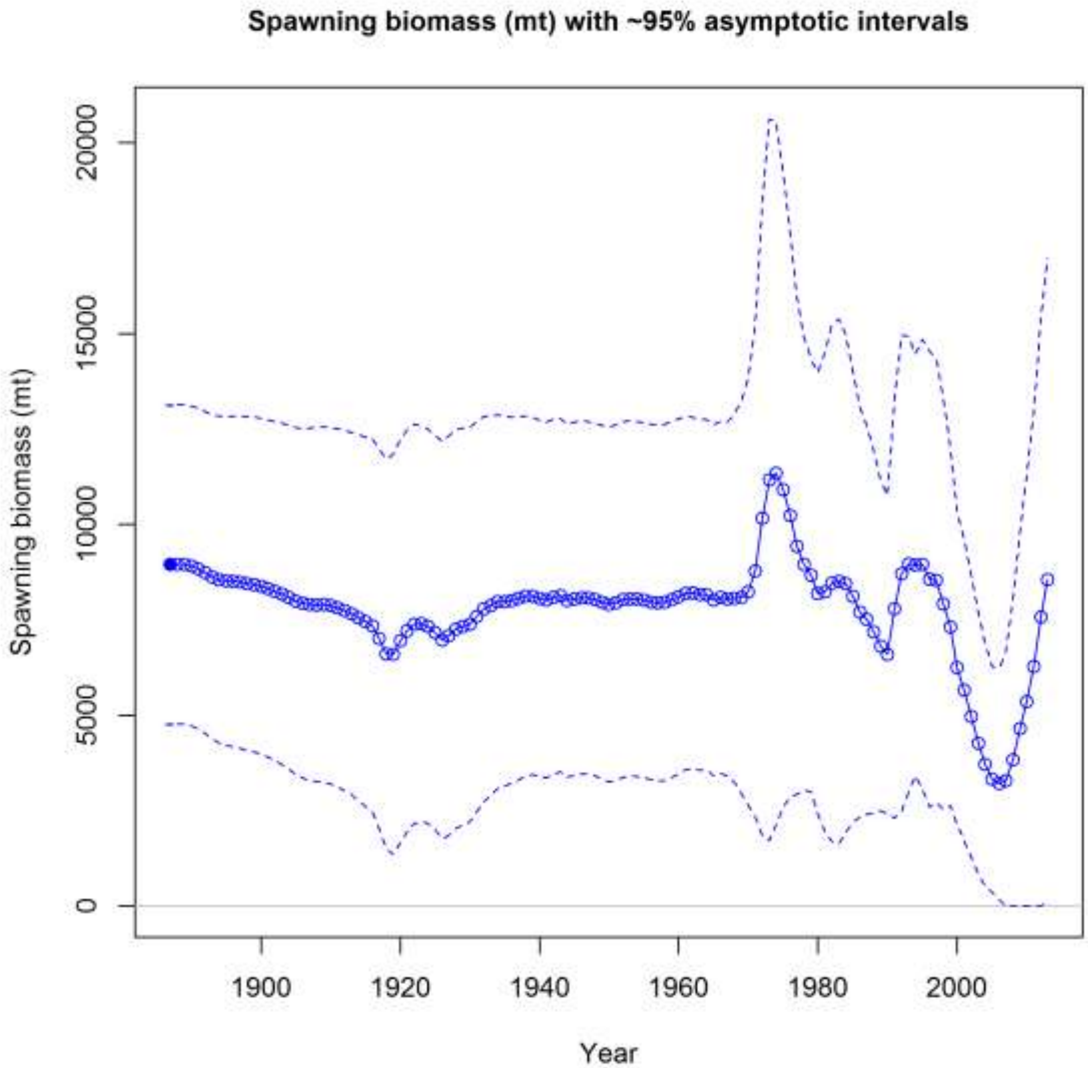


**Figure b: Estimated time series of annual spawning biomass from the base model (open circle and solid line) with approximate asymptotic 95% confidence intervals (dashed lines).**

## Recruitment

The Beverton-Holt stock recruitment function was assumed in this assessment. Both stock-recruit parameters, virgin recruitment ($R_0$) and steepness ($h$) were estimated in the model. While there was no informative prior for $R_0$, a prior for $h$ that were commonly used for flatfish species (mean = 0.80, $SD$=0.09), was used in the assessment. Annual recruitment deviations were estimated between 1966 and 2011.

Annual recruitment deviations were treated in a log-normal distribution with $\sigma_R$ fixed at 0.45. Estimated recruitments for the last 11 years (2004 to 2013), along with approximate asymptotic 95% intervals, are listed in Table c, and the annual recruitments for all years are plotted in Figure

c.  Low recruitments occurred from the early 2000s to the mid-2000s.  Recruitments in recent years have been at or above the long term average, with a strong recruitment in 2010.

**Table c.  Recent trend in recruitment.**

| Year | Estimated recruitment (1,000s) | ~95% confidence interval |
|---|---|---|
| 2004 | 130606 | 24513-695886 |
| 2005 | 137966 | 25586-743954 |
| 2006 | 236307 | 43538-1282584 |
| 2007 | 233162 | 43338-1254442 |
| 2008 | 217592 | 41261-1147488 |
| 2009 | 269346 | 51577-1406577 |
| 2010 | 421590 | 80414-2210282 |
| 2011 | 263968 | 49184-1416690 |
| 2012 | 200639 | 37343-1078010 |
| 2013 | 231713 | 43286-1240367 |

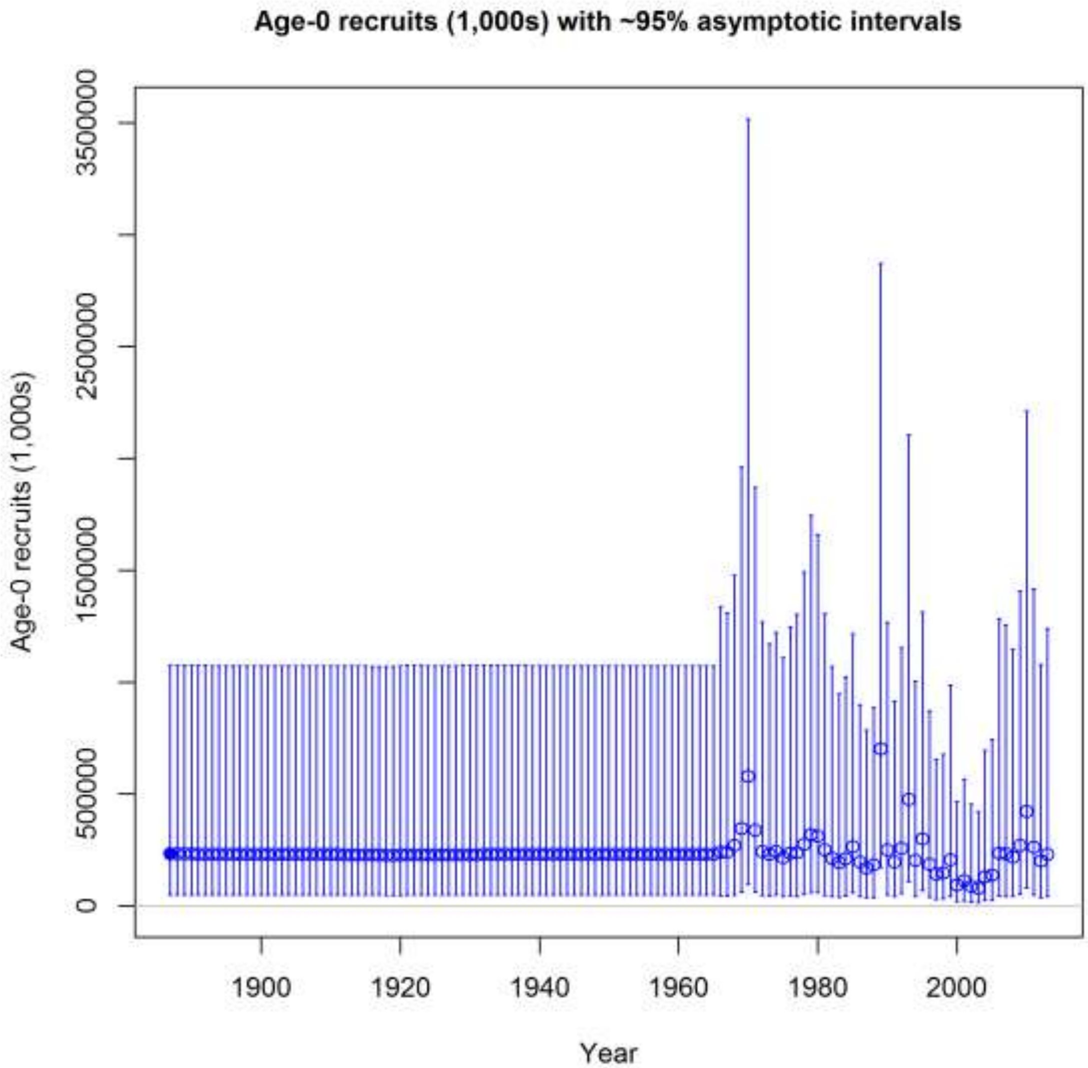


**Figure c: Estimated annual recruitment and approximate asymptotic 95% intervals from the base case assessment model, 1888-2013.**

## Exploitation status

The stock is estimated to be at 95.5% of its unfished level at the beginning of 2013 (Table b), well above the management target for flat fish of $B_{25\%}$ (Figure d). The estimated spawning potential ratio (1-SPR) was 10.4% at the beginning of 2012, and was well below the (1-SPR) target $F_{MSY}$ targe of 70% (Table d and Figure e). Proportional harvest rates were generally low (Table d).

The STAR Panel did not recommend the results from this assessment to be used for management as there exist large uncertainties in the scales of biomass estimates as compared to estimates from fishery-independent surveys (see the STAR Panel report for details). As such, no reference points will be reported in this assessment.

**Table d. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate (catch divided by biomass of age-0 and older fish)**

| Year | Estimated 1-SPR (%) | ~95% confidence interval | Harvest rate (proportion) | ~95% confidence interval |
|---|---|---|---|---|
| 2004 | 26.1 | 0-54.2 | 0.141 | 0.008-0.274 |
| 2005 | 23.2 | 0-50.1 | 0.111 | 0-0.222 |
| 2006 | 24.9 | 0-53.6 | 0.115 | 0-0.236 |
| 2007 | 22.1 | 0-49.2 | 0.080 | 0-0.175 |
| 2008 | 18.7 | 0-43.2 | 0.052 | 0-0.116 |
| 2009 | 21.6 | 0-48.6 | 0.064 | 0-0.141 |
| 2010 | 13.8 | 0-33.7 | 0.032 | 0-0.069 |
| 2011 | 12.5 | 0-30.2 | 0.028 | 0-0.061 |
| 2012 | 10.4 | 0-25.2 | 0.024 | 0-0.050 |

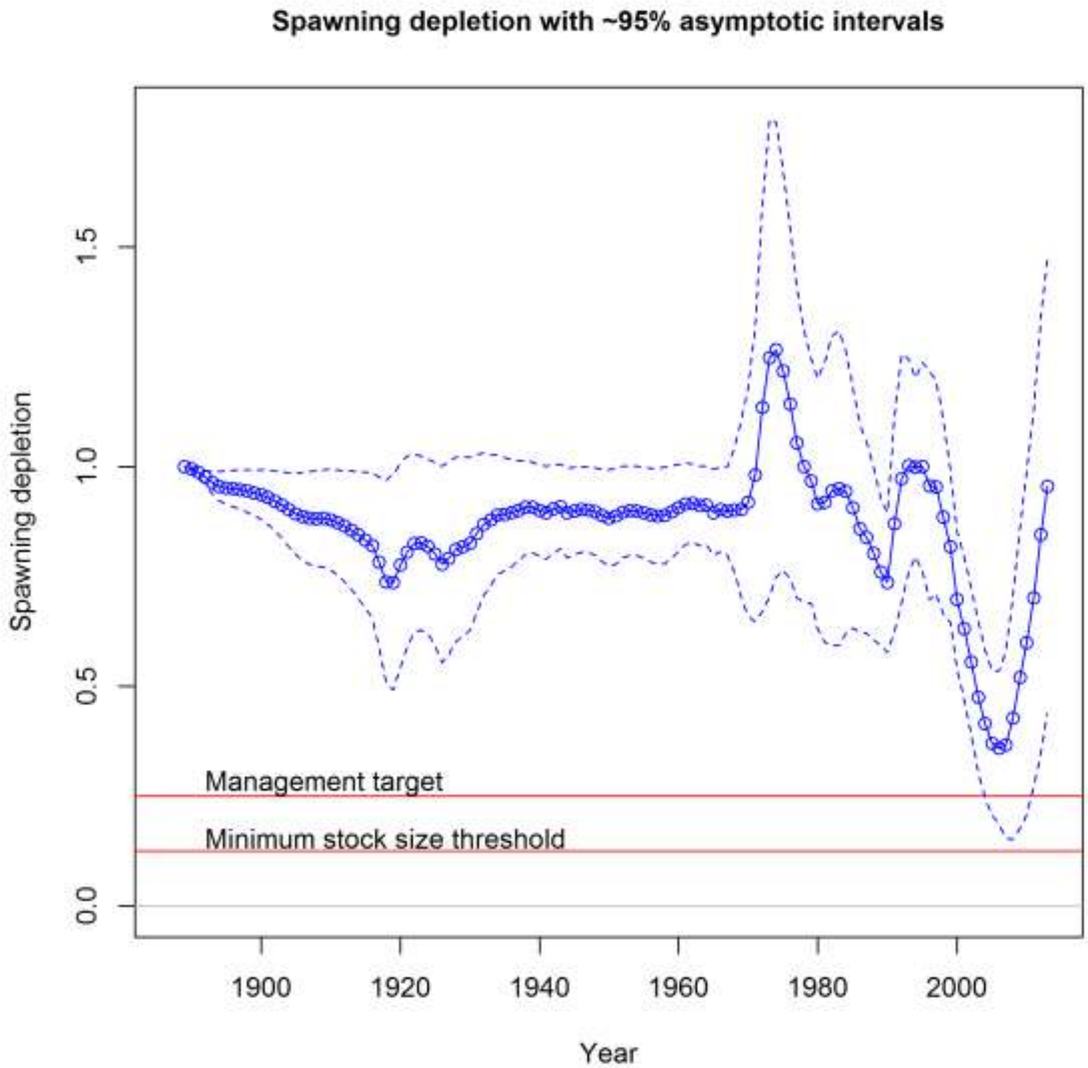


**Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.**

## Ecosystem considerations

Pacific sanddabs play an important role in trophic interactions in the continental ecosystems along the Pacific coast, primarily because it is relatively abundant, and more importantly, it serves as trophic links among low levels of invertebrate preys and high level trophic predators. Pacific sanddabs feed on variety of benthic and pelagic invertebrates, and coastal pelagic species (e.g., northern anchovies). Many piscivorous fishes, some of which are important commercial species, feed on Pacific sanddabs. Other predators include marine mammals and sea birds. The results of this assessment will provide some baseline information for future studies on trophic interactions in ecosystem research.

## Management performance

Pacific sanddabs on the west coast are managed as part of the Other Flatfish stock complex. Harvest specifications (overfishing limits (OFLs), acceptable biological catches (ABCs), and annual catch limits (ACLs)) are managed at the complex level and calculated as the sum of estimated harvest specification contributions from the component stocks, which include Pacific sanddab, rex sole, sand sole, starry flounder and four other species. Prior to 2011, the overfishing level, now called the OFL, was called the ABC and the ACL was called the optimum yield (OY). The OFLs (ABCs prior to 2011) for Pacific sanddab have been estimated using on catch-based methods. Since 2011, the method used to estimate the OFL was depletion-based stock reduction analysis (DBSRA). The ACL since 2011 was set equal to the ABC; the ABC was based on a 30.6% reduction from the OFL based on scientific uncertainty (category 3 stock with a sigma of 1.44) and the Council's tolerance of risk (overfishing probability (P*) of 0.40). From 2005-2010, the overfishing limit (then called the ABC) was based on the highest recent year (1981-2003) landed catch (1,364 mt in 1995) with an assumed discard rate of 57% based on the Oregon trawl Enhanced Data Collection Program (EDCP) study results during 1995-1997 to determine an overfishing limit of 3,172 mt (PFMC 2004). The overfishing limit contribution of Pacific sanddabs to the Other Flatfish complex was reduced by 25% to determine an annual total catch limit (then called OY) of 2,379 mt during 2005-2010 (Table f). Prior to 2005 the Other Flatfish ABC and OY (analogous to the current OFL and ACL, respectively) was 7,700 mt. The basis for these harvest specifications was not documented but is believed to have been based on average catches of the aggregate species comprising the complex in the 1970s. A contribution Pacific sanddab-based harvest specification was not calculated.

The management performance in recent years for Pacific sanddab has been good; the average 2005-2012 total annual catch has been about 23% of the ACL/OY contribution (Table f).

**Table f. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.**

| Year | OFL (mt) | ACL (mt) | Commercial Landings (mt) | Estimated Total Catch (mt) |
|---|---|---|---|---|
| 2004 | NA | NA | 456.6 | 860 |
| 2005 | 3172 | 3172 | 347.3 | 629 |
| 2006 | 3172 | 3172 | 412.5 | 666 |
| 2007 | 3172 | 3172 | 292.2 | 512 |
| 2008 | 3172 | 3172 | 196.5 | 389 |
| 2009 | 3172 | 3172 | 290.7 | 562 |
| 2010 | 3172 | 3172 | 146.3 | 322 |
| 2011 | 4943 | 3432 | 1462. | 339 |
| 2012 | 4943 | 3432 | 159.2 | 326 |
| 2013 | 4801 | 3332 | NA | NA |

## Unresolved problems and major uncertainties

Uncertainties in the model structure and parameter estimations were explored through sensitivity and profile analyses. Asymptotic confidence intervals were estimated and reported for all key parameters and management quantities. Data uncertainties included historical catches and estimates of historical discard rates of Pacific sanddab from the commercial trawl fisheries, as well as lack of length and age composition data in the early years of the fisheries.

Both the NWFSC and triennial surveys provided estimates of biomass of Pacific sanddabs. These estimates were much higher than those estimated in the assessment model. Although the catchability coefficient (*Q*) was treated as a nuisance (scalar) parameter, which is typical of most assessments, the nominal estimate for these values from the trawl surveys was very high. For example, the estimated catchability coefficient was 19.4 for the NWFSC combined shelf-slope trawl survey. Given that these surveys did not cover the entirety of suitable Pacific sanddab habitat (the survey were not conducted depths shallower than 50 m), it was expected that these catchability coefficients should be less than (or close to) one. However, it was also noted that previous nominal catchability coefficients for flatfish have varied by approximately an order of magnitude (from 0.31 for Arrowtooth flounder to 3.36 for Petrale sole, with the other three species ranging from 0.7 to 1.79, arithmetic scale). This demonstrates that uncertainties in the scales of biomass estimates relative to estimates from fishery-independent surveys are frequently high, although both the STAT and the STAR Panel agreed that the scale of the discrepancies for this species exceeded the level at which confidence in the model could be achieved. A range of factors could contribute to these uncertainties, including the assumption that all areas are suitable habitat for Pacific sanddab (untrawlable areas are likely to be less suitable) and herding effects of the trawl gear (Bryan *et al*. in review). A suite of model sensitivities suggests that tensions existed in the model between conditional age-at-length data and other composition and index data that may have constrained the total biomass by influencing model estimates of natural mortality, selectivity or other factors. However, both the STAT and the STAR Panel agreed that if the biomass levels estimated by the NWFSC trawl survey are a reasonable representation of the actual biomass of Pacific sanddabs in the ecosystem, then the impacts of both historical and contemporary catches on the stock are likely to be very minimal.

Larger Pacific sanddabs have been a desirable component of the nearshore flatfish fishery for over 100 years (CDFG 1949), and the high catches of California Pacific sanddabs in the 1910s and 1920s were consistent with high effort by trawl fisheries on other components of the nearshore assemblage (such as California halibut, starry flounder and English sole). However, the species has not always been a primary target for commercial trawl fisheries, and their relatively small sizes have long been associated with high, yet highly uncertain, discard rates. Thus, as with other stocks, there are uncertainties regarding historical catches, and particularly historical discard rates. Sensitivity analyses were conducted to assess these uncertainties.

Reliable length and age composition data for Pacific sanddab were only available in recent years, most of which came from the NWFSC survey. As these data provided critical information in the assessment model for estimating growth, natural mortality, and the stock-recruitment relationship, it is uncertain whether estimates based on recent year data represent stock dynamics in the early years. A comparison of maturity estimates from recent data with one study conducted in the 1950s suggests that the size at 50% maturity has shifted substantially (approximately 6 cm) to the left, such that a majority of 1 year old fish are reproductively active. A similar shift was documented in an assessment of English sole (Stewart 2007). Despite considerable efforts to develop comprehensive age and life history information, natural mortality remains highly uncertain, particularly as ecological theory would suggest that a small, fast growing species with a relatively high natural mortality rate is unlikely to have constant mortality across all ages. However, sensitivity to a Lorenzen natural mortality function did not improve model behavior or fits to the data.

All key parameters, including growth, mortality, and the stock recruitment relationship, were estimated in this assessment. There were uncertainties associated with this approach because of strong correlations among these parameters. This was demonstrated by large effects of priors (e.g., steepness prior) on the model outputs. A sensitivity analysis where the steepness prior was not used showed that estimated steepness was lower and that the current stock depletion would be slightly lower without the use of the steepness prior (e.g. freely estimated).

## Research and data needs

1) The proportion of the total catch of Pacific sanddab were discarded is uncertain. Discard rates varied among fisheries and states. The WCGOP has provided important information on discard rates, as well as length composition of discards in recent years. It will be important to continue to collect these data in future years. In addition, it will be helpful to record the catch of Pacific sanddab separately from other sanddab species. This is particularly informative when length composition data for both retained and discarded catches are available for the species.
2) Continue estimating catch and collecting length compositions of Pacific sanddabs in the recreational fishery. An increased sample size of length data from both retained and discarded catches from the fishery will provide more accurate information on estimates of fishery selectivity.
3) A coastwide juvenile groundfish survey data is available for most years since 2001, and has been used in assessments of other groundfish. However, sanddabs were not identified to the species level in the northern survey areas, and thus truly coast-wide data is not available for this species. Data from a more limited geographic range does not indicate a strong correlation between juvenile abundance and subsequent recruitment to the adult population, however species level data in recent years may provide useful information on the annual recruit strength and may help in estimating the stock recruitment relationship.
4) Continuations of collecting data on reproductive biology of Pacific sanddabs will provide more comprehensive data for future assessments. This is particularly important that data are to be collected from the northern area (i.e. Oregon and Washington) and from the southern California. More data from other seasons (i.e. winter months) will also provide

more complete information on spawning frequencies and spawning seasons. Consideration of the potential causes, and consequent influence on model results and dynamics, of the apparent shift in the maturity curve from maturity estimates in the 1950s would also be beneficial.

5) Stock and catch data from both Mexico and Canada have not been used in this assessment. Although there are some data and samples from the Canadian catches on Pacific sanddab, there is no information from Mexican fisheries on the species. Data gathering on the Pacific sanddab catches from Mexican waters will be useful to estimate potential impacts on the U.S. stock.
6) Pacific sanddab along the U.S. coast have been treated as a single stock in this assessment, as there is no genetic study on the stock structure of this species. Although this assumption is likely reasonable given the extended larval duration (200 to 250 days) of pelagic young-of-the-year sanddabs, genetic studies on the stock structure of Pacific sanddab could help to determine potential stock structure in future assessments.
7) The discrepancy between the survey biomass estimates and the model estimates of total biomass suggest either that the survey is dramatically overestimating total biomass for some unknown reason, or that the model us unreasonably constrained to estimating a lower biomass. Alternative sources of information, or alternative types of analyses, may shed light on both the factors that appear to drive variability in catchability for small flatfish in bottom trawl surveys would be beneficial. Alternative means of analyzing trawl survey data, or of conducting more focused surveys that could shed light on catchability issues and relative abundance and density of this species in the ecosystem, may also be beneficial.
8) Pacific sanddabs play an important role in the ecosystem, and likely experience high natural mortality rates, rates which are likely to vary both with size and age, and over space and time. A greater understanding of the appropriate mortality functions and the extent to which ecosystem changes may have altered natural mortality rates in either space or time would benefit future assessments.

**Table g. Summary table of the results from the base model.**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 456.6 | 347.3 | 412.5 | 292.2 | 196.5 | 290.7 | 146.3 | 146.2 | 159.2 | NA |
| Estimated total catch (mt) | 860 | 629 | 666 | 512 | 389 | 562 | 322 | 339 | 326 | NA |
| OFL (mt) | NA | 3172 | 3172 | 3172 | 3172 | 3172 | 3172 | 4943 | 4943 | 4801 |
| ACL (mt) | NA | 3172 | 3172 | 3172 | 3172 | 3172 | 3172 | 3432 | 3432 | 3332 |
| 1-SPR (%) | 26.1 | 23.2 | 24.9 | 22.1 | 18.7 | 21.6 | 13.8 | 12.5 | 10.4 | NA |
| Exploitation rate (catch/ age 0+ biomass) | 0.141 | 0.111 | 0.115 | 0.080 | 0.052 | 0.064 | 0.032 | 0.028 | 0.024 | NA |
| Age 0+ biomass (mt) | 11567 | 11933 | 11713 | 12059 | 12488 | 12130 | 13069 | 13244 | 13479 | NA |
| Spawning Biomass | 3719 | 3319 | 3210 | 3281 | 3832 | 4654 | 5362 | 6277 | 7568 | 8554 |
| ~95% Confidence Interval | 541-6897 | 357-6281 | 181-6239 | 0-6657 | 0-8048 | 0-9834 | 0-11286 | 0-12933 | 0-15412 | 128-16980 |
| Recruitment | 130606 | 137966 | 236307 | 233162 | 217592 | 269346 | 421590 | 263968 | 200639 | 231713 |
| ~95% Confidence Interval | 24513-695866 | 25586-743954 | 43538-1282584 | 43338-1254442 | 41261-1147488 | 51577-1406577 | 80414-2210282 | 49184-1416690 | 37343-1078010 | 43286-1240367 |
| Depletion (%) | 41.5 | 37.1 | 35.9 | 36.6 | 42.8 | 52.0 | 59.9 | 70.1 | 84.5 | 95.5 |
| ~95% Confidence Interval | 24.7-58.4 | 20.7-53.5 | 18.2-53.5 | 15.5-57.7 | 15.1-70.5 | 17.7-86.3 | 20.8-99.0 | 27.3-100.13 | 34.7-134.4 | 43.7-147.3 |

# 1 Introduction

## 1.1 Basic Information

Pacific sanddab (*Citharichthys sordidus*) is a left-eyed flounder of the family Paralichthyidae and is widely distributed along the Pacific west coast from the Bering Sea to Cabo San Lucas, at the tip of Baja California (Arora 1951, Miller and Lea 1972, Hart 1973, Rackowski and Pikitch. 1989, Kramer *et al*. 1995, Love *et al*. 2005). Early studies reported that the species is the most abundant in the north-central portion of California from Eureka to San Francisco, but were also fairly common in southern California (Rackowski and Pikitch 1989). Early studies also reported that the species is usually found at depths between 18m and 275m and most commonly found at depths between 35m and 95m (Arora 1951, Roedel 1953, Demory 1971, Miller and Lea 1972, Hart 1973). On Oregon's continental shelf, Pacific sanddab is the most abundant small flatfish on sandy-bottom in the depths between 74 and 102m (Pearcy 1978). Young Pacific sanddab (ages 0 and 1) are also found to be concentrated in the same depth range (Donohoe 2000). Pacific sanddab was also found to be relatively more abundant in shallow waters at higher latitudes (Chamberlain 1979).

Pacific sanddab are generally not considered a primary target for commercial fisheries along the U.S. west coast, but they are nevertheless highly prized by the commercial and recreational fisheries for their excellent edibility (CDFG 2001), and have long been an important component of the nearshore flatfish fishery, commanding a high price in fresh fish markets (CDFG 1949, Arora 1951). Commercial catches of Pacific sanddab were mostly from bottom trawl fisheries, and there is a long history of catches (Table 1and Figure 1). Recreational catches of Pacific sanddab are from the hook and line fishery and most of this catch is from southern California waters. Some recreational anglers target Pacific sanddab in southern California, mostly from small boats and CPFVs (CDFG 2001).

Pacific sanddabs can growth to 35cm in length. They are sexually dimorphic, with females attaining larger sizes than males. Analysis of growth rates for both sexes between the southern and northern areas (divided at the California-Oregon border at $42^{o}$ N lat.) showed no significant difference in growth rates for both sexes between the two areas (Figure 7 and also see biology section below). In this assessment, Pacific sanddabs occurring in all waters off the U.S. west coast was treated as a single stock.

There are no genetic or tagging studies informing stock structure of Pacific sanddab along the U.S. Pacific coast. Bottom trawl surveys in recent years (both NWFSC and triennial surveys) showed that Pacific sanddab are commonly caught along the coastal areas of all U.S. waters (Figure 2 to Figure 5). Recent fishery observer data also showed a similar pattern (Figure 6).

Pacific sanddabs play an important role in the coastal ecosystems in the U.S. waters, particularly because they are a relatively abundant species and are important prey items to a wide range of marine predators, including piscivorous fishes, sea mammals, and sea birds (Field *et al*. 2006, Levin *et al*. 2006).

## 1.2 Map

This assessment is for Pacific sanddab occurring in U.S. waters off California, Oregon, and Washington. Maps depicting the distribution of two scientific surveys (the NWFSC survey and the triennial survey) are shown in Figure 2 to Figure 5. Two commercial fisheries (the California fishery and Oregon/Washington fishery) were modeled separately south and north of the California-Oregon border at $42^{o}$ N lat., which allowed easy fishery data summaries for the assessment and for accessing state fishery regulations on the fisheries. Spatial distributions of commercial fishery catches of Pacific sanddab in recent years are based on WCGOP observations. A map depicting relative commercial trawl catch rates of Pacific sanddab by latitude and depth is provided by the NWFSC (Figure 6, provided by Ian Taylor, NWFSC).

## 1.3 Life History

Pacific sanddabs can attain lengths of 35 cm and weights of 0.9 kg (Arora 1951), though most are less than 25 cm and 0.2 kg (CDFG 2001). They are sexually dimorphic, with females attaining larger sizes than males (Arora 1951; Appendix B). Females are reported to live up to 12 to 13 years with very few individuals being older than 11 years old (Arora 1951, recent aging data). Maximum age of males is one or two years less than females. An early study showed that about 50% of female Pacific sanddabs mature at a length of about 19cm (about 3 years old) in California (Arora 1951). However, recent studies indicate that fish mature at smaller sizes (details in Biology section).

While Pacific sanddabs have been reported to depths of 275 m, they are most frequently found in sandy-bottomed continental shelf waters shallower than 100 m (Arora 1951, Pearcy and Hancock 1978). Pacific sanddabs are benthic dwellers but are also found pelagically; adults are frequently collected in mid-water trawl surveys (Pearcy and Hancock 1978; Sakuma, pers. comm.). Pacific sanddabs primarily feed pelagically on crustaceans (euphausiids, copepods, cumaceans), cephalopods, and small fishes (larval and adult northern anchovy and other small fishes [Pearcy and Hancock 1978, Rackowski 1989]). In turn pelagic larval sanddabs are consumed by commercially important fish species such as tuna and salmon (Horn 1980, Rackowski 1989). Pacific sanddabs are likely an important forage species of fishes and sea birds as juveniles and adults due to their size, prevalence, and propensity to occupy pelagic waters.

Early reproductive studies showed that Pacific sanddab caught off central California spawn between June and September, with peak activity in August, and suggested individual females spawn multiple times a year (Arora 1951, Chamberlain 1979). A recent field study conducted in the same region showed that spawning extends into the fall and early winter and confirmed that individuals spawn multiple times a year (Appendix B). The spawning season appears to occur later with increasing latitude. Barss (1976) noted that Pacific sanddab spawn in summer off Oregon, while Ureña (1989) suggested spawning in the same region extended from late summer to early spring. In Puget Sound spawning was reported to occur from February through May (Barss 1976).

A study on the reproductive biology of Pacific sanddabs based on samples collected from the Monterey Bay area was conducted by the Fisheries Ecology Division of the SWFSC in 2012 and 2013 (Appendix B). The study showed that Pacific sanddabs are capable of spawning multiple times in a spawning season, and the spawning season may last from July through January. On average, captive female Pacific sanddabs had a spawning frequency of 1.6 days and were capable of spawning on successive days. Initial batch fecundity estimates from wild-caught female sanddabs ranged from 810 to 17,400 (mean = 6,350) eggs released per spawn. Batch fecundity increased linearly with length; however, relative batch fecundity showed no significant relationship with length. The study also showed that Pacific sanddab mature at smaller sizes (50% maturity at a length of 13cm) than those estimated by Arora (1951) from the same area.

Pacific sanddabs are oviparous broadcast spawners. Fertilized eggs are transparent and small (0.78-0.84 mm), and newly hatched larvae are transparent or nearly so (Moser and Sumida 1996). Eggs and larvae drift with currents. Larvae may be found many miles from shore (Barss 1976) but are most abundant in nearshore bongo (Moser *et al*. 2001, Brodeur *et al*. 2008) and midwater trawl (Ureña 1989) collections. Eye migration initiates at 16-25 mm standard length (SL), and the entire metamorphosis process takes up to 5 months (Donohoe 2000). The larval and metamorphic-stage duration is long (up to 271 days), and Pacific sanddabs settle at sizes as large as 39 mm SL (Sakuma and Larson 1995; Donohoe 2000). Abundance patterns of Pacific sanddabs at various stages of eye migration and metamorphosis suggest the process of settlement is gradual. Individuals collected over the mid-continental shelf at depths of 50-99 m were older relative to fish collected on the upper continental and outer shelf (Donohoe 2000). Sakuma and Larson (1995) found that, while there was generally an even distribution of the various metamorphic stages, the number of small fish decreased with depth.

## 1.4 Ecosystem Considerations

Pacific sanddabs are a relatively abundant species in the coastal environment, particularly in shelf waters between approximately 30 and 150 m depth. As such, they represent a substantial fraction of the standing biomass, particularly that of smaller individuals, and play an important role in food web interactions, particularly as a prey item to a wide range of higher trophic level predators, including piscivorous fishes, sea birds, and sea mammals. As a smaller, rapidly growing and early maturing species, Pacific sanddabs can best be characterized as having a relatively low vulnerability to overfishing (Cope et al. 2011), and trends of increased abundance in recent decades would be consistent with the characterization of ecosystem trends in the California Current as favoring smaller, more high turnover species, particularly flatfish, (Levin et al. 2006). For example, the latter manuscript described a decline in the average weight of flatfish over time, such that the average flatfish caught in 2001 had only 57% of the weight of the average flatfish caught in 1980. Moreover, Levin *et al*. (2006) also characterized an inverse relationship of trends in population density and length at maturity, such that species with smaller lengths at maturity tended to exhibit population increases while larger species exhibited declines.

Ecosystem models also suggest that as larger, piscivorous fishes decline in response to fishing, smaller species that tend to be prey items for larger species are likely to either increase or remain at relatively high abundance levels even in the face of substantial fishing mortality. In a model of the Northern California Current ecosystem, Field *et al*. (2006) found that stronger food web interactions could be observed in commercially important species such as shrimp and small flatfish (including sanddabs, English sole, and rex sole), where increases in abundance appeared to be associated with declines in predation mortality as many of their key predators experienced population declines in response to fishing. Kaplan et al. (2012) found similar results, in exploring alternative fishing scenarios they found that those scenarios with strong increases in fishing mortality on all exploited groups led to increased abundance of many of the smaller bodied prey groups, such as small flatfish. Although both models included “small flatfish” as an aggregate of multiple species, the general result is robust and illustrates that the a priori assumption for this species is that declines in predators in response to fishing should have decreased natural mortality rates to some extent and could have led to increased population productivity even in the face of higher fishing mortality. To consider these potential factors more closely, a comprehensive literature search of the role of this species in the food web was undertaken, with particular emphasis on known or likely predators and the likely relative predation pressure that might be associated with each.

With respect to their foraging behavior and prey selectivity, Pacific sanddabs in general are known to forage largely (but not exclusively) on pelagic prey items. Kravitz et al. (1977) evaluated the feeding habits of five species of flatfish on the Oregon shelf, and found that Pacific sanddabs fed heavily on northern anchovies, euphausiids, shrimps, amphipods and crab larvae. Pearcy and Handcock (1978) assessed the food habits of slender sole and Pacific sanddab, both of which they characterized as chiefly pelagic feeders. Pacific sanddabs specifically fed on about

75% euphausiids and calanoid copepods, 7% polychaetes, and trace amounts of mollusks, echinoderms and other (principally benthic) taxa. Wakefield (1984) also reports on diet data for Pacific and speckled sanddabs, although limited to a small number of samples (33), a more diverse prey base was described, principally mysids, euphpausiids, and other crustaceans, but including modest amounts of cephalopods, gelatinous zooplankton, sculpins and poachers, tomcod, butter sole and other pleuronectids (presumably juvenile stages of most of these).

The known and suspected predators of Pacific sanddabs (and sanddabs more generally, where not identifiable to the species level) are many, and varied. Large flatfish, skates, other piscivorous fishes and marine mammals (particularly nearshore pinnipeds) are likely among the greatest sources of mortality, particularly for larger individuals, while pelagic young-of-the-year and recently settled individuals are also important prey for pelagic predators such as salmon, Pacific hake, rockfish and seabirds.

With respect to salmon as predators, Merkel (1957) found that Chinook off of central California fed primarily on anchovy and other forage fish, juvenile rockfish, and euphausiids, with sanddabs (not identified to species) present in very modest amounts (10, out of over 2500 fishes identified to species or genus). The size range in this study was 2.5 to 5 cm, suggesting that most were pelagic young-of-year. Other salmon food habits studies have similarly found trace amounts of either sanddabs or small flatfish (Silliman 1941, Brodeur et al 1987, Brodeur and Pearcy 1990), however we suspect that these pelagic predators are typically feeding on pelagic young-of-the-year. Pacific hake is another pelagic predator that feeds primarily on krill and small forage fishes, but occasionally on small flatfishes and other prey. Approximately 2% of the diet by weight is estimated to be small flatfish in the AFSC food habits database (which contains data on over 10,000 hake stomachs); most could not be identified to the species level, although Pacific sanddab accounted for over half of those that could. Gotschall (1969) also found Pacific sanddab to be among the most frequently occurring fishes in over 500 hake stomachs (from northern California shrimping grounds). Size data aggregated into all flatfish show that Pacific hake largely prey on flatfish smaller than 14 cm in length, and very infrequently on flatfish from 14 to 27 cm; consequently most predation is again likely to be on age 0 or age 1 Pacific sanddabs, although they clearly feed on Pacific sanddabs larger than pelagic young-of-the-year. Given the large biomass of Pacific hake, this could translate into non-trivial amounts of predation, although predation on fish greater than two years of age is likely to be minimal. Finally, Humboldt squid (*Dosidicus gigas*), a typically subtropical predator that was highly abundant in California Current waters from 2003 through 2009, were observed to have fed on Pacific sanddab, which were present in nearly 2% of Humboldt squid stomachs examined during 2005 and 2006, ranging in size from 13 to 23 cm fork length (Field *et al*. 2007).

Most large flatfish have been documented predators of Pacific sanddab (or sanddab species more generally). Orcutt (1950) describes the food habits of starry flounder (*Platichthysstellatus*) as primarily benthic invertebrates such as amphipods (and other crustaceans), mollusks (primarily bivalves) and echinoderms, but noted that larger (>300 mm) starry flounder would also prey on fishes, including Pacific sanddabs. As starry flounder tend to have a relatively shallow distribution (typically found within 80 m depth) and can achieve large sizes (up to 900 mm), they likely represent a potentially respectable source of predation for Pacific sanddabs as well. California halibut (*Paralichthy scalifornicus*) are among the most abundant, commercially important large flatfish in nearshore California waters, where they are the target of significant trawl, hook and line and (historically) gillnet fisheries. Adults feed primarily on fishes, with most studies showing northern anchovy to be the most important prey species, but including numerous species of croakers, turbots, Pacific hake, rockfish, perches, and sanddabs. In none of the studies reviewed by Allen (1990) were sanddabs a major component, but they were a non-trivial component in many of the studies cited. Arrowtooth flounder are a large, piscivorous northern flatfish that are likely one of the most significant predators in northern waters. Gotschall (1969) examined over 400 Arrowtooth flounder stomachs in the mid-1960s , collected from northern California shrimping grounds, and found that while crustaceans (primarily ocean shrimp and krill) were among the most important prey, fishes were also important prey and Pacific sanddabs were the most numerous of the ten species of fish encountered (followed by slender sole and rex sole). Wakefield (1990) also found that rock sole fed on a substantial proportion of sanddabs (nearly 25%) as well as other pleuronectids.

Other more benthic oriented predators include Pacific sablefish (*Anoplopoma fimbria* ), another abundant groundfish species that may prey fairly frequently on Pacific sanddab, particularly younger, smaller individuals in the shallower depth strata (in deeper depth strata, overlap is minimal). Buckley *et al*. (1999) found that Pacific sanddab occurred with modest frequency in the stomachs of sablefish caught in shallower depths, but were among one of the most important prey by weight, while Laidig *et al*. (1997) found no evidence of predation on Pacific sanddabs in a comparably sized study (albeit one that focused on animals captured from greater depths, where spatial overlap was minimal). Lingcod (*Ophiodon elongatus*) are another abundant, piscivorous predator whose range overlaps considerably more with Pacific sanddabs. Steiner (1979) evaluated food habits from 148 lingcod (over four seasons) caught at neritic reefs (typically 20 to 50 m depth) off of the central Oregon coast, and found a wide range of prey items, which included approximately 2.2% unidentified pleuronectids and 1.2% sanddabs (along with respectable numbers of other flatfishes identified to species). Wakefield (1984) described the diets of four lingcod caught off of Newport, Oregon as consisting entirely of pleuronectids (21% sanddabs, 4% unidentified pleuronectids) and unidentified fishes (75%).

Finally, skates also represent a substantial source of predation mortality for Pacific sanddabs. Wakefield (1984) reported on the stomach contents of several *Raja* species caught in nearshore waters off of central Oregon in 1979 (n=51, most *R. Binoculata*). Benthic shrimp (mostly crangonid species) were the most important prey, however Pacific and speckled sanddabs (*Citharichthys* spp.) were amongst the most important fish prey, making up an average of more than 10% of all prey over all species. Other small flatfish (including rex, butter and English sole) were also important prey. Robinson (2007) examined longnose skate food habits off of central California (over 600 stomachs) and found that Pacific sanddabs were the third most frequently encountered fish (after shortbelly rockfish and unidentified rockfish), with fishes in turn representing the majority of prey items by percent weight and percent frequency of occurrence. Given that those samples were collected at depths ranging from 15 to >500 m, such that perhaps half of the total samples were collected outside of the range of sanddabs, it seems clear that longnose (and other) skate species are likely among the more important sanddab predators.

Many breeding seabirds in the California Current specialize on juvenile (young-of-year) groundfish during the breeding season, and although juvenile rockfish are typically among the more important prey items (Ainley and Boekelheide 1990), pigeon guillemots appear to be a sanddab specialist, with as much as 50 to 60% of observed prey items described as either Pacific or speckled sanddabs in some studies (Robinette *et al*. 2007), and Brandts cormorants are frequent predators of Pacific sanddabs as well (Ainley and Boekelheide 1990). Sea lions in central California also preyed on Pacific sanddabs. Although coastal pelagic species (Pacific sardine, northern anchovy and market squid) and other groundfish (particularly rockfish and Pacific hake) were of considerably greater importance, Weise and Harvey (2008) estimated that California sea lions consumed on the order of 150 to 175 tons of Pacific sanddab in 1998 and 1999, comparable to commercial fisheries landings during this same time period and region.

Although there appear to be relatively few "specialists" on Pacific sanddab (with the likely exception of Pigeon Guillemots), the relative importance of this species as prey for such a wide range of both commercially and ecologically important species suggests that they represent an important source of energy transfer from lower to higher tropic levels. As such, their role in the ecosystem may be worth greater consideration with respect to management practices and target biomass levels, as the current "target" biomass of 25% of the unfished level could represent a non-trivial impact on the availability of Pacific sanddabs for predators. Recent empirical and simulation studies (Cury et al., Smith et al. Kaplan et al. 2013) have indicated that the impacts of fisheries removals on predators and other components of the ecosystem are likely to be relatively modest when populations are reduced to roughly half of their unfished or unexploited level, but become increasingly severe as populations are reduced to below 20 to 30% of the unfished level, levels that correspond with the current proxy targets for flatfish biomass. The recent flatfish proxy harvest levels were not developed in recognition of such considerations, however such considerations could be germane to management, particularly for flatfish species that have been shown to have numerous food web interactions. Although there are no signs that Pacific sanddabs have historically experienced such high exploitation rates, and no expectation of such impacts in the immediate future based on the constraints and effort levels of current fisheries, such factors might be relevant to future management decisions and analyses.

## 1.5 Fishery Information

There is a long history of commercial catches on Pacific sanddab (CDFG 1949, Barss 1976). Sette and Fiedler (1928) reported that landings of flatfish in California waters were first reported in 1892. The first available landing of Pacific sanddab in Oregon waters was in 1942 (Gertseva *et al*. 2010, Karnowski *et al*. 2012). There were also commercial catches for mink foods in both California and Oregon waters in the 1950s and 1960s (Best 1959 and 1961, Nitsos and Reed 1965). Reported total catches of Pacific sanddab were high in the late 1920s. And there was an increasing trend from the 1960s and reached the highest catch level in the late 1990s (Figure 1). Discards of Pacific sanddab in commercial trawl fisheries were high, primarily due to its small size (Sampson 2002, John Wallace, NWFSC, personal communication). Catches of the species in recent years were in the range of 200 mt and 400 mt. In this assessment, four fishing fleets were defined and modeled: (1) the California trawl fishery; (2) the combined Oregon and Washington trawl fishery; (3) the mink food fishery, and (4) the recreational fishery. Detailed definitions and descriptions for each fishery are described in the fishery-dependent data section.

## 1.6 Management History and Performance

Pacific sanddabs have been under federal management since the implementation of the groundfish FMP in 1982 and managed within the Other Flatfish complex of unassessed flatfish species. Harvest specifications (overfishing limits (OFLs), acceptable biological catches (ABCs), and annual catch limits (ACLs)) are managed at the complex level and calculated as the sum of estimated harvest specification contributions from component stocks such as Pacific sanddab. Prior to 2011, the overfishing level, now called the OFL, was called the ABC and the ACL was called the optimum yield (OY). The OFLs (ABCs prior to 2011) for Pacific sanddab have been estimated using on catch-based methods. Since 2011, the method used to estimate the OFL was depletion-based stock reduction analysis (DBSRA). The ACL since 2011 was set equal to the ABC; the ABC was based on a 30.6% reduction from the OFL based on scientific uncertainty (category 3 stock with a sigma of 1.44) and the Council's tolerance of risk (overfishing probability (P*) of 0.40). From 2005-2010, the overfishing limit (then called the ABC) was based on the highest recent year (1981-2003) landed catch (1,364 mt in 1995) with an assumed discard rate of 57% based on the Oregon trawl Enhanced Data Collection Program (EDCP) study results during 1995-1997 to determine an overfishing limit of 3,172 mt (PFMC 2004 ). The overfishing limit contribution of Pacific sanddabs to the Other Flatfish complex was reduced by 25% to determine an annual total catch limit (then called OY) of 2,379 mt during 2005-2010 (Table 1). Prior to 2005 the other flatfish ABC and OY (analogous to the current OFL and ACL, respectively) was 7,700 mt. The basis for these harvest specifications was not documented but is believed to have been based on average catches of the aggregate species comprising the complex in the 1970s. A contribution Pacific sanddab-based harvest specification was not calculated until 2005.

The management performance in recent years for Pacific sanddab has been good; the average 2005-2012 total annual catch has been about 23% of the ACL/OY contribution (Table 2).

Appendix A details the history of management measures pertinent to Pacific sanddabs.

### 1.7 Fisheries off Canada, Alaska, and Mexico

Although Pacific sanddab are widely distributed from the Bering Sea to Baja California, there have been no records that Pacific sanddab have been assessed in waters off Alaska, Canada and Mexico. Data reports of the AFSC on bottom trawl surveys in the Gulf of Alaska indicate encounters of Pacific sanddab, but no abundance or biomass estimates were reported, indicating only a few individual fish being caught by the surveys (von Szalay *et al*. 2010, Tom Wilderbuer, AFSC, personal communication).

In Canada, annual total catches ranged between 4.3mt to 101.1mt between 1996 and 2012 (Table 2, Kate Rutherford, Fisheries and Oceans Canada, personal communication). However, most catches were discarded. Discard rates were very high, with nearly all catches being discarded before 2001, and close to 70% of the total catch being discarded in recent years.

There is no published information on Pacific sanddab fishery in Mexico. A Google search shows that there are some recreational fishery catches in the Mexican waters.

## 2 Assessment

### 2.1 Data

Summary of data sources and time periods of each data set are presented in Figure 8. Brief descriptions of each data set follow:

1) Fishery independent survey data from both the NMFS triennial bottom trawl survey (1980 to 2004) and recent years of the NWFSC bottom trawl survey (2003 to 2012). The triennial survey data provided indices of abundance, length composition data by sex, and spatial distributions of survey catches. The NWFSC survey provided indices of abundance, length composition data, age-at-length composition data, estimates of growth, and spatial distribution of survey catches.
2) Biological data, including estimates of maturity and fecundity, were taken from recent field samplings in the Monterey Bay area (full report in Appendix B).
3) Aging data were obtained from examining otoliths from the NWFSC survey and commercial trawl fisheries. A total of 12,590 otoliths were aged between 1995 and 2012.
4) Historical commercial landings from both Oregon and California waters were provided by the Oregon and California data projects. Some records for early years were directly taken from published literature.
5) Recent commercial landings from all states were downloaded from the PacFIN database and from the WCGOP.

6) Estimates of discard rates in Oregon Fisheries are obtained from the Pikitch study for the years 1985 to 1987. Estimates of discard rates of commercial fisheries from recent years are used from the WCGOP. Limited length composition data were also provided by both data sets.
7) Recent recreational catches from California and Oregon were downloaded from the RecFIN database. Recent recreational catch estimates were provided by the Washington Department of Fish and Wildlife. Discard rates and discard length composition data from the California recreational fisheries were estimated from the California CPFV (Commercial Passenger Fishing Vessels) survey. Historical recreational landings were obtained from the estimates of the CPFV data base.

### 2.1.1 Fishery Independent Survey

#### 2.1.1.1 NWFSC Survey

The NWFSC survey is an ongoing bottom trawl survey, and has been conducted by the Northwest Fisheries Science Center since 2003. This survey provided the most comprehensive data for this assessment, including estimated annual biomass, age and length frequency data, and spatial distribution of the species. Age and length data were used to construct annual age-at-length matrixes in the assessment, which enabled the assessment model to internally estimate growth for both sexes of Pacific sanddab.

The survey is based on a random-grid design and it covers the coastal waters from California to Washington (Keller *et al*. 2007); survey trawls were deployed in the depth ranges between 55 m and 1,271 m (Figure 2 and Figure 3). Initial analysis of the survey data indicated that Pacific sanddab were rarely caught at depths greater than 250m (Table 4). Therefore, all data from depths greater than 250m were excluded from the catch rate analysis.

Figure 9 and Figure 10 show the proportions of positive hauls and the catch rates of positive hauls of the survey by latitude and by depth, respectively. Proportions of positive tows by latitude showed a slightly decreasing trend from south to north, ranging from close to 90% in the southern area to about 40% in the northern area (top panel, Figure 9). However, there was no trend in catch rates of positive tows between the northern and southern areas (bottom panel, Figure 9). Proportions of positive tows by depth showed a decreasing trend (top panel, Figure 10). There were no large differences of catch rates of positive tows by depth (bottom panel, Figure 10).

Boxplots of length and age data from the NWFSC survey were used to depict mean lengths and ages by sex and their variance along gradients of latitude and depth (Figure 11 to Figure 14). In general, plots showed that mean lengths (Figure 11) and mean ages (Figure 13) of both sexes tend to be slightly higher in the northern area ($41^{o}$ N lat.) than those in the southern area. There were no such trends in mean lengths (Figure 12) and mean ages (Figure 14) along the depth gradient.

Length composition data by sex from the NWFSC survey from 2003 to 2012 are shown in Figure 15, and conditional age-at-length for both sexes from 2003 to 2012 are depicted in Figure 16 and Figure 17, respectively. Annual numbers of length measurements and fish aged by sex, and percentages of length measurements and fish aged are listed in Table 5 and Table 6, respectively. Annual numbers of trawl hauls were used as initial sample sizes for both length and age composition data.

Estimates of Pacific sanddab biomass from the NWFSC survey were developed using a GLMM model developed by NWFSC scientists (Thorson *et al*. 2011, Thorson *et al*. 2012, Thorson and Ward, in press). The model has being commonly used in many stock assessment models, including those used in the current stock assessment cycle. In the analysis, numbers of iterations of MCMC simulation were compared, and it was found that one million MCMC iteration (with six parallel chains) was generally sufficient as its outputs were comparable to those from a larger number of MCMC iterations (e.g., 2 million and 5 million). The thinning factor in MCMC simulations was set to be between 500 and 1000 with the half of iterations treated as burn-in runs. Estimated biomass using these survey data for years between 2002 and 2012 are listed in Table 7, and plotted in Figure 18 along with their standard deviations.

#### 2.1.1.2 Triennial Survey

The triennial survey, which also used bottom trawl gears, was conducted by the Alaska Fisheries Science Center (AFSC) between 1977 and 2001, and by the Northwest Fisheries Science Center (NWFSC) in 2004. Detailed survey methods and sampling designs were described in Dark and Wilkins (1994) and Weinberg *et al*. (2002). All of the trawls were conducted between early summer through early fall, but actual survey timing changed slightly over time. The 1977 data were not used in this assessment mainly because the minimum trawl depth of 91 m differed from all other survey years, which had minimum depths of 55 m. Water hauls identified from the survey (Zimmermann *et al*., 2001, Zimmermann *et al*. 2003) and those hauls conducted in Canadian waters were excluded from the analysis Exclusion of the 1977 data from the analysis, as well as data from water hauls and from Canadian waters, has been common practice in stock assessments that used the triennial survey data (He *et al*. 2011, Hicks and Wetzel 2011, Haltuch *et al*. 2013).

Figure 4 and Figure 5 show spatial distributions of catch rates of Pacific sanddab in Washington, Oregon, and California waters from this survey. These data indicate Pacific sanddab are widely distributed along the U.S. west coast. Proportions of positive hauls and the catch rates of positive hauls were not significantly different along the U.S. west coast (Figure 19). Summary statistics of haul catch data by three depth zones (<=150 m, 150-250 m, and >250 m) showed that proportions of positive hauls and catch rates of positive hauls decreased dramatically as depths increased (Figure 20), and that Pacific sanddab were rarely caught in depths greater than 250m (Table 8 and Figure 20). Like the NWFSC survey, all hauls from depths greater than 250m from the survey were excluded from catch rate analysis.

Box plots of length data from the triennial survey were used to depict mean lengths by sex and their variance along gradients of latitude and depth (Figure 21 and Figure 22). The plots showed that mean lengths of both sexes tend to be slightly higher in high latitudes than those in low latitudes. There were no such trends in mean lengths along the depth gradient. Both trends were similar to those from the NWFSC survey.

The survey data from the entire time period (1980-2004) was stratified into two time periods (1980 to 1992, and 1994 to 2004) in many recent stock assessments (Stewart 2007). Splitting the triennial survey time series into two-time periods has been commonly used for flatfish assessments, such as in the petrale sole (*Eopsetta jordani*) stock assessment (Haltuch *et al*. 2013), and the Dover sole (*Microstomus pacificus*) stock assessment (Hicks and Wetzel 2011). This stratification was done because the survey timing changed seasonally mid-July to late September between 1980 and 1992, to the May to July period between 1994 and 2004 (Figure 23). This change of survey time may affect the availability of species being assessed. Initial analysis to assess the effects of survey time period on survey indices and assessment results was conducted and it showed that the survey time period had minimal effects on the survey indices on estimated Pacific sanddab abundance (Figure 24), with very similar time series of abundance indices from using one-time period or using two-time periods. However, the estimated index CVs were different, with larger CVs from using two-time periods than those using one-time period. This was expected as splitting the survey creates two short time series and abundance trends are informed by less data. Further analysis regarding the use of one or two time series during model development indicated there were large effects on stability of the stock assessment models. In particular, estimated catchability coefficients (*Q*) and added survey CVs were very different between time periods. Treating the survey as two separated time series resulted in much a more stable model, with slightly better fits of survey data to assessment models. Therefore, the survey was modeled as two independent time series, with the early year period (1980 to 1992), labeled as "TriEarlyYr" and late year time period (1995 to 2004), labeled as "TriLateYr". A sensitivity analysis using one-time period of the triennial survey was also conducted to compare the assessment results between these two approaches.

Length frequency distributions of the triennial survey data by year and by sex are plotted in Figure 25. The plots showed that there were generally smaller fish for both sexes in the later years than in the early years. However, no statistical tests were conducted to show that these patterns were significantly different, or that these patterns resulted from different recruitments during these two time periods. Summaries of numbers of hauls and length measurements by year and by sex for the triennial survey are presented in Table 9. As for the NWFSC survey, annual numbers of trawl hauls were used as initial sample sizes for the length composition data.

Estimates of Pacific sanddab biomass from the triennial survey were done using a GLMM method similar to that used in analyzing the NWFSC survey data. As in the analysis of the NWFSC survey data, different iterations of MCMC simulations were also conducted and it was found that one million MCMC iterations (with six parallel chains) was generally sufficient as those outputs were very similar to those from larger numbers of MCMC iterations (e.g., 5 million). The thinning factor for MCMC simulations was set to be between 500 and 1000 with half of the iterations treated as burn-in runs. Biomass estimates for both survey time periods are provided in Table 11, and plotted in Figure 27and Figure 28 with their standard deviations.

A GIS analysis was conducted to calculate total areas by three depth zones (0-49 m, 50-150 m, and 151-250 m) of the coastal waters off all three states (Table 10, Rebecca Miller, SWFSC, personal communication). This analysis indicates that 23.2% of the EEZ depths out to 250 m are shallow depths <50 m. This analysis indicates that the Pacific sanddab biomass estimates generated from the NWFSC and triennial surveys may have under-estimated total biomass of because both surveys did not sample these shallow areas.

#### 2.1.1.3 SWFSC FED Ecology Survey

A regional fisheries ecology survey, using both trawl and longline gear, was conducted by the Fisheries Ecology Division of the Southwest Fisheries Science Center (SWFSC FED) between 2001 and 2005. The trawl survey was conducted by chartering a commercial trawl vessel in the Monterey Bay area between depths of 16m and 275m. The survey used a cod-end liner with ¾ inch mesh. Only trawls conducted in <=250 m were used in the analysis, resulting in a total of 71 hauls used in the analysis. The survey was conducted in all months except May. Data collected from this survey included catch numbers and weights by species, trawl depth, trawl duration, and other gear-related information. Although the fixed gear effort did occasionally encounter sanddabs, those data are not used here.

The main purpose of this survey was to collect ecology data on the groundfish species in the Monterey Bay area. Data from this survey was only used to examine relative depth distributions of Pacific sanddab in the area. Raw catch rates (number of fish caught per trawl hour) by three depth zones are presented in Figure 33. It showed that catch rate was low in the depth zones of <50 m and >150 m. Mean lengths and their standard deviations by sex and by three depth zones are presented in Figure 34. These data indicate that Pacific sanddab caught in the shallow depth zone (<=50 m) were slightly smaller than those caught in deeper zones. In this survey, it was observed that catches of speckle sanddabs were rare, and that the only times they were caught were from trawls in less than 30m bottom depths. Most of speckle sanddabs catches were less than 20cm in length.

#### 2.1.1.4 Pelagic Juvenile Survey

Pelagic young-of-the-year (YOY) sanddabs have been monitored in the central California region since 1987, and from the region between Cape Medocino, CA and the U.S./Mexico border since 2004, in an annual May/June survey of pelagic juvenile groundfish (Juvenile rockfish ecosystem assessment survey) conducted by the Fisheries Ecology Division of the Southwest Fisheries Science Center (Sakuma *et al*. 2006, Ralston *et al*. 2013). Although the survey began in 1983, sanddabs were not identified to the species level until 1987, and unfortunately in a companion survey conducted by the Pacific Whiting Conservation Cooperative and the Northwest Fisheries Science Center from 2001 through 2010 (see Sakuma et al. 2006), sanddabs were also not identified to the species level. In the FED survey, pelagic YOY groundfish and other micronekton are sampled during hours of darkness (as some pelagic YOY can avoid the net during daylight hours) at a range of fixed stations, with trawls typically conducted at 30 meters headrope depth (shallow stations are sampled at 10 meters) using a modified Cobb midwater trawl with a 26 meter footrope depth and a 9.5 mm codend liner. Additional details are provided in the references listed above.

This survey was developed to provide abundance indices for age 0 (YOY) rockfish for use in stock assessments and to support fisheries oceanography studies, but has also resulted in time series of abundance for other YOY groundfish and a wide range of other micronektonic forage species (e.g., market squid, coastal pelagic species, mesopelagic species, krill) as well as time series of physical data, seabird and mammal observations, in order to better evaluate other ecosystem interactions (e.g., Field *et al*. 2010, Santora *et al*. 2011, Santora *et al*. 2012, Wells *et al*. 2012). These assemblages also appear to covary in time, with sanddab species tending to be more abundant during periods of high abundance of other YOY groundfish, market squid, and krill, and less abundant during periods when mesopelagic species and coastal pelagic species (Pacific sardine and northern anchovy) are in relatively greater abundance (Bjorkstedt *et al*. 2011, Ralston, Sakuma and Field, unpublished data).

Initial investigations into the early life history of Pacific sanddabs in particular were initiated by Sakuma and Larson (1995) who characterized the distribution and early life history of pelagic YOY Pacific and speckled sanddabs. They characterized the metamorphic development of pelagic juveniles in considerably greater detail than will be presented here, and summarized available information on the ages of pelagic YOY Pacific sanddabs, which were found to spend up to (and perhaps more than) 271 days in the pelagic YOY state prior to settling to benthic habitat (speckled sanddabs were found to have pelagic stages up to 324 days; Sakuma and Larson 1995 and references therein). It was found that earlier life history stages often occurred shallower in the water column, while later stages tended to have a slightly deeper distribution, potentially related to decreased buoyancy as a result of increased otolith size and bone development. All stages tended to be widely distributed, with some suggestion that earlier life history stages were more abundant offshore and later stages were more abundant nearshore (presumably as they approached the age and/or size associated with settlement). This widespread distribution was also noted by Santora *et al*. (2012). Metamorphisis (to the benthic life history stage) in both species was found to occur in a wide range of sizes, suggesting little change in body size during this period. Due to this observation, as well as the fact that size and age data are only available for a small number of years, the abundance indices developed for this species did not adjust for the relative age and size of individuals, as has been done for juvenile rockfish in order to account for size-dependent mortality prior to settlement (Ralston and Howard 1995, Ralston *et al*. 2013). Abundance indices were developed for both the core survey area (1987 through 2012) and the expanded survey area (2004-2012), using a delta-glm approach comparable to the approach taken with juvenile abundances in other studies (e.g., Ralston *et al*. 2013). The models included year, station and temporal (binned Julian day) effects, although there is some indication that due to the widespread distribution of YOY sanddabs, station clusters or groups would likely be a more appropriate means of evaluating this species, and alternative model structures are still under consideration. Interestingly, there was very strong coherence between the coastwide and core area indices for the time period in which they overlapped (Figure 35), which has not been reported with most other rockfish species (e.g., Ralston 2010). Although this initially provided some hope that the core area index could correlate well with recruitments inferred from age, size and abundance data in the stock assessment, preliminary analysis of both indices suggested no indication of any relationship between either index and the recruitment time series produced by the base model. Due to this mismatch between potential pre-recruit indices and the recruitment indices from the model, it was determined that inclusion of a pre-recruit index into the assessment model at this stage was premature, until the potential mechanisms for the mismatch could be further explored.

### 2.1.2 Biology

#### 2.1.2.1 Length-Weight Relationship

A length-weight relationship was derived from using the standard power function of $W = aL^b$ where $L$ is total length in centimeters, $W$ is weight in grams, and $a$ and $b$ are coefficients. Both coefficients are sex-specific and were estimated using 2003-2012 NWFSC survey data. The estimated coefficients are: $W = 0.00005117L^{3.214}$ for females, and $W = 0.00007419L^{3.081}$ for males (Figure 36).

#### 2.1.2.2 Growth

The von Bertalanffy growth model was used in the assessment. Analyses on the length at age data indicate sexually dimorphic growth of Pacific sanddab, with females being smaller at younger ages and larger at older ages than males. A re-parameterized growth model available in SS was used in this assessment. The three growth parameters were *L1*, *L2* and *K*, where *L1* is length at age 0, *L2* is length at age 11, and *K* is the von Bertalanffy growth coefficient. All these parameters were estimated internally in the assessment model.

#### 2.1.2.3 Natural Mortality

It is expected that the natural mortality rate (*M*) for Pacific sanddabs is high, relative to other large flatfishes (e.g., Petrale and Dover soles), because of their short life span and high predation rate on the species. Male natural mortality rate was expected to be higher than those of females as males have a shorter life span than females. Priors for both sexes were calculated using Hoenig's maximum ages, von Bertalanffy's growth coefficients (*K*), asymptotic lengths, and mean temperature (Owen Hamel, NWFSC, personal communication). Estimated natural mortalities were 0.3212 (SD=0.3600 in log space) for females and 0.3735 (SD=0.3598 in log space) for males. These priors were used in the assessment model, and natural mortality rates for both sexes were internally estimated.

#### 2.1.2.4 Maturity and Fecundity

The only available maturity data on Pacific sanddab prior to a recent study initiated by the SWFSC (described in Appendix B) was from a study of female fish collected from the San Francisco region fish markets in the 1930s and 1940s (Arora 1951). Maturity was determined by measuring oocytes from the ovary using a dissecting microscope and eye-piece micrometer. Data from 227 females collected in the month of August (determined to be the peak month of spawning) were used to construct the maturity curve. While Arora collected females with total lengths (TL) as small as 95 mm in other months, in the month of August the smallest were 150 mm. Of the 13 females 150-169 mm examined in August, none were mature. Based on Arora's data, female Pacific sanddab first matured at 170 mm TL, reached 50% maturity at approximately 190 mm TL, and nearly all fish were mature by 220 mm TL.

A recent field study examining the reproductive biology and ecology of Pacific sanddab in the Monterey Bay area found that females mature at significantly smaller sizes (approximately 12 to 13 cm) than those reported by Arora (1951). A similar shift to smaller size (and younger age) at maturity was found in English sole (Stewart 2007). Details of this study, including data collection and laboratory examinations on maturity and fecundity, are presented in Appendix B.

In this study maturity was determined macroscopically, with a subset of tissues examined histologically to confirm staging. During the peak spawning period, August to November, most mature ovaries had hydrated oocytes (HO), that were in the final stages of maturation, with ovulation and spawning of those oocytes imminent. Hydrated oocytes are readily distinguished from other maturing oocytes due to their large size and translucent appearance. Macroscopic staging outside of the peak spawning period did not allow for accurate assignment of maturity stage; therefore, the maturity curve was constructed from data collected from 154 females during the peak spawning period. There is a sharp increase in the slope of the maturation curve, going from 0 fish mature in the 110-119 mm TL size block to 50% of the fish being mature in the 120-129 mm block to all fish being mature by 140 mm (Figure 37).

Maturity of male Pacific sanddab was examined only macroscopically in the recent study (Appendix B). All males collected appeared to be mature; all testes were opaque and tan in color. Testes appeared similar throughout the year with no detectable changes in appearance during the reproductive season.

Female fecundity in Pacific sanddab has not been thoroughly examined. Fecundity has been examined as part of the recent reproductive ecology study (Appendix B), but fecundity values should be considered preliminary as samples from only 50 females have been analyzed and not all ovarian tissue samples from those individuals have been examined histologically. Batch fecundity (the number of eggs released per spawning event) values ranged from 810 to 17,400 (mean=6,350 ± 610). Relative batch fecundity (the number of eggs per gram ovary-free body weight released per spawning event) values ranged from 15 to 115 (mean=61 ± 4). Initial analysis show that while batch increases with length, there appears to be no significant relationship between relative batch fecundity and length. Fecundity by length and weight are plotted in Figure 38 and Figure 39, respectively. In this assessment, spawning biomass was used to represent stock status, and stock depletion was computed as ratios of annual spawning biomass relative to the virgin spawning biomass.

#### 2.1.2.5 Sex Ratio

The sex ratio at birth was assumed to be 1:1. However, both survey and fishery catches showed that higher proportions of female were caught than those of males (Table 5, Table 6, Table 9, Table 13, and Table 14). This could result from dimorphic growth between two sexes. Females could inhabit differently from males, but there were no data in supporting this hypothesis.

### 2.1.2.6 Aging and Aging Precision and Bias

Considerable effort was put into aging Pacific sanddab since this was the first time this species as assessed. All aging was done at the Fishery Ecology Division of the SWFSC, with otolith samples collected from the NWFSC survey as well as from the California and Oregon trawl fisheries. Aging effort was concentrated on the samples from the NWFSC survey because the survey had the most otolith samples and these samples were from the most recent years. The NWFSC aging data were also used in constructing conditional age-at-length data matrices that enabled the assessment model to estimate growth rates internally. These data are also useful in estimation of recent recruitment.

Prior to February 2012, no one at the Santa Cruz Laboratory had experience with aging of Pacific sandddabs, and only a few sanddabs had been aged from the collections of available otoliths (ODFW commercial). After an extensive literature search, we could not find any source of information on how to do production aging of this species so we began an effort to develop an aging criteria for the species. To develop the criteria, we used several approaches, including margin examination to determine edge type; growth ring analysis to examine the pattern of annulus formation; daily aging of young fish to confirm the location of the first annulus; and image processing to attempt to distinguish between checks and true annuli.

Firstly, we determined the best way to view the presumed annuli. We examined otoliths following conventional aging techniques such as the break-and-burn, break-and-bake, and thin sectioning methods as well as burning, kiln-baking, and surface viewing of whole otoliths. After using each of these methods on many fish of different sizes, we found that any method of heating the otoliths destroyed all visible marks. Apparently this is also true of petrale sole otoliths (Patrick MacDonald, NWFSC, Personal Communication, November 2012). Thin sectioning did not provide any assistance in viewing the marks. Image processing to enhance marks in photomicrographs of otoliths provided mixed results and was abandoned. Whole, unburned otoliths provided the clearest viewing, and were determined to be the preferred method for aging this species. The next step was to determine when the winter growth zone formed on the edge of the otolith. To do this, we used several hundred otoliths from fish collected in various months and from fish of both sexes of various sizes. It became clear that “winter” growth zones could be readily detected on the edge of otoliths at any time of the year; this was true for fish of all sizes and both sexes. Subsequent data on the life history of this species indicated that this species is a broadcaster spawner with an extended reproductive season lasting from late spring through early winter which may produce a spawning check. Other species have been shown to produce a spawning check in the otolith.

The next step was to measure the first three apparent annuli. We measured the diameter of each presumed annuli along the dorso-ventral axis from several hundred fish. We found that there were two modes for the size of the first annuli with some fish having a very small first annulus. Since this seemed to be an anomaly, we reexamined otoliths lacking the small first annulus to determine if one was present but just too faint to be readily identified. Even with image enhancement, we concluded that not all fish had that small inside annulus. Since this seemed unusual, we attempted to do daily increment counts on younger fish within the small inside annulus.

Daily increment counts were very difficult to perform; however, on several fish, we were able to determine that the small inside annulus represented less than 200 days of life. Donohoe (2000) previously performed daily increment aging on this species and found a similar pattern. He concluded the small inside check was formed after the completion of eye migration during metamorphosis and did not represent a full year of growth.

The final step in developing the aging criteria was to look at a large number of otoliths and attempt to understand the growth pattern. Two agers working side by side viewed the otoliths and reached an agreed upon age. We assumed that in most cases, fish would slow down their growth with age. We also found that while some otoliths had many checks, there was still an overriding pattern of growth which could be detected. We also noted that if an otolith appeared to have many false marks in the first years of life, it would indicate the possible presence of checks in later years. Using the above information, we settled on the following aging criteria: both otoliths were needed to determine an age, surface aging was required for all otoliths, if a faint inside mark was present it was not counted, and if winter growth was present on the outer edge during the summer, it was not counted as an actual annulus. Given the difficulty of aging this species, we agreed to have a high level of cross-reads between agers and second reads by the same ager to prevent age reading drift which resulted in approximately 20% of otoliths being read at least two times.

Table 17 show the numbers of otolith samples aged from the California and Oregon fisheries and from the NWFSC survey that were used in the assessment. No otolith samples were available from other sources. Note that there were generally many more otolith samples of females than those of males. Even for the survey samples, there were about twice as many as otolith samples from females than those from males. In the Oregon fishery, there were about eight times more otolith samples from females than those from males (Table 17). The same case was also found in the length composition data, where there were many more length samples from females than from males.

A total of 12,590 otoliths were ultimately aged for this assessment, including 1,550 otoliths aged by both readers in order to estimate aging biases and aging errors. Selections of otolith samples were stratified-random as attention was paid to select a range of ages from different sampling sources ((1,116 from the NWFSC survey, 208 from the California fishery, and 226 from the Oregon fishery)). Aging error data were analyzed using an ADMB program written by Andrè Punt (University of Washington) with front end programs and output analysis written by James Thorson (NWFSC). Plots of aging bias and errors are presented in Figure 40. Comparisons of aging bias and aging errors with true age and no errors are presented in Figure 41 and Figure 42. Estimated aging bias and aging errors from the analysis were used in the assessment.

### 2.1.3 Fishery Dependent Data

#### 2.1.3.1 Definition of Fishing Fleets and Fishery Landings

Four fishing fleets were defined and used in this assessment. Modeled fleets included three commercial fishing fleets and one recreational fleet. Two commercial bottom trawl fisheries were defined as the California bottom trawl fishery (thereafter referred to as the CA fishery) and combined Oregon and Washington bottom trawl fishery (thereafter referred to as the OR/WA fishery). Both fisheries included minor catches from other bottom trawl gears (i.e., shrimp trawls) and other fishing gears. These catches might also include small portions of other small sanddab species, such as speckled sanddabs (*Citharichthys stigmaeus*), which share similar habitats and have similar spatial distributions as Pacific sanddab (Rackowski and Piktich 1989). However, any such catches are likely to be minimal, as an analysis of California species composition data for the 2003-2011 period (in which the sanddab market category was sampled) indicated that over 98% of landed fish were Pacific sanddabs. All catch records (i.e., PacFIN estimates and/or observed total mortality estimates) from south of the California-Oregon border at $42^{o}$ N. lat. were combined into the CA fishery, and all catch records from north of $42^{o}$ N. lat. were combined into the OR/WA fishery. Although these two fisheries shared some similar characteristics, they were treated as separated fisheries because (1) the OR/WA fishery tend to discard more Pacific sanddabs than the CA fishery; and (2) data sources, including catch and composition data collections, were different between the two fisheries.

The third commercial fishery was defined as the mink, or animal food fishery, which covered most areas off northern California and Oregon. The fishery was active from the early 1950s to the late 1970s, with some small catches in the 1980s and early 1990s, and the main gear for this fishery was bottom trawl. The primary goal of this fishery was to catch fish as food to support mink and other animal farms, and as such virtually all of the catch was landed, such that no discards are assumed to take place. The lack of discards was the primary rationale for treating these landings as a separate fishery. The fourth fishery was defined as the recreational fishery, and was set to cover all catches from all waters off the three states by anglers mainly using hook and line gears. The majority of recreational catches were from the California waters. The time series of estimated annual landings by all four fisheries are listed in Table 1 and plotted in Figure 1.

Commercial landings of Pacific sanddabs for both the CA and OR/WA fisheries in recent years were obtained from the PacFIN database (1981 to 2001, and 2012) and from the total mortality estimates provided by the WCGOP (2002 to 2011). These data indicated about two third of commercial landings of Pacific sanddabs were from California.

Efforts on constructing historical commercial landings from California waters have been ongoing in recent years, based on recovered block summary and fish ticket data (Pearson *et al*. 2008, Ralston *et al*. 2010). Commercial landings for Pacific sanddab by month, gear, and port were constructed between 1969 and 1980, and the landings by month and block were constructed between 1931 and 1968. These data were then summarized to obtain annual total landings of Pacific sanddab for the CA fishery. Note that the high catches of sanddabs in the historical period (between 1916 and the 1940s, but declining through the 1930s and 1940s) is consistent with other ongoing efforts to understand the spatial patterns of development of California groundfish fisheries. Specifically, in the earliest years of the fishery, catches tended to take place in shallower waters, closer to primary ports, as demonstrated by the observation that landings of Pacific sanddab, Starry flounder, California halibut and English sole were at relative high levels during the 1910s and 1920s (CDFW 1949). The block summary data (which begin ~ 1930) indicate that over the seventy years since that period, catches have taken place in areas of increasingly deeper habitat, with an increasing distance between catch locations and ports, and in increasingly inclement weather conditions (Miller et al. in review).

Commercial landings between 1916 and 1930 were obtained from a published report (Staff of the Bureau of Marine Fisheries 1949). In the report, annual landings of sanddabs were recorded (Table 44 in the report) between 1916 and 1947. The reported catches consisted of two small flatfishes (Pacific and speckled sanddabs). However, catches of speckled sanddab were very small, and were not separated from the total sanddab catches in the report. In this assessment, it is assumed that all reported catches were Pacific sanddab. The report also stated that nearly all catches were from trawls. Prior to 1938, most landings were from the San Francisco region. After 1938, 47% of landings were from the San Francisco region while 40% of landings were from the Eureka area. There was a small amount of sanddab catch from southern California from hook-and-line gear, but these catches were not separated in the report.

Commercial landings prior to 1916 were difficult to obtain. The only source of data was from the summarized landings of aggregated species market categories along the U.S. west coast between 1892 and 1926 (Sette and Fiedler 1928). In the report, landings of flatfish were first recorded in 1892, and yearly landings were recorded in 3 to 7 year intervals between 1892 and 1915. The reported total flatfish landings of 13 million pounds in 1915 were comparable to that in the California report (Staff of the Bureau of Marine Fisheries 1949). To get estimates of Pacific sanddab landings between 1888 and 1915, the following two-step procedure was taken. First, total flatfish landings for those years that had missing landing data between 1888 and 1915 were linearly interpolated with those years that had landing estimates. The landing for 1888 was set to zero. Second, the annual landings for Pacific sanddab were then estimated by assuming that 11.66% of flatfish landings in those years were Pacific sanddab. This was the average percentage of Pacific sanddab catches of the total flatfish catches between 1916 and 1920.

Historical landings of Pacific sanddab in the Oregon waters were obtained through the Historical Reconstruction Project (Karnowski et al. 2012, V. Gertseva, NWFSC, personal communication). The reconstructed data were provided by Gertseva of the NWFSC and included commercial landings of Pacific sanddab between 1896 and 1986, and catches of Pacific sanddab for animal foods between 1942 and 1979. In the Reconstruction Project report, it estimated that most Pacific sanddab catches were from trawl gears.

There were very few historical records of Pacific sanddab catches in Washington waters. The Washington Department of Fish and Wildlife (WDFW) provided some limited estimates of Pacific sanddab landings between 1970 and 1980 (Theresa Tsou, personal communication). To get estimates of historical landings of Pacific sanddab in Washington waters before 1980, a constant ratio of catches between the Oregon and Washington fisheries was obtained by using an average catch ratio of the species between these two states between 1981 and 2011; this ratio was then applied to the Oregon catch between 1896 and 1980 to obtain historical landings of Pacific sanddab in Washington waters.

The commercial trawl fishery targeting fish for animal food, mainly for mink farms, started in 1953 in California (Best 1959 and 1961, Nitsos and Read 1965). In Oregon, a portion of the landings of flatfish and rockfish were used as mink foods from 1942 through the 1970s (Harry 1956, Karnowski *et al*. 2012). Catches from mink food fisheries from both states were treated as a separate fishery from other commercial trawl fisheries because it is assumed almost all catches were retained and discards were minimal. Because there were no composition data from the fishery, fishery selectivity could not be estimated independently. It was assumed that selectivity for this fishery was the same as the CA fishery in the assessment model.

Total catches of all fish species for animal foods in California ranged from 436 mt in 1953 to 1,817 mt in 1960. Catches of sanddab were low, generally consisting of less than 2% of total fish catches during the period. Most catches of sanddab were from northern California (Eureka and San Francisco areas). The California Department of Fish and Game started collecting data on animal food in 1953. Total annual catches of animal foods between 1953 and 1962 were reported in the published literature (Best 1959 and 1961, Nitsos and Reed 1965). Annual catches of Pacific sanddab were available only for years between 1958 and 1962 and might not be complete for some ports of landing. An average catch ratio of sanddab over all animal food landings between 1958 and 1963 was calculated to estimate 1.230% of all landings for animal foods for the whole time period were of sanddab. This ratio was then applied to total animal food landings between 1953 and 1957 to obtain estimates of sanddab landings for those years.

There were no published records of animal food landings in California after 1962. The only data source available after 1962 were reported total animal food landings in the CALCOM database (market category 992). The recorded landings showed that large animal food landings occurred in the mid-1960s (around 1,300 mt) and almost no landings in the late 1970s. There were some reported landings in the same market category in 1980s, but it was unclear if these landings were for mink foods, so these landings were not included in estimating catches for Pacific sanddab. To get estimates of animal food landings of Pacific sanddab between 1963 and 1979, the same sanddab catch ratio (1.230%) was applied to total landings of animal foods for the same time period.

There were no records of landings of Pacific sanddab for animal food in California before 1953. However, it was expected there were some landings in those early years as there were some estimated landings in Oregon. To resolve this issue, an estimated landing of 5.5 mt in 1953 was used to assume the amount of sanddab landed annually in the animal food fishery between 1942 (the first year of reported animal food landings in Oregon) and 1952.

The Oregon historical catch reconstruction project provided estimated catches of Pacific sanddab for mink foods (Gertseva *et al*.2010, Karnowski *et al*. 2012). Annual estimates of the Oregon animal food landings were provided by Gertseva (NWFSC, personal communication). Most mink food catches were between 1953 and 1977, and the catches ranged between 2.5 mt to 80.5 mt. This is the same time period when there were mink food catches in California.

There were no records of mink food catches in Washington. One possible way to get estimates of mink food catches in Washington was to use the commercial catch ratio between these two states. Overall, it was assumed that mink food catches in Washington were very small; therefore, no animal food catches from Washington waters were included in this assessment.

Estimated recreational catches of Pacific sanddab between 1980 and 2012 were obtained from the RecFIN database. Estimated catches were the sums of weight of type A catches (examined by samplers) and type B1 catches (reported by anglers as dead fish). Separate estimates were obtained for all California waters and for the Oregon and Washington waters combined. Since there were no estimates in the RecFIN database between 1990 and 1992, these missing values were linearly interpolated with three-year averages before 1989 and after 1993. In general, recreational catches were much higher in California waters than those in Oregon/Washington waters. In California, recreational catches ranged from 12 mt in 1987 to 216 mt in 1981, and the average catch during 2002-2011 was 51 mt. In Oregon/Washington waters, estimated catches ranged from <1 mt in recent years to the highest catch of 102 mt in 1997; average catches in recent years (2006-2011) have been very low (<0.2 mt). A small amount of estimated recreational catch (<0.3 mt) from the Washington recreational fishery (Tsou, WDFW, personal communication) in recent years was also added to total coastwide recreational catches.

Recreational catches from California in 1979 were obtained from a published record (Holliday et al. 1984). There were no records of sanddab catches from Oregon and Washington waters that year. Estimated total catch (Type A) from California waters was 78 mt between July and December of 1979. By comparing type B1 catch from the same time period and extending the estimate to the whole year, it was estimated that the total recreational catch in California waters was 174.8 mt in 1979.

Historical recreational catches from both Oregon and Washington are relatively low based on recent RecFIN data. There were no records of historical recreational catches from California before 1979. Estimates of the California recreational catches from 1971 to 1978 were constructed using a regression estimator of the CPFV logbook and the RecFIN database during periods when data were available. These estimates may not be accurate because Pacific sanddabs were not explicitly identified in CPFV logbooks. The catches included other sanddab species (i.e., speckle sanddab). However, catches of other sanddab species were relatively small compared to catches of Pacific sanddab.

### 2.1.3.2 Fishery discards

One of the main characteristics of the Pacific sanddab fisheries was that discard rates were high in commercial trawl catches, mainly because the species was often not a primary targeted by commercial trawl fleets, and the species are generally too small to have high values in fish markets. Estimates of historical discard rates in commercial fisheries were difficult as there were no reliable studies on the species. The first discard study available was from Pikitch *et al*. (1988) on the Oregon trawl fishery. Estimated discard rates of Pacific sanddab were between 48% and 58% of total catches from 1986 to 1988 (Wallace *et al*. 1996, John Wallace, NWFSC, personal communication). A similar discard rate (50.5%) was also observed in the Oregon trawl fisheries in the mid-1990s (Sampson 2002). There were no estimates of discards in the California trawl fishery during the same time period. Estimated discard rates by commercial trawl fisheries in recent years (2002 to 2011) were however available from the WCGOP observer program.

There were some historical studies on discards of commercial trawl fisheries. Harry (1956) took 12 sampling trips on the Oregon otter trawl fishery in 1950. With exception of two sampling trips that were to catch fish for mink foods, he estimated that nearly all of Pacific sanddab caught were discarded, primarily due to fish being caught were too small and would be unmarketable. In the same report, discard rates for other major flatfishes were also high. The discard rates was 27.4% for English sole (*Parophrys vetulus*), 17.0% for Dover sole (*Microstomus pacificus*), and 32.5% for petrale sole (*Eopstetta jordani*).

In summarizing the San Francisco trawl fishery in 1934, Clark (1935) reported that sanddab (scientific name used in the report is *Orthopsetta sordida*) consisted of 7% of total catches in weight, while high catches were pointed-nosed sole (*Parophrys vetulus*) (46%) and round-nosed sole (*Eopsetta jordani*) (20%). In describing the California trawl fishery in 1935, Clark (1936) reported that sanddab was one of five major species in fishery production. He also reported that trawls operated mostly in the depths between 25 to 100 fathoms between San Francisco and the Oregon border. Although many flatfishes were discarded because fish were too small for markets, some small sanddab (6 inches) were kept. Majority of sanddab caught, however, were around 8 inches (around 20cm).

A series of on-board trawl samples were conducted in the Morro Bay area from 1957 to 1958 (Heimann and Miller 1960). Since majority of trawls were sampled in the rockfish trawl area, the flatfish, including Pacific sanddab, only made up 4.5% of the total catches. Out of 257 pounds of sanddab caught, all were discarded.

In the Monterey Bay area, analysis of catch compositions from 1960 showed high percentages of sanddab catches were discarded (Heimann 1963). Of ten shallow water trawls (30-60 fathoms) sampled between Pigeon Point and Point Sur, a total of 1,010 pounds of sanddab were caught and 40.1% of fish were discarded. Of nineteen intermediate-depth trawls (60-130 fathoms) sampled between Pigeon Point and Point Sur, a total of 43 pounds of sanddab were caught and 37% of fish were discarded. Of four deep water trawls (130-200 fathoms), no sanddab was caught.

Herrmann and Harry reported sampling results on Oregon trawl vessels between 1950 and 1961 (Herrmann and Harry 1963). The results were summarized from a total of 41 sampling trips and 383 trawling tows (Table 1, Herrmann and Harry 1963). Of the total 11,983 pounds of Pacific sanddab caught, all were discarded. Total recorded catches varied greatly between years and within years. For example, there were 6,694 pounds of sanddab caught in 1950 but no sanddab caught in 1950. In 1951, one trip caught 3,581 pounds of sanddab while another trip caught none (Table 3, Herrmann and Harry 1963).

In 1974, TenEyck and Demory examined utilization of flatfish caught by Oregon fisheries and also found high discard rates of Pacific sanddab (TenEyck and Demory 1975). On a total of eight trawl trips they sampled, a total of 903 fish were caught and 641 of them were discarded. Discard rate differed between sexes, with discard rates being 71.9% for females and 93.8% for males.

In light of inconsistence of historical estimates of discard rates on Pacific sanddab, none of these estimates were used in the assessment. Historical discard rates for the OR/WA fishery was set to be the mean discard rate from the 1988 Pikitch study (average of 1985 to 1987, John Wallace, NWFSC, personal communication). Discard rates between 2002 and 2010 for each fishery were obtained from the recent WCGOP observer program (Table 16). In general, discard rates in recent years were higher in the OR/WA fishery (average = 0.6184) than those in the CA fishery (average = 0.3254). Since there were no discard estimates in the CA fishery prior to 2002, an average discard rate (=0.3256) between 2002 and 2009 from the WCGOP observer program was used as historical discard rate for the CA fishery (Table 16).

### 2.1.3.3 California CPFV Recreational Fishery Survey

***Recent year (1999-2011) CPFV data***

The California Department of Fish and Wildlife (CDFW) conducted CPFV (Commercial Passenger Fishing Vessels) recreational survey in the California waters from Monterey Bay through southern California (mostly in southern California) between 1999 and 2011 (Reilly *et al*. 1998). Melissa Monk of the SWFSC retrieved and analyzed the data, and provided a time series of the survey indices during these years. Length composition data of retained and discarded fish were also retrieved from the survey.

For the survey index analysis, data were analyzed at the drift level. Drifts meeting the following criteria were excluded from analyses:

1. trips outside U.S. waters;
2. drifts deeper than 60 fm (data availability);
3. drifts in conservation areas (e.g., Cowcod Conservation Areas and MPAs) established prior to 2012 which prohibit the take of finfish;
4. drifts in large bays or harbors (e.g., San Francisco Bay,and San Diego Harbor);
5. drifts missing both starting and ending location;
6. drifts identified as having possible erroneous location or time data;
7. drifts missing the number of observed anglers.

Fishing time and number of observed anglers were limited to 95% of the data to remove potential outliers. Remaining drifts were between 5 and 120 minutes in duration and 14-18 anglers observed.

The following methods were applied to identify regions of suitable habitat, and to determine the number of drifts to include in the analysis. The locations of positive encounters were mapped, using the drift starting locations. Regions of suitable habitat were defined by creating detailed hulls (similar to an alpha hull) with a 0.01 decimal degree buffer around a location or cluster of locations (Data East 2003). Any portion of a region that intersected with land was removed. As an example of the buffers, a region with only one positive encounter has an ellipsoid area of 3.22km$^2$. Each drift (both positive and zero-catch) was assigned to the region with which it intersected. Drifts that did not intersect with a region were considered structural zeroes, i.e., outside of the species habitat, and not used in the analysis. Data were filtered for each species to exclude regions that did not consistently produce catch of the species of interest (i.e. having fewer than 5 years with positive observations).

A total of 173 buffered areas were identified from the CDFW data ($N$ = 15830, positive $N$ = 2154). Of these, 24 areas (53% of the total $km^2$ defined as suitable habitat) had at least 5 years of positive observations. Sampling coverage was insufficient to test for difference in CPUE trends among regions (i.e. an interaction between YEAR and REGION variables) and one index was created for California.

The selected data ($N$ = 10197; positive $N$ = 1693) contained categorical variables for YEAR (11 levels) and two possible additional effects, MONTH (12 levels), and 15-fm depth bins ("DEP15", 4 levels). The data were analyzed using a delta GLMM method developed by the SWFSC FED. The distribution for positives was lognormal (which was strongly favored over gamma by a delta AIC of 327). The binary model used a logit transformation which was indistinguishable from the alternatives. In both submodels, stepwise BIC removed all interaction terms. The final positive and binomial models without interactions retained YEAR, DEP15, and REGION, and MONTH (Table 18). The annual abundance indices (YEAR effects) are shown in Figure 31.

***CPFV early year length composition data (1975-1998)***
Recreational length composition data in early years came from three sampling sources in California. The CDFW have historically collected catch and length information for groundfish through their CPFV observer program. There were two surveys in southern California, one in the 1970s and the other in the 1980s. The survey from 1975-1978 measured a total of 876 Pacific sanddabs in 180 trips. There were only 16 Pacific sanddabs (caught in 8 trips) sampled in 1975, so this year was excluded from further analysis. The survey from 1986-1989 measured a total of 2,188 Pacific sanddabs in 271 trips. All measurements were retained from this survey. There was also another survey in northern and central California from 1987-1998, where a total of 2,274 Pacific sanddabs were sampled in 484 trips. The first year of this survey focused only in Monterey Bay and sample sizes were small (3 Pacific sanddabs in 2 trips); therefore 1987 was excluded from further analysis. Sex was not identified for these fish.

Annual trips that caught Pacific sanddabs and the number of lengths sampled from these surveys can be found in Table 12. The number of Pacific sanddabs measured per trip was low, ranging from 2.1 to 9.5 fish, compared to those from other surveys and/or fisheries. Length samples were aggregated to port-complex-month to be comparable to other length sample sizes used in this assessment.

There was an overlap between two surveys in the years 1988 and 1989. Since this assessment is a coastwide assessment, the length compositions from the two surveys in these two years were combined. Figure 32 showed that there were small differences between length frequency distributions in the two areas.

### 2.1.3.4 Fishery Length and Age Composition Data
There were no composition data available from the mink food fishery. Available composition data from fisheries included the following:

1) length composition data by sex and by retained/discarded fish for the Oregon trawl fishery from the mesh study in 1990 (John Wallace, NWFSC, personal communication);
2) combined sex length composition data for discarded catches for both CA and OR/WA fisheries from 2006 to 2011 from the WCGOP;
3) length composition data by sex for retained fish from the CA trawl fishery from 2003 to 2012 downloaded from the PacFIN database;

4) length composition data by sex for retained fish from the OR/WA trawl fishery from 1994 to 2012 downloaded from the PacFIN database;
5) length composition data by retained/discarded fish for recreational catches were obtained from the CA recreational survey. The data were from two sources: (1) the CPFV data of retained catches between 1976 and 1998, and (2) the recent survey data between 1999 and 2001 (Melissa Monk, SWFSC, personal communication);
6) age composition data by sex for retained fish from the CA trawl fishery for years of 2003, 2007, and 2008. Otolith samples for these fish were provided by the ODFW; and
7) age composition data by sex for retained fish from the OR/WA trawl fishery from 1995 to 2012 (no data for some years). Otoliths for these fish were provided by the CDFW.

Numbers of sampled trips and length measurements for all fisheries are listed in Table 13 to Table 15. Numbers of sampled trips and fish aged for all fisheries are listed in Table 17. For both CA and OR/WA fisheries, sampled trips are defined as sample numbers in port sampling records. Numbers of fish per sample ranged between 31 and 52 for both fisheries.

## 2.2 History of Modeling Approaches Used for This Stock

This is the first time that Pacific sanddab has been assessed. No stock assessment has been done for Pacific sanddab in Alaska, Canada, and Mexico.

## 2.3 Model Description

### 2.3.1 Basic Model Structures

This assessment was based on an age-structured population model, commonly used in U.S. west coast groundfish assessment modeling. One stock of Pacific sanddabs was assumed since there is no strong evidence that shows differences by area in growth, fecundity, and other biological characteristics. There have been some catches reported in Canadian and Mexican waters, but no data were used for this assessment. It is assumed that catches in those waters have minimum impact on the Pacific sanddab population in the waters off the U.S. west coast and there are no significant migrations of Pacific sanddabs between these areas.

The population model was structured as a two-sex model given evidence of sexually dimorphic growth and sex-specific natural mortality rates.

### 2.3.2 Fishing Fleets and Surveys

Four fishing fleets and three fishery-independent surveys were defined and used in this assessment. Details on these fishing fleets and survey are described in above.

### 2.3.3 Modeling software

The modeling software used in this assessment is Stock Synthesis 3 (SS3, version 4.23O, April 2013), developed by Richard Methot (Methot and Wetzel 2013). R programs developed at the NWFSC, including R software packages for GLMM and aging error analysis and r4ss software, were used in analyzing data and producing graphics for this assessment (r4ss, Taylor *et al*. 2012).

### 2.3.4 General Model Specifications

This assessment assumed that a single stock of Pacific sanddabs occurs along the U.S. west coast, and that the stock was subject to fishing by four fisheries (see details in the previous sections). Most commercial catches were from bottom trawl gears. All selectivity functions are length-based, asymptotic, and sex-specific where data are available. A Beverton-Holt stock-recruitment relationship is modeled in this assessment.

This assessment assumes sexually dimorphic growth, and sex-specific natural mortality and length-weight relationship. Natural mortality was assumed to be constant for all ages in each sex.

The likelihood components included in the assessment model are: catches, discards, indices, length and age compositions, recruitment deviations, parameters priors, and parameter soft bounds. All input files for the SS program are attached in Appendix D (page 284).

### 2.3.5 Estimated and Fixed Parameters

#### 2.3.5.1 Parameter Priors

Priors for two sets of parameters, stock recruitment steepness (*h*) and natural mortality rate (*M*) by sex, were modeled in this assessment. The steepness prior derived for flatfish species from the Myers meta-analysis (Myers et al. 1999) was used (mean = 0.80, and SD = 0.09) (Figure 55). Sex-specific priors for natural mortality were based on a metal-analysis provided by Owen Hamel (NWFSC, personal communication). Input parameters to Hamel's analysis included mean temperature, asymptotic lengths, and growth rates (*K*) from preliminary analysis of available data. Estimated median values of *M* from Hamel's analysis for female and male were 0.321 and 0.374, respectively (Figure 56).

#### 2.3.5.2 Life History Parameters

Details on specifications of life history parameters were described in the Biology Section. Growth and natural mortalities for both sexes were estimated internally, while other life history parameters, including the length-weight relationships and maturity, were estimated outside the assessment and fixed in the assessment model.

#### 2.3.5.3 Stock-Recruitment Parameters

A density-dependent Beverton-Holt stock-recruitment relationship is assumed for this assessment. The log of virgin recruitment ($ln(R_0)$) and steepness (*h*) are estimated in the model. Recruitment deviations are estimated from 1966 to 2011, and stratified in three time periods, early-year period (1966-1976), main period (1977-2011), and late-year period (2012-2013). Recruitment variability parameter ($\sigma_R$) was set to 0.45, which was evaluated during model development and found to be stable and slightly larger than that of the estimated root mean square error (RMSE) in the base model.

#### 2.3.5.4 Survey and Fishery Selectivity Parameters

Selectivity functions for all surveys and fisheries were assumed to be length-based and to be asymptotic. Sex-specific selectivity was used where sex-specific composition data were available. Because there are no composition data available from the mink food fishery, its selectivity was assumed to be the same as the CA fishery. Age selectivity was set to 1.0 for all ages because there were age-0 fish catches in the NWFSC trawl survey.

### 2.3.6 Data Weighting

The data weighting process involved changing input sample sizes for the composition data and adding extra variance to abundance indices. For composition data, if both length and age data were taken from the same individual fish, these data would need to be down-weighted to avoid double-use of the data. The main purpose of the process is to reduce disproportional effects of particular data on overall model fits (Stewart and Hamel, in review).

There are two steps in the data weighting process. First, initial sample sizes for composition data and initial standard deviations (SD) or coefficient of variances (CVs) for index data are inputted into the assessment model. The model is run once and the SS program produces estimates of effective sample sizes for each set of composition data and an extra SD for each set of indices. Second, estimates of effective sample sizes and extra SDs are then inputted to the model to replace the initial sample sizes and SDs, and then the model is re-run. Additional steps can be taken following the same procedure in the second step, but it has been common practice in groundfish assessments to use this two-step weighting process, as additional steps often produce comparable model outputs. The SS program is capable of estimating extra SD internally. In this case, only effective sample sizes for composition data are needed in the second step. This is the approach that was used in this assessment.

In this assessment, there were only length composition data available from the triennial survey double-use of the composition data was not an issue. Numbers of trawl tows were used as initial sample sizes for the survey. For the NWFSC survey, both length and age composition data were used in the model. Because the age composition data were used as conditional age-at-length compositions, numbers of trawl tows were still used as initial sample sizes for the length composition inputs while numbers of fish aged were used initial sample sizes for the conditional age-at-length composition. The estimated effective sample sizes for the NWFSC survey were slightly larger (about 112%) than those of the initial sample sizes for the length composition data, but were about 18% of the initial sample sizes for the conditional age-at-length composition data. For both commercial trawl fisheries, because both length and age composition data were used in the model, overall weighting (lambda values in the SS program) were set to be 0.5 to account for double-usages of both composition data.

One additional issue of data weighting is how to determine standard deviation of recruitment deviations ($\sigma_R$). In this assessment, an initial value of $\sigma_R$ was set to be slightly larger than the estimated RMSE of the recruitment deviations. The model was then rerun to ensure that $\sigma_R$ was consistently slightly larger than RMSE. This iterative process could be done in the early model development but the process may need to be repeated if there are major changes in model structures and data inputs.

## 2.4 Model Selection and Evaluation

### 2.4.1 Key Assumptions and Structural Choices

Selection of the base model was based on balances of data availability, model realism, and parsimony. As this is the first time the Pacific sanddab stock is being assessed, much efforts was made to evaluate fishing fleet structures, selectivity patterns, sex-specific biological and fishing parameters, and other productivity parameters (e.g., stock-recruitment, natural mortality). The selection process started with fixing some key parameters, such as natural mortality rates and steepness, at their prior values, and then gradually set these parameters to be estimated. During the process, many exploratory model runs were also conducted to evaluate sex-offset selectivity and time-varying selectivity functions.

Key assumptions in the base model included the following: (1) the Beverton-Holt stock-recruit function; (2) asymptotic selectivity functions for all fleets and both sexes; and (3) time-invariant catchability coefficients (Qs) for all surveys. It was also assumed that reported catches, by all commercial and recreational fleets, were accurate, especially in recent years, and that historical catches of Pacific sanddabs might not be well recorded.

Discard rates were relatively high for Pacific sanddabs. It was assumed in this assessment that all discarded fish were dead in trawl fisheries. Since there were no data available to estimate discard mortality in the recreational fishery, a 50% of discard mortality rate was assumed for the recreational fishery. This assumption has minimum effects on model outputs since discard rates in the recreational fishery are low (about 6% of total catch).

A series of sensitivity analysis were conducted to evaluate these key assumptions (see the Uncertainty and sensitivity analysis section).

### 2.4.2 Alternative models considered

Alternative models that were explored during the model selection process included: (1) treating the triennial survey as one continuous survey series; and (2) using time block on commercial trawl fishery selectivity in 2003. These alternative models were not used in the base model for a variety of reasons. For the triennial survey, it has been suggested that differences in survey timing between the early and late survey periods may affect CPUE of flatfish. Splitting the survey into two indices has been done in other west coast flatfish assessment. Using time block on commercial trawl fisheries (e.g., time block in 2003 when RCAs were implemented coastwide) has also been done in many groundfish assessments. A time block in 2003 was not used in the base model because there were no length or age composition data before 2003 from the CA trawl fishery.

There were few alternative models considered and explored during the STAR Panel review (see details in the STAR Panel Recommendations section). The base model adopted during the STAR Panel review includes the following changes to the pre-STAR base model: (1) add time-varying retention for two commercial trawl fisheries in 2001 to reflect changes of fishery management (IFQ); (2) modify discard rates for two commercial trawl fisheries to better fits to the discard mortalities reported by the WCGOP observer program; (3) remove the discard estimate for the 2003 OR/WA to better fit observed and estimate discard mortalities for the OR/WA trawl fishery in recent years; (4) remove length frequency data of the 1990 mesh size study from the assessment model as there was no evidence that the study used the similar trawl gears as used in the fisheries during that time; and (5) use the revised recreational CPUE data.

### 2.4.3 Model Convergence, Jitter and Phase Analysis and Repeated Model Runs

To ensure that the assessment model produced stable outputs and was not affected by ranges of initial conditions and phase setting, a series of tests on model stability were conducted. This included jitter analysis, in which initial parameter vales were jittered by randomly alternating initial parameter values by 5% and rerunning the model. The phase analyses were conducted by alternating phases for most estimated parameters. Repeated model runs were done by running the same model multiple times. Outputs from all these test runs showed that the proposed model was stable. That is, all test runs converged well with convergence criteria close to or less than convergence criteria (0.01), and all test runs produced the same outputs.

## 2.5 Response to STAR Panel Recommendations

1) Compare growth differences between Arora (1951) and Lefebvre (2012) or simply compare mean length-at-age.
    - Response: In the Arora study, fish were aged primarily by scale annuli and scale widths, although otoliths were somehow included in the criteria (actual aging method not entirely clear). Thus, the mean size at age data may not be directly comparable. However, there is no evidence of a dramatic difference between mean size at age from Arora (n=87) and that from the aged fish from the trawl survey (n=~7000). Consequently, it appears that the substantial shift in size at maturity indicated by a comparison of the two studies does reflect a shift in maturity, but not necessarily growth, at age.

2) Use the new recreational CPUE index, the revised mink food fishery catches, put a retention time block at 2011, and use empirical discard estimates, and remove the 2003 OR/WA discard rate estimate in the new base model. All additional analyses should use this new base model.
   - Response: A new model was constructed according to the recommendations. Estimated discarded catches were more comparable to those estimated by the WCGOP in recent years. The new model indicated lower virgin recruitment and the stock was less depleted, as the stock depletion changed from 60.6% in the pre-STAR model to 74.3%.
3) Sensitivity run for the pre-1930s CA catch history by doubling and halving the CA trawl catches prior to 1930.
   - Response: Doubling the pre-1930s CA catches resulted in higher virgin spawning biomass and much less stock depletion than those runs without doubling or halving. Halving the pre-1930s CA catches resulted in no changes of stock dynamics in recent years. Additional information with regard to the scale of the small flatfish fishery during this time period was presented, demonstrating that California fisheries for other nearshore flatfish (including California halibut, starry flounder and English sole) were substantial during this time period (Pacific sanddab represented on the order of 10-15% of the total California small flatfish catch during this period), and that larger Pacific sanddabs were considered a desirable and marketable species during this time period.
4) Clarify Wallace (1996) mesh size study data were filtered adequately to inform fishery discard rates and catch composition.
   - Response: Further examinations of the Wallace 1990 mesh size study (published in 1996) indicated no sufficient evidence to support the same mesh size being used between the study and fisheries. Length frequency data from the study were then removed from the assessment.
5) Justify why only triennial survey index data were removed in the sensitivity run. Explore removing the length comp. data as well. Additionally, provide a sensitivity run removing the early triennial survey index and comp. data.
   - Response: Two model runs were conducted. In the first run, all data from the early time period of the triennial survey, including length composition and survey indices, were removed. In the second run, all data from the survey were removed. The results showed that removing data from the early time period had large effects than removing all triennial data. It suggested that there might be some conflicting signals between data in these two time periods. The Panel and STAT team discussed the utilities of the survey data, and it was agreed that the survey data can be included in the assessment model.
6) Test the influence of the fishery age comps. and survey conditional age-at-length data by 1) removing age comps., 2) fixing growth parameters from the base model and removing conditional age-at-length data, and 3) fixing growth parameters from the base model and removing all these data to explore reasons for the variable scale of the SSB.
   - Response: Three assessment model runs, corresponding to each of three requests listed above, were conducted. The results showed that removing only fishery age composition data had relatively small effects on the model outputs, but that removing conditional age-at-length data (with fixed growth rates before data removal) had very large effects on the model outputs. Removing the conditional age-at-length data resulted in estimates of higher virgin recruitment, and larger natural mortality, along with larger uncertainties in these estimates. The results were more consistent with the survey estimates of Pacific sanddab total biomass.
7) Profile on ln(R0) with each likelihood component (by fleet, survey, and data component).

- Response: Because it is a relatively new r4ss function, STAT team was not be able to complete the profile runs and plots. The STAR Panel indicated that the request was intended to be a diagnostic tool.

8) There was no formal Request #8 from the STAR Panel. The STAT team made an effort to test a simple production model to test scales on the estimated virgin recruitments. This run was conducted by (1) fixing all parameter values at the proposed base model, except virgin recruitment; and (2) setting all recruit deviations to zeros. The results showed similar time series trends in spawning biomass and about 25% higher in virgin recruitment. Stock depletion level was about 11% higher from using the simple production model. The model was consistent with declining stock trends during increased exploitation rates during the 1990s and increasing stock trends as catches declined during the 2000s.
9) Using the new base model (provisions from requests 2 and 4, use the 2011 trawl discard rates for 2012 for both CA and OR/WA fleets), provide a run exploring a Lorenzen *M* or some other modeling structure to allow higher *Ms* for younger fish. Show the total likelihood, including the number of estimated parameters.
   - Response: Five runs from using Lorenzen M with reference ages fixed at ages 1 to 5 were completed and the model outputs were compared among these runs and the proposed base model. Estimated Lorenzen *Ms* were higher in high reference ages than those in low reference ages. Similar trends were also estimated in virgin recruitments and stock depletions. The STAR and STAT Teams agreed that there were ecological reasons to consider the Lorenzen curve as a more appropriate mortality function for rapidly growing, high turnover species such as Pacific sanddab, but that there was relatively little direct support for this alternative in the data.
10) Provide a sensitivity analysis that allow dome-shaped selectivity for all surveys except for one fishery (which selects for the largest fish), which should remain asymptotic. M should be fixed according to the new base model. Provide fits to the comps. aggregated across all years. Show the total likelihood, including the number of estimated parameters.
    - Response: Three model runs were conducted in responds to this request: (1) all selectivity functions were set to be dome-shaped except the CA fishery; (2) selectivity functions for all fisheries were set to be dome-shaped and selectivity functions for all surveys were set to be asymptotic; and (3) all selectivity function were set to be dome-shaped. Key model outputs and aggregated model fits to the composition data from these Runs were presented. Overall, model outputs from the Runs (1) and (2) were not dramatically different from the proposed base model. But the outputs from Run (2) indicated higher virgin recruitment (about twice as much) than the proposed model, along with much large uncertainties in spawning biomass estimates.
11) If requests 9 and/or10 do not result in significant changes to model results, provide these runs with removal of conditional age-at-length (fix growth parameters according to the new base model).
    - Response: Additional runs were conducted by removing the conditional age-at-length data on the model runs from the Requests 9 and 10. In general, model outputs from these runs were similar to previous runs without the conditional age-at-length data. Without the conditional age-at-length data, estimated virgin recruitments were higher and the stock was less depleted, along with larger confident intervals on estimated biomass and depletion levels.
12) The STAT team also conducted test model runs with *Q* prior derived from other flatfish assessments (Table 19). In the first test run, extra standard deviations for the survey indices were estimated and the model outputs were very similar to those from the base model. In the second test run, standard deviations were not estimated and standard deviation for the *Q* prior was set to be very small to force the model to fit estimated biomass from the surveys. The

results show improved fits between model and survey estimates, but estimates of other model parameters seemed to be beyond reasonable ranges.

## 2.6 Base-Model Results

Estimated parameter values and their standard deviations are listed in Table 20. Parameter estimates were in reasonable ranges. Estimated growth curves by sex are plotted in Figure 57. While males were at slightly larger size at age 0 than females, females grew faster than males and attained a large size. Estimated natural mortality for females is lower than that for males (Table 20), similar to the patterns found for many other west coast groundfish species. Because of differences in natural mortality and growth rates, it is expected that there are more females at older ages than males. This is supported by the observations that more females were sampled than males.

Comparisons of selectivity functions for all surveys and fishing fleets are plotted in Figure 58. Individual selectivity curves by sex and for each survey and fishery are plotted from Figure 59 to Figure 71. Fishery retentions curves and discard mortality rates by length are also presented in these plots where discards occurred. In general, fisheries tended to select larger fish than surveys. Sex-specific selectivity was evident in all surveys and fisheries, with males selected at smaller size than females (Figure 58 to Figure 71).

Fits of the base model to composition data from all surveys and fishing fleets were presented in Figure 72 to Figure 105. Detailed fits to each composition data set are presented in Appendix C. These figures provided general diagnostics of the model fits to the composition data. Specifically, they help to visually identify outliers and serial patterns of the model fits to the composition data. Included in these figures were:

1. aggregated length and age composition fits across time by fleet for each data set;
2. Pearson residuals of each composition datum point;
3. comparisons of observed and effective sample sizes by year for each data set; and
4. conditional age-at-length fits and standard deviations by year.

In general, the base model was able to fit composition data well. There was a notable lack of fit to the OR/WA female age frequencies between 1995 and 2005 and for males between 1995 and 2001 (Figure 78, Figure 84, and Figure 85). A similar but less severe pattern was also observed for the fit to the CA female age frequencies in 2007 and 2008 (Figure 78 and Figure 84). This lack of fit to the data might result from interactions between sex-specific growth and selectivity as the model fitted well to all other composition data from the same fisheries during the same periods.

Effective sample sizes for length and age composition data were generally larger than input samples sizes (Figure 86 to Figure 94). In the base model tuning process, these input sample sizes were adjusted upward from 1.16 to 3.86 times. One exception was for the conditional age-at-length data from the NWFSC survey, in which the observed sample size was adjusted downward to 0.18 of the input sample sizes. This was likely because numbers of fish aged were used as the input sample sizes. There were no apparent lacks of fits in conditional age-at-length data (Figure 105). Standard deviations of the fits were larger in young and old fish than those in the middle age range. This was expected as there were few age samples in the young and older age groups.

The base model fit well to patterns of the estimated biomass from the NWFSC survey (Figure 106). During the periods between 2003 and 2012, in which the estimates were available, the estimated biomass was lowest in 2007 with an increasing trend since then. There were generally lacks of fit to the other three indices (both periods of the triennial survey and the recreational survey) (Figure 107 to Figure 109). This suggested that these three indices were less informative of stock biomass. Sensitivity runs were conducted to evaluate effects of the lack of fit to these surveys, and it was found that these lacks of fit minimally affected model outputs (see the Sensitivity analysis section).

It was expected that catchability coefficients (*Q*) from all trawl surveys should be less than zero (in log scale), because these surveys were only conducted in depths greater than 55 m, and Pacific sanddabs are found shallower than 55 m. However, the internally calculated catchability coefficients are much greater than one (Table 20). Estimated catchability coefficients (*Q*) were 19.39, 4.78, and 13.5 for the NWFSC survey and two triennial surveys, respectively. This could be due to overestimation of biomass from all surveys (NWFSC and both triennial surveys), since surveys were conducted on the trawlable grounds and expansions of swept-are biomass estimates assume that all areas are trawlable and that all areas are suitable habitats for Pacific sanddabs. Average estimated total biomass from the NWFSC survey between 2003 and 2012 was about 50,000 mt, which was much larger than the estimate of virgin biomass (Table 21). In addition, high biomass estimates from surveys may result from herding effects of trawl gears that could also lead to inaccurate calculations of density in trawlabe areas (Haltuch *et al*. 2013). However, these reasons alone may not fully explain such large discrepancies between estimates of the assessment model and the surveys. The STAR Panel identified that there exist large uncertainties in the scale of biomass estimates between the model and survey estimates of biomass.

Fits of the base model to the discard rate data for three fleets (excluding the mink food fishery) are presented in Figure 110 to Figure 112. Although fits to the data are within reasonable ranges, they showed some lack of fits to two commercial trawl fisheries. Sensitivity analyses were conducted to assess the effects of fishery discard rates on model outputs (see the Sensitivity analysis section).

The estimated stock-recruitment function, along with its bias-adjusted curve and estimated annual recruitments, is presented in Figure 113. Time series of recruitment deviations, spawning biomass, and stock depletion are presented in Figure 114 to Figure 116. Figure 114 shows that recruitments were at or near the lowest level between 2000 and 2005 in the last 50 years during which the recruitment estimates were made, but increased to an above average level in recent years (2007 to 2011), with a very strong 2010 year class.

Spawning biomass and stock depletion, along with their approximate asymptotic 95% confidence intervals, are estimated to be above the target levels for all years (Figure 115 and Figure 116). Table 21 lists the annual time series of the population and fishery summary statistics, including biomass, catch, stock depletion, SPR and relative exploitation rate. The estimated stock depletion in 2013 was 0.955 (95.5%).

## 2.7 Uncertainty and Sensitivity Analyses

A series of uncertainty and sensitivity analysis were conducted on the base model. Sensitivity analyses were conducted on fishery discard rates, historical catch estimates, fish maturity function, and inclusion of triennial survey and recreational indices. Sensitivity analyses were also conducted on the inputted model parameters, such as the prior on stock-recruitment steepness (*h*). Likelihood profile runs on stock-recruit steepness (*h*), natural mortality (M), and virgin recruitment ($R_0$) were also conducted, along with a retrospective analysis that sequentially excludes the last three years of input data. Other sensitivities runs conducted during the STAR Panel review include using the Lorenzen function of natural mortality, using dome-shaped selectivity functions on surveys, and excluding the conditional age-at-length data to evaluate their effects on the model outputs.

### 2.7.1 Sensitivity Analysis of Discard Rates

Fishery discard rates were considered to be one of the most uncertain inputs to the model because discard rates on fishery catches were high and there is very limited information on fishery discards. In the analysis, discard rates for all fishing fleets were increased and decreased by 20%, and sensitivity runs with theses discard rates were compared with the base model outputs. Model outputs on the estimated time series of spawning biomass and stock depletion from these two sensitivity runs were compared with those from the base model (Figure 117 and Figure 118). Model performance and summary outputs are listed in Table 22. The analysis showed that although discard rates had a moderate effect on model results, especially spawning biomass at early years, they had a minimum effect on stock depletion.

### 2.7.2 Sensitivity Analysis of Historical Catch Data

The historical catch data for Pacific sanddab are also uncertain because discard rates were high and also because catches may include other small sanddab species, such as speckled sanddab. A sensitivity analysis was conducted by reducing and increasing 20% of catches by all fleets before 1980. Time series of spawning biomass and stock depletion from this sensitivity analysis were compared with the base model outputs in Figure 119 and Figure 120. Model performance and summary outputs from this analysis are listed in Table 22. The analysis showed that reduction of historical catches lead to increases in spawning biomass and that the stock was less depleted in 2013. Increases of the historical catches by 20% resulted in a change of estimated stock depletion from 60.6% to 55.8% in 2013.

### 2.7.3 Sensitivity Analysis of Steepness Prior

A sensitivity analysis was also conducted to evaluate using a steepness prior in the assessment. In the non-h prior run, a non-informative prior was used (by setting "Prior type = (-1)" and standard deviation to 99). Comparisons of model outputs are plotted in Figure 121 and Figure 122. Model performance and summary outputs from the analysis are listed in Table 23. The comparisons showed that whether to include an *h*-prior in the assessment had large effects on the model outputs. Without using an *h*-prior, *h* was estimated to be 0.431, which was lower than the estimated *h* of 0.753 when the *h*-prior was used. As expected, virgin recruitment ($R_0$) was estimated to be higher without the *h*-prior in the base model, and the stock depletion changed from 95.5% in the base model to 68.9% when a non-informative prior was used.

### 2.7.4 Sensitivity Analysis of Maturity Schedules

A sensitivity analysis was conducted to evaluate two different maturity functions: (1) a maturity function based on recently collected maturity data between August and November, which was used in the base model; and (2) maturity function derived using data collected by Arora in 1951. Comparison plots of spawning biomass and stock depletion from these two sensitivity runs are presented in Figure 123 and Figure 124. Model performance and summary outputs from using these two maturity functions are listed in Table 23. They showed that spawning biomass was lower using Arora's maturity function than estimated spawning biomass those using the recent data to inform the maturity function. The stock depletion changed from 95.5% in the base model to 80.7% when the Arora's maturity function was used.

### 2.7.5 Sensitivity Analysis on excluding Triennial and Recreational Survey Indices

The base model runs showed poor fits to both the triennial and recreational survey indices of abundance. Sensitivity analyses were conducted to evaluate the effects of these indices on estimated stock status. In the analyses, indices of both surveys were excluded while composition data from these surveys were retained in the model. Comparisons of spawning biomass and stock depletions from these sensitivity runs are presented in Figure 125 to Figure 128. Model performance and summary outputs from exclusion of these two survey indices are listed in Table 24. The results suggest that both indices had minimal effects on estimated stock status.

### 2.7.6 Sensitivity Analysis on Lorenzen natural mortality estimation

It is expected that natural mortality of Pacific sanddab would decrease as fish grow larger, probably due to decreases in predations. Sensitivity analyses were conducted to evaluate the effects of changes of natural mortality by age on estimated stock status. In the analyses, six reference ages (1 to 6) were used. Estimated natural mortalities by ages are presented in Figure 129. Comparisons of spawning biomass and stock depletions from these sensitivity runs are presented in Figure 130 and Figure 131. Model performance and summary outputs from exclusion of these two survey indices are listed in Table 25. The results showed comparable outputs between the base model and the model using the Lorenzen function with reference age at 5 years old.

### 2.7.7 Sensitivity Analysis on applying dome-shaped selectivity to surveys

A sensitivity analysis was conducted by applying dome-shaped selectivity to all surveys while selectivities for all fisheries were kept asymptotic. With six more parameters, the model outputs are similar to the base model (Table 26, Figure 132 and Figure 133).

### 2.7.8 Sensitivity Analysis on excluding conditional age-at-length data

To evaluate effects of the NWFSC conditional age-at-length data on the model outputs and estimated catchability coefficients, a sensitivity analysis was conducted by removing all data after growth parameters were fixed at the values estimated in the base model. Model performance and summary outputs from the analysis are presented in Table 26, and Figure 134 and Figure 135. Without the conditional age-at-length data, estimated virgin recruitment (ln($R_0$)) is much higher than that estimated in the base model. Estimated natural mortalities were also higher, being 0.612 and 0.72 for females and males. Stock depletion changes from 95.5% in the base model to 120.2%. Estimated catchability coefficients reduce from 19.39. 4.78, and 13.54 in the base model to 6.04, 2.88, and 5.41 for the NWFSC and both triennial surveys, respectively. This suggests large effects of this data set on estimation of stock productivity and catchability coefficients of the surveys.

### 2.7.9 Likelihood Profiles

Sensitivity analyses using likelihood profiles were conducted on three important model parameters: (1) stock-recruitment steepness ($h$), (2) virgin recruitment ($R_0$), and natural mortality ($M$) for both sexes. These parameters are estimated in the model.

**Steepness ($h$) Profile**

Steepness profile runs were conducted across a range of $h$ values (0.3 and 1.0 at an interval of 0.05). A likelihood profile and comparisons of spawning biomass and stock depletion vs. steepness are presented in Figure 136 to Figure 138. The analysis showed that the steepness prior had a large effect on estimates of steepness parameter (Figure 136), and therefore had large effect on estimates of spawning biomass and stock depletion (Figure 137and Figure 138). These results confirmed results of the sensitivity analysis using a non-information prior on steepness (see section 2.7.3).

**Virgin Recruitment ($R_0$) Profile**

Spawning biomass and stock depletion from the profile run on the virgin recruit parameter are presented in Figure 139 to Figure 141. The results showed that changes in negative log likelihood values were relatively small, compared to the profiles of steepness and natural mortality. This suggests that the data were not very informative in estimating virgin recruitment.

**Natural Mortality (*M*) Profile**
Spawning biomass and stock depletion from the profile run on natural mortality are presented in Figure 142 to Figure 144. As expected, estimated spawning biomass and stock depletion are sensitive to natural mortality. The higher values of natural mortality, the more productive the stock, which lead to higher spawning biomass and a less depleted stock.

### 2.7.10 Retrospective Analysis
The retrospective analysis was conducted by excluding the last two years of data. A similar run by excluding the last three years of data could not be done because time-varying selectivity was applied in the last two years. Comparisons of spawning biomass and stock depletion of these runs with the base model are presented in Figure 145 and Figure 146, and model performance and summary outputs are listed in Table 27. Spawning biomass and stock depletion from not using last year's data were very similar to the base model estimates, but estimation without using the last three-year's data indicated a much higher spawning biomass and a less depleted stock. However, there were greater uncertainties, as shown with larger asymptotic confidence intervals, in estimates of spawning biomass and stock depletion as these data were removed.

# 3 Regional management considerations
Pacific sanddabs are managed within the Other Flatfish complex without any regional stratification of harvest specifications or allocations on the U.S. west coast. Given that there is no evidence of stock structure on the U.S. west coast (e.g., differential growth rates by area), regional estimates of biomass were not made. The catch and survey data can be used to post stratify relative biomass if regional management allocations are considered.

# 4 Research Needs
1) Both the NWFSC and triennial surveys provided estimates of biomass of Pacific sanddabs. These estimates were much higher than those estimated in the assessment model. Although the catchability coefficient (*Q*) was treated as a nuisance (scalar) parameter, which is typical of most assessments, the nominal estimate for these values from the trawl surveys was very high. For example, the estimated catchability coefficient was 19.4 for the NWFSC combined shelf-slope trawl survey. Given that these surveys did not cover the entirety of suitable Pacific sanddab habitat (the survey were not conducted depths shallower than 50 m), it was expected that these catchability coefficients should be less than (or close to) one. Further studies on the model structure, as well as on estimated survey biomass, are needed to provide general guidelines for future assessments of this species.
2) One of major uncertainties in the Pacific sanddab catch history has been the proportions of catches discarded. Discard rates varied among fisheries and states. The WCGOP has provided important information on the discard rates and length composition of discarded catches in recent years. It will be important that these data continue to be collected in the future. In addition, future assessments will benefit if Pacific sanddabs are identified separately from other sanddab species in landings and discards. This is particularly informative when length composition data for both retained and discarded catches are available for the species.

3) Continued collection of recreational catch data for Pacific sanddabs is recommended. Increases in sample sizes of length composition data from both retained and discarded catch will provide more accurate information on estimates of fishery selectivity.
4) A coastwide juvenile groundfish survey data is available for most years since 2001, and has been used in assessments of other groundfish. However, sanddabs were not identified to the species level in the northern survey areas, and thus truly coastwide data is not currently available for this species. Data from a more limited geographic range does not indicate a strong correlation between juvenile abundance and subsequent recruitment to the adult population, despite the fact that correlations (albeit not extremely strong) are typically observed for rockfish recruitment indices and subsequent realized recruitment based on assessment results. The reasons for this disparity are of interest with respect to early life history dynamics and recruitment processes.
5) Stock and catch data from both Mexico and Canada have not been used in this assessment. Although there are some data of Pacific sanddab and samples from Canadian fisheries, there is no information from Mexican fisheries on the species. Data on Pacific sanddab catches in Mexican waters will be useful to estimate potential impacts on the U.S. west coast stock.
6) The Pacific sanddabs stock on the U.S. coast has been treated as a single stock in this assessment since there is no genetic study on the stock structure of this species. A genetic study on the stock structure of Pacific sanddabs will help to determine the stock structure in future assessments.
7) The implications of fully achieving potential yield with the current harvest policy on predators and the ecosystem should be more fully explored.

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# 7 Tables

**Table 1. Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1888 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.**

| Year | CA trawl fishery | Oregon & Washington trawl fishery | Recreational fishery | Mink food fishery | Landings | Catches |
|---|---|---|---|---|---|---|
| 1888 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1889 | 59.0 | 0.0 | 0.0 | 0.0 | 59.0 | 76.7 |
| 1890 | 118.1 | 0.0 | 0.0 | 0.0 | 118.1 | 153.9 |
| 1891 | 177.1 | 0.0 | 0.0 | 0.0 | 177.1 | 231.7 |
| 1892 | 236.1 | 0.0 | 0.0 | 0.0 | 236.1 | 310.7 |
| 1893 | 217.6 | 0.0 | 0.0 | 0.0 | 217.6 | 287.9 |
| 1894 | 199.1 | 0.0 | 0.0 | 0.0 | 199.1 | 264.5 |
| 1895 | 180.6 | 0.0 | 0.0 | 0.0 | 180.6 | 240.5 |
| 1896 | 198.7 | 0.0 | 0.0 | 0.0 | 198.7 | 265.0 |
| 1897 | 216.7 | 0.0 | 0.0 | 0.0 | 216.7 | 289.5 |
| 1898 | 234.7 | 0.0 | 0.0 | 0.0 | 234.7 | 314.1 |
| 1899 | 252.8 | 0.0 | 0.0 | 0.0 | 252.8 | 339.0 |
| 1900 | 291.5 | 0.0 | 0.0 | 0.0 | 291.5 | 392.0 |
| 1901 | 330.3 | 0.0 | 0.0 | 0.0 | 330.3 | 446.0 |
| 1902 | 369.0 | 0.0 | 0.0 | 0.0 | 369.0 | 500.6 |
| 1903 | 407.8 | 0.0 | 0.0 | 0.0 | 407.8 | 556.5 |
| 1904 | 446.5 | 0.0 | 0.0 | 0.0 | 446.5 | 613.3 |
| 1905 | 429.8 | 0.0 | 0.0 | 0.0 | 429.8 | 593.9 |
| 1906 | 413.1 | 0.0 | 0.0 | 0.0 | 413.1 | 573.2 |
| 1907 | 396.4 | 0.0 | 0.0 | 0.0 | 396.4 | 551.3 |
| 1908 | 379.6 | 0.0 | 0.0 | 0.0 | 379.6 | 528.3 |
| 1909 | 422.1 | 0.0 | 0.0 | 0.0 | 422.1 | 587.9 |
| 1910 | 464.5 | 0.0 | 0.0 | 0.0 | 464.5 | 648.5 |
| 1911 | 506.9 | 0.0 | 0.0 | 0.0 | 506.9 | 710.6 |
| 1912 | 549.3 | 0.0 | 0.0 | 0.0 | 549.3 | 774.5 |
| 1913 | 591.7 | 0.0 | 0.0 | 0.0 | 591.7 | 840.3 |
| 1914 | 634.1 | 0.0 | 0.0 | 0.0 | 634.1 | 908.2 |
| 1915 | 676.6 | 0.0 | 0.0 | 0.0 | 676.6 | 978.3 |
| 1916 | 1010.9 | 0.0 | 0.0 | 0.0 | 1010.9 | 1488.7 |
| 1917 | 1193.8 | 0.0 | 0.0 | 0.0 | 1193.8 | 1818.4 |
| 1918 | 794.5 | 0.0 | 0.0 | 0.0 | 794.5 | 1242.5 |
| 1919 | 321.9 | 0.0 | 0.0 | 0.0 | 321.9 | 499.6 |
| 1920 | 327.4 | 0.0 | 0.0 | 0.0 | 327.4 | 495.2 |
| 1921 | 355.6 | 0.0 | 0.0 | 0.0 | 355.6 | 525.8 |
| 1922 | 531.1 | 0.0 | 0.0 | 0.0 | 531.1 | 774.2 |
| 1923 | 618.7 | 0.0 | 0.0 | 0.0 | 618.7 | 898.7 |

**Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.**

| Year | CA trawl fishery | Oregon & Washington trawl fishery | Recreational fishery | Mink food fishery | Landings | Catches |
|---|---|---|---|---|---|---|
| 1924 | 771.0 | 0.0 | 0.0 | 0.0 | 771.0 | 1126.7 |
| 1925 | 885.8 | 0.0 | 0.0 | 0.0 | 885.8 | 1314.8 |
| 1926 | 518.9 | 0.0 | 0.0 | 0.0 | 518.9 | 777.0 |
| 1927 | 404.9 | 0.0 | 0.0 | 0.0 | 404.9 | 601.5 |
| 1928 | 502.9 | 0.0 | 0.0 | 0.0 | 502.9 | 739.8 |
| 1929 | 477.1 | 0.0 | 0.0 | 0.0 | 477.1 | 696.8 |
| 1930 | 279.6 | 0.0 | 0.0 | 0.0 | 279.6 | 403.7 |
| 1931 | 214.5 | 0.0 | 0.0 | 0.0 | 214.5 | 304.9 |
| 1932 | 301.5 | 0.5 | 0.0 | 0.0 | 302.0 | 424.1 |
| 1933 | 247.7 | 0.2 | 0.0 | 0.0 | 247.9 | 344.9 |
| 1934 | 347.9 | 0.1 | 0.0 | 0.0 | 348.0 | 481.4 |
| 1935 | 306.4 | 0.2 | 0.0 | 0.0 | 306.7 | 423.1 |
| 1936 | 282.0 | 0.9 | 0.0 | 0.0 | 282.9 | 389.5 |
| 1937 | 234.1 | 4.6 | 0.0 | 0.0 | 238.7 | 328.5 |
| 1938 | 301.2 | 0.1 | 0.0 | 0.0 | 301.2 | 412.3 |
| 1939 | 368.2 | 14.2 | 0.0 | 0.0 | 382.4 | 527.3 |
| 1940 | 353.4 | 25.5 | 0.0 | 0.0 | 378.9 | 527.0 |
| 1941 | 200.5 | 30.5 | 0.0 | 0.0 | 230.9 | 325.1 |
| 1942 | 160.4 | 78.5 | 0.0 | 5.6 | 244.4 | 352.7 |
| 1943 | 229.2 | 197.9 | 0.0 | 5.9 | 433.1 | 643.2 |
| 1944 | 250.1 | 34.3 | 0.0 | 6.3 | 290.6 | 407.3 |
| 1945 | 268.6 | 15.1 | 0.0 | 5.6 | 289.2 | 399.8 |
| 1946 | 308.0 | 17.1 | 0.0 | 5.8 | 331.0 | 456.8 |
| 1947 | 318.2 | 38.1 | 0.0 | 6.5 | 362.8 | 506.1 |
| 1948 | 365.0 | 61.6 | 0.0 | 10.0 | 436.6 | 614.3 |
| 1949 | 327.6 | 83.0 | 0.0 | 9.9 | 420.5 | 600.8 |
| 1950 | 312.9 | 3.9 | 0.0 | 7.3 | 324.1 | 448.3 |
| 1951 | 246.8 | 5.3 | 0.0 | 8.8 | 260.9 | 359.1 |
| 1952 | 299.5 | 0.1 | 0.0 | 9.2 | 308.8 | 422.3 |
| 1953 | 313.2 | 5.5 | 0.0 | 23.1 | 341.8 | 463.1 |
| 1954 | 341.8 | 7.3 | 0.0 | 30.1 | 379.3 | 512.5 |
| 1955 | 354.5 | 25.4 | 0.0 | 30.7 | 410.6 | 561.3 |
| 1956 | 358.0 | 1.3 | 0.0 | 39.8 | 399.1 | 537.1 |
| 1957 | 313.9 | 0.1 | 0.0 | 57.1 | 371.1 | 491.9 |
| 1958 | 184.4 | 0.8 | 0.0 | 98.5 | 283.6 | 354.6 |

**Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.**

| Year | CA trawl fishery | Oregon & Washington trawl fishery | Recreational fishery | Mink food fishery | Landings | Catches |
|---|---|---|---|---|---|---|
| 1959 | 211.7 | 3.2 | 0.0 | 28.0 | 242.9 | 324.4 |
| 1960 | 158.0 | 8.1 | 0.0 | 37.7 | 203.8 | 267.0 |
| 1961 | 225.2 | 5.6 | 0.0 | 41.4 | 272.2 | 357.2 |
| 1962 | 308.4 | 9.5 | 0.0 | 31.7 | 349.5 | 467.0 |
| 1963 | 252.0 | 3.3 | 0.0 | 30.8 | 286.1 | 379.5 |
| 1964 | 452.7 | 6.1 | 7.1 | 34.1 | 500.0 | 670.5 |
| 1965 | 217.3 | 2.4 | 7.4 | 38.8 | 266.0 | 348.6 |
| 1966 | 326.6 | 9.1 | 15.5 | 27.1 | 378.4 | 506.2 |
| 1967 | 311.6 | 11.2 | 15.7 | 31.1 | 369.6 | 494.2 |
| 1968 | 324.1 | 9.4 | 65.9 | 25.8 | 425.3 | 555.9 |
| 1969 | 315.7 | 22.1 | 73.7 | 24.5 | 436.1 | 574.1 |
| 1970 | 307.8 | 30.3 | 57.7 | 14.3 | 410.1 | 553.3 |
| 1971 | 353.9 | 28.9 | 29.1 | 13.0 | 424.9 | 592.0 |
| 1972 | 417.7 | 55.0 | 28.5 | 5.2 | 506.3 | 739.0 |
| 1973 | 410.0 | 93.1 | 36.2 | 4.3 | 543.7 | 831.6 |
| 1974 | 442.4 | 117.8 | 33.4 | 47.5 | 641.0 | 978.0 |
| 1975 | 460.6 | 175.3 | 19.9 | 63.1 | 719.0 | 1090.3 |
| 1976 | 586.9 | 157.0 | 25.5 | 40.0 | 809.4 | 1179.7 |
| 1977 | 367.2 | 116.9 | 11.0 | 35.1 | 530.2 | 748.2 |
| 1978 | 337.1 | 116.8 | 2.5 | 0.4 | 456.8 | 646.4 |
| 1979 | 600.0 | 224.1 | 174.9 | 0.1 | 999.1 | 1350.8 |
| 1980 | 580.8 | 186.1 | 87.6 | 0.8 | 855.4 | 1205.4 |
| 1981 | 427.4 | 162.9 | 216.0 | 0.8 | 807.0 | 1116.5 |
| 1982 | 480.1 | 244.7 | 46.3 | 2.8 | 773.9 | 1215.1 |
| 1983 | 259.1 | 246.8 | 38.5 | 4.9 | 549.4 | 907.0 |
| 1984 | 251.1 | 280.6 | 40.0 | 0.7 | 572.4 | 951.3 |
| 1985 | 442.4 | 188.8 | 57.6 | 1.1 | 689.8 | 1061.4 |
| 1986 | 445.6 | 170.2 | 51.4 | 5.6 | 672.8 | 1002.8 |
| 1987 | 533.5 | 237.2 | 12.6 | 0.4 | 783.6 | 1189.0 |
| 1988 | 528.0 | 122.9 | 66.6 | 0.5 | 717.9 | 1047.4 |
| 1989 | 638.7 | 90.8 | 21.1 | 12.1 | 762.7 | 1132.1 |
| 1990 | 653.1 | 227.6 | 33.5 | 0.4 | 914.6 | 1424.6 |
| 1991 | 561.3 | 322.7 | 33.3 | 0.1 | 917.4 | 1546.2 |
| 1992 | 283.3 | 322.4 | 33.3 | 6.3 | 645.2 | 1220.1 |
| 1993 | 352.9 | 288.2 | 49.3 | 0.0 | 690.4 | 1318.7 |

**Table 1 (continued). Annual landings (mt) and catches (mt) of Pacific sanddab by four fishing fleets from 1988 to 2012. Catches include landings and estimated discards. See text for detail description of each fishery.**

| Year | CA trawl fishery | Oregon & Washington trawl fishery | Recreational fishery | Mink food fishery | Landings | Catches |
|---|---|---|---|---|---|---|
| 1994 | 683.3 | 524.4 | 34.5 | 0.0 | 1242.1 | 2321.0 |
| 1995 | 677.5 | 685.5 | 14.3 | 13.2 | 1390.5 | 2539.5 |
| 1996 | 789.3 | 105.3 | 50.2 | 0.0 | 944.8 | 1537.3 |
| 1997 | 930.2 | 241.5 | 35.5 | 0.0 | 1207.3 | 2043.5 |
| 1998 | 644.3 | 132.5 | 13.3 | 9.0 | 799.0 | 1326.1 |
| 1999 | 930.1 | 273.6 | 20.9 | 0.0 | 1224.6 | 1999.7 |
| 2000 | 744.6 | 150.1 | 62.4 | 0.0 | 957.2 | 1464.0 |
| 2001 | 793.1 | 109.9 | 46.9 | 15.0 | 964.9 | 1436.7 |
| 2002 | 387.7 | 362.5 | 153.9 | 0.0 | 904.2 | 1417.4 |
| 2003 | 204.6 | 386.0 | 47.3 | 12.7 | 650.6 | 1123.6 |
| 2004 | 235.4 | 221.2 | 44.6 | 22.1 | 523.2 | 860.3 |
| 2005 | 207.5 | 139.8 | 45.7 | 5.3 | 398.3 | 628.6 |
| 2006 | 340.7 | 71.8 | 23.1 | 4.9 | 440.6 | 666.4 |
| 2007 | 161.8 | 130.4 | 19.7 | 3.3 | 315.3 | 512.0 |
| 2008 | 73.5 | 123.0 | 27.3 | 5.4 | 229.1 | 389.1 |
| 2009 | 200.6 | 90.1 | 28.4 | 7.7 | 326.7 | 561.7 |
| 2010 | 101.5 | 44.8 | 42.7 | 8.9 | 198.0 | 322.3 |
| 2011 | 45.1 | 101.1 | 81.2 | 8.4 | 235.7 | 338.6 |
| 2012 | 59.5 | 99.7 | 53.2 | 9.4 | 221.8 | 325.5 |

**Table 2 Recent trend in commercial landings and estimated total catch relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass.**

| Year | OFL (mt) | ACL (mt) | Commercial landings (mt) | Estimated total catch (mt) |
|---|---|---|---|---|
| 2004 | NA | NA | 456.6 | 860.3 |
| 2005 | 3172 | 2379 | 347.3 | 628.6 |
| 2006 | 3172 | 2379 | 412.5 | 666.4 |
| 2007 | 3172 | 2379 | 292.2 | 512.0 |
| 2008 | 3172 | 2379 | 196.5 | 389.1 |
| 2009 | 3172 | 2379 | 290.7 | 561.7 |
| 2010 | 3172 | 2379 | 146.3 | 322.3 |
| 2011 | 4943 | 3432 | 146.2 | 338.6 |
| 2012 | 4943 | 3432 | 159.2 | 325.5 |
| 2013 | 4801 | 3332 | NA | NA |

**Table 3 Annual summaries of coastal wide landings and discards of Pacific sanddabs in Canada. Summary data were provided by Kate Rutherford of the Fisheries and Oceans Canada.**

| Year | Landings (mt) | Discards (mt) | Total catch (mt) | Discard rate (%) |
|---|---|---|---|---|
| 1996 | 0.0 | 4.3 | 4.3 | 100.0 |
| 1997 | 0.0 | 14.7 | 14.7 | 100.0 |
| 1998 | 0.0 | 12.5 | 12.5 | 100.0 |
| 1999 | 0.0 | 21.5 | 21.5 | 100.0 |
| 2000 | 0.0 | 62.5 | 62.5 | 100.0 |
| 2001 | 0.1 | 52.2 | 52.2 | 99.9 |
| 2002 | 0.4 | 72.7 | 73.1 | 99.5 |
| 2003 | 0.8 | 95.6 | 96.4 | 99.1 |
| 2004 | 1.2 | 99.9 | 101.1 | 98.8 |
| 2005 | 1.7 | 35.2 | 36.9 | 95.5 |
| 2006 | 0.5 | 19.9 | 20.5 | 97.4 |
| 2007 | 1.1 | 25.0 | 26.1 | 95.8 |
| 2008 | 2.3 | 8.7 | 11.0 | 79.4 |
| 2009 | 4.0 | 8.9 | 12.9 | 69.1 |
| 2010 | 2.8 | 27.4 | 30.2 | 90.8 |
| 2011 | 10.0 | 39.4 | 49.3 | 79.8 |
| 2012 | 7.1 | 19.5 | 26.6 | 73.3 |

**Table 4 Summary of positive catch hauls and catch weight by three depth strata from the NWFSC survey. Percentages of total catch weight were calculated among three depth strata. No trawl hauls in the deep stratum were used in the catch rate analysis.**

| Depth stratum | Depth range (m) | No haul | Positive catch haul | % of Positive haul | % of total catch weight |
|---|---|---|---|---|---|
| Shallow | 55-150 | 2183 | 1754 | 80.3 | 94.3 |
| Middle | 151-250 | 935 | 207 | 22.1 | 5.7 |
| Deep | >250 | 3334 | 0 | 0.0 | 0.0 |

**Table 5 Summary of annual number of hauls, total length measurements, and length measurement by sex from the NWFSC survey from 2003 to 2012.**

| Year | No haul | No. length | No. length per haul | No. female | No. male | % of female |
|---|---|---|---|---|---|---|
| 2003 | 132 | 8852 | 67.1 | 5251 | 3601 | 59.3 |
| 2004 | 165 | 10933 | 66.3 | 7093 | 3840 | 64.9 |
| 2005 | 218 | 10111 | 46.4 | 6223 | 3888 | 61.5 |
| 2006 | 178 | 5940 | 33.4 | 3727 | 2213 | 62.7 |
| 2007 | 190 | 4326 | 22.8 | 2815 | 1511 | 65.1 |
| 2008 | 203 | 4536 | 22.3 | 2791 | 1745 | 61.5 |
| 2009 | 214 | 2823 | 13.2 | 1743 | 1080 | 61.7 |
| 2010 | 239 | 1486 | 6.2 | 942 | 544 | 63.4 |
| 2011 | 242 | 4521 | 18.7 | 2897 | 1624 | 64.1 |
| 2012 | 244 | 4593 | 18.8 | 2929 | 1664 | 63.8 |

**Table 6 Summary of annual number of hauls, total fish aged, and number of fish aged by sex from the NWFSC survey from 2003 to 2012. Note that there were no fish aged in 2009.**

| Year | No hauls | No. fish | No female | No. male | % of female |
|---|---|---|---|---|---|
| 2003 | 58 | 779 | 501 | 278 | 64.3 |
| 2004 | 156 | 1429 | 966 | 463 | 67.6 |
| 2005 | 211 | 988 | 626 | 362 | 63.4 |
| 2006 | 176 | 708 | 465 | 243 | 65.7 |
| 2007 | 185 | 729 | 526 | 203 | 72.2 |
| 2008 | 202 | 768 | 520 | 248 | 67.7 |
| 2010 | 234 | 1009 | 640 | 369 | 63.4 |
| 2011 | 216 | 742 | 482 | 260 | 65.0 |
| 2012 | 241 | 819 | 545 | 274 | 66.5 |

**Table 7: Estimated biomass of Pacific sanddab and standard errors (natural log of estimates) using GLMM analysis from the NWFSC survey.**

| Year | Biomass (mt) | Standard error (ln) |
|---|---|---|
| 2003 | 58,254 | 0.2102 |
| 2004 | 49,940 | 0.2205 |
| 2005 | 37,508 | 0.1845 |
| 2006 | 37,337 | 0.1964 |
| 2007 | 25,816 | 0.1954 |
| 2008 | 39,337 | 0.1911 |
| 2009 | 56,781 | 0.1892 |
| 2010 | 65,278 | 0.1837 |
| 2011 | 56,331 | 0.1813 |
| 2012 | 73,364 | 0.2042 |

**Table 8 Summary of positive catch hauls and catch weight by three depth strata from the triennial survey. Percentages of total catch weight were calculated among three depth strata. No trawl hauls in the deep stratum were used in the catch rate analysis.**

| Depth stratum | Depth range (m) | No haul | Positive catch haul | % of Positive haul | % of total catch weight |
|---|---|---|---|---|---|
| Shallow | 50-150 | 2394 | 1940 | 81.0 | 96.7 |
| Middle | 151-250 | 663 | 113 | 17.0 | 3.3 |
| Deep | >250 | 894 | 15 | 1.6 | <0.001 |

**Table 9 Summary of annual number of hauls, total length measurements, and length measurement by sex from two time periods of the triennial trawl survey from 1980 to 2004. Note that there were no fish aged for the triennial survey.**

| Year | No. hauls | No. length | No length per haul | No. female length | No. male length | % of female length |
|---|---|---|---|---|---|---|
| Early year | | | | | | |
| 1980 | 5 | 574 | 114.8 | 447 | 127 | 77.9 |
| 1983 | 16 | 2632 | 164.5 | 1445 | 1187 | 54.9 |
| 1986 | 11 | 1021 | 92.8 | 636 | 385 | 62.3 |
| 1989 | 90 | 8638 | 96.0 | 4846 | 3792 | 56.1 |
| 1992 | 147 | 12778 | 86.9 | 7595 | 5183 | 59.4 |
| Late year | | | | | | |
| 1995 | 149 | 16438 | 110.3 | 9132 | 7306 | 55.6 |
| 1998 | 223 | 20516 | 92.0 | 12465 | 8051 | 60.8 |
| 2001 | 231 | 19262 | 83.4 | 10830 | 8432 | 56.2 |
| 2004 | 166 | 16548 | 99.7 | 8962 | 7586 | 54.2 |

**Table 10: Summary statistics from a GIS analysis on areas by three depth zones of the coastal waters off all three states (CA, OR, and WA).**

| Depth zone (m) | Area ($km^2$) | % of area |
|---|---|---|
| 0-49 | 14,161 | 23.2 |
| 50-150 | 36,145 | 57.3 |
| 151-250 | 12,357 | 19.6 |

**Table 11: Estimated biomass of Pacific sanddab and standard errors (natural log of estimates) using GLMM analysis from the triennial survey for two time periods. Two time periods were defined as early year time period (1980 to 1992) and late year time period (1995 to 2004).**

| Year | Estimated biomass (mt) | Standard error (ln) |
|---|---|---|
| Early year | | |
| 1980 | 3,372 | 0.4217 |
| 1983 | 9,224 | 0.3438 |
| 1986 | 10,263 | 0.3322 |
| 1989 | 29,374 | 0.3511 |
| 1992 | 18,623 | 0.3163 |
| Late year | | |
| 1995 | 45,513 | 0.4727 |
| 1998 | 31,152 | 0.6505 |
| 2001 | 46,639 | 0.4462 |
| 2004 | 65,976 | 0.3929 |

**Table 12 Summary of annual numbers of sampling trips, port complex-month counts, fish measured for length compositions, and fish measured for length per sample trip and per port complex-month counts from the CA CPFV sampling. Sex was not identified in the sampling.**

| Year | No. trips | No. port complex-month | No. fish | No. fish per trip | No fish per port complex-month |
|---|---|---|---|---|---|
| 1976 | 71 | 38 | 308 | 4.3 | 8.1 |
| 1977 | 44 | 27 | 239 | 5.4 | 8.9 |
| 1978 | 57 | 36 | 311 | 5.5 | 8.6 |
| 1986 | 62 | 39 | 480 | 7.7 | 12.3 |
| 1987 | 69 | 42 | 323 | 4.7 | 7.8 |
| 1988 | 82 | 46 | 380 | 4.6 | 8.3 |
| 1989 | 151 | 74 | 1432 | 9.5 | 19.4 |
| 1990 | 23 | 13 | 67 | 2.9 | 5.2 |
| 1991 | 20 | 11 | 104 | 5.2 | 9.5 |
| 1992 | 46 | 23 | 185 | 4.0 | 8.0 |
| 1993 | 37 | 21 | 198 | 5.4 | 9.4 |
| 1994 | 49 | 25 | 249 | 5.1 | 10.0 |
| 1995 | 75 | 28 | 329 | 4.4 | 11.8 |
| 1996 | 67 | 25 | 388 | 5.8 | 15.5 |
| 1997 | 58 | 25 | 294 | 5.1 | 11.8 |
| 1998 | 14 | 10 | 30 | 2.1 | 3.0 |

**Table 13 Summary of annual sampling trips, fish measured for length compositions, and fish aged for age compositions from the CA fishery. Length data included samples from both retained and discard catches while all age data were from retained catches. Sex was not identified in the discard length data.**

| Year | No. trips | No. fish | No. fish per trip | No. female | % of female |
|---|---|---|---|---|---|
| **Length data retained** | | | | | |
| 2003 | 23 | 1212 | 52.7 | 901 | 74.3 |
| 2004 | 14 | 755 | 53.9 | 579 | 76.7 |
| 2005 | 13 | 967 | 74.4 | 719 | 74.4 |
| 2006 | 28 | 1971 | 70.4 | 1649 | 83.7 |
| 2007 | 27 | 1451 | 53.7 | 1257 | 86.6 |
| 2008 | 22 | 1212 | 55.1 | 1045 | 86.2 |
| 2009 | 16 | 752 | 47.0 | 638 | 84.8 |
| 2010 | 17 | 684 | 40.2 | 618 | 90.4 |
| 2011 | 4 | 246 | 61.5 | 217 | 88.2 |
| 2012 | 8 | 1212 | 151.5 | 304 | 85.6 |
| **Length data discarded** | | | | | |
| 2006 | 98 | 625 | 6.4 | NA | NA |
| 2007 | 49 | 328 | 6.7 | NA | NA |
| 2008 | 61 | 386 | 6.3 | NA | NA |
| 2009 | 28 | 212 | 7.6 | NA | NA |
| 2010 | 37 | 337 | 9.1 | NA | NA |
| 2011 | 82 | 660 | 8.0 | NA | NA |
| **Age data retained** | | | | | |
| 2003 | 8 | 349 | 43.6 | 217 | 62.1 |
| 2007 | 13 | 440 | 33.8 | 374 | 85.0 |
| 2008 | 8 | 316 | 39.5 | 263 | 83.2 |

**Table 14 Summary of annual sampling trips, fish measured for length compositions, and fish aged for age compositions from the OR/WA fishery. Length data included samples from both retained and discard catches while all age data were from retained catches. Sex was not identified in the discard length data.**

| Year | No. trips | No. fish | No. fish per trip | No. female | % of female |
|---|---|---|---|---|---|
| **Length data retained** | | | | | |
| 1994 | 3 | 147 | 49.0 | 75 | 51.0 |
| 1995 | 4 | 215 | 53.8 | 127 | 59.1 |
| 1996 | 2 | 160 | 80.0 | 96 | 60.0 |
| 1997 | 11 | 584 | 53.1 | 515 | 88.2 |
| 1998 | 9 | 588 | 65.3 | 502 | 85.4 |
| 1999 | 5 | 251 | 50.2 | 229 | 91.2 |
| 2000 | 8 | 413 | 51.6 | 363 | 87.9 |
| 2001 | 9 | 398 | 44.2 | 352 | 88.4 |
| 2002 | 11 | 538 | 48.9 | 468 | 87.0 |
| 2003 | 8 | 340 | 42.5 | 329 | 96.8 |
| 2004 | 11 | 478 | 43.5 | 438 | 91.6 |
| 2005 | 11 | 566 | 51.5 | 502 | 88.7 |
| 2006 | 17 | 804 | 47.3 | 746 | 92.8 |
| 2007 | 21 | 630 | 30.0 | 577 | 91.6 |
| 2008 | 15 | 465 | 31.0 | 440 | 94.6 |
| 2009 | 25 | 925 | 37.0 | 818 | 88.4 |
| 2010 | 25 | 834 | 33.4 | 784 | 94.0 |
| 2011 | 23 | 829 | 36.0 | 725 | 87.5 |
| 2012 | 19 | 709 | 37.3 | 638 | 90.0 |
| **Length data discarded** | | | | | |
| 2006 | 80 | 879 | 11.0 | NA | NA |
| 2007 | 48 | 484 | 10.1 | NA | NA |
| 2008 | 39 | 362 | 9.3 | NA | NA |
| 2009 | 79 | 1037 | 13.1 | NA | NA |
| 2010 | 32 | 407 | 12.7 | NA | NA |
| 2011 | 127 | 1678 | 13.2 | NA | NA |
| **Age data retained** | | | | | |
| 1995 | 2 | 92 | 46.0 | 53 | 57.6 |
| 1997 | 10 | 480 | 48.0 | 427 | 89.0 |
| 1999 | 5 | 236 | 47.2 | 215 | 91.1 |
| 2001 | 9 | 382 | 42.4 | 335 | 87.7 |
| 2003 | 5 | 207 | 41.4 | 204 | 98.6 |
| 2005 | 10 | 521 | 52.1 | 460 | 88.3 |
| 2006 | 2 | 60 | 30.0 | 54 | 90.0 |
| 2007 | 14 | 492 | 35.1 | 426 | 86.6 |
| 2009 | 16 | 494 | 30.9 | 427 | 86.4 |
| 2011 | 16 | 551 | 34.4 | 500 | 90.7 |
| 2012 | 2 | 92 | 46.0 | 53 | 57.6 |

**Table 15 Summary of annual sampling trips, fish measured for length compositions for both retained and discarded catches for the 2005 recreational fishery. Discard data were only available were from 2005 sampling.**

| Year | No. trips | No. fish |
|---|---|---|
| **Length data retained** | | |
| 2005 | 28 | 102 |
| **Length data discarded** | | |
| 2005 | 71 | 112 |

**Table 16: Estimated discard rates for the CA and OR/WA fisheries and their standard deviations (StdDev). Discard rate and its standard deviation for the CA fishery in 1986 were averages of estimates between 2002 and 2010.**

| Year | CA discard rate | CA stdDev | OR/WA discard rate | OR/WA discard StdDev |
|---|---|---|---|---|
| 1986 | ***0.3256*** | ***0.051*** | 0.5124 | 0.4064 |
| 2002 | 0.2064 | 0.0379 | 0.7068 | 0.1071 |
| 2003 | 0.3288 | 0.0257 | 0.8785 | 0.1290 |
| 2004 | 0.2450 | 0.0877 | 0.6261 | 0.1517 |
| 2005 | 0.3579 | 0.0585 | 0.5874 | 0.1197 |
| 2006 | 0.3260 | 0.0001 | 0.4662 | 0.1081 |
| 2007 | 0.2810 | 0.0709 | | |
| 2008 | 0.3205 | 0.0993 | 0.4854 | 0.0948 |
| 2009 | 0.4417 | 0.0745 | 0.5784 | 0.0708 |
| 2010 | 0.4210 | 0.0033 | | |
| **Average of 2002-2010** | **0.3254** | | **0.6184** | |

**Table 17: Numbers of otolith aged from California and Oregon fisheries and from the NWFSC survey. No otolith samples were taken from the triennial survey and recreational fishery. Numbers of sampling trips were used as initial sample sizes for both fisheries. Numbers of fish aged were used as initial sample sizes in the conditional age-at-length matrix for NWFSC survey.**

| Source and year | Female | Male | Total | No of sample | No. fish per sample |
|---|---|---|---|---|---|
| **California fishery total** | 866 | 238 | 1105 | 29 | 34.3 |
| 2003 | 168 | 106 | 274 | 8 | 38.6 |
| 2007 | 426 | 76 | 502 | 13 | 41.0 |
| 2008 | 272 | 56 | 328 | 8 | 46.0 |
| | | | | | |
| **Oregon fishery total** | 3102 | 413 | 3515 | 89 | 48.0 |
| 1995 | 53 | 39 | 92 | 2 | 47.2 |
| 1997 | 427 | 53 | 480 | 10 | 42.4 |
| 1999 | 215 | 21 | 236 | 5 | 41.4 |
| 2001 | 336 | 46 | 382 | 9 | 52.1 |
| 2003 | 204 | 3 | 207 | 5 | 30.0 |
| 2005 | 460 | 61 | 521 | 10 | 35.1 |
| 2007 | 54 | 6 | 60 | 2 | 30.9 |
| 2009 | 426 | 66 | 492 | 14 | 34.4 |
| 2011 | 427 | 67 | 494 | 16 | 48.0 |
| 2012 | 500 | 51 | 551 | 16 | 47.2 |
| | | | | | |
| **NWFSC survey total** | 5271 | 2700 | 7971 | | |
| 2003 | 501 | 278 | 779 | | |
| 2004 | 966 | 463 | 1429 | | |
| 2005 | 626 | 362 | 988 | | |
| 2006 | 465 | 243 | 708 | | |
| 2007 | 526 | 203 | 729 | | |
| 2009 | 520 | 248 | 768 | | |
| 2010 | 640 | 369 | 1009 | | |
| 2011 | 482 | 260 | 742 | | |
| 2012 | 545 | 274 | 819 | | |
| | | | | | |
| **Grand total** | 9239 | 3351 | 12590 | | |

**Table 18: Estimated CPUE indices and CVs from the GLMM analysis for the California recreational fishery survey (CPFV survey) between 1999 and 2011. The indices were provided by Melissa Monk of the SWFSC.**

| Year | Index | CV |
|---|---|---|
| 1999 | 0.1658 | 0.194 |
| 2000 | 0.1504 | 0.299 |
| 2001 | 0.2214 | 0.444 |
| 2002 | 0.1992 | 0.289 |
| 2003 | 0.4135 | 0.265 |
| 2004 | 0.3477 | 0.230 |
| 2005 | 0.0801 | 0.202 |
| 2006 | 0.2417 | 0.150 |
| 2007 | 0.1421 | 0.162 |
| 2008 | 0.1473 | 0.133 |
| 2009 | 0.1636 | 0.120 |
| 2010 | 0.2693 | 0.121 |
| 2011 | 0.2937 | 0.106 |

**Table 19: Catchability coefficient values for the NWFSC survey estimated in recent flatfish assessments. Average and standard deviation are used as prior for test runs during the STAR Panel review.**

| Species | Arithmetic Q | Ln Q | Source |
|---|---|---|---|
| English sole | 1.22 | 0.198 | Cope *et al*. in review |
| Rex sole | 1.79 | 0.582 | Cope *et al*. in review |
| Dover sole | 0.70 | -0.362 | Hicks 2011 |
| Petrale sole | 3.36 | 1.211 | Haltuch *et al*. 2013 |
| Arrowtooth flounder | 0.31 | -1.171 | Kaplan *et al*. 2011 |
| | | | |
| **Average** | **1.475** | **0.388** | |
| **Standard deviation** | **1.191** | **0.174** | |

**Table 20: Key model parameters in the base case assessment model. Symbol (*) indicates if prior was available to the parameter. Prior type for natural mortality (*M*) was lognormal, with mean = (-1.136) and *SD*=0.3600 for female and with mean = (-0.9848) and *SD* = 0.3598 for male. Prior type for steepness (*h*) was normal, with mean = 0.8 and *SD* = 0.09. A total of 102 parameters were estimated in the base model.**

| Parameter | Parameter bounds | No. of parameter | Estimated? | Value |
|---|---|---|---|---|
| **Natural mortality (*M*)** | | | | |
| *Female | 0.01-2.0 | 1 | Yes | 0.459 |
| *Male | 0.01-2.0 | 1 | Yes | 0.566 |
| | | | Yes | |
| **Stock recruitment** | | | | |
| Ln($R_0$) virgin recruitment | 0.1-30.0 | 1 | Yes | 12.36 |
| *Steepness (*h*) | 0.2-1.0 | 1 | Yes | 0.768 |
| Recruitment variability ($\sigma_R$) | 0.0-1.5 | 1 | No | 0.450 |
| Ln(Early recruitment devs): 1966-1975 | -3.0-3.0 | 10 | Yes | Vary |
| Ln(Early recruitment devs): 1976-2011 | -5.0-5.0 | 36 | Yes | Vary |
| Ln(Early recruitment devs): 2012-2013 | -3.0-3.0 | 2 | Yes | Vary |
| | | | | |
| **Female growth** | | | | |
| *L1* (length at age 0) | 2-20 | 1 | Yes | 4.23 |
| *L2* (length at age 11) | 10-40 | 1 | Yes | 30.33 |
| Von Bertalanffy *K* | 0.01-0.50 | 1 | Yes | 0.169 |
| Growth CV young | 0.02-0.35 | 1 | Yes | 0.299 |
| Growth CV old | 0.02-0.35 | 1 | Yes | 0.042 |
| | | | | |
| **Male growth** | | | | |
| *L1* (length at age 0) | 2-20 | 1 | Yes | 4.66 |
| L2 (length at age 11) | 10-40 | 1 | Yes | 26.47 |
| Von Bertalanffy *K* | 0.01-0.50 | 1 | Yes | 0.212 |
| Growth CV young | 0.02-0.35 | 1 | Yes | 0.250 |
| Growth CV old | 0.02-0.35 | 1 | Yes | 0.056 |
| | | | | |
| **Catchability (*Q*) and extra SD for *Q*** | | | | |
| Recreational survey *Q* | | 1 | No | 0.00012 |
| NWFSC survey *Q* | | 1 | No | 19.39 |
| Triennial early survey *Q* | | 1 | No | 4.776 |
| Triennial late survey *Q* | | 1 | No | 13.54 |
| Extra SD Recreational survey *Q* (ln) | 0.001-2.0 | 1 | Yes | 0.242 |
| Extra SD NWFSC survey | 0.001-2.0 | 1 | No | 0.001 |
| Extra SD for triennial early survey | 0.001-2.0 | 1 | Yes | 0.433 |
| Extra SD for triennial late survey | 0.001-2.0 | 1 | Yes | 0.094 |

***Table continued from previous page.***

| Parameter | Parameter bounds | No. of parameter | Estimated? | Value |
|---|---|---|---|---|
| **<u>Fishery selectivity</u>** | | | | |
| **CA fishery** | | | | |
| Peak (female) | 10-34.5 | 1 | Yes | 34.26 |
| Ascending width (female) | -4-12 | 1 | Yes | 3.983 |
| Retention inflection | 3-34.5 | 1 | Yes | 24.43 |
| Retention slope | 0.1-10.0 | 1 | Yes | 1.291 |
| Retention asymptotic | 0.001-1.0 | 1 | Yes | 0.986 |
| Peak (male offset) | -15.0-15.0 | 1 | Yes | -2.478 |
| Ascending width (male offset) | -15.0-15.0 | 1 | Yes | 0.056 |
| Time-varying retention inflection | -5.0-5.0 | 1 | Yes | 0.0261 |
| Time-varying retention slope | -5.0-5.0 | 1 | Yes | 0.3924 |
| Time-varying retention asymptotic | -5.0-5.0 | 1 | Yes | 2.0263 |
| **OR/WA fishery** | | | | |
| Peak (female) | 10-34.5 | 1 | Yes | 34.50 |
| Ascending width (female) | -8-12 | 1 | Yes | 3.675 |
| Retention inflection | 3-34.5 | 1 | Yes | 26.09 |
| Retention slope | 0.1-10.0 | 1 | Yes | 1.206 |
| Retention asymptotic | 0.001-1.0 | 1 | Yes | 0.886 |
| Peak (male offset) | -15.0-15.0 | 1 | Yes | -0.011 |
| Ascending width (male offset) | -15.0-15.0 | 1 | Yes | 0.053 |
| Time-varying retention inflection | -5.0-5.0 | 1 | Yes | -0.106 |
| Time-varying retention slope | -5.0-5.0 | 1 | Yes | 0.122 |
| Time-varying retention asymptotic | -5.0-5.0 | 1 | Yes | 0.198 |
| **Recreational fishery** | | | | |
| Peak (female) | 10-34.5 | 1 | Yes | 29.74 |
| Ascending width (female) | -4-12 | 1 | Yes | 3.686 |
| Retention inflection | 3-34.5 | 1 | Yes | 14.01 |
| Retention slope | 0.1-10.0 | 1 | Yes | 3.289 |
| Retention asymptotic | 0.001-1.0 | 1 | Yes | 0.990 |
| **<u>Survey selectivity</u>** | | | | |
| **NWFSC survey** | | | | |
| Peak (female) | 10-34 | 1 | Yes | 28.44 |
| Ascending width (female) | -4-12 | 1 | Yes | 3.785 |
| Peak (male offset) | -15.0-15.0 | 1 | Yes | -3.764 |
| Ascending width (male offset) | -15.0-15.0 | 1 | Yes | -0.481 |
| **Triennial early years** | | | | |
| Peak (female) | 10-34 | 1 | Yes | 34.00 |
| Ascending width (female) | -4-12 | 1 | Yes | 4.311 |
| Peak (male offset) | -15.0-15.0 | 1 | Yes | -4.805 |
| Ascending width (male offset) | -15.0-15.0 | 1 | Yes | -0.411 |
| **Triennial late years** | | | | |
| Peak (female) | 10-34 | 1 | Yes | 30.82 |
| Ascending width (female) | -4-12 | 1 | Yes | 4.398 |
| Peak (male offset) | -15.0-15.0 | 1 | Yes | -6.258 |
| Ascending width (male offset) | -15.0-15.0 | 1 | Yes | -0.811 |

**Table 21: Time series of population status, outputs, and exploitation from the base assessment model.**

| Year | Total biomass (mt) | Spawning biomass (mt) | Recruit (*1000) | Total catch (mt) | Depletion | SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|
| 1888 | 14622 | 8954 | 232532 | 0 | 1.000 | 1.000 | 0.0000 |
| 1889 | 14452 | 8954 | 232532 | 77 | 1.000 | 0.985 | 0.0052 |
| 1890 | 14288 | 8910 | 232446 | 154 | 0.995 | 0.970 | 0.0106 |
| 1891 | 14127 | 8835 | 232295 | 232 | 0.987 | 0.956 | 0.0160 |
| 1892 | 13964 | 8737 | 232096 | 311 | 0.976 | 0.941 | 0.0217 |
| 1893 | 13992 | 8623 | 231858 | 288 | 0.963 | 0.944 | 0.0203 |
| 1894 | 14028 | 8554 | 231713 | 265 | 0.955 | 0.947 | 0.0187 |
| 1895 | 14072 | 8519 | 231637 | 241 | 0.951 | 0.951 | 0.0171 |
| 1896 | 14020 | 8507 | 231611 | 265 | 0.950 | 0.946 | 0.0189 |
| 1897 | 13968 | 8485 | 231564 | 289 | 0.948 | 0.942 | 0.0206 |
| 1898 | 13915 | 8455 | 231499 | 314 | 0.944 | 0.937 | 0.0225 |
| 1899 | 13861 | 8420 | 231422 | 339 | 0.940 | 0.932 | 0.0243 |
| 1900 | 13752 | 8381 | 231335 | 392 | 0.936 | 0.923 | 0.0282 |
| 1901 | 13641 | 8323 | 231207 | 446 | 0.930 | 0.913 | 0.0323 |
| 1902 | 13527 | 8252 | 231046 | 501 | 0.922 | 0.903 | 0.0365 |
| 1903 | 13409 | 8171 | 230860 | 556 | 0.913 | 0.893 | 0.0409 |
| 1904 | 13288 | 8083 | 230652 | 613 | 0.903 | 0.883 | 0.0454 |
| 1905 | 13295 | 7989 | 230427 | 594 | 0.892 | 0.883 | 0.0444 |
| 1906 | 13315 | 7932 | 230287 | 573 | 0.886 | 0.885 | 0.0431 |
| 1907 | 13346 | 7901 | 230213 | 551 | 0.882 | 0.888 | 0.0416 |
| 1908 | 13385 | 7891 | 230187 | 528 | 0.881 | 0.891 | 0.0399 |
| 1909 | 13278 | 7895 | 230198 | 588 | 0.882 | 0.882 | 0.0444 |
| 1910 | 13164 | 7866 | 230126 | 649 | 0.879 | 0.872 | 0.0491 |
| 1911 | 13043 | 7813 | 229991 | 711 | 0.873 | 0.862 | 0.0541 |
| 1912 | 12916 | 7741 | 229808 | 775 | 0.865 | 0.851 | 0.0594 |
| 1913 | 12781 | 7655 | 229586 | 840 | 0.855 | 0.840 | 0.0650 |
| 1914 | 12639 | 7559 | 229331 | 908 | 0.844 | 0.828 | 0.0710 |
| 1915 | 12492 | 7455 | 229047 | 978 | 0.833 | 0.816 | 0.0773 |
| 1916 | 11767 | 7343 | 228736 | 1489 | 0.820 | 0.757 | 0.1191 |
| 1917 | 11226 | 7006 | 227741 | 1818 | 0.782 | 0.714 | 0.1511 |
| 1918 | 11709 | 6606 | 226445 | 1243 | 0.738 | 0.752 | 0.1082 |
| 1919 | 13024 | 6596 | 226410 | 500 | 0.737 | 0.860 | 0.0436 |
| 1920 | 13153 | 6948 | 227564 | 495 | 0.776 | 0.871 | 0.0414 |
| 1921 | 13178 | 7211 | 228358 | 526 | 0.805 | 0.873 | 0.0427 |
| 1922 | 12782 | 7389 | 228866 | 774 | 0.825 | 0.840 | 0.0617 |

**Table (continued): Time series of population status, outputs, and exploitation from the base assessment model.**

| Year | Total biomass (mt) | Spawning biomass (mt) | Recruit (*1000) | Total catch (mt) | Depletion | SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|
| 1923 | 12590 | 7392 | 228873 | 899 | 0.826 | 0.824 | 0.0715 |
| 1924 | 12232 | 7330 | 228699 | 1127 | 0.819 | 0.795 | 0.0903 |
| 1925 | 11907 | 7170 | 228237 | 1315 | 0.801 | 0.768 | 0.1072 |
| 1926 | 12621 | 6963 | 227609 | 777 | 0.778 | 0.827 | 0.0649 |
| 1927 | 12989 | 7083 | 227976 | 601 | 0.791 | 0.857 | 0.0495 |
| 1928 | 12792 | 7260 | 228500 | 740 | 0.811 | 0.841 | 0.0597 |
| 1929 | 12894 | 7319 | 228668 | 697 | 0.817 | 0.849 | 0.0559 |
| 1930 | 13504 | 7383 | 228849 | 404 | 0.825 | 0.901 | 0.0322 |
| 1931 | 13776 | 7582 | 229394 | 305 | 0.847 | 0.925 | 0.0238 |
| 1932 | 13559 | 7783 | 229915 | 424 | 0.869 | 0.906 | 0.0324 |
| 1933 | 13747 | 7867 | 230127 | 345 | 0.879 | 0.922 | 0.0261 |
| 1934 | 13495 | 7971 | 230384 | 481 | 0.890 | 0.901 | 0.0361 |
| 1935 | 13611 | 7975 | 230392 | 423 | 0.891 | 0.911 | 0.0317 |
| 1936 | 13685 | 8009 | 230476 | 389 | 0.894 | 0.917 | 0.0291 |
| 1937 | 13819 | 8053 | 230581 | 329 | 0.899 | 0.929 | 0.0244 |
| 1938 | 13661 | 8118 | 230736 | 412 | 0.907 | 0.915 | 0.0304 |
| 1939 | 13450 | 8121 | 230742 | 527 | 0.907 | 0.897 | 0.0389 |
| 1940 | 13438 | 8060 | 230598 | 527 | 0.900 | 0.895 | 0.0391 |
| 1941 | 13823 | 8017 | 230494 | 325 | 0.895 | 0.929 | 0.0242 |
| 1942 | 13784 | 8095 | 230681 | 353 | 0.904 | 0.925 | 0.0261 |
| 1943 | 13284 | 8136 | 230778 | 643 | 0.909 | 0.881 | 0.0474 |
| 1944 | 13652 | 8007 | 230471 | 407 | 0.894 | 0.914 | 0.0304 |
| 1945 | 13671 | 8047 | 230566 | 400 | 0.899 | 0.916 | 0.0297 |
| 1946 | 13568 | 8079 | 230643 | 457 | 0.902 | 0.907 | 0.0339 |
| 1947 | 13478 | 8071 | 230623 | 506 | 0.901 | 0.899 | 0.0375 |
| 1948 | 13283 | 8037 | 230542 | 614 | 0.898 | 0.882 | 0.0457 |
| 1949 | 13287 | 7954 | 230341 | 601 | 0.888 | 0.882 | 0.0451 |
| 1950 | 13542 | 7901 | 230211 | 448 | 0.882 | 0.905 | 0.0338 |
| 1951 | 13732 | 7947 | 230324 | 359 | 0.888 | 0.921 | 0.0270 |
| 1952 | 13620 | 8028 | 230520 | 422 | 0.897 | 0.911 | 0.0315 |
| 1953 | 13548 | 8051 | 230577 | 463 | 0.899 | 0.905 | 0.0344 |
| 1954 | 13456 | 8046 | 230564 | 513 | 0.899 | 0.897 | 0.0381 |
| 1955 | 13364 | 8015 | 230489 | 561 | 0.895 | 0.889 | 0.0419 |
| 1956 | 13391 | 7966 | 230371 | 537 | 0.890 | 0.892 | 0.0403 |
| 1957 | 13469 | 7944 | 230318 | 492 | 0.887 | 0.898 | 0.0369 |

**Table (continued). Time series of population status, outputs, and exploitation from the base assessment model.**

| Year | Total biomass (mt) | Spawning biomass (mt) | Recruit (*1000) | Total catch (mt) | Depletion | SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|
| 1958 | 13744 | 7953 | 230340 | 355 | 0.888 | 0.922 | 0.0266 |
| 1959 | 13822 | 8033 | 230534 | 324 | 0.897 | 0.929 | 0.0242 |
| 1960 | 13959 | 8108 | 230711 | 267 | 0.906 | 0.941 | 0.0197 |
| 1961 | 13784 | 8193 | 230910 | 357 | 0.915 | 0.926 | 0.0262 |
| 1962 | 13578 | 8206 | 230940 | 467 | 0.916 | 0.908 | 0.0342 |
| 1963 | 13735 | 8155 | 230821 | 380 | 0.911 | 0.921 | 0.0279 |
| 1964 | 13215 | 8166 | 230847 | 670 | 0.912 | 0.876 | 0.0493 |
| 1965 | 13770 | 8016 | 230491 | 349 | 0.895 | 0.924 | 0.0260 |
| 1966 | 13474 | 8081 | 241912 | 506 | 0.903 | 0.898 | 0.0375 |
| 1967 | 13488 | 8048 | 240358 | 494 | 0.899 | 0.900 | 0.0366 |
| 1968 | 13363 | 8066 | 269628 | 556 | 0.901 | 0.888 | 0.0409 |
| 1969 | 13322 | 8084 | 345390 | 574 | 0.903 | 0.884 | 0.0415 |
| 1970 | 13358 | 8228 | 579491 | 553 | 0.919 | 0.887 | 0.0377 |
| 1971 | 13306 | 8783 | 338486 | 592 | 0.981 | 0.884 | 0.0359 |
| 1972 | 13111 | 10156 | 243987 | 739 | 1.134 | 0.867 | 0.0406 |
| 1973 | 13051 | 11168 | 231374 | 832 | 1.247 | 0.862 | 0.0440 |
| 1974 | 12957 | 11339 | 244282 | 978 | 1.266 | 0.854 | 0.0525 |
| 1975 | 12898 | 10904 | 217228 | 1090 | 1.218 | 0.849 | 0.0616 |
| 1976 | 12810 | 10225 | 235867 | 1180 | 1.142 | 0.841 | 0.0715 |
| 1977 | 13291 | 9428 | 237623 | 748 | 1.053 | 0.882 | 0.0489 |
| 1978 | 13411 | 8957 | 275233 | 646 | 1.000 | 0.893 | 0.0440 |
| 1979 | 12453 | 8659 | 320495 | 1351 | 0.967 | 0.809 | 0.0931 |
| 1980 | 12434 | 8189 | 311834 | 1205 | 0.915 | 0.809 | 0.0847 |
| 1981 | 12402 | 8227 | 250919 | 1117 | 0.919 | 0.804 | 0.0772 |
| 1982 | 12255 | 8464 | 213629 | 1215 | 0.945 | 0.795 | 0.0831 |
| 1983 | 12659 | 8510 | 193996 | 907 | 0.950 | 0.828 | 0.0632 |
| 1984 | 12661 | 8444 | 211274 | 951 | 0.943 | 0.828 | 0.0681 |
| 1985 | 12532 | 8112 | 266280 | 1061 | 0.906 | 0.817 | 0.0790 |
| 1986 | 12585 | 7693 | 196094 | 1003 | 0.859 | 0.822 | 0.0773 |
| 1987 | 12297 | 7507 | 168783 | 1189 | 0.838 | 0.799 | 0.0945 |
| 1988 | 12345 | 7180 | 184382 | 1047 | 0.802 | 0.802 | 0.0880 |
| 1989 | 12146 | 6808 | 702990 | 1132 | 0.760 | 0.787 | 0.0961 |
| 1990 | 11685 | 6588 | 249855 | 1425 | 0.736 | 0.749 | 0.1080 |
| 1991 | 11425 | 7785 | 195742 | 1546 | 0.869 | 0.729 | 0.1059 |
| 1992 | 11848 | 8710 | 257299 | 1220 | 0.973 | 0.762 | 0.0806 |

**Table (continued). Time series of population status, outputs, and exploitation from the base assessment model.**

| Year | Total biomass (mt) | Spawning biomass (mt) | Recruit (*1000) | Total catch (mt) | Depletion | SPR | Relative exploitation rate |
|---|---|---|---|---|---|---|---|
| 1993 | 11936 | 8971 | 476777 | 1319 | 1.002 | 0.769 | 0.0854 |
| 1994 | 11191 | 8936 | 204425 | 2321 | 0.998 | 0.711 | 0.1459 |
| 1995 | 10993 | 8947 | 300395 | 2540 | 0.999 | 0.696 | 0.1640 |
| 1996 | 11685 | 8562 | 186339 | 1537 | 0.956 | 0.749 | 0.1045 |
| 1997 | 11246 | 8539 | 142740 | 2044 | 0.954 | 0.715 | 0.1435 |
| 1998 | 11929 | 7921 | 147896 | 1326 | 0.885 | 0.769 | 0.1031 |
| 1999 | 11252 | 7318 | 205671 | 2000 | 0.817 | 0.716 | 0.1698 |
| 2000 | 11574 | 6241 | 94208 | 1464 | 0.697 | 0.740 | 0.1423 |
| 2001 | 11395 | 5657 | 112345 | 1437 | 0.632 | 0.726 | 0.1563 |
| 2002 | 11191 | 4971 | 88235 | 1417 | 0.555 | 0.708 | 0.1761 |
| 2003 | 11346 | 4256 | 79726 | 1124 | 0.475 | 0.722 | 0.1624 |
| 2004 | 11567 | 3719 | 130606 | 860 | 0.415 | 0.739 | 0.1414 |
| 2005 | 11933 | 3319 | 137966 | 629 | 0.371 | 0.768 | 0.1108 |
| 2006 | 11713 | 3210 | 236307 | 666 | 0.359 | 0.751 | 0.1153 |
| 2007 | 12059 | 3281 | 233162 | 512 | 0.366 | 0.779 | 0.0801 |
| 2008 | 12488 | 3832 | 217592 | 389 | 0.428 | 0.813 | 0.0518 |
| 2009 | 12130 | 4654 | 269346 | 562 | 0.520 | 0.784 | 0.0637 |
| 2010 | 13069 | 5362 | 421590 | 322 | 0.599 | 0.862 | 0.0317 |
| 2011 | 13244 | 6277 | 263968 | 339 | 0.701 | 0.875 | 0.0280 |
| 2012 | 13479 | 7568 | 200639 | 326 | 0.845 | 0.896 | 0.0237 |
| 2013 | | 8554 | 231713 | | 0.955 | | |

**Table 22: Model performances and output summaries of the sensitivity analysis on discard rates, and historical catch data.**

| Performance and output | Base | Discard rates -20% | Discard rates +20% | Historical catches -20% | Historical catches +20% |
|---|---|---|---|---|---|
| **Management quantities** | | | | | |
| 2013 depletion | 0.955 | 1.104 | 0.778 | 0.977 | 96.6 |
| 2012 SPR | 0.896 | 0.934 | 0.837 | 0.905 | 89.8 |
| | | | | | |
| **Negative log-likelihood** | | | | | |
| Total | 774.138 | 764.454 | 784.757 | 773.274 | 775.261 |
| Indices | -15.117 | -16.135 | -13.906 | -15.171 | -15.201 |
| Length comp. | 482.288 | 477.518 | 487.612 | 481.596 | 482.654 |
| Age comp. | 364.370 | 364.002 | 365.194 | 364.576 | 364.495 |
| Discard | -59.494 | -62.045 | -56.678 | -59.366 | -59.524 |
| | | | | | |
| **Key model parameters** | | | | | |
| Ln($R_0$) | 12.36 | 12.82 | 11.89 | 12.47 | 12.37 |
| Steepness ($h$) | 0.768 | 0.781 | 0.759 | 0.771 | 0.766 |
| Female $M$ | 0.459 | 0.524 | 0.385 | 0.474 | 0.459 |
| Male $M$ | 0.566 | 0.642 | 0.424 | 0.582 | 0.567 |
| Female $L$ at $A_1$ | 4.23 | 4.14 | 4.24 | 4.21 | 4.24 |
| Female $L$ at $A_2$ | 30.33 | 30.38 | 30.17 | 30.31 | 30.35 |
| Female $K$ | 0.169 | 0.165 | 0.178 | 0.169 | 0.168 |
| Male $L$ at $A_1$ | 4.66 | 4.62 | 4.76 | 4.67 | 4.65 |
| Male $L$ at $A_2$ | 26.47 | 26.52 | 26.45 | 26.48 | 26.47 |
| Male $K$ | 0.212 | 0.206 | 0.216 | 0.210 | 0.212 |

**Table 23: Model performances and output summaries of the sensitivity analysis on use of non-informative steepness (*h*) prior and maturity functions.**

| Performance and output | Base | Non-informative *h* prior | Maturity (Arora 1951) |
|---|---|---|---|
| **Management quant** | | | |
| 2013 depletion | 0.955 | 0.689 | 0.807 |
| 2013 SPR | 0.896 | 0.884 | 0.862 |
| | | | |
| **Negative log-likelihood** | | | |
| Total | 774.138 | 772.520 | 774.314 |
| Indices | -15.117 | -14.748 | -15.136 |
| Length comp. | 482.288 | 482.48 | 482.24 |
| Age comp. | 364.370 | 363.608 | 364.416 |
| Discard | -59.494 | -59.480 | -59.459 |
| | | | |
| **Key model parameters** | | | |
| Ln($R_0$) | 12.36 | 12.51 | 12.35 |
| Steepness (*h*) | 0.768 | 0.376 | 0.776 |
| Female *M* | 0.459 | 0.456 | 0.456 |
| Male *M* | 0.566 | 0.562 | 0.564 |
| Female *L* at $A_1$ | 4.23 | 4.30 | 4.22 |
| Female *L* at $A_2$ | 30.33 | 30.26 | 30.32 |
| Female *K* | 0.169 | 0.171 | 0.170 |
| Male *L* at $A_1$ | 4.66 | 4.71 | 4.65 |
| Male *L* at $A_2$ | 26.47 | 26.49 | 26.47 |
| Male *K* | 0.212 | 0.211 | 0.212 |

**Table 24: Model performances and output summaries of the sensitivity analysis on exclusions of the triennial and recreational survey indices. Note that likelihood values of these runs are not directly comparable.**

| Performance and output | Base | No triennial survey indices | No recreational survey indices |
|---|---|---|---|
| **Management quantities** | | | |
| 2013 depletion | 0.955 | 0.865 | 0.759 |
| 2013 SPR | 0.896 | 0.865 | 0.830 |
| | | | |
| **Negative log-likelihood** | | | |
| Total | 774.138 | *772.863* | *777.407* |
| Indices | -15.117 | *-15.953* | *-11.344* |
| Length comp. | 482.288 | *482.726* | *484.217* |
| Age comp. | 364.370 | *363.647* | *362.738* |
| Discard | -59.494 | *-59.815* | *-60.303* |
| | | | |
| **Key model parameters** | | | |
| Ln($R_0$) | 12.36 | 12.03 | 11.77 |
| Steepness ($h$) | 0.768 | 0.760 | 0.754 |
| Female $M$ | 0.459 | 0.418 | 0.386 |
| Male $M$ | 0.566 | 0.522 | 0.487 |
| Female $L$ at $A_1$ | 4.23 | 4.18 | 4.26 |
| Female $L$ at $A_2$ | 30.33 | 30.27 | 30.23 |
| Female $K$ | 0.169 | 0.174 | 0.176 |
| Male $L$ at $A_1$ | 4.66 | 4.63 | 4.64 |
| Male $L$ at $A_2$ | 26.47 | 26.45 | 26.43 |
| Male $K$ | 0.212 | 0.216 | 0.220 |

**Table 25: Model performances and output summaries of the sensitivity analysis on using the Lorenzen function on estimates of natural mortality. Six runs were conducted using the reference ages between age 1 to age 6. The Listed natural mortality rates are those rates at reference ages.**

| Performance and output | Base | Reference age at 1 | Reference age at 2 | Reference age at 3 | Reference age at 4 | Reference age at 5 | Reference age at 6 |
|---|---|---|---|---|---|---|---|
| **Management quantities** | | | | | | | |
| 2013 depletion | 0.955 | 0.601 | 0.696 | 0.767 | 0.848 | 0.916 | 0.963 |
| 2013 SPR | 0.896 | 0.727 | 0.779 | 0.814 | 0.848 | 0.874 | 0.891 |
| **Negative log-likelihood** | | | | | | | |
| Total | 774.138 | 779.39 | 777.163 | 775.873 | 775.020 | 774.379 | 773.895 |
| Indices | -15.117 | -13.64 | -13.960 | -14.188 | -14.435 | -14.643 | -14.801 |
| Length comp. | 482.288 | 486.437 | 485.141 | 484.338 | 483.499 | 482.779 | 482.292 |
| Age comp. | 364.370 | 362.226 | 362.355 | 362.507 | 362.767 | 363.081 | 363.345 |
| Discard | -59.494 | -60.329 | -60.305 | -60.248 | -60.148 | -60.071 | -59.998 |
| **Key model parameters** | | | | | | | |
| Ln($R_0$) | 12.36 | 12.48 | 13.02 | 13.449 | 13.948 | 14.396 | 14.740 |
| Steepness ($h$) | 0.768 | 0.763 | 0.759 | 0.758 | 0.759 | 0.760 | 0.762 |
| Female $M$ | 0.459 | 0.625 | 0.561 | 0.523 | 0.512 | 0.505 | 0.495 |
| Male $M$ | 0.566 | 0.719 | 0.659 | 0.622 | 0.615 | 0.613 | 0.608 |
| Female $L$ at $A_1$ | 4.23 | 3.40 | 3.40 | 3.41 | 3.42 | 3.43 | 3.43 |
| Female $L$ at $A_2$ | 30.33 | 29.92 | 30.09 | 30.21 | 30.34 | 30.45 | 30.53 |
| Female $K$ | 0.169 | 0.196 | 0.187 | 0.180 | 0.173 | 0.166 | 0.161 |
| Male $L$ at $A_1$ | 4.66 | 4.08 | 4.05 | 4.03 | 4.03 | 4.03 | 4.03 |
| Male $L$ at $A_2$ | 26.47 | 26.20 | 26.29 | 26.37 | 26.44 | 26.49 | 26.54 |
| Male $K$ | 0.212 | 0.237 | 0.229 | 0.223 | 0.216 | 0.210 | 0.205 |
| $Q$ NWFSC survey | 19.39 | 27.67 | 26.36 | 25.46 | 24.57 | 23.84 | 23.31 |
| $Q$ early triennial survey | 4.78 | 4.71 | 5.31 | 5.46 | 5.60 | 5.70 | 5.79 |
| $Q$ late triennial survey | 13.54 | 15.46 | 15.29 | 15.17 | 15.08 | 14.96 | 14.86 |

**Table 26: Model performances and output summaries of the sensitivity analysis on using dome-shaped selectivity functions for surveys and exclusions of the conditional age-at-length data (CAAL) from the base model. Note that likelihood values from both runs are not comparable to the base model run.**

| Performance and output | Base | Dome-shaped selectivity for surveys | No CAAL data |
|---|---|---|---|
| **Management quantities** | | | |
| 2013 depletion | 0.955 | 0.971 | 1.202 |
| 2013 SPR | 0.896 | 0.900 | 0.981 |
| | | | |
| **Negative log-likelihood** | | | |
| Total | 774.138 | *772.669* | *417.611* |
| Indices | -15.117 | *-15.373* | *-17.081* |
| Length comp. | 482.288 | *480.799* | *460.605* |
| Age comp. | 364.370 | *364.882* | *31.653* |
| Discard | -59.494 | *-59.245* | *-59.753* |
| | | | |
| **Key model parameters** | | | |
| Ln($R_0$) | 12.36 | 12.37 | 13.94 |
| Steepness ($h$) | 0.768 | 0.773 | 0.801 |
| Female $M$ | 0.459 | 0.458 | 0.612 |
| Male $M$ | 0.566 | 0.566 | 0.720 |
| Female $L$ at $A_1$ | 4.23 | 4.22 | 4.23 |
| Female $L$ at $A_2$ | 30.33 | 30.37 | 30.33 |
| Female $K$ | 0.169 | 0.169 | 0.169 |
| Male $L$ at $A_1$ | 4.66 | 4.64 | 4.66 |
| Male $L$ at $A_2$ | 26.47 | 26.47 | 26.47 |
| Male $K$ | 0.212 | 0.213 | 0.212 |
| NWFSC survey $Q$ | 19.39 | 18.62 | 6.04 |
| Triennial early survey $Q$ | 4.776 | 4.79 | 2.88 |
| Triennial late survey $Q$ | 13.54 | 13.15 | 5.41 |

**Table 27: Model performances and output summaries of the retrospective analysis to prior three years. Negative log-likelihood values were not listed as they were incomparable among the models.**

| Model | Base | -1 year | -2 years | -3 years |
|---|---|---|---|---|
| **Management quantities** | | | | |
| 2013 depletion | 0.955 | 1.130 | 1.275 | |
| 2012 SPR | 0.896 | 0.939 | 0.950 | |
| | | | | |
| **Key parameters** | | | | |
| Ln($R_0$) | 12.36 | 13.16 | 13.55 | |
| Steepness ($h$) | 0.768 | 0.778 | 0.791 | |
| Female $M$ | 0.459 | 0.570 | 0.600 | |
| Male $M$ | 0.566 | 0.679 | 0.699 | |
| Female $L$ at $A_1$ | 4.23 | 5.23 | 4.32 | |
| Female $L$ at $A_2$ | 30.33 | 30.89 | 31.13 | |
| Female $K$ | 0.169 | 0.123 | 0.127 | |
| Male $L$ at $A_1$ | 4.66 | 5.35 | 4.45 | |
| Male $L$ at $A_2$ | 26.47 | 26.74 | 26.61 | |
| Male $K$ | 0.212 | 0.247 | 0.188 | |

**Table 28: Summary table of input data and model results between 2004 and 2013.**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Commercial landings (mt) | 456.6 | 347.3 | 412.5 | 292.2 | 196.5 | 290.7 | 146.3 | 146.2 | 159.2 | NA |
| Estimated total catch (mt) | 860 | 629 | 666 | 512 | 389 | 562 | 322 | 339 | 326 | NA |
| OFL (mt) | NA | 3172 | 3172 | 3172 | 3172 | 3172 | 3172 | 4943 | 4943 | 4801 |
| ACL (mt) | NA | 3172 | 3172 | 3172 | 3172 | 3172 | 3172 | 3432 | 3432 | 3332 |
| 1-SPR (%) | 26.1 | 23.2 | 24.9 | 22.1 | 18.7 | 21.6 | 13.8 | 12.5 | 10.4 | NA |
| Exploitation rate (catch/ age 0+ biomass) | 0.141 | 0.111 | 0.115 | 0.080 | 0.052 | 0.064 | 0.032 | 0.028 | 0.024 | NA |
| Age 0+ biomass (mt) | 11567 | 11933 | 11713 | 12059 | 12488 | 12130 | 13069 | 13244 | 13479 | NA |
| Spawning Biomass | 3719 | 3319 | 3210 | 3281 | 3832 | 4654 | 5362 | 6277 | 7568 | 8554 |
| ~95% Confidence Interval | 541-6897 | 357-6281 | 181-6239 | 0-6657 | 0-8048 | 0-9834 | 0-11286 | 0-12933 | 0-15412 | 128-16980 |
| Recruitment | 130606 | 137966 | 236307 | 233162 | 217592 | 269346 | 421590 | 263968 | 200639 | 231713 |
| ~95% Confidence Interval | 24513-695866 | 25586-743954 | 43538-1282584 | 43338-1254442 | 41261-1147488 | 51577-1406577 | 80414-2210282 | 49184-1416690 | 37343-1078010 | 43286-1240367 |
| Depletion (%) | 41.5 | 37.1 | 35.9 | 36.6 | 42.8 | 52.0 | 59.9 | 70.1 | 84.5 | 95.5 |
| ~95% Confidence Interval | 24.7-58.4 | 20.7-53.5 | 18.2-53.5 | 15.5-57.7 | 15.1-70.5 | 17.7-86.3 | 20.8-99.0 | 27.3-100.13 | 34.7-134.4 | 43.7-147.3 |

# 8 Figures

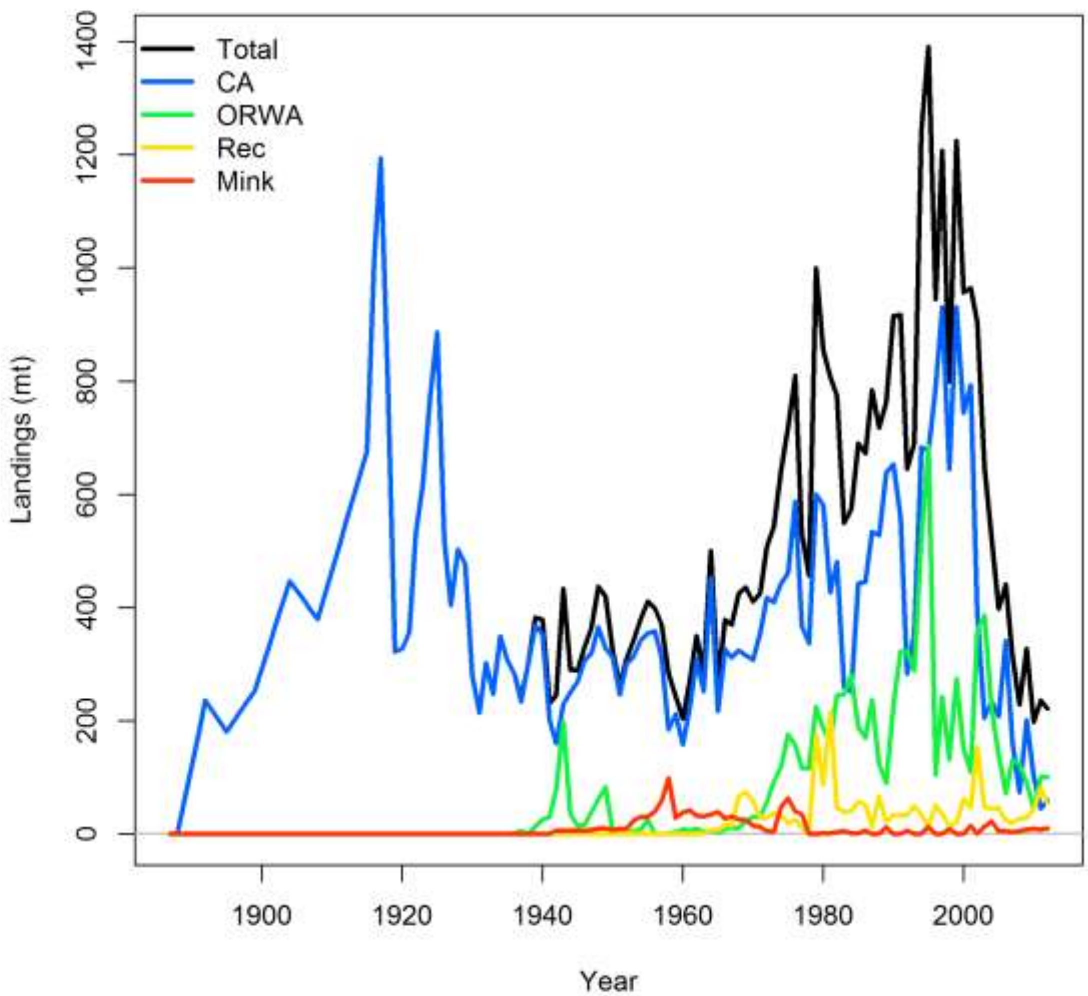



**Figure 1. Time series of total landings and landings by four fisheries of Pacific sanddab from 1888 to 2012. Small amount of survey catches between 1980 and 2012 were added to the Mink fishery.**

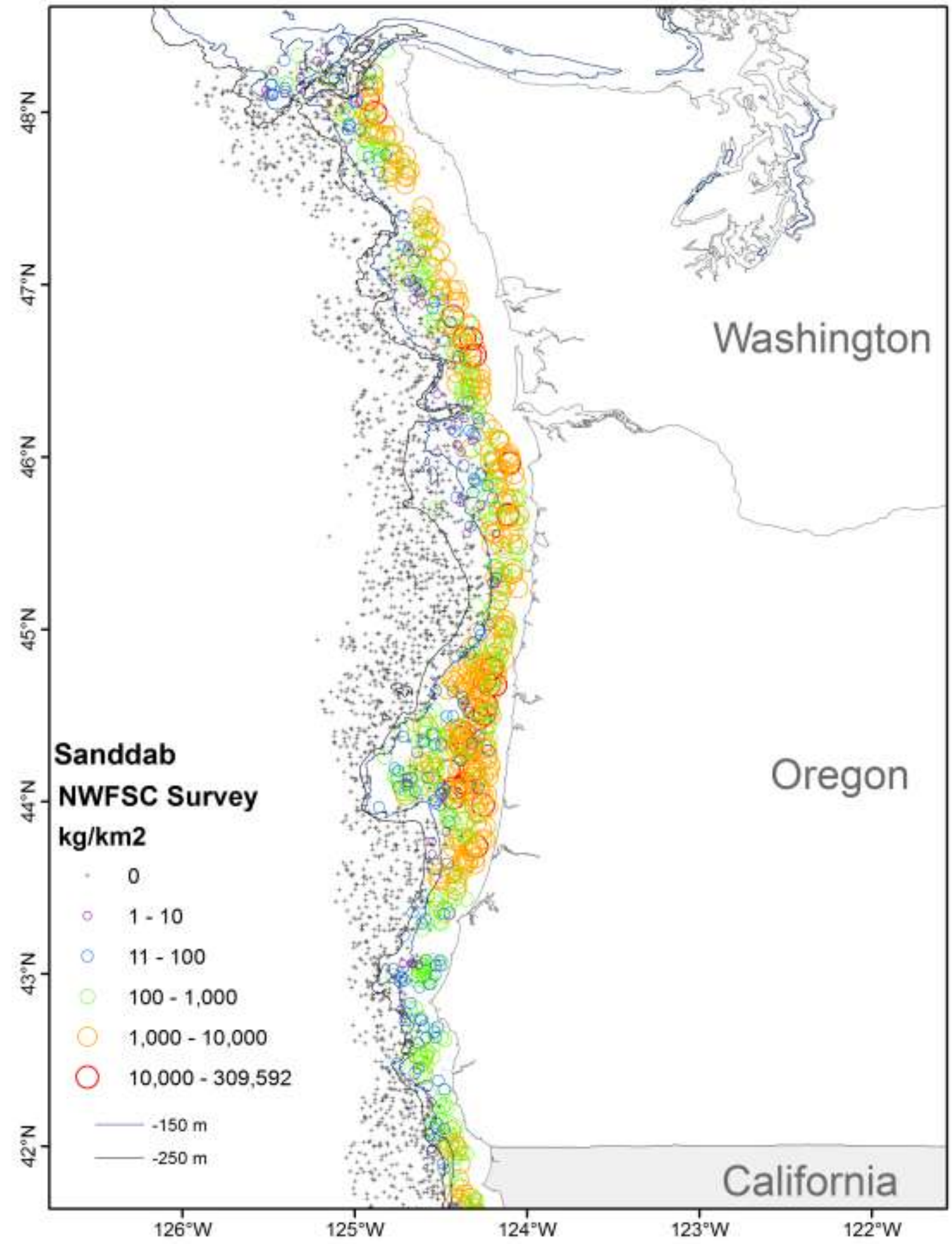



**Figure 2. Spatial distribution of raw catch rates of Pacific sanddab from NWFSC trawl survey hauls in Oregon and Washington waters for time periods of 2003 and 2012. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)**

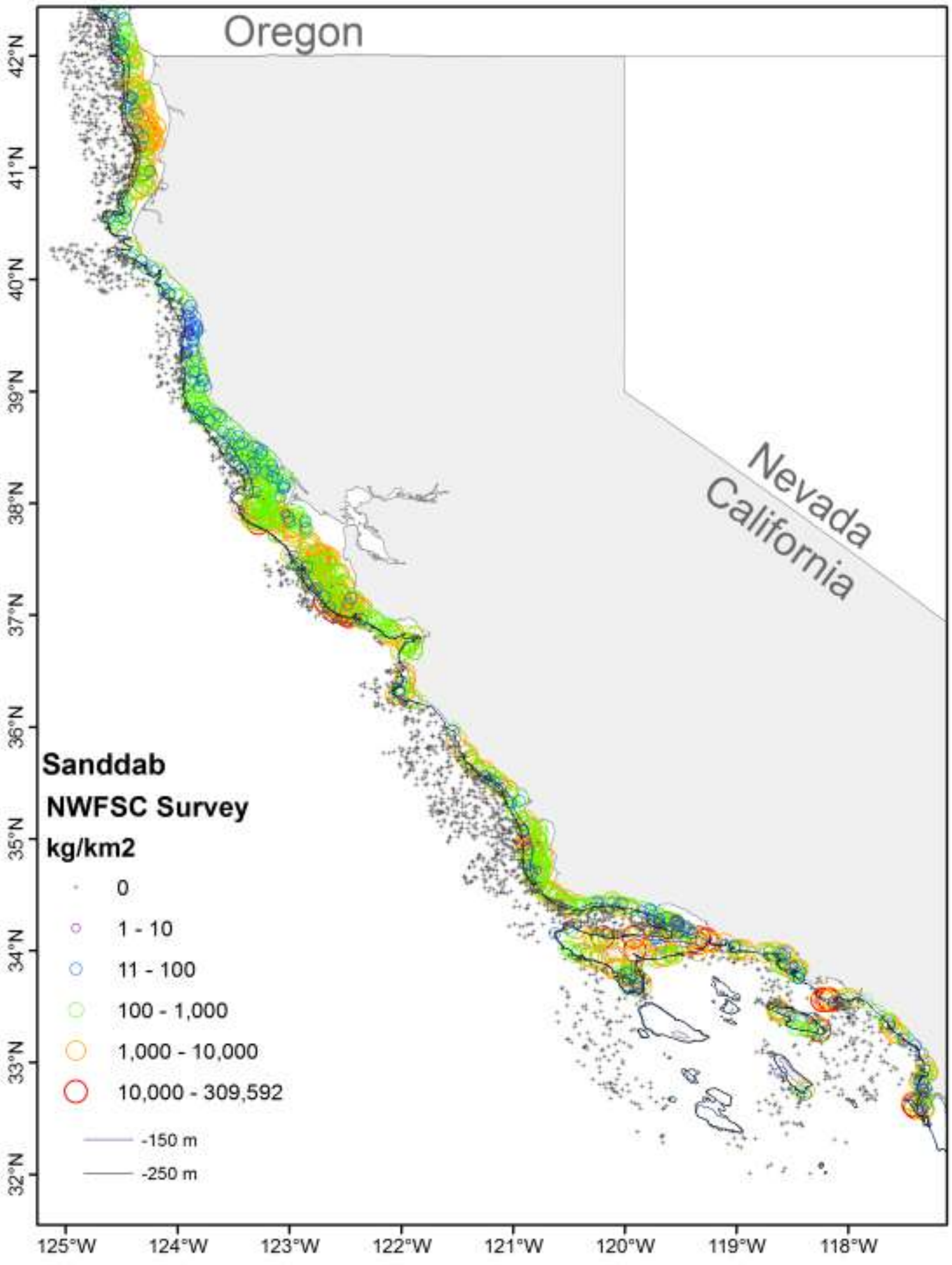



**Figure 3. Spatial distribution of raw catch rates of Pacific sanddab from NWFSC trawl survey hauls in California waters for time periods of 2003 and 2012. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)**

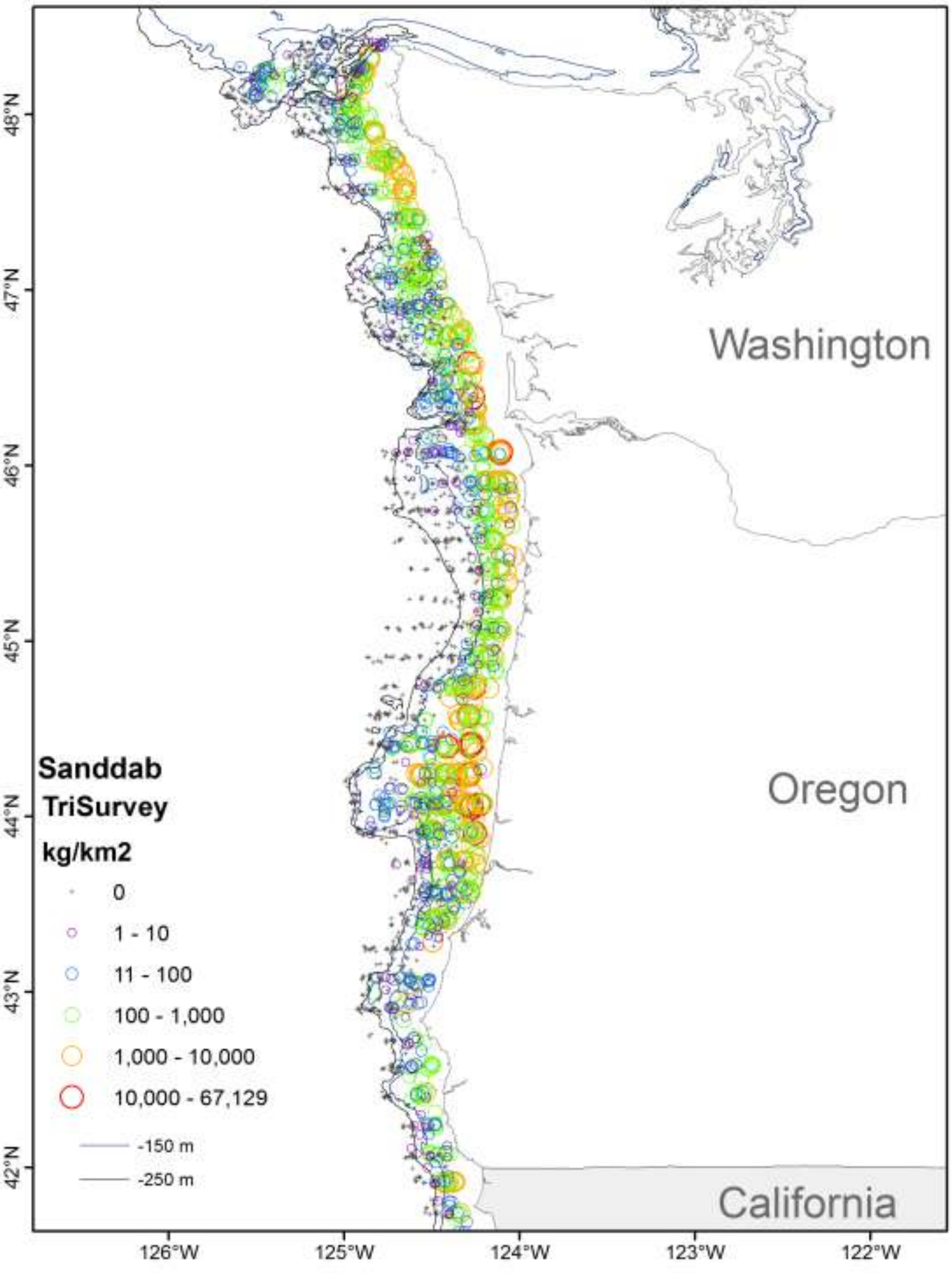



**Figure 4. Spatial distribution of catch rates of Pacific sanddab from triennial trawl survey hauls in Oregon and Washington waters for time periods of 1980 and 2004. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)**

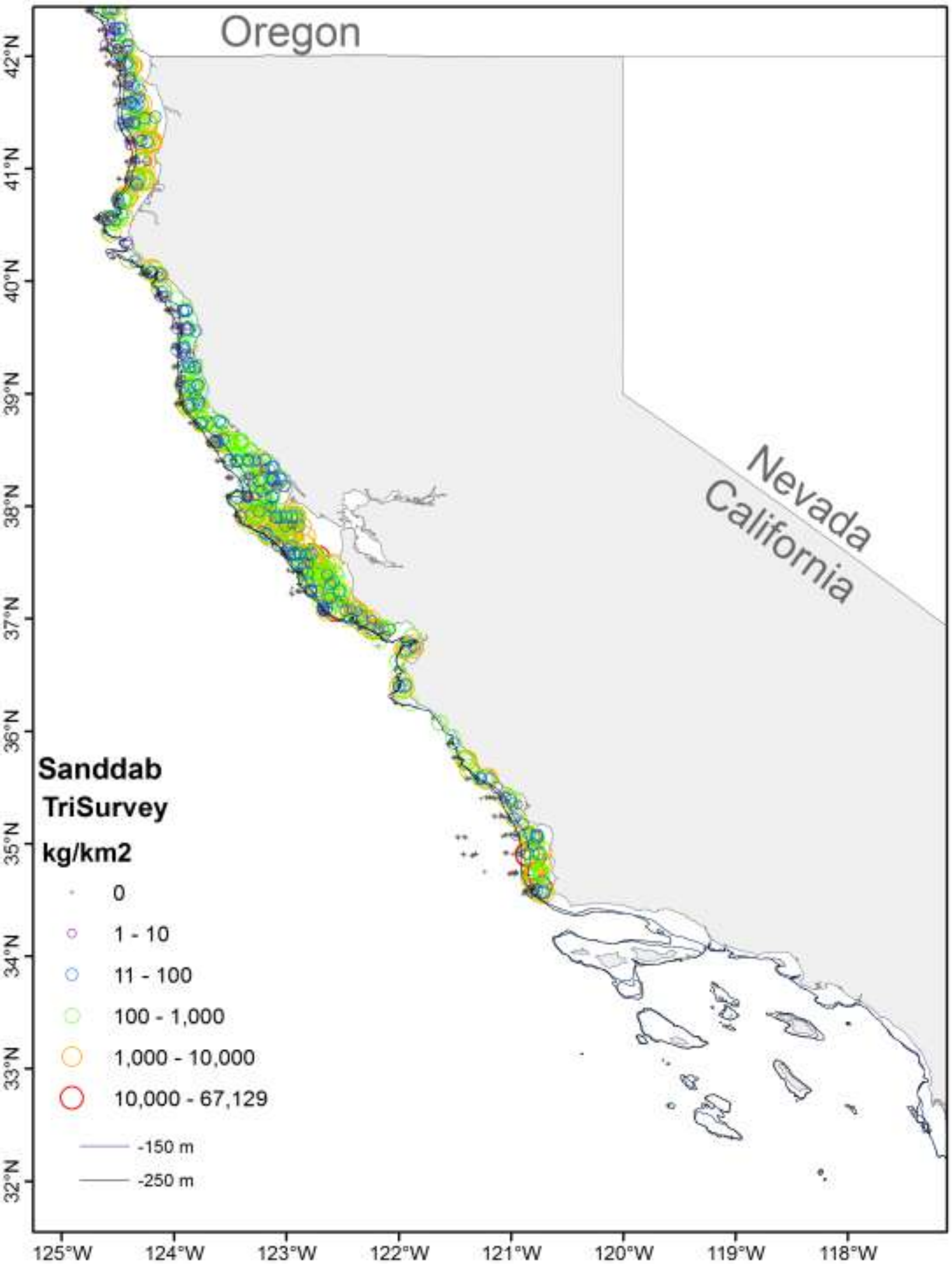



**Figure 5. Spatial distribution of catch rates of Pacific sanddab from triennial trawl survey hauls in California waters for time periods of 1980 and 2004. Contour lines of 150m and 250m are shown. Note that sizes and color of circles represent catch rate in log scale. (Credit Rebecca Miller, SWFSC)**

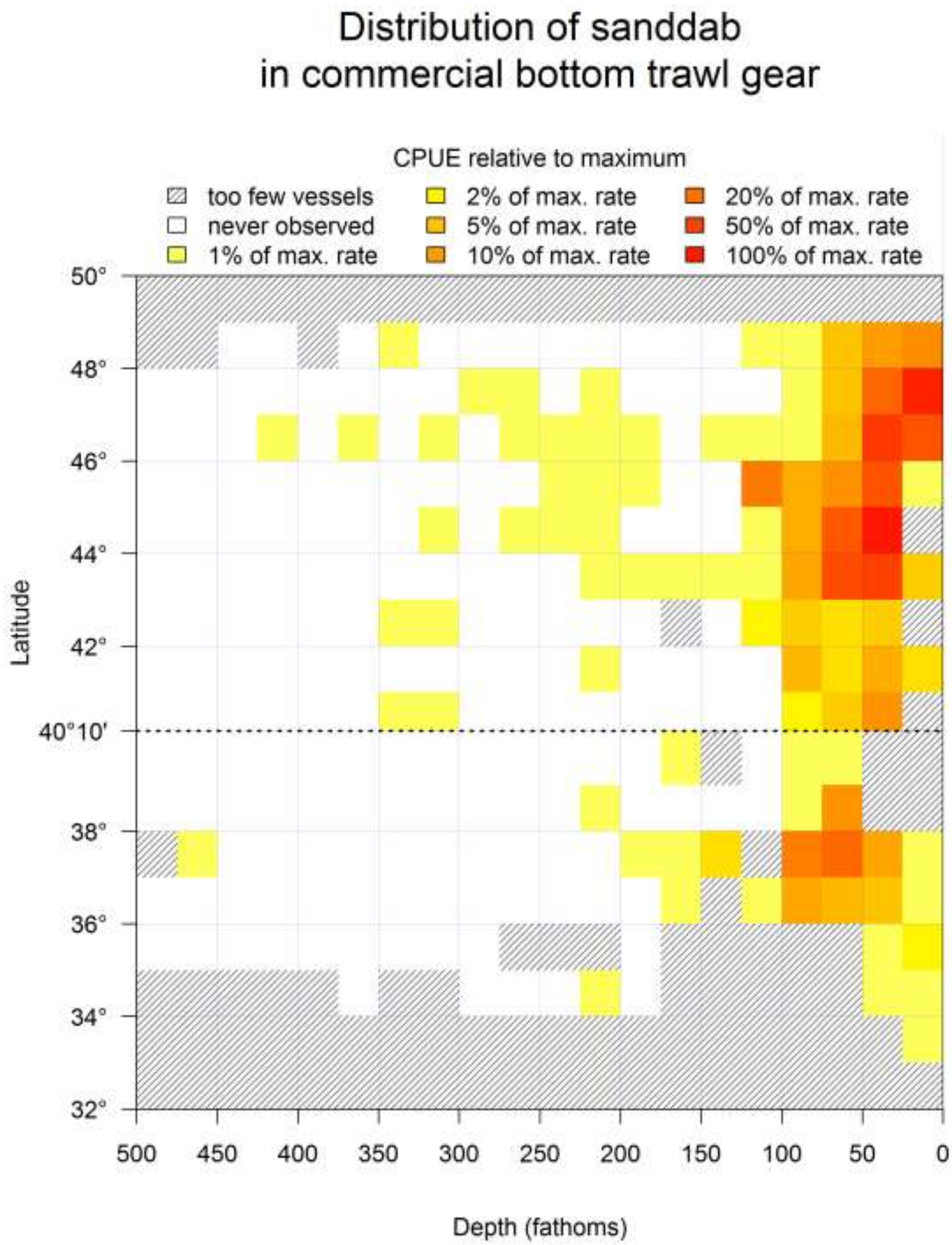



**Figure 6. Plots of relative commercial trawl catch per unit effort (CPUE) from the WCGOP observer data between 2002 and 2011 by latitude and depth along the U.S. Pacific coast (credit of Ian Taylor of NWFSC). The map only shows data from more than three vessels in each grid.**

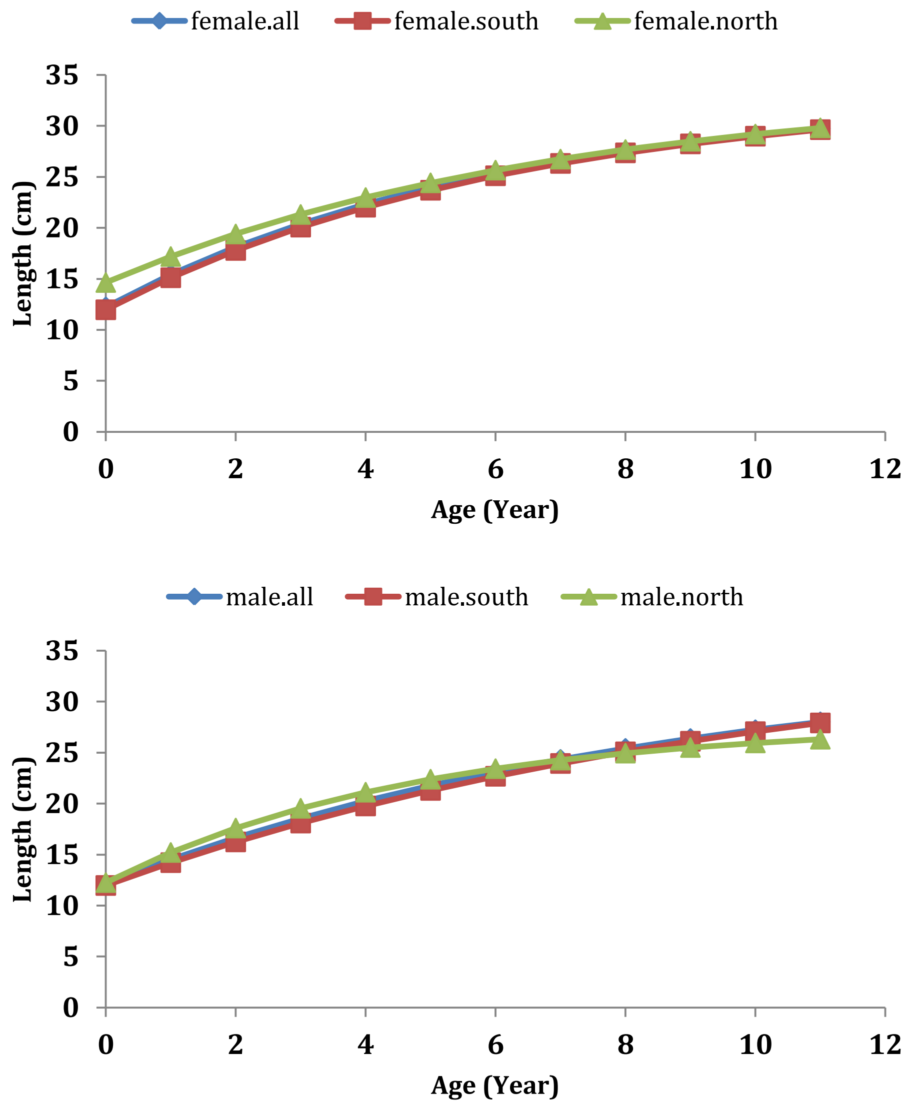



**Figure 7. Comparison plots of growth by sex and by area using the NWFSC survey data from 2003 to 2012. Two areas are defined as northern and southern areas (divided by latitude of 42° at the boarder of California and Oregon).**

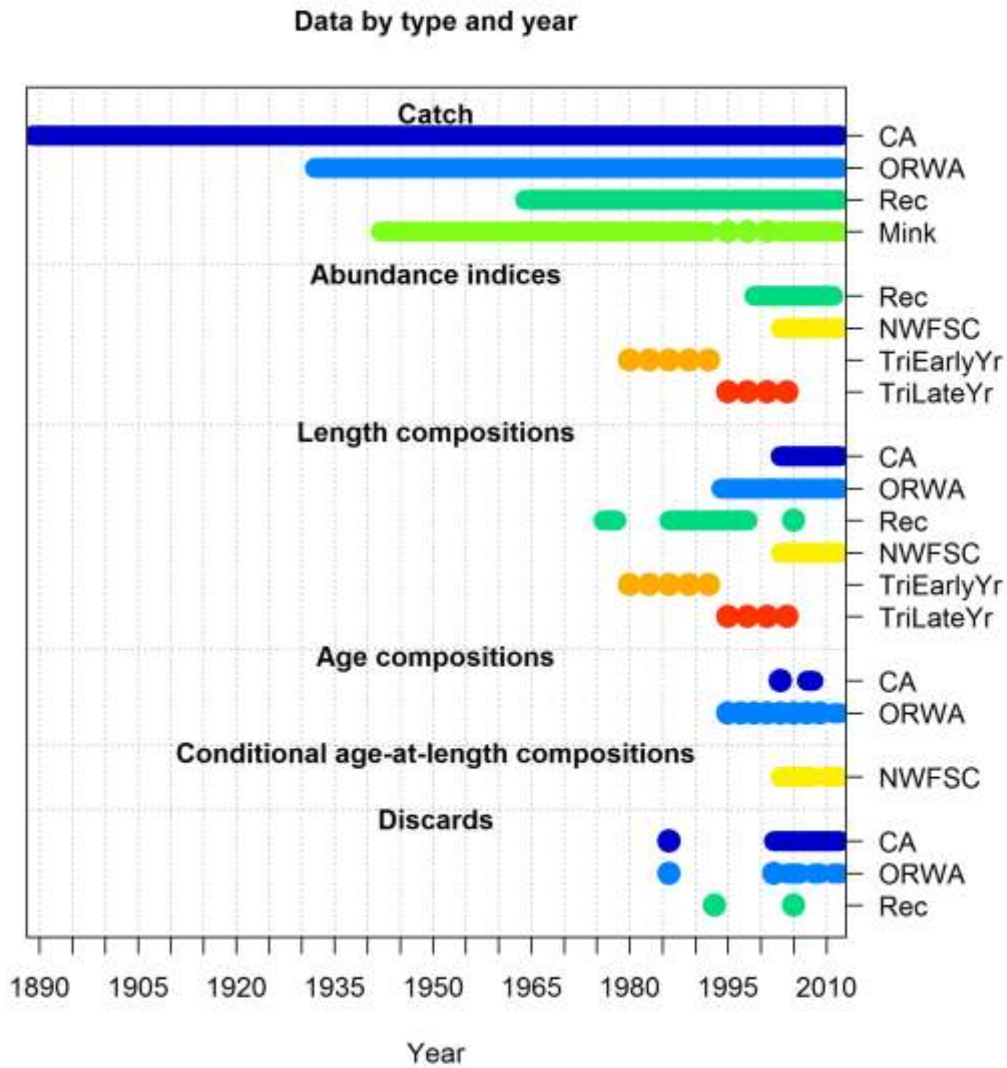



**Figure 8. Summary of data sources and time periods of availability of each data set that were used in this assessment.**

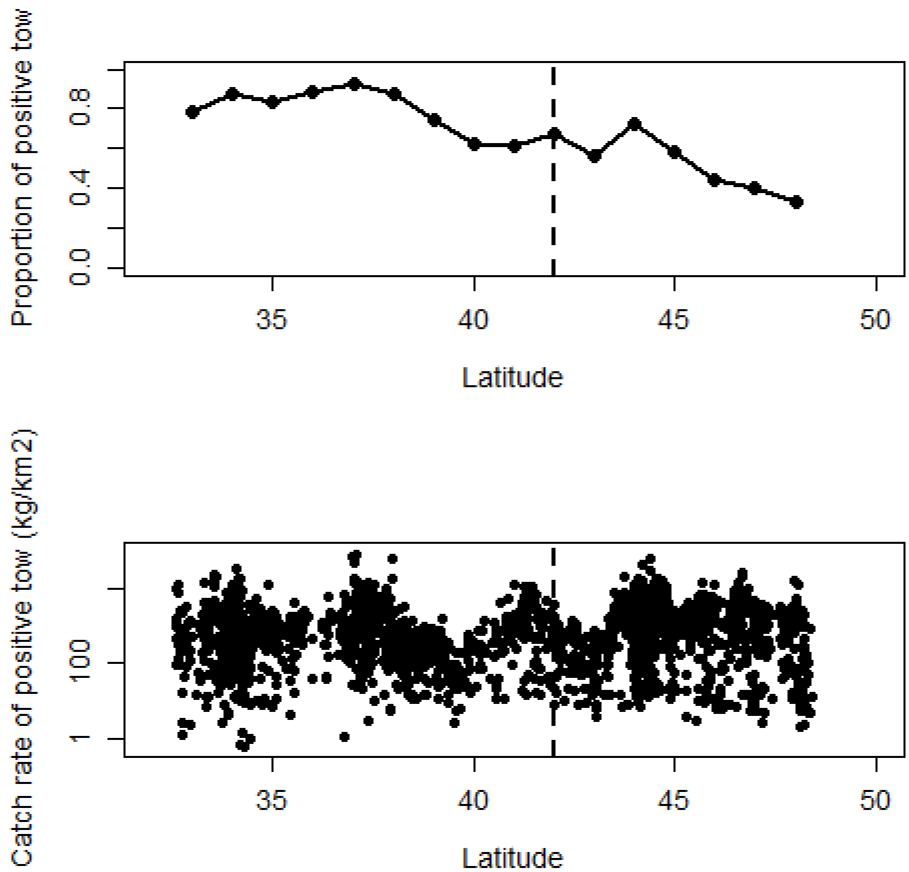



**Figure 9. Plots of the proportion of positive tows (top panel) and the catch rates of positive tows (bottom panel) by latitude for NWFSC survey data. Vertical dash lines show latitude line 42 degree (boarder of Oregon and California). Note that y-axis on the bottom panel is in log-scale.**

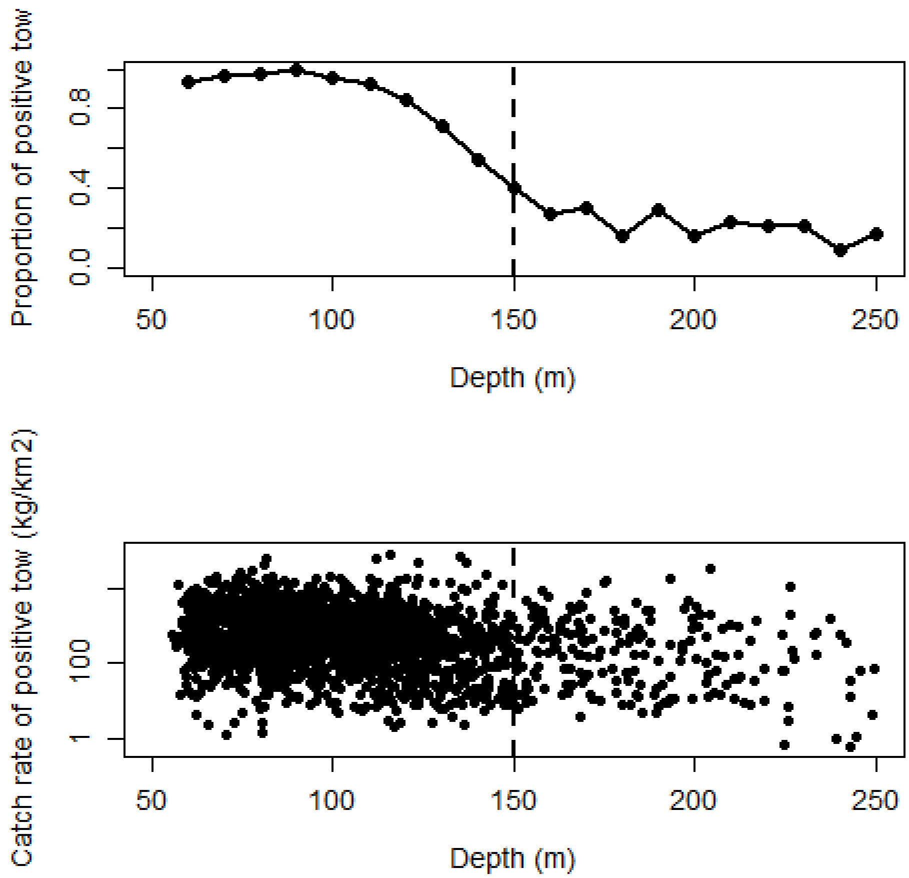



**Figure 10. Plots of the proportion of positive hauls (top panel) and the catch rates of positive tows (bottom panel) by depth zones for NWFSC survey data. Vertical dash lines show depths of 150m and 250m. Note that y-axis on the bottom panel is in log-scale.**

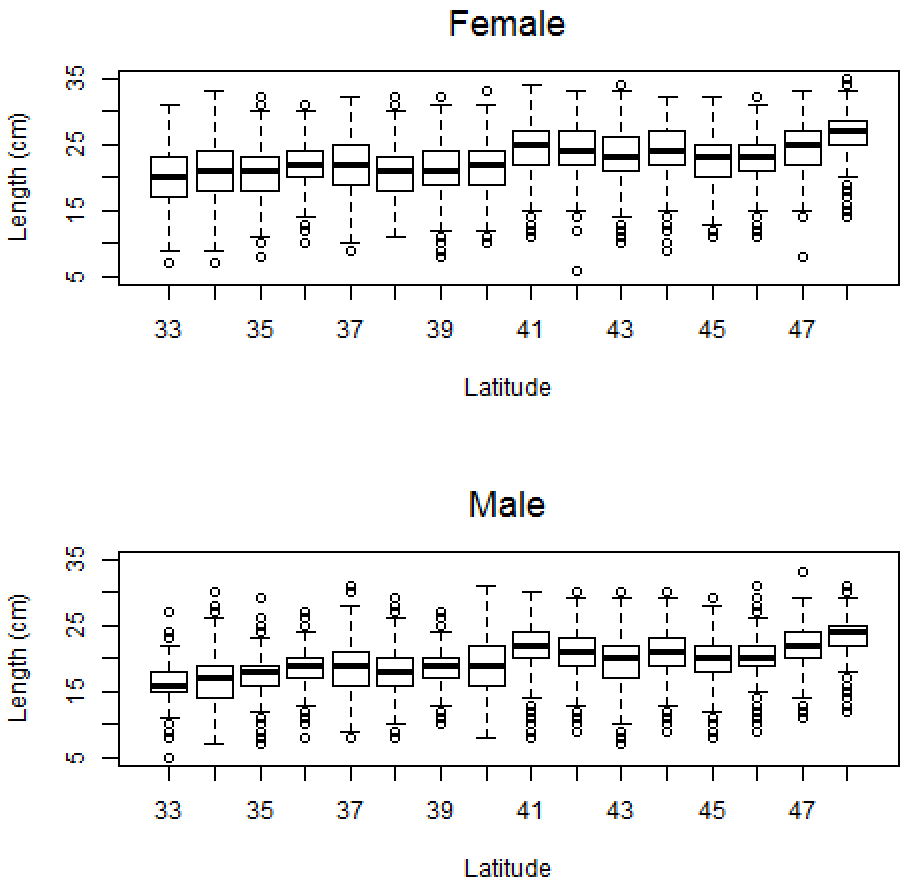



**Figure 11. Comparison box plots of raw length data from the NWFSC survey by sex and by latitude.**

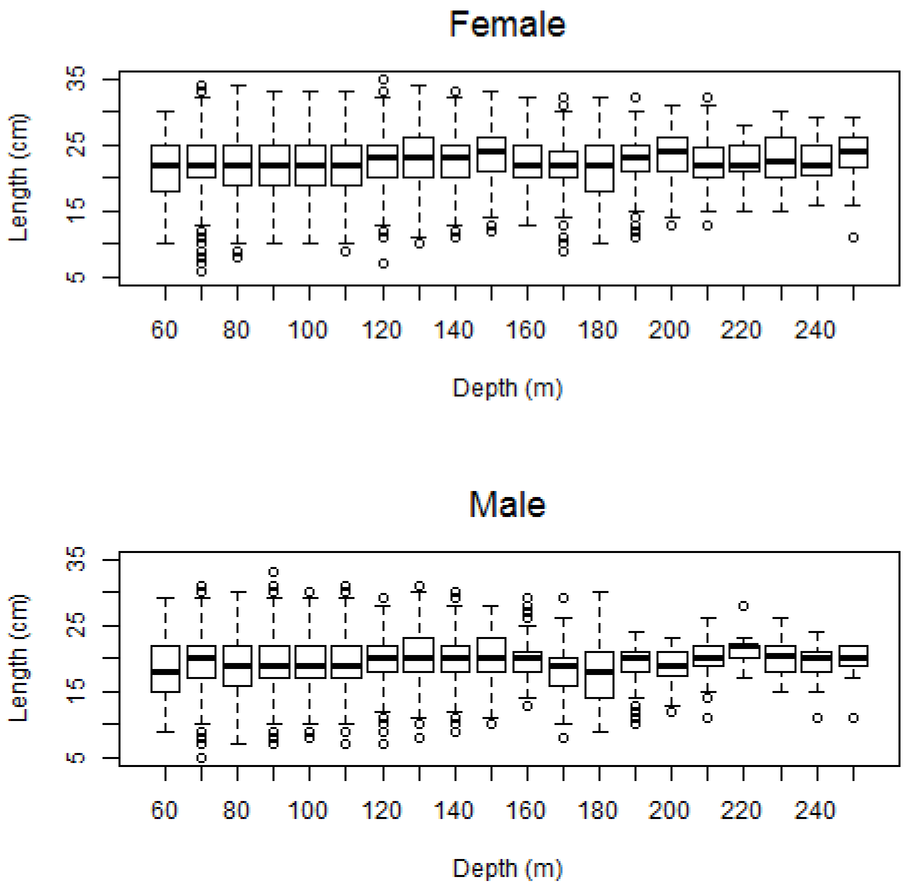



**Figure 12. Comparison box plots of raw length data from the NWFSC survey by sex and by depth.**

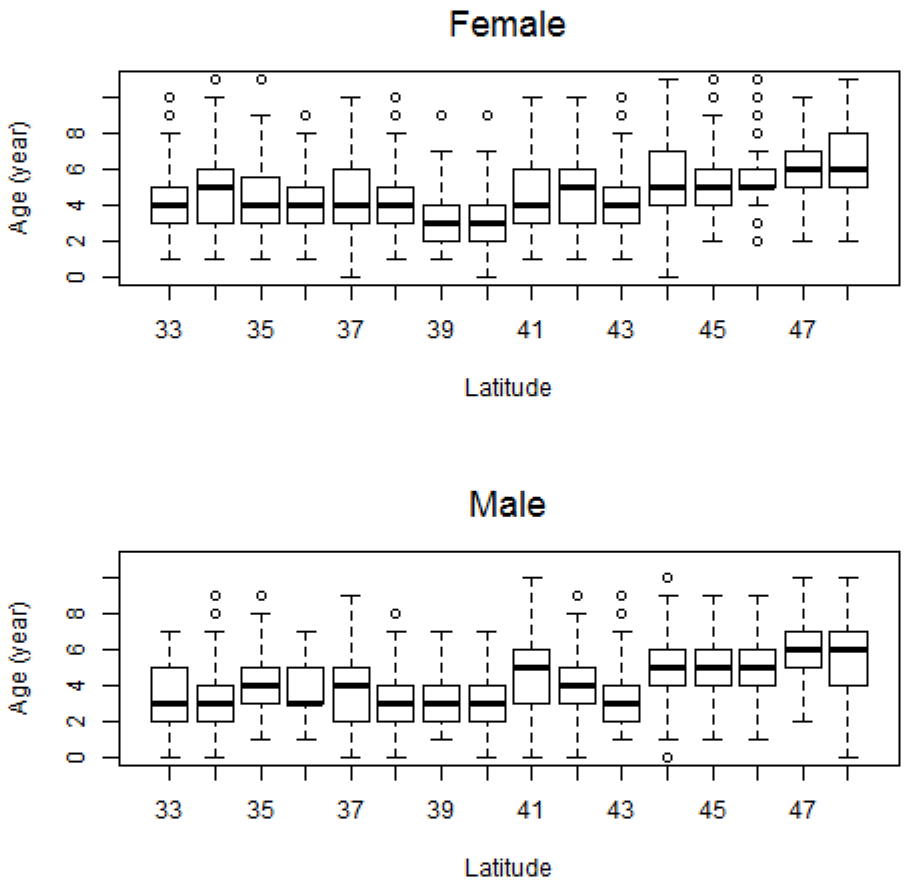



**Figure 13. Comparison box plots of raw age data from the NWFSC survey by sex and by latitude.**

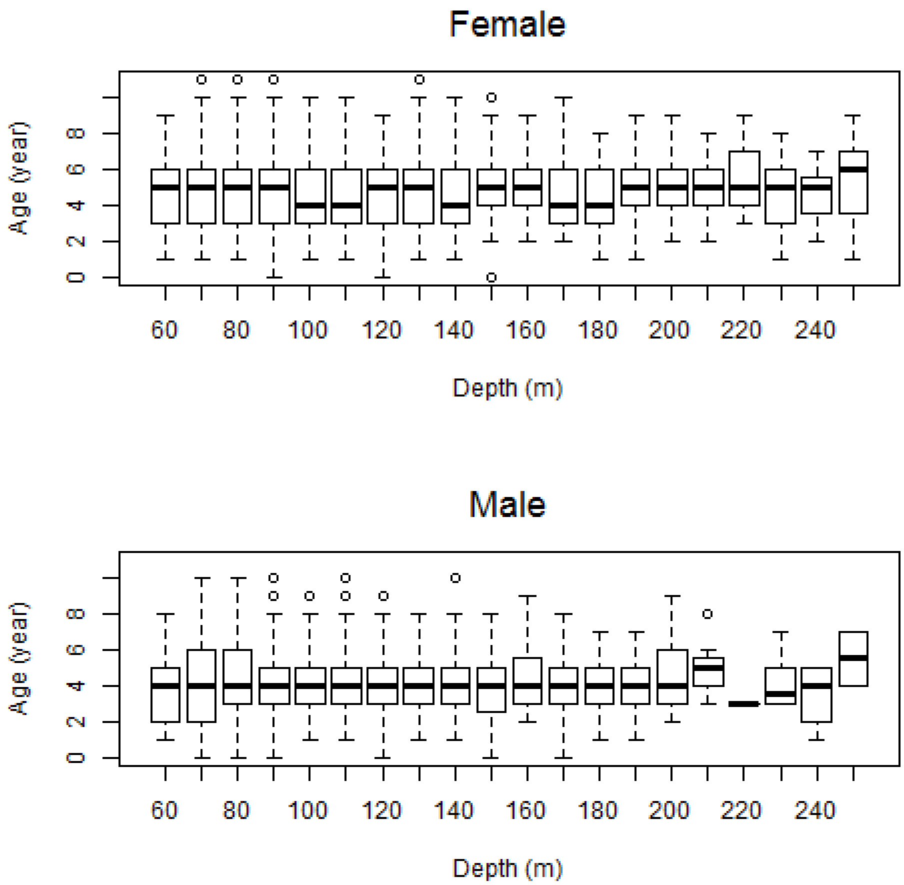



**Figure 14. Comparison box plots of raw age data from the NWFSC survey by sex and by depth.**

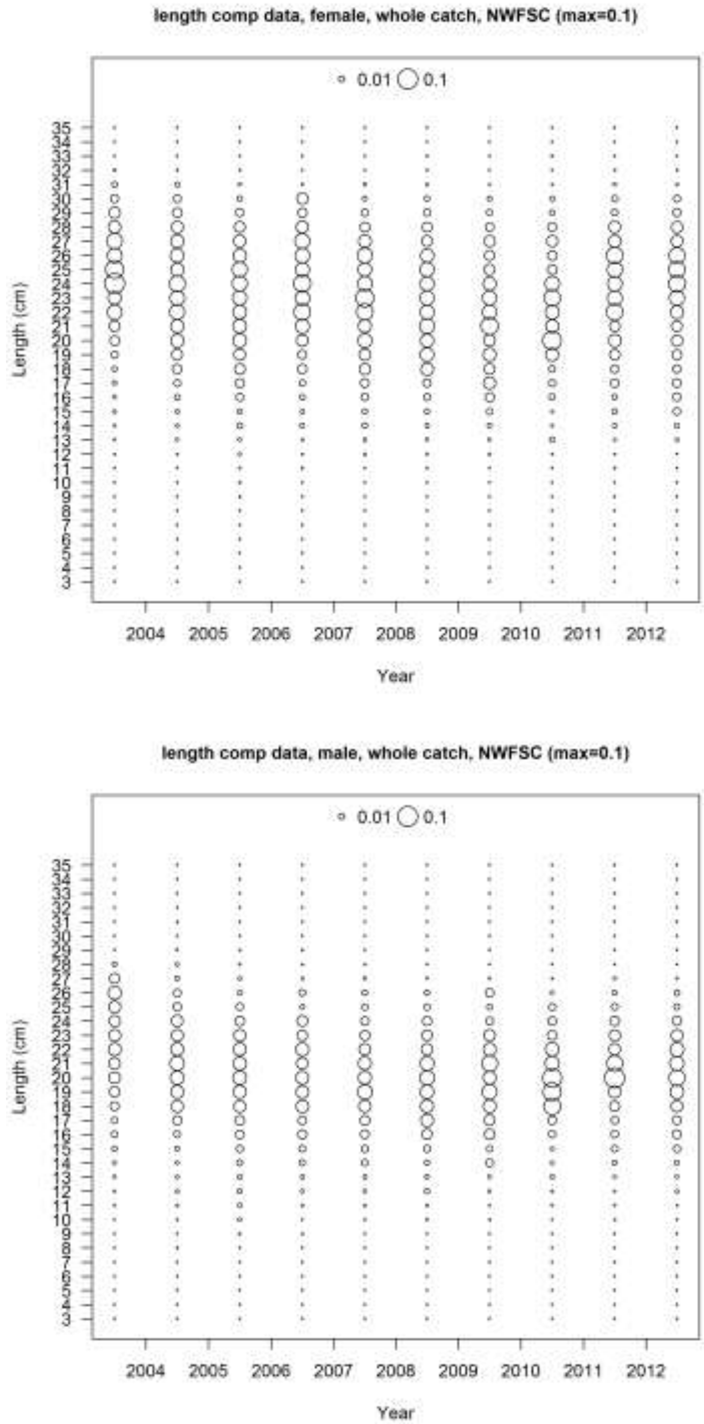



**Figure 15. Length composition data by sex used in the assessment model from the NWFSC survey from 2003 to 2012.**

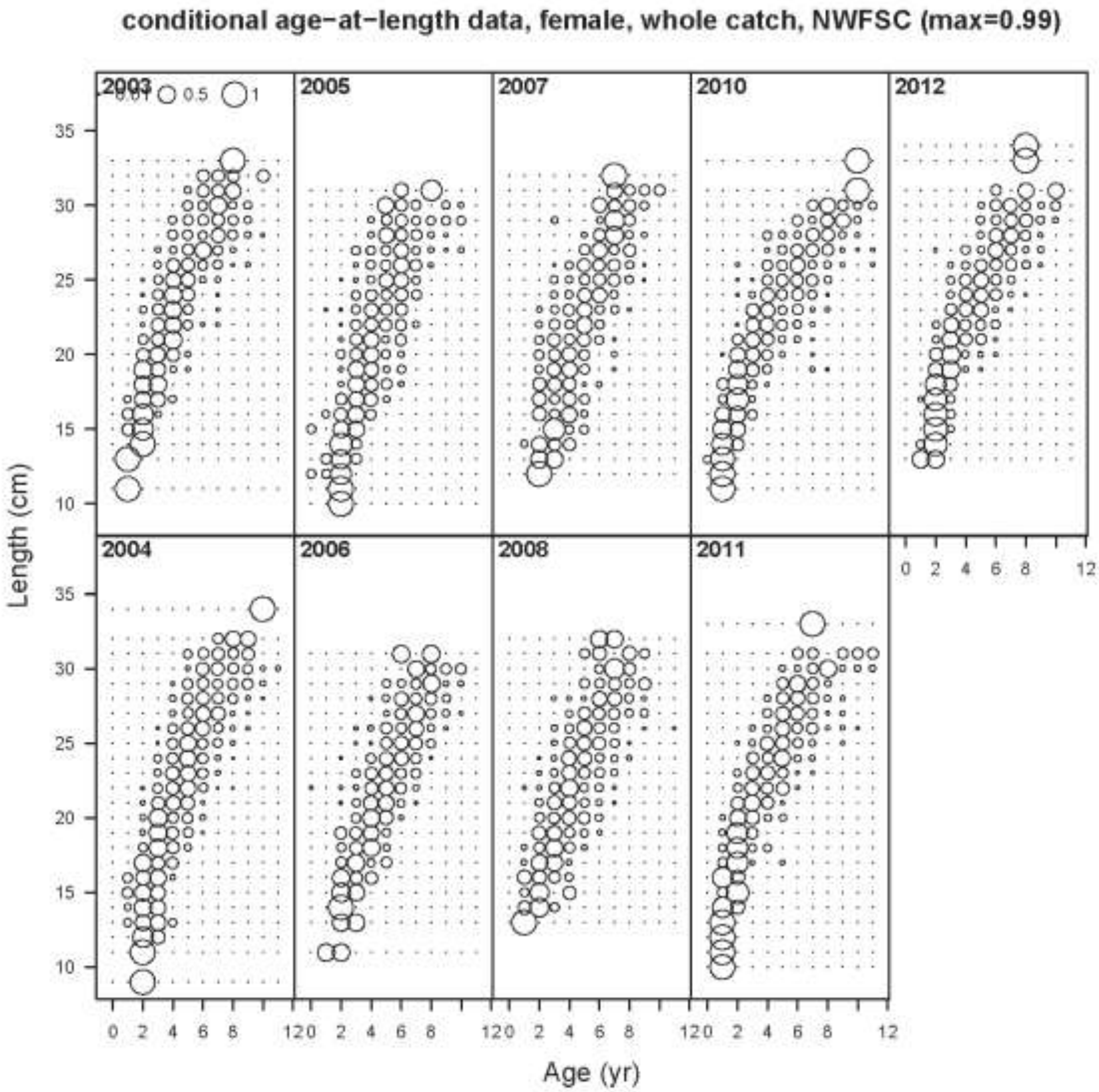



**Figure 16. Plots of conditional age-at-length frequencies for females from the NWFSC survey from 2003 to 2012.**

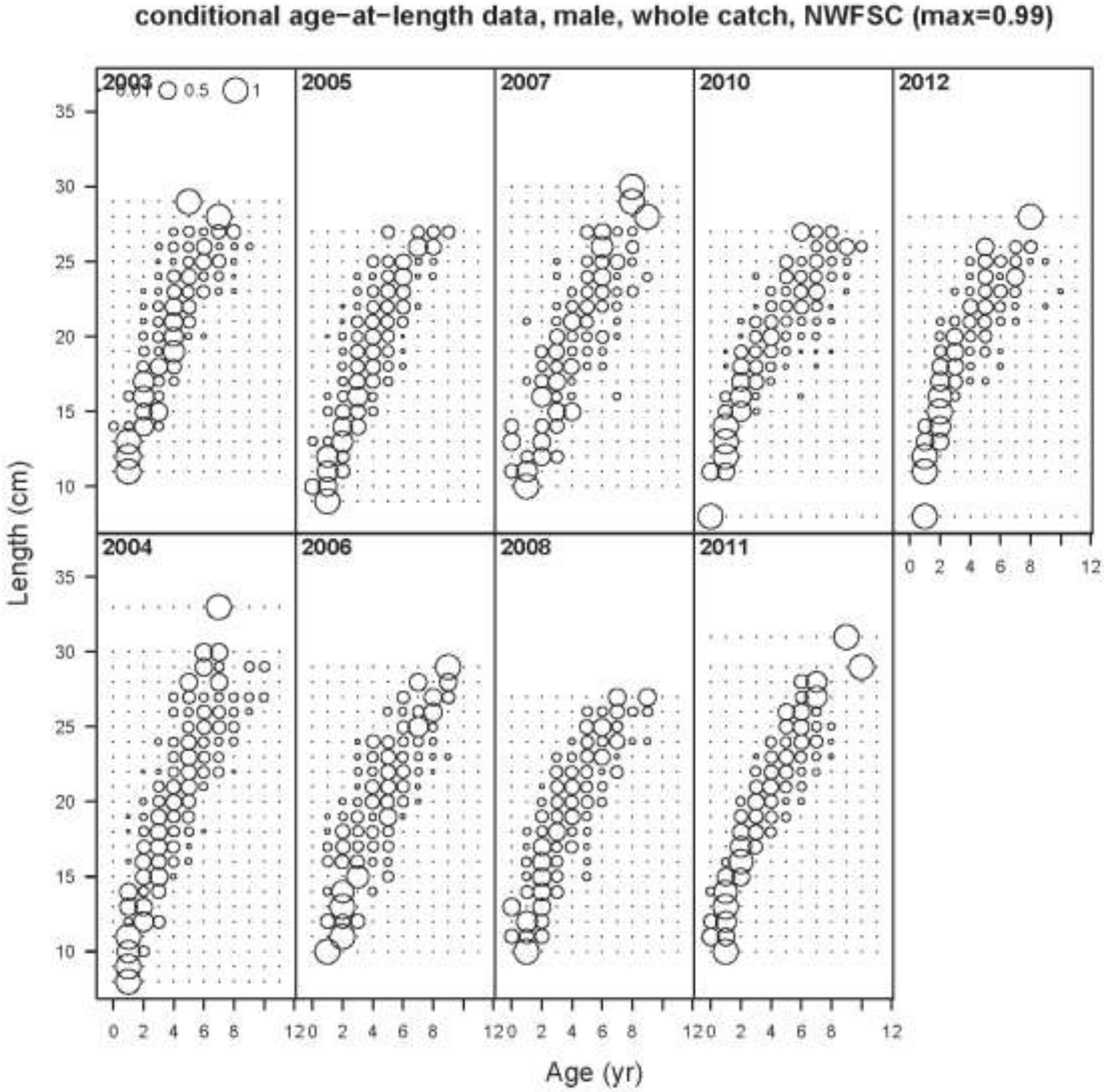



**Figure 17. Plots of conditional age-at-length frequencies for males from the NWFSC survey from 2003 to 2012.**

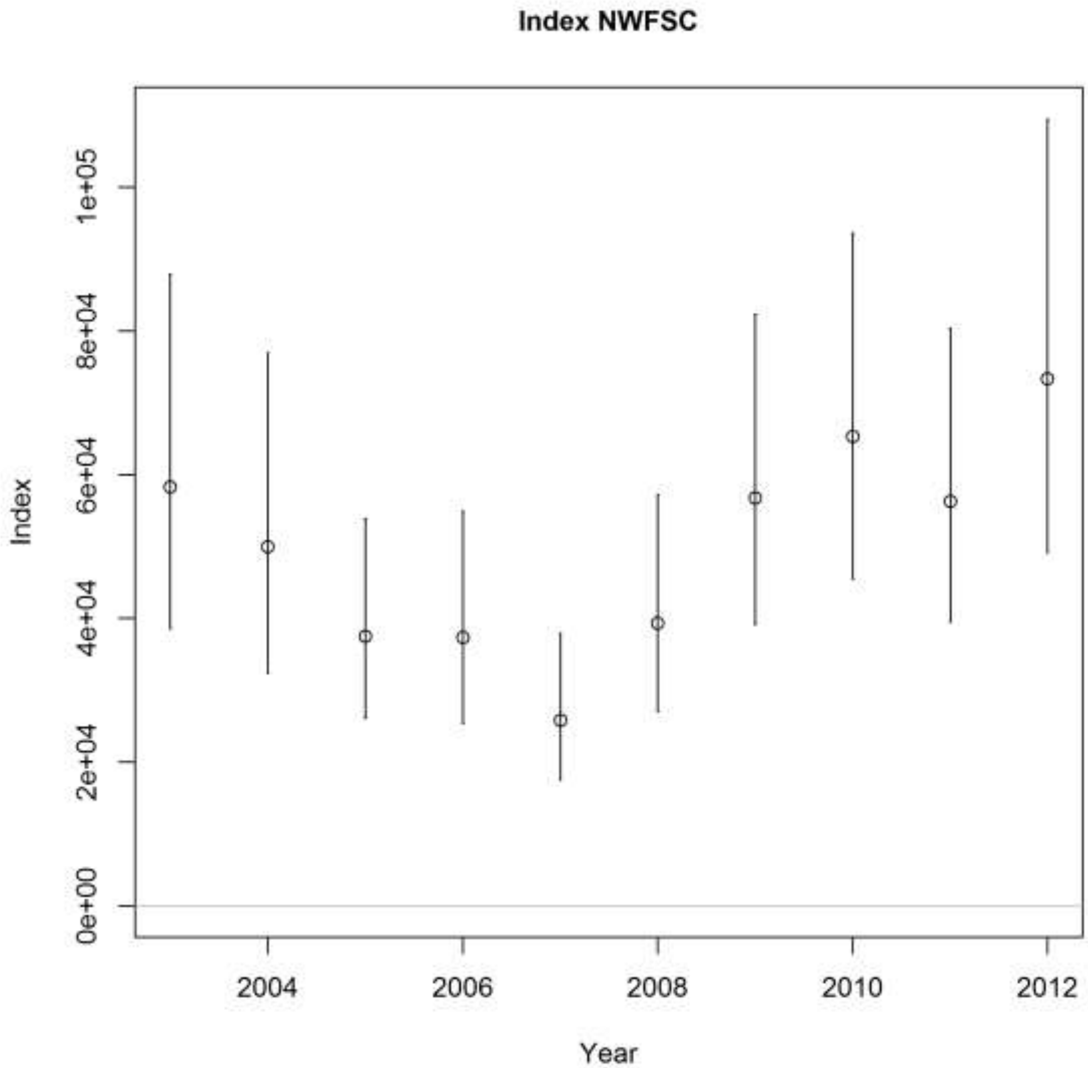



**Figure 18. Estimated biomass and their standard deviations from the GLMM analysis for the NWFSC survey.**

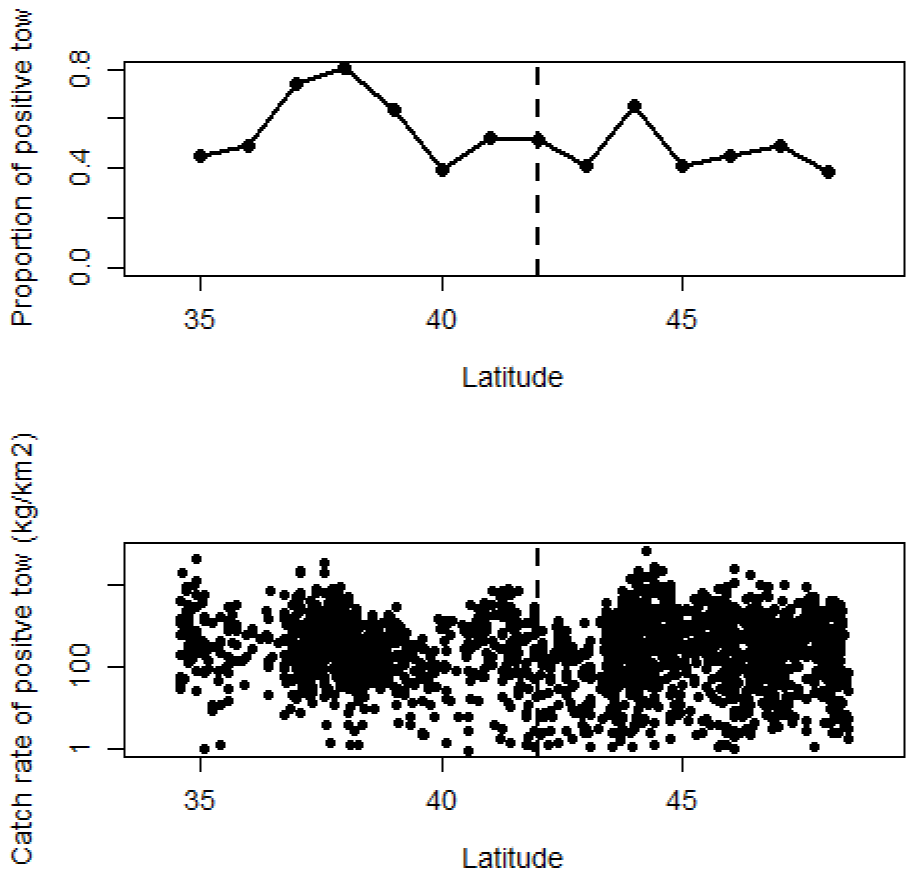



**Figure 19. Plots of the proportion of positive tows (top panel) and the catch rates of positive tows (bottom panel) by latitude for triennial survey data. Vertical dash lines show latitude line 42 degree (boarder of Oregon and California). Note that y-axis on the bottom panel is in log-scale.**

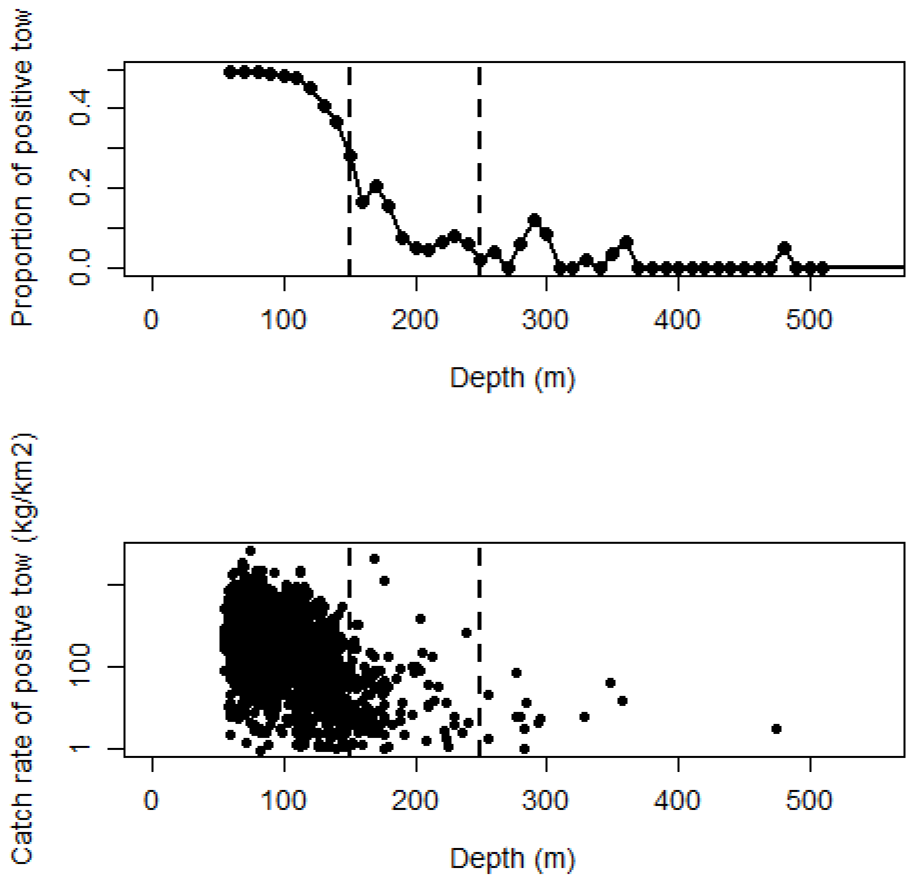



**Figure 20. Plots of the proportion of positive hauls (top panel) and the catch rates of positive tows (bottom panel) by depth zones for triennial survey data. Vertical dash lines show depths of 150m and 250m. Note that y-axis on the bottom panel is in log-scale.**

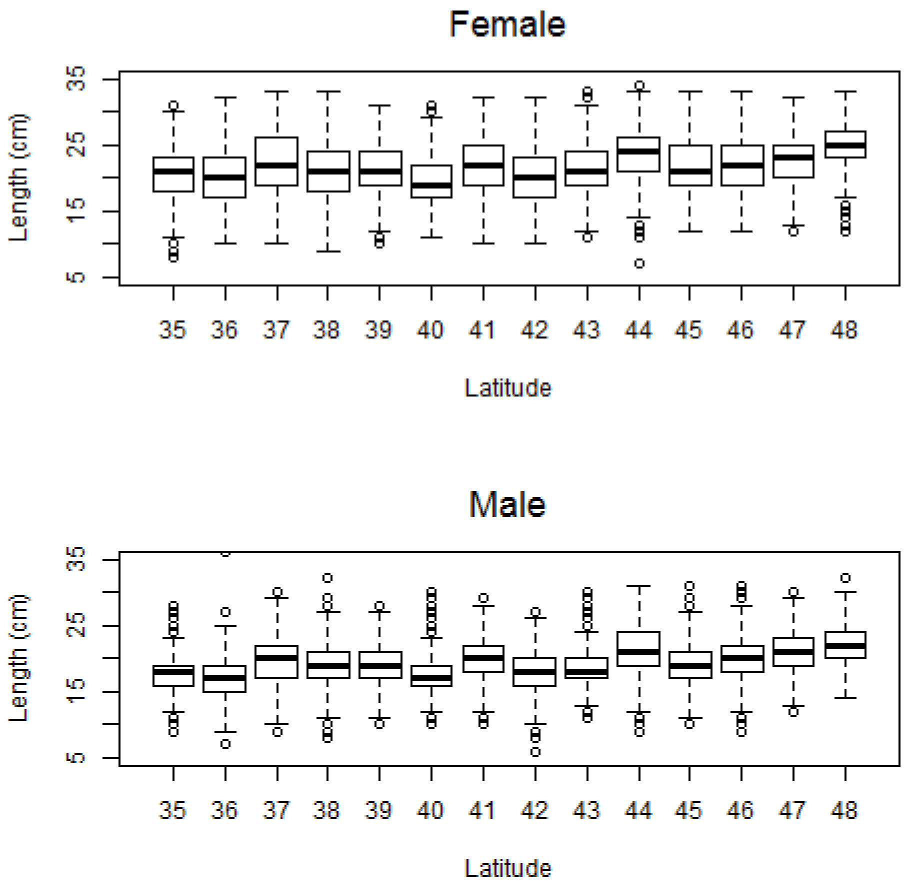



**Figure 21. Comparison box plots of raw length data from the triennial survey by sex by latitude.**

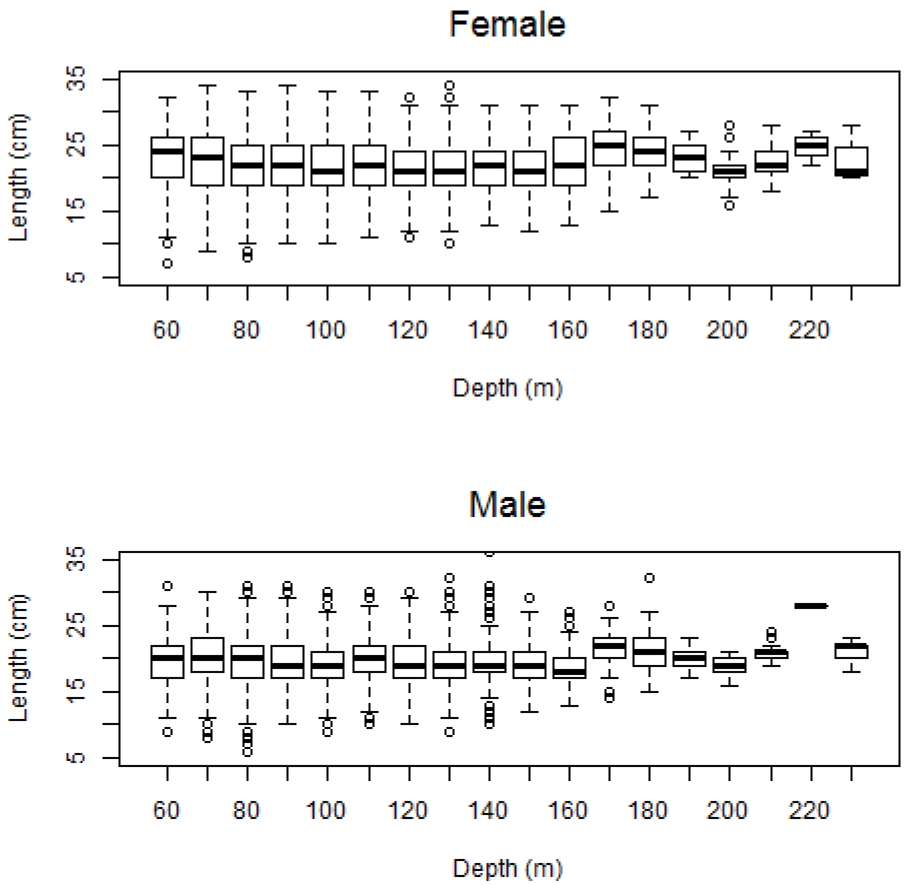



**Figure 22. Comparison box plots of raw length data from the triennial survey data by sex and by depth.**

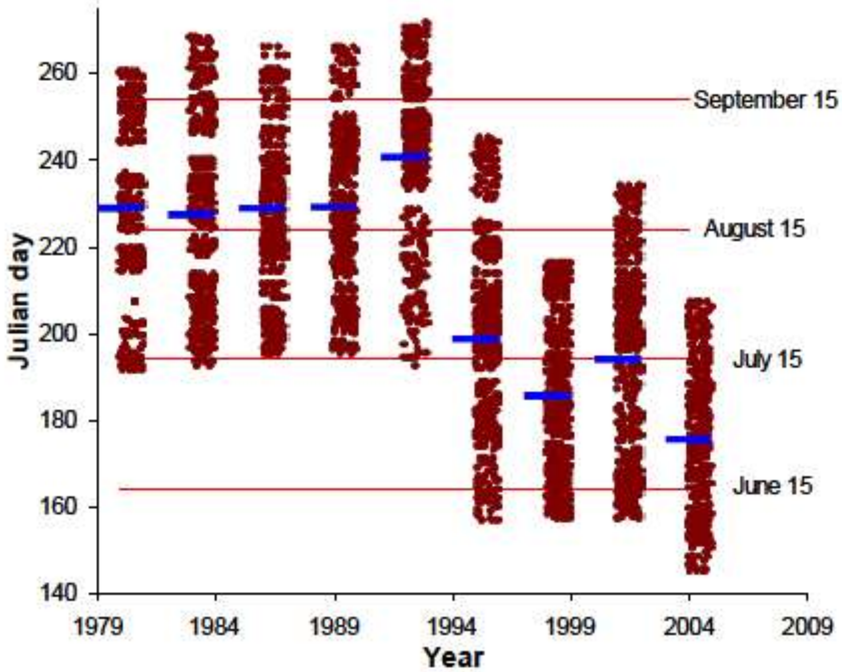



**Figure 23. Distribution of date of operation for the triennial survey (1980-2004). Solid bars show the mean date for each survey year, points represent individual haul dates, but are jittered to allow better delineation of the distribution of individual points. (Figure and caption copied from Hicks and Wetzel (2011), and original figure from Stewart (2007)).**

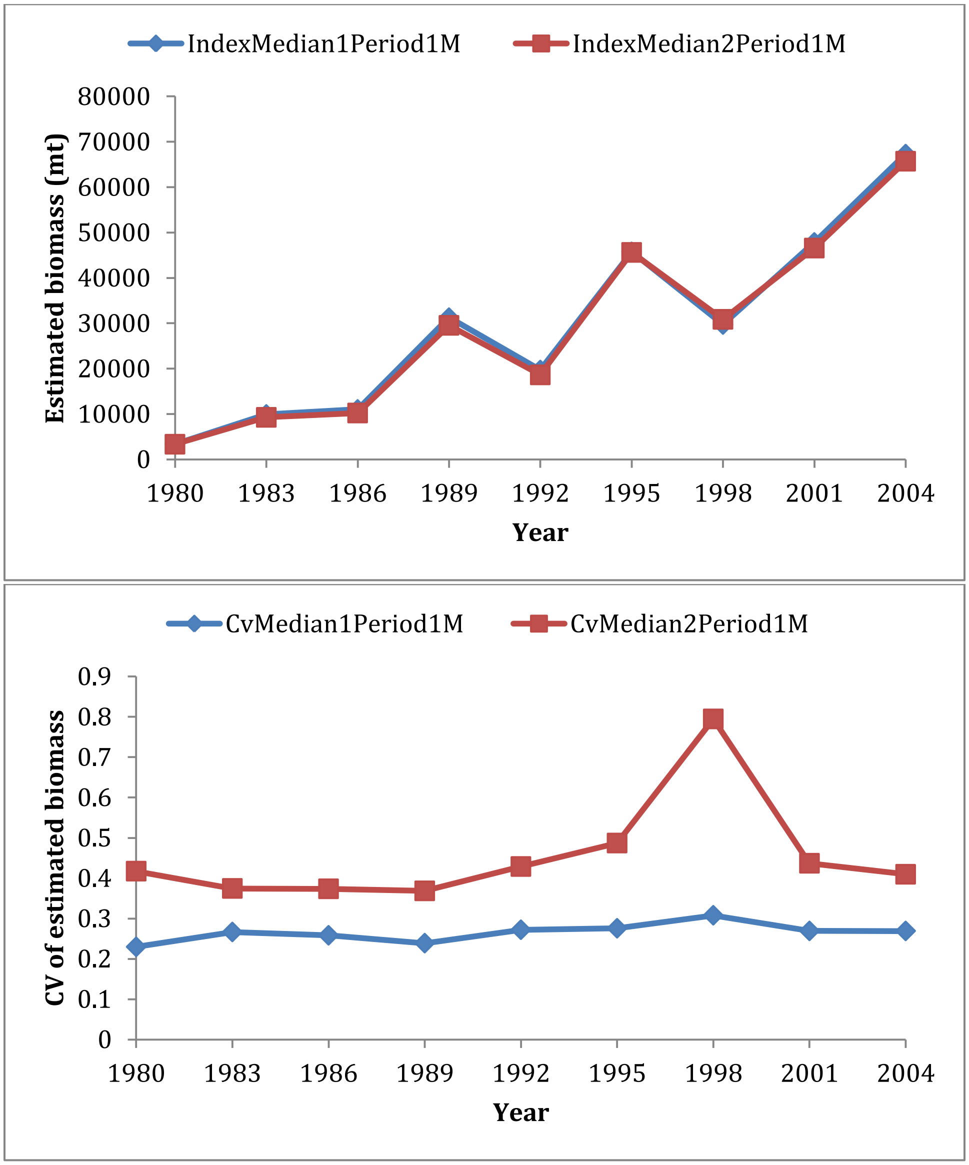



**Figure 24. Comparisons of estimated abundance indices for Pacific sanddab from the triennial trawl survey between 1980 and 2004 using one time period and two time periods (top panel), and their associated CVs (bottom panel). Blue lines are statistics from using one time period approach while red lines are those from using two-time period approach.**

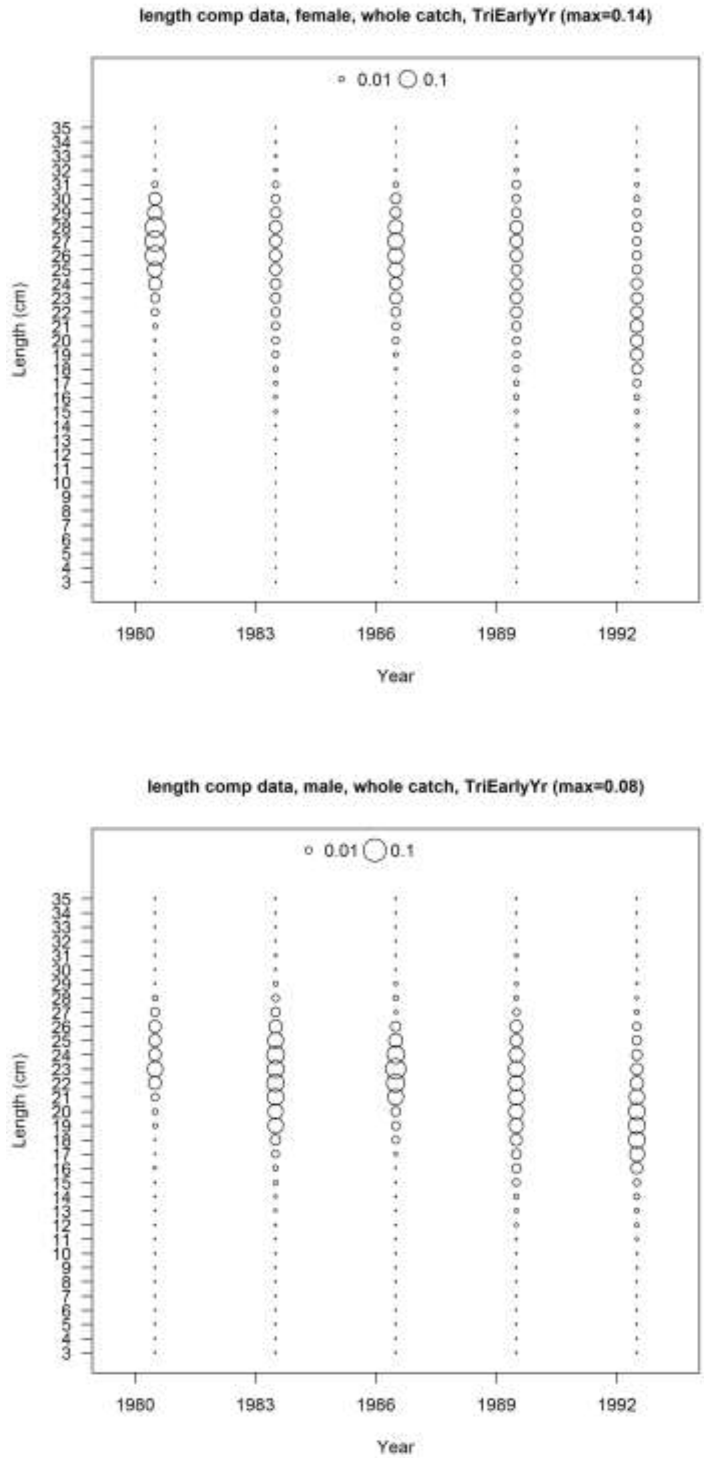



**Figure 25. Plots of length frequency distributions of females (top panel) and males (bottom panel) from the early year triennial survey used in the assessment model between 1980 and 1992.**

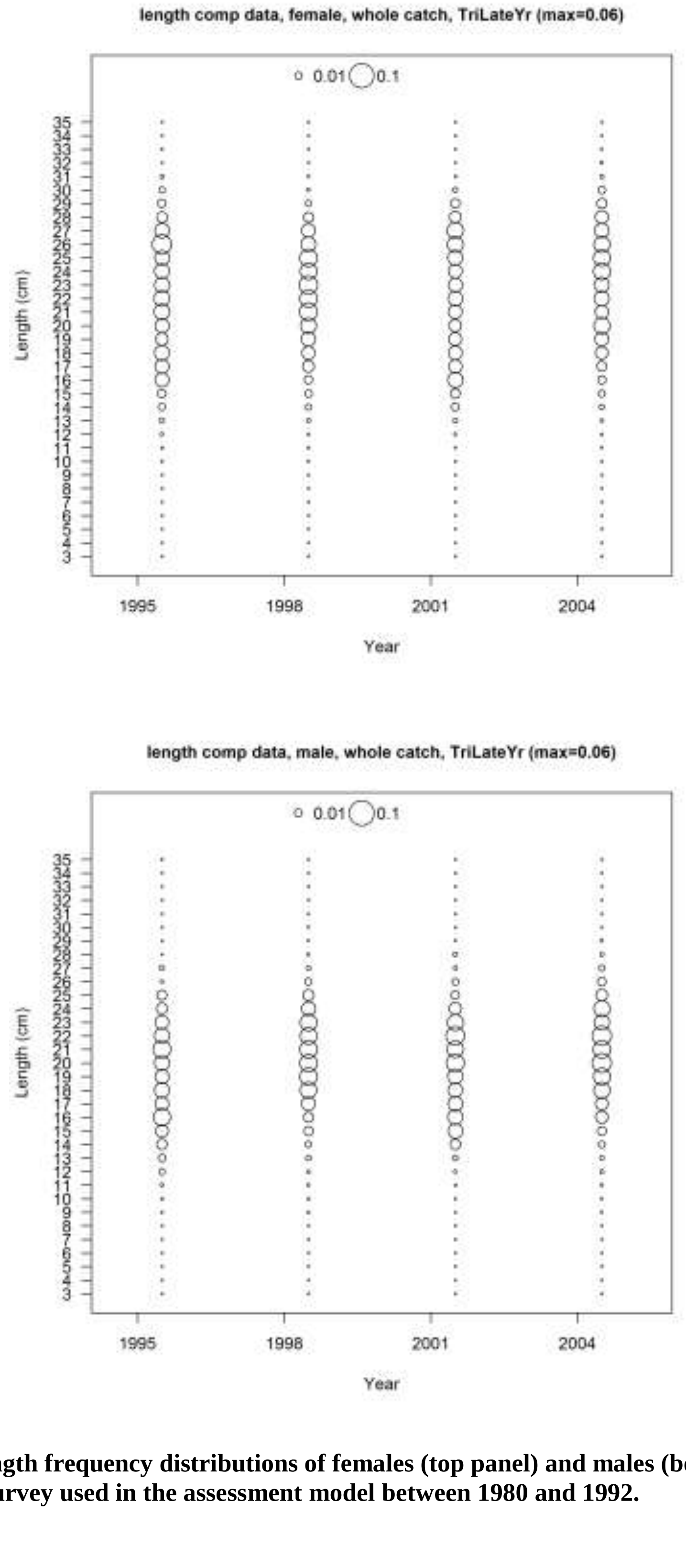



**Figure 26. Plots of length frequency distributions of females (top panel) and males (bottom panel) from the early year triennial survey used in the assessment model between 1980 and 1992.**

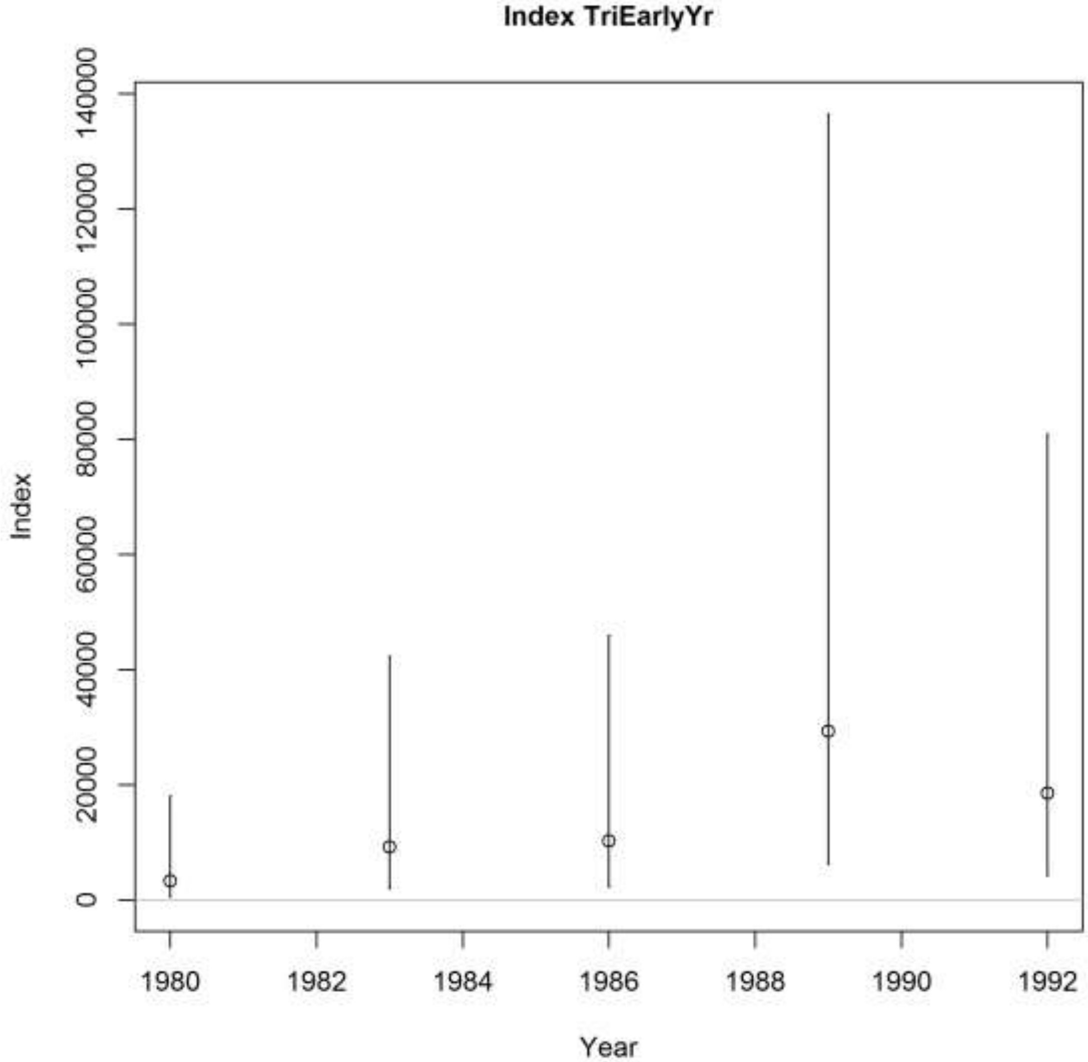



**Figure 27. Estimated biomass from the GLMM analysis for early years (1980-1992) of the triennial survey.**

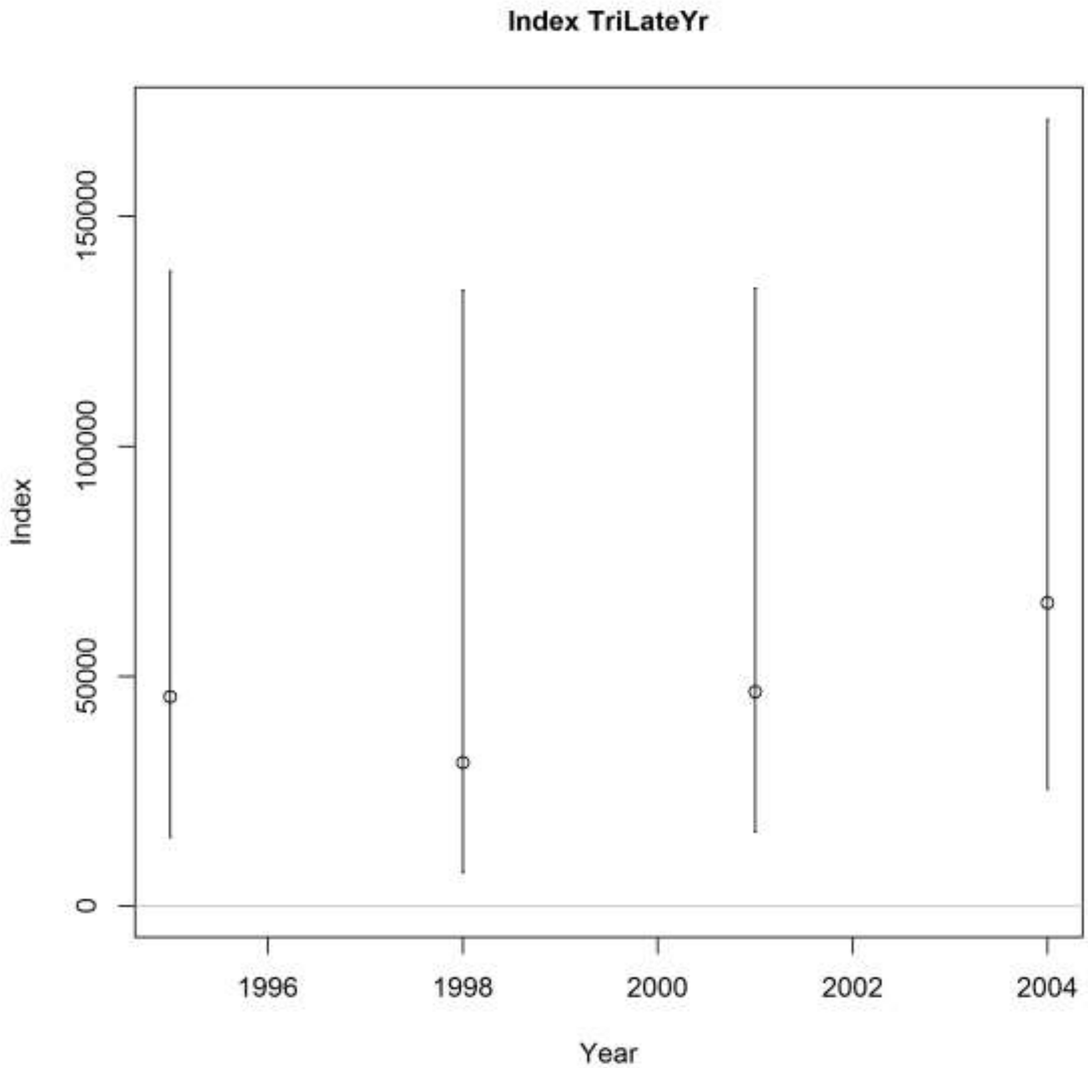



**Figure 28. Estimated biomass from the GLMM analysis for late years (1994-2001) of the triennial survey.**

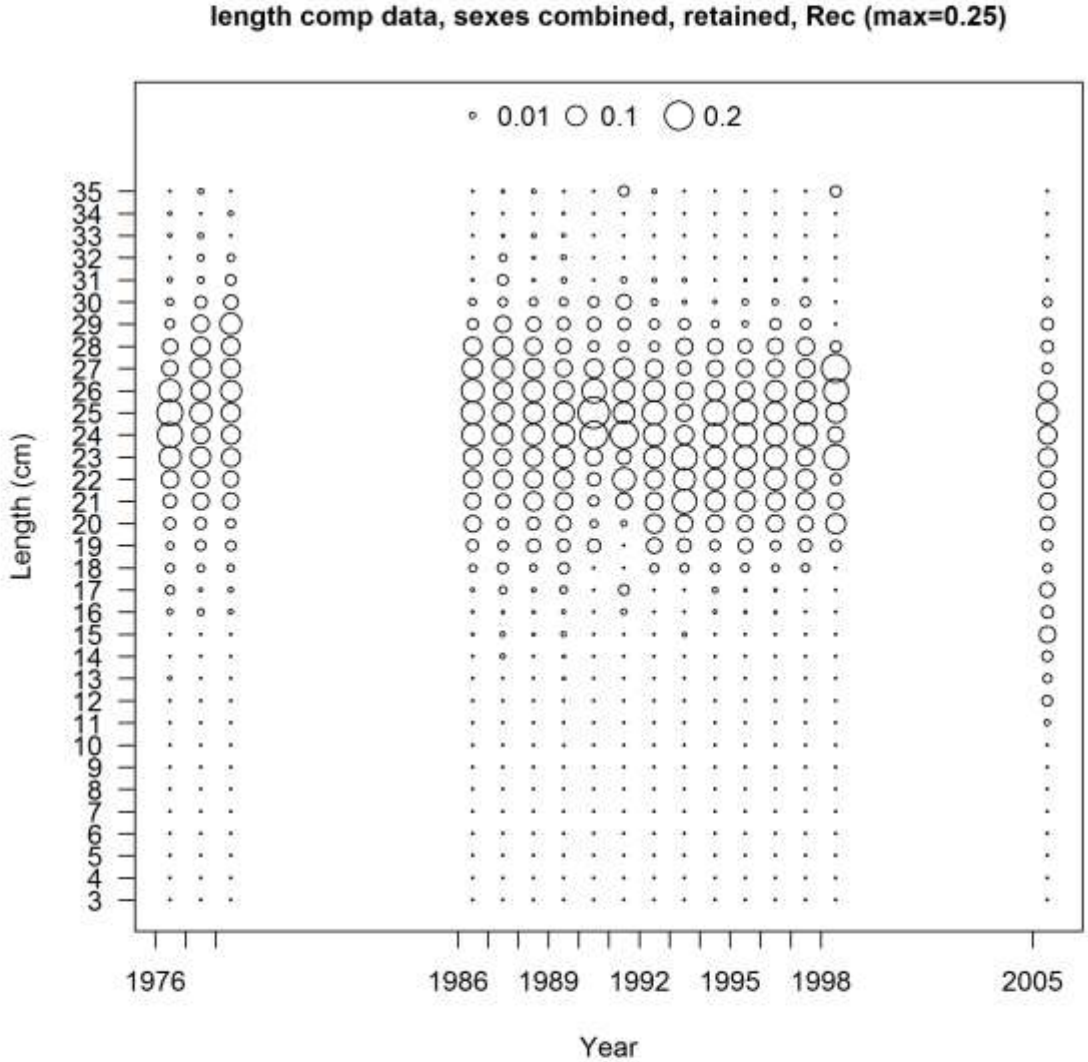



**Figure 29. Length frequency distributions of retained catches from the recreational fishery (sexes combined) from 1976 to 2005. Data were from the CDFW Commercial Passenger Fishing Vessels (CPFV) sampling program.**

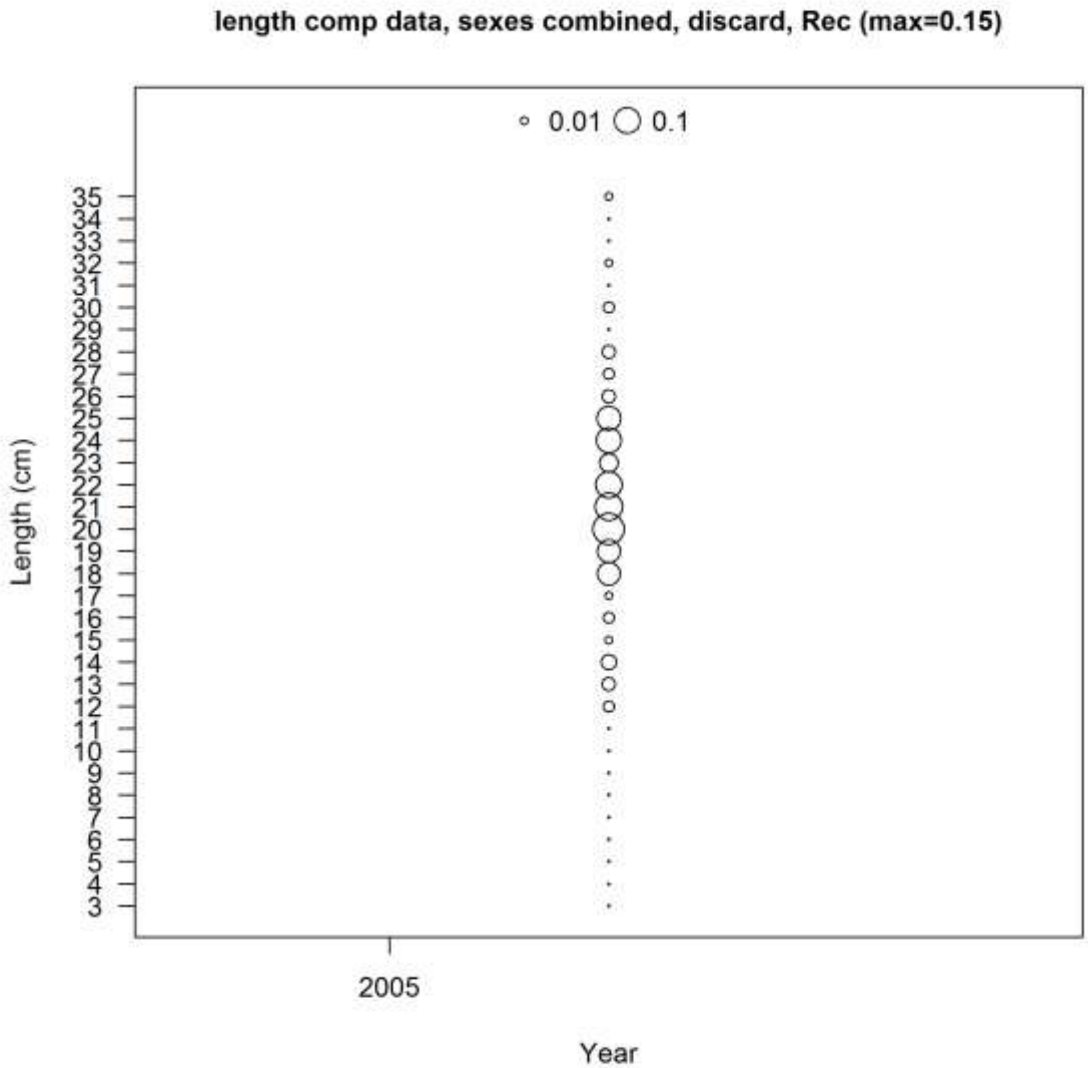



**Figure 30. Length frequency distributions of discarded catches from the recreational fishery (sexes combined) in 2005. Data were from the CDFW Commercial Passenger Fishing Vessels (CPFV) sampling program.**

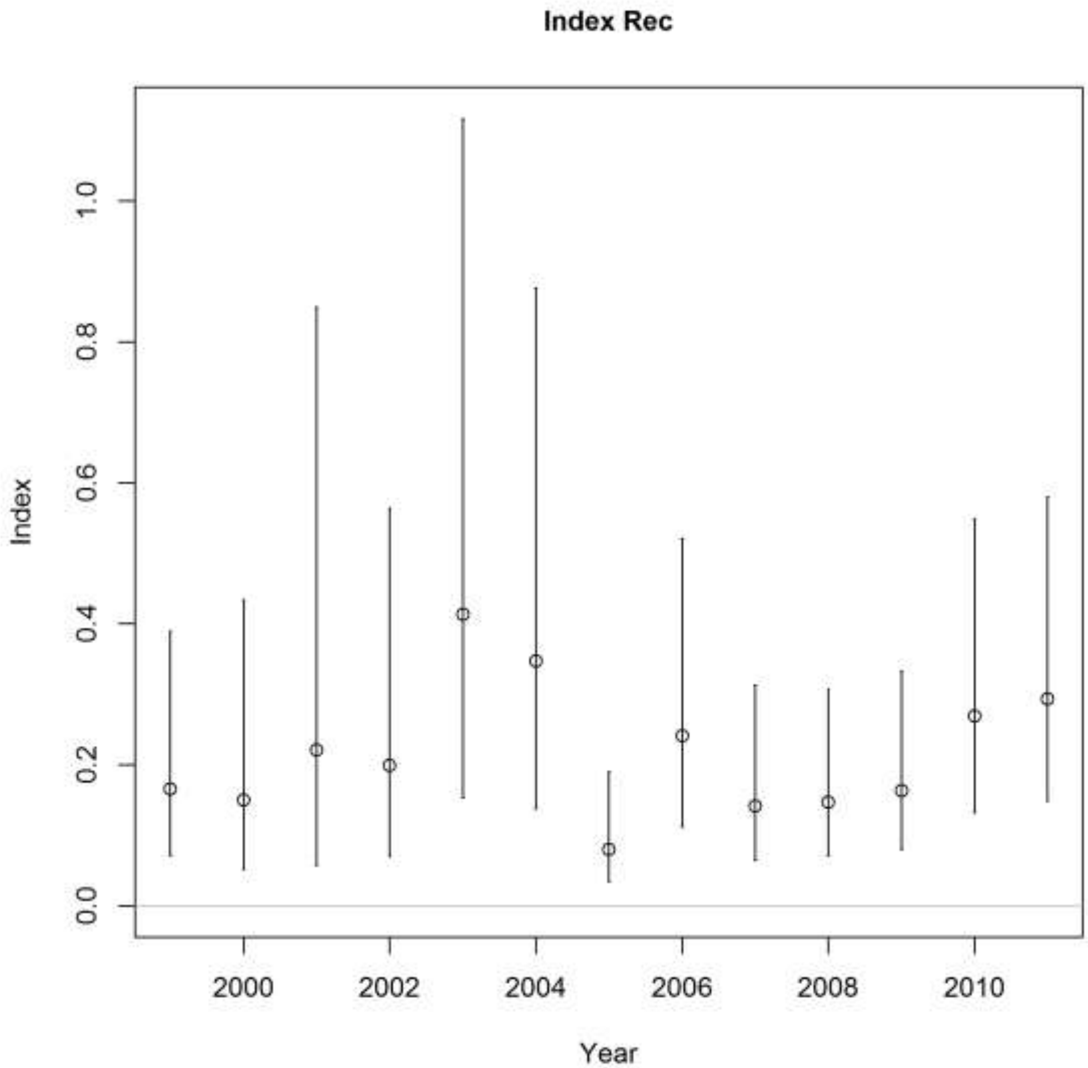



**Figure 31. Estimated CPUE indices and CVs from the GLM analysis for the California recreational fishery survey (CPFV survey) between 1999 and 2011. The indices were provided by Melissa Monk of the SWFSC).**

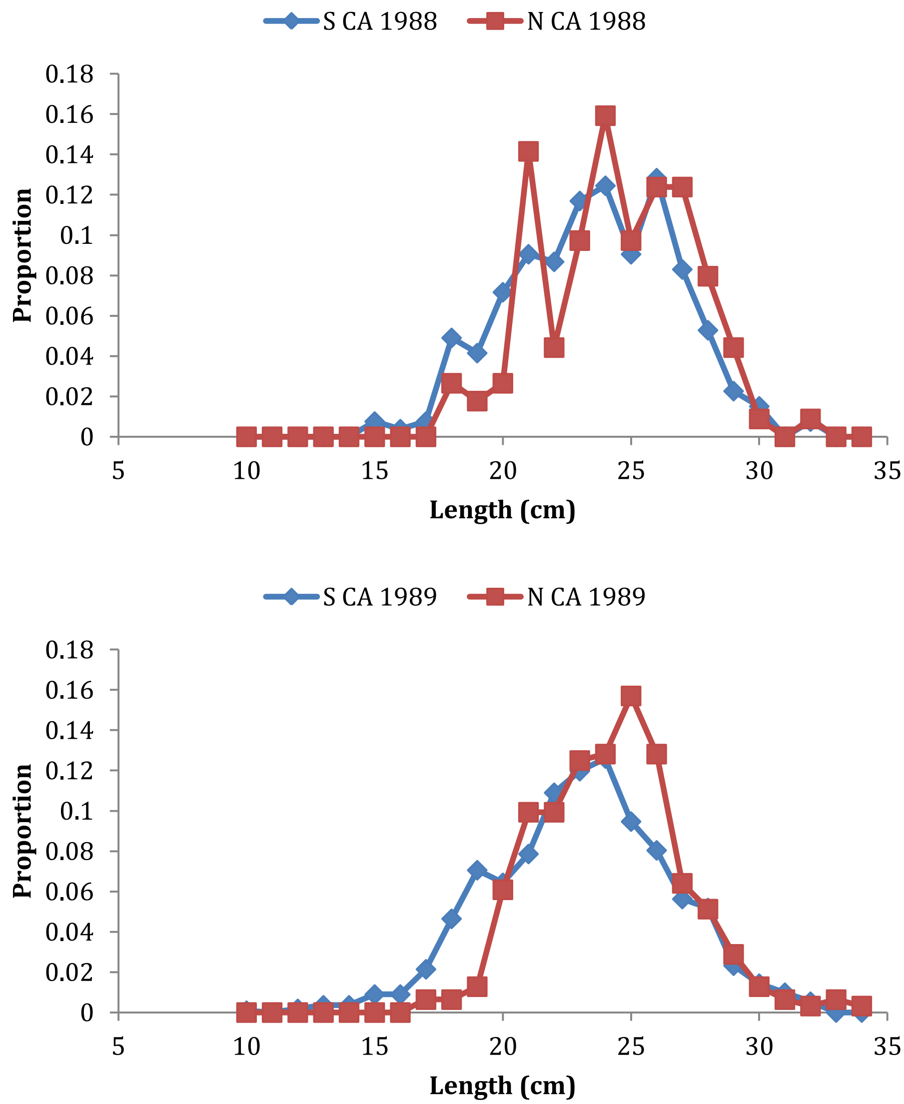



**Figure 32. Comparison plots of length frequency distributions of CPFV samples from southern and northern California in 1988 and 1989.**

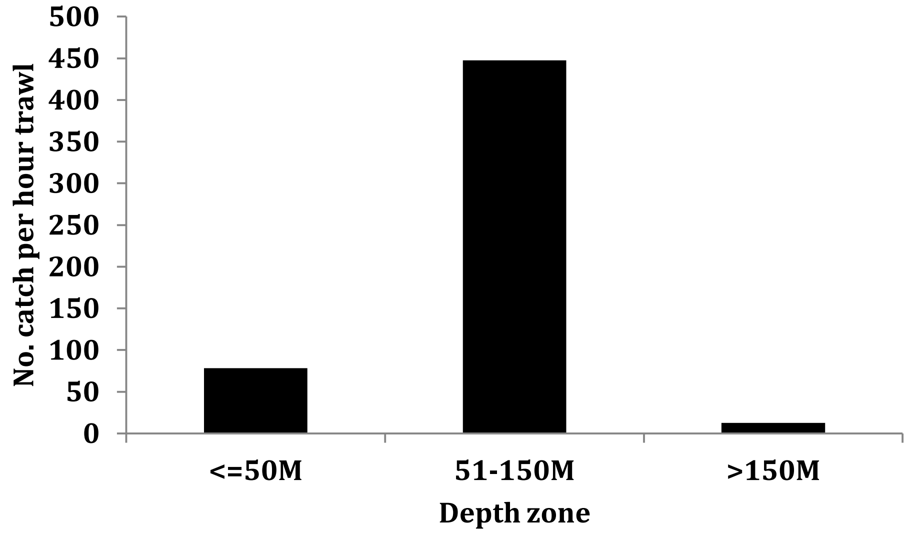
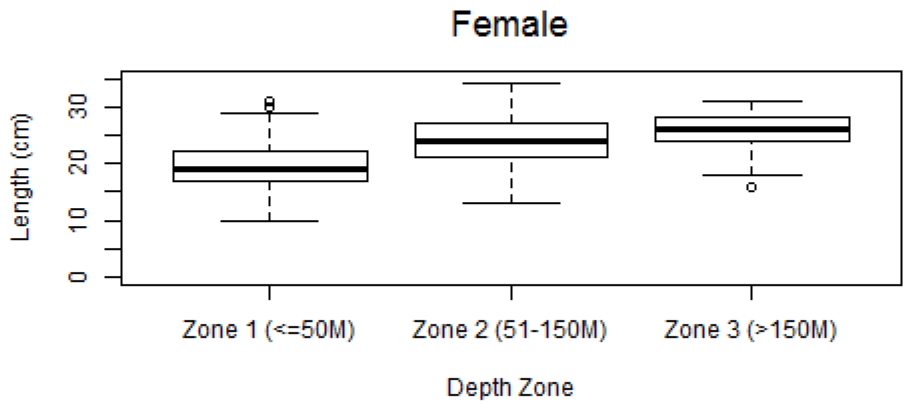



**Figure 33. Raw catch rate in three depth zones from the SWFSC FED ecology survey in the Monterey Bay area between 2002 and 2004. Numbers of tows for three depth zones were 28, 28, and 15, respectively.**



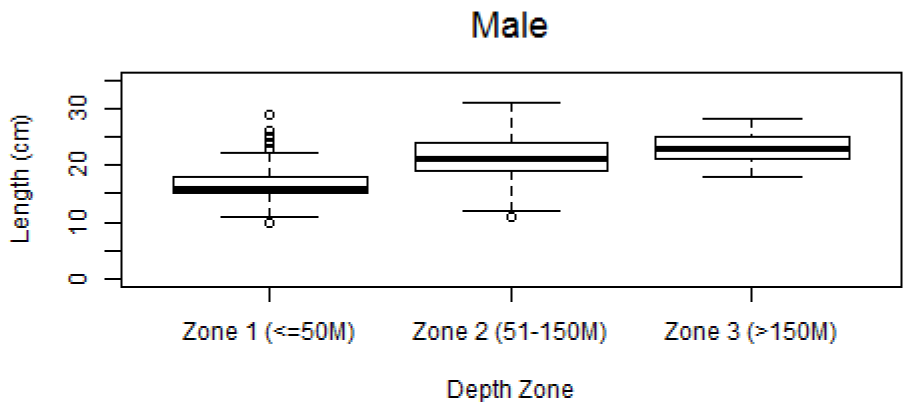




**Figure 34. Mean lengths and their standard deviations by sex for Pacific sanddab catches from the SWFSC FED ecology survey between 2001 and 2005 in the Monterey Bay area.**

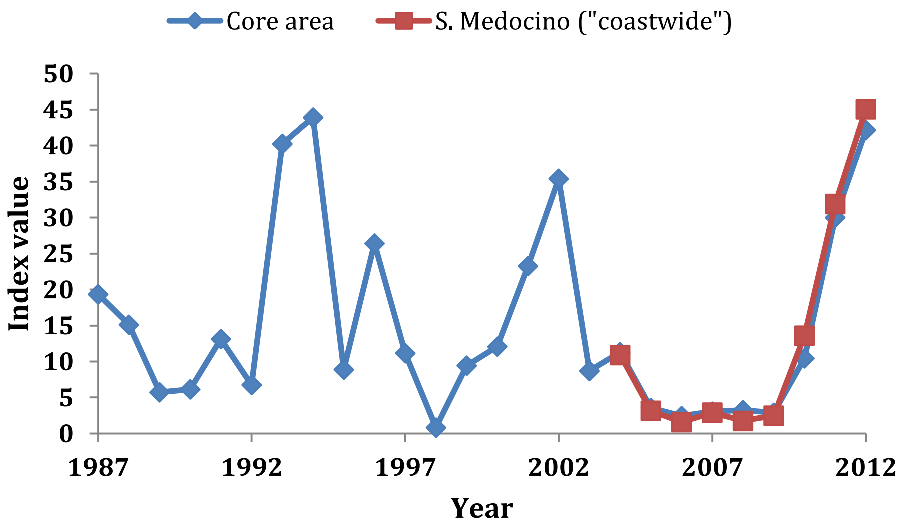



**Figure 35. Comparisons of juvenile survey indices between the SWFSC FED (core area) and PWCC/NWFSC (coastwide) surveys from 1987 to 2012.**

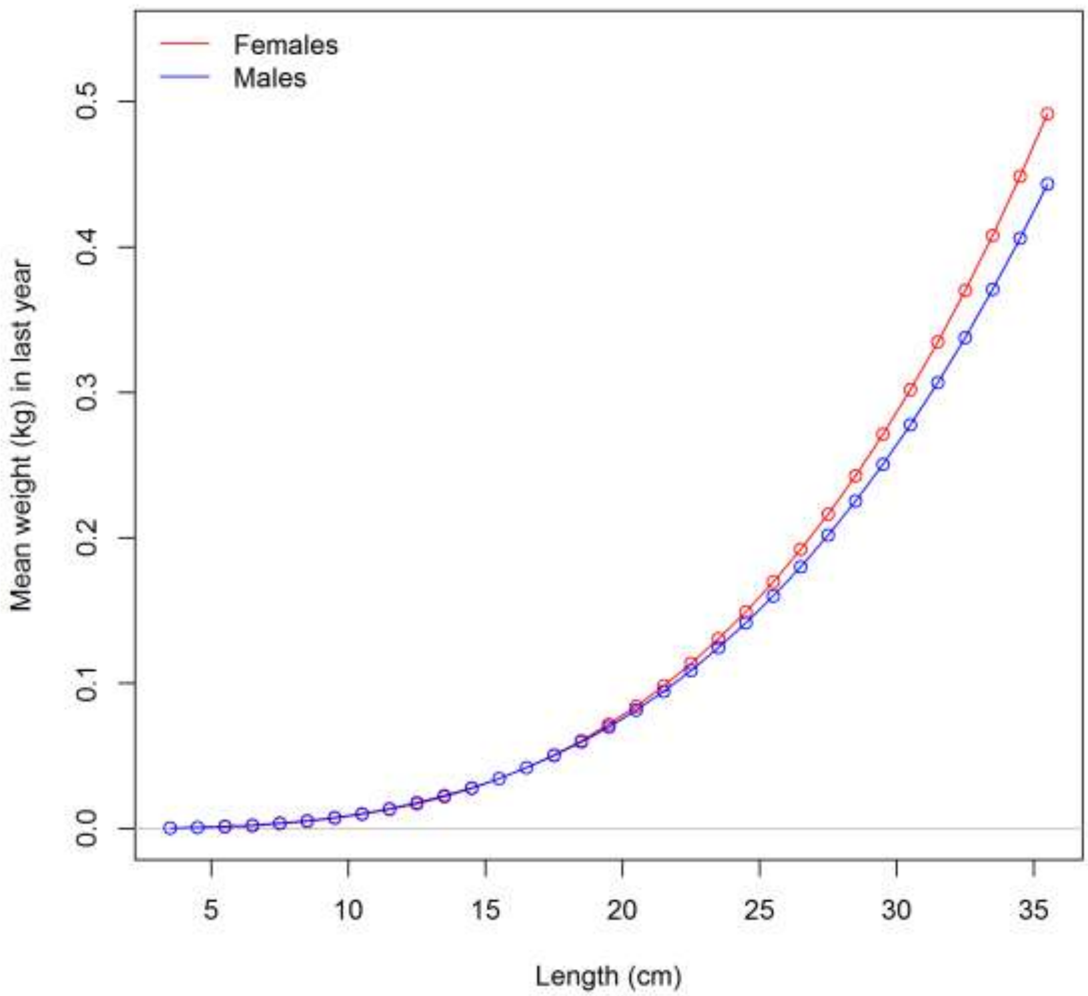



**Figure 36. Length-weight relationships by sex of Pacific sanddab used in this assessment.**

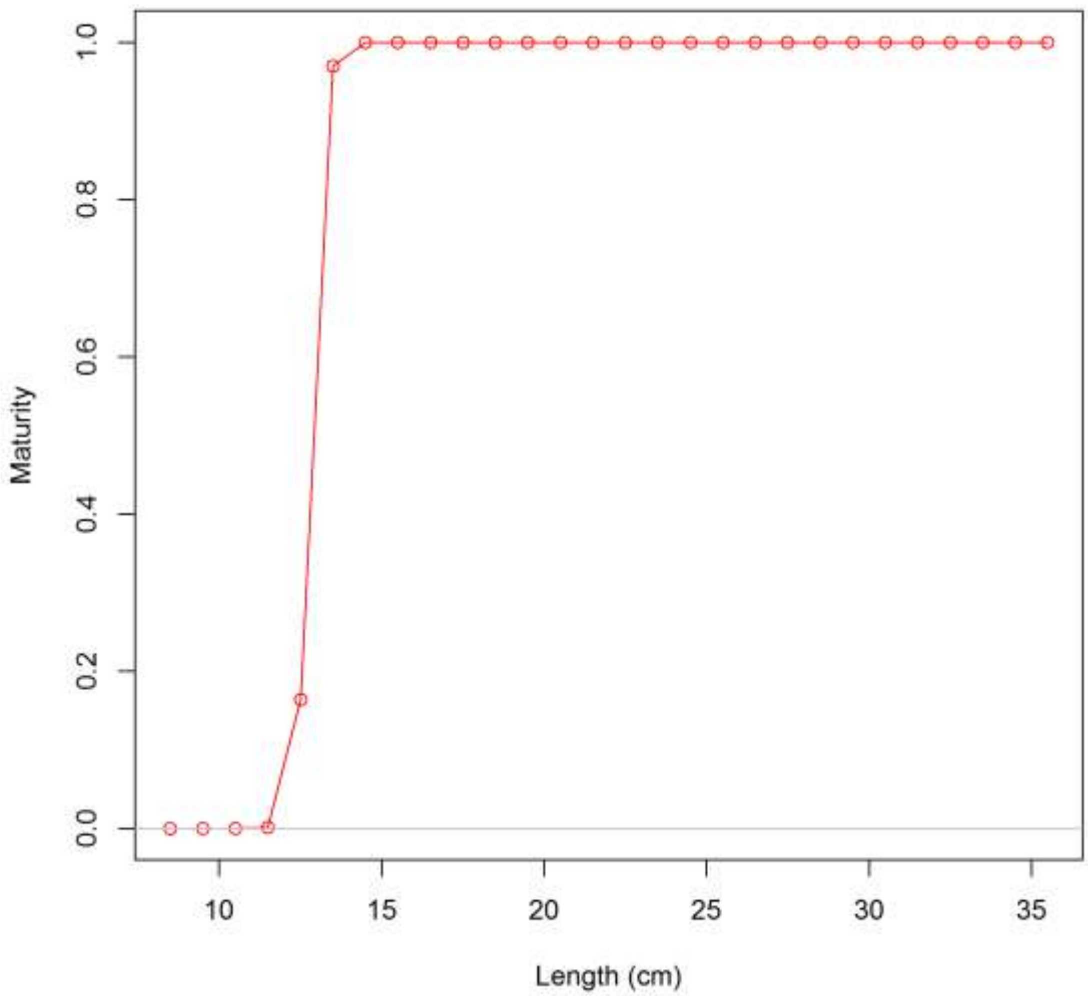



**Figure 37. Maturity ogive of females of Pacific sanddab used in this assessment.**

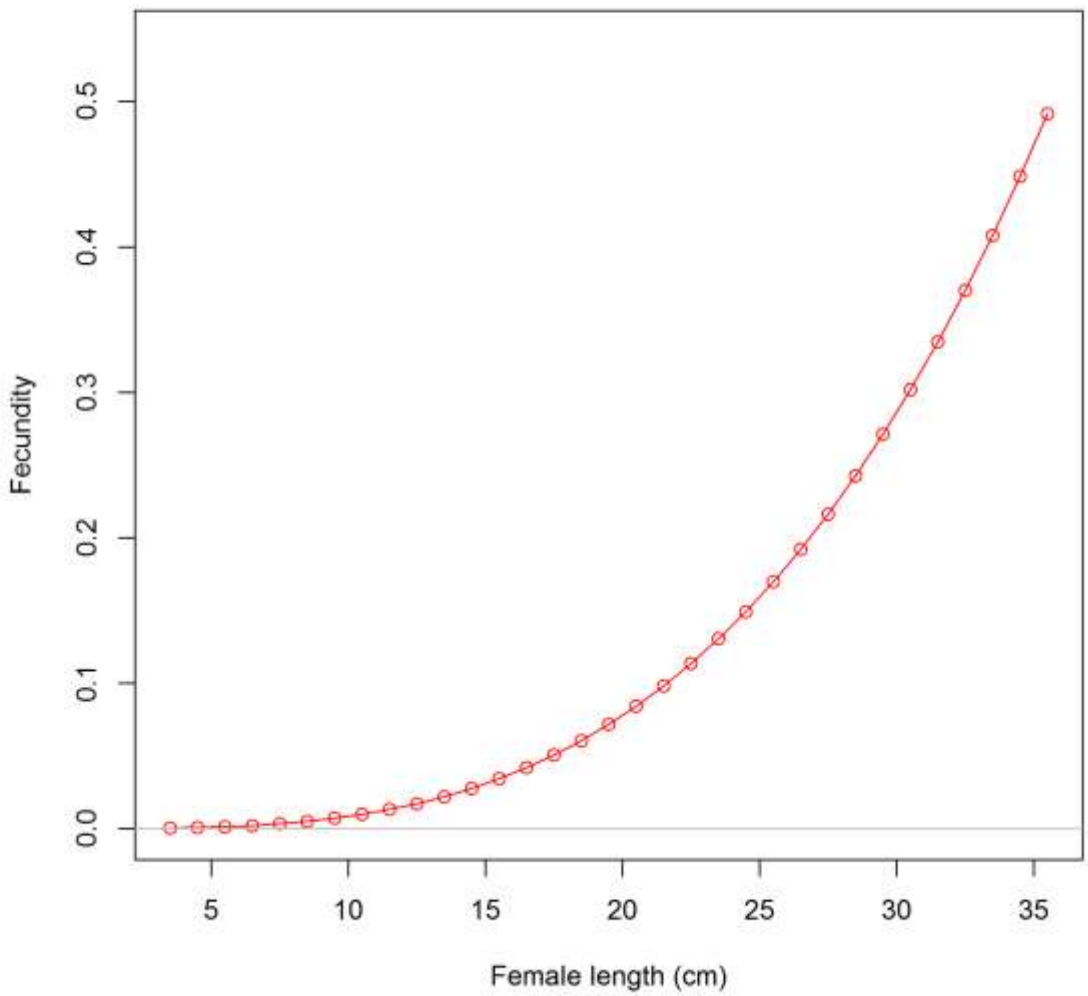



**Figure 38. Fecundity by length of Pacific sanddab used in this assessment.**

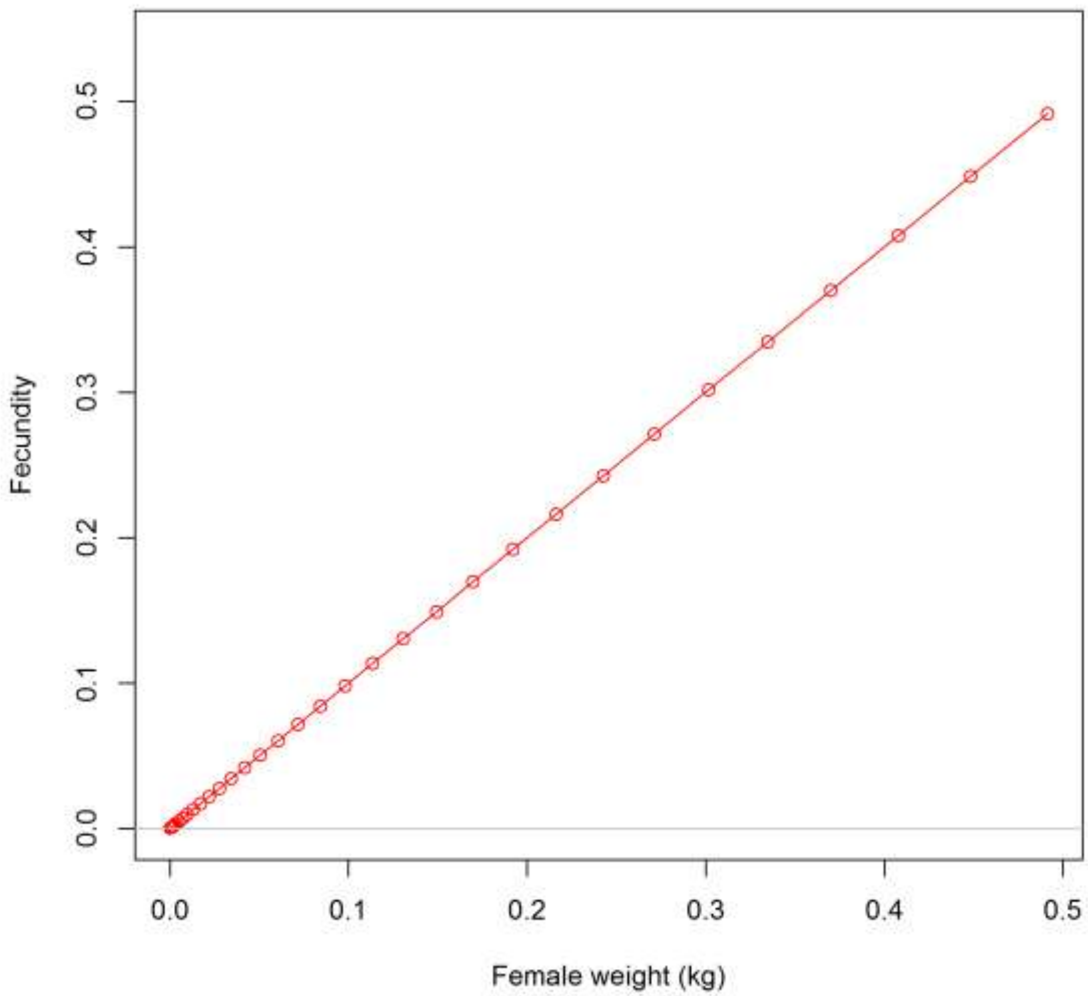



**Figure 39. Fecundity by weight of Pacific sanddab used in this assessment.**

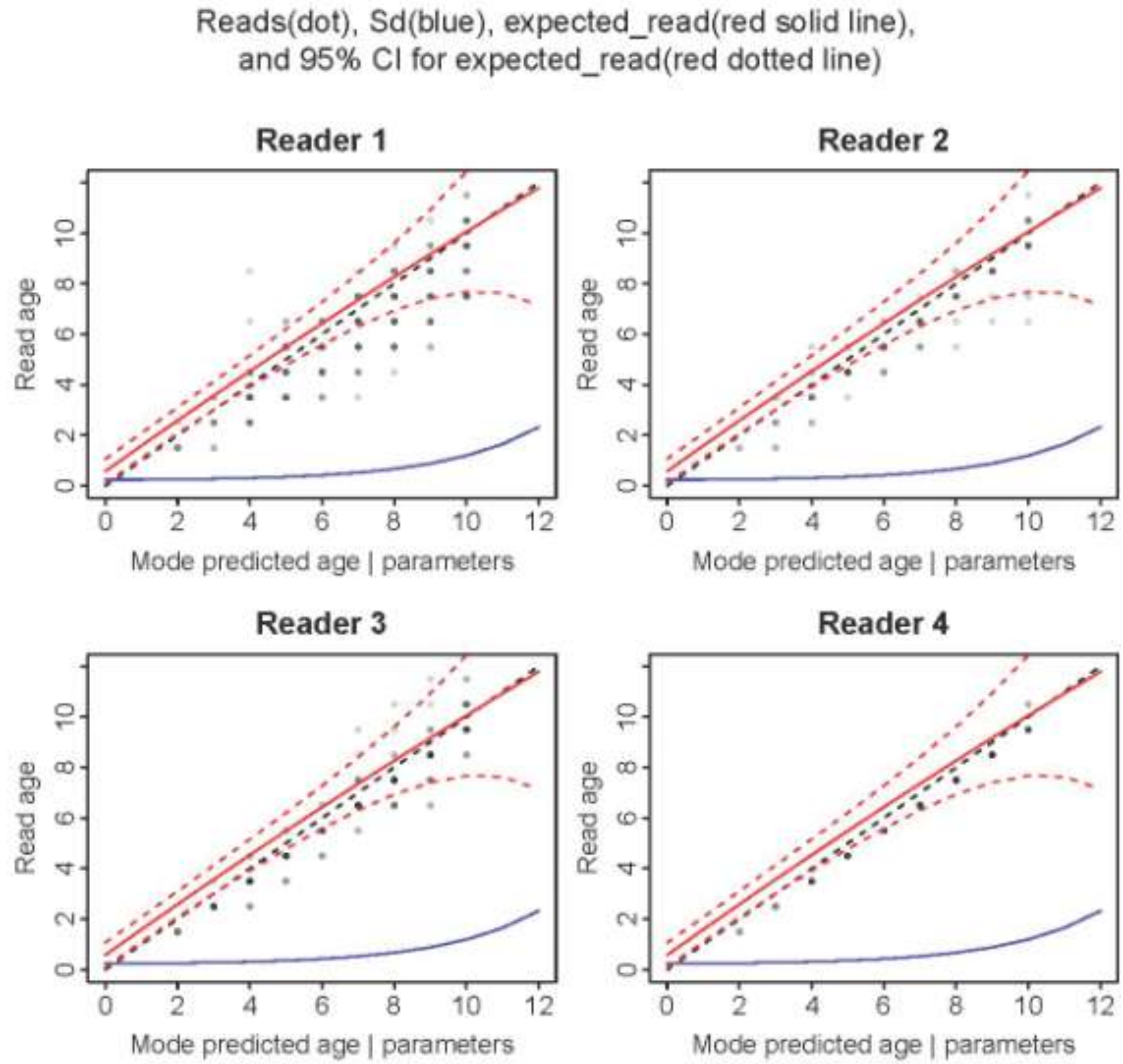



**Figure 40. Plots of aging bias and errors at different age classes by four readers. Line and dot symbols are specified at top of the figure. The graph was produced from a R program written by J. Thorson. Readers 1 and 2 are double reads from same ager and Readers 3 and 4 are double reads from the second reader.**

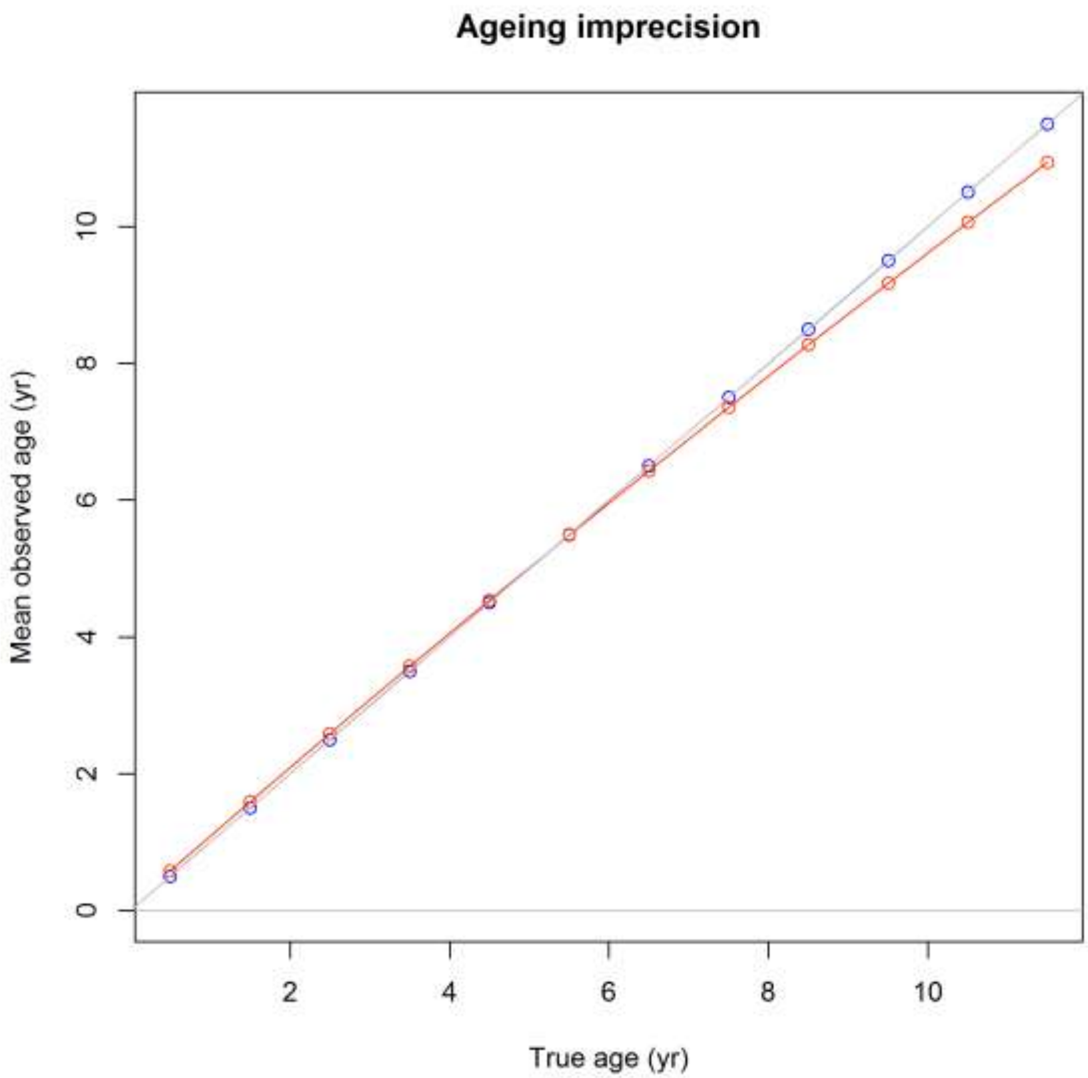



**Figure 41. Plots of aging bias at different age classes (red line), which was used in the assessment. The blue is a reference line that assumes no aging bias.**

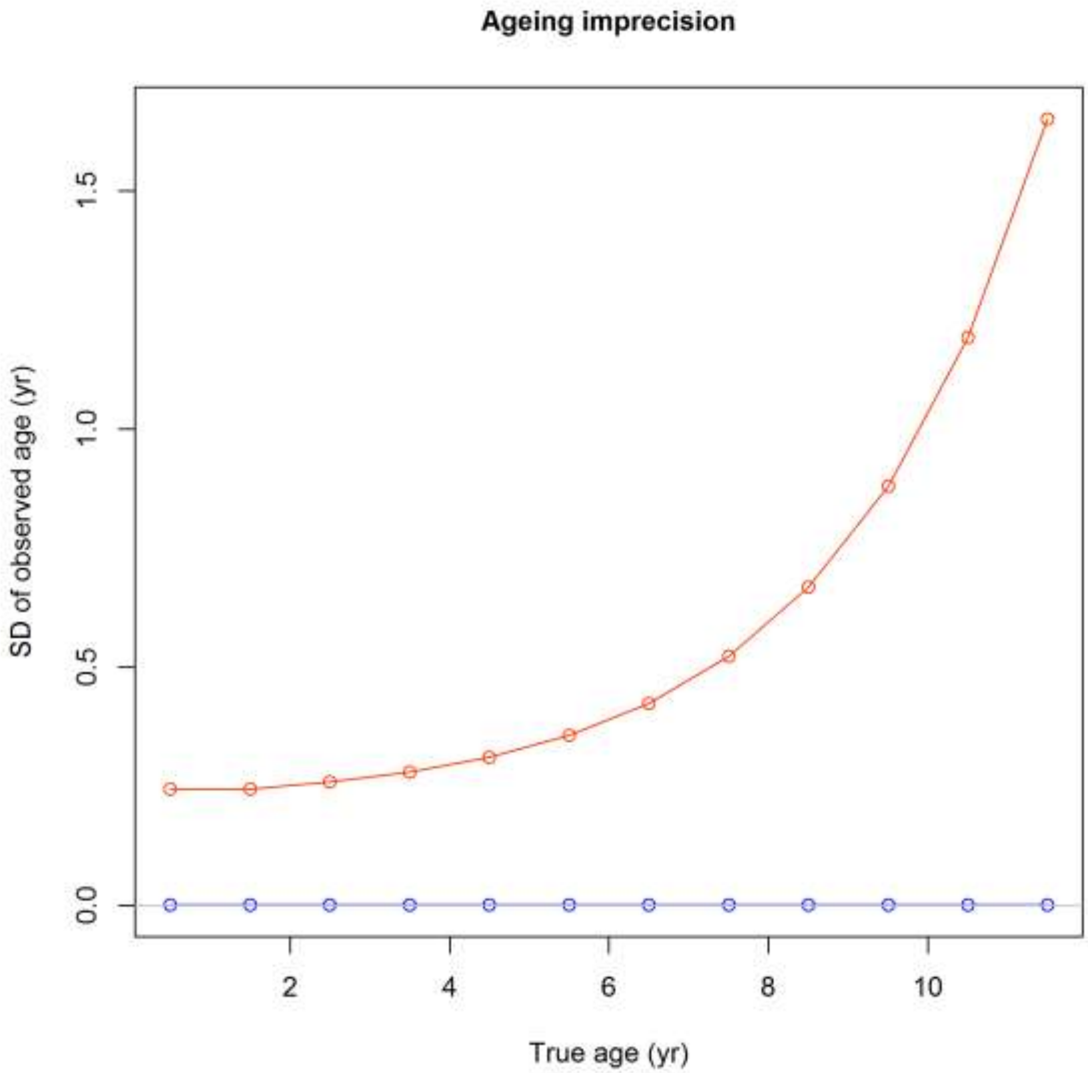



**Figure 42. Plots of aging error in terms of standard deviations (SD) at different age classes (red line), which was used in the assessment. The blue line is a reference that assumes no aging errors.**

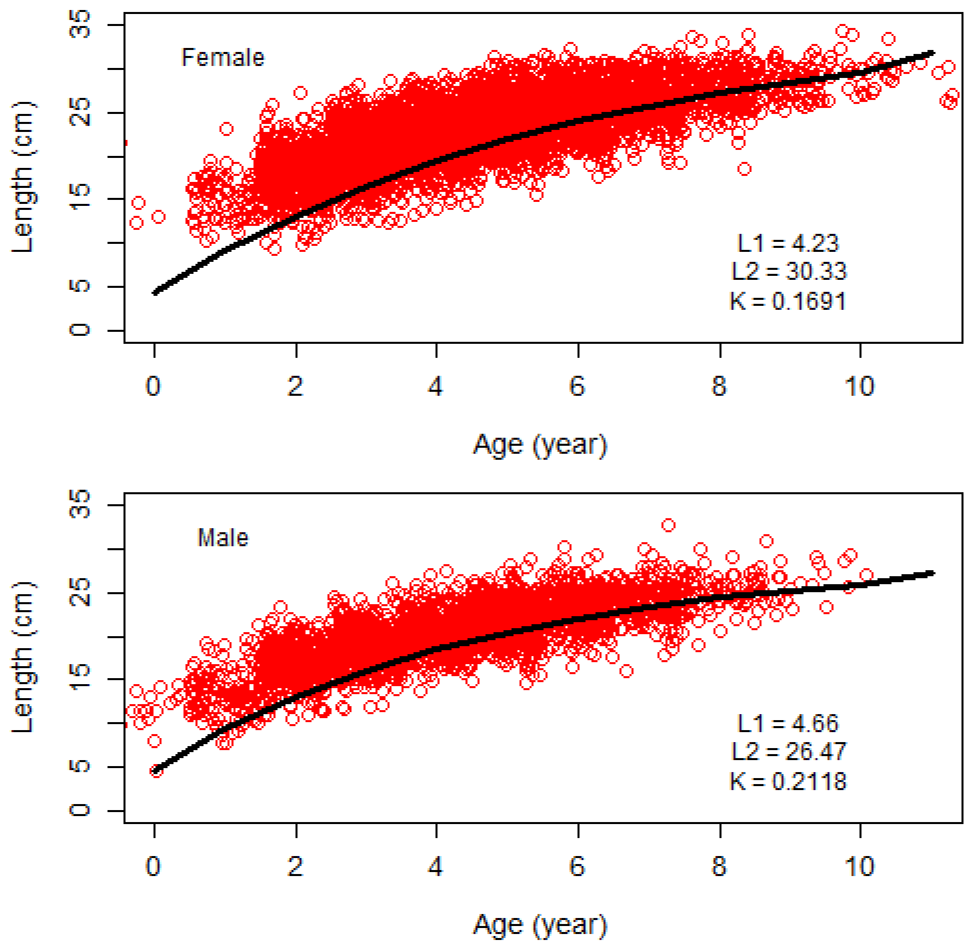



**Figure 43. Age-at-length data plot from the NWFSC survey data (red circles) for females (top panel) and males (bottom panel), and fitted growth curve from the base model (black lines). Datum points (red circles) were randomly jittered by plus and minus of 0.5 along both axis to show densities of data. L1 and L2 are estimated lengths at ages 0 and 11, respectively, for both sexes.**

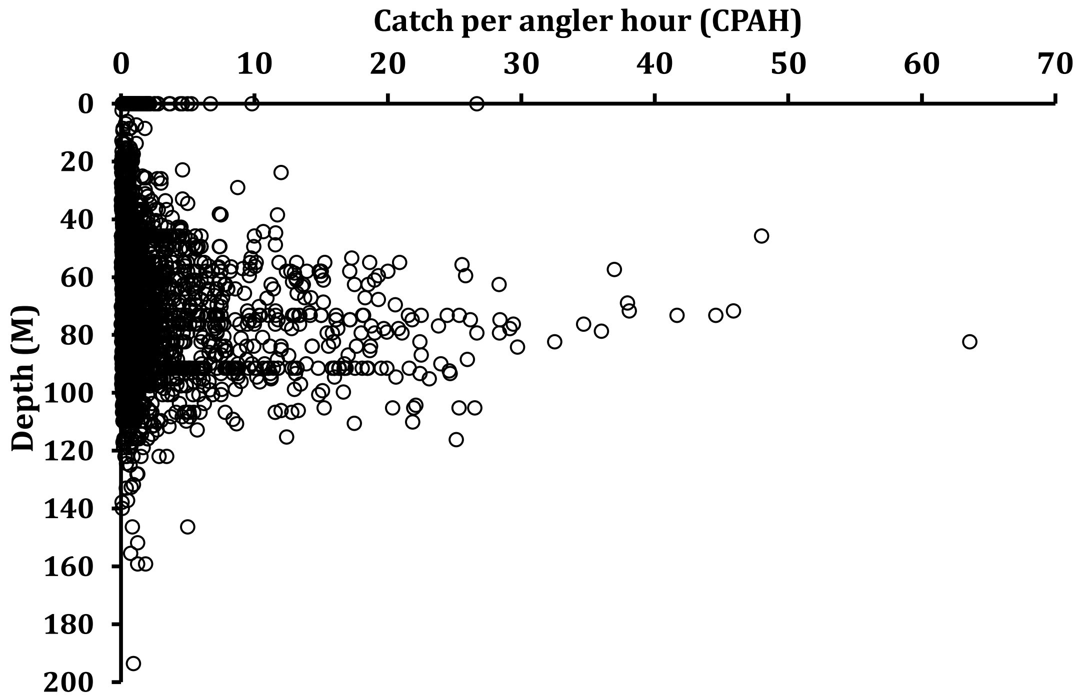



**Figure 44. Plot of raw recreational catch rates (catch per angler hour) by depth in California waters. Most samples were from south of Santa Barbara. Data with greater than 500 fish encountered were not included in the plot (8 out of 2,873). Data were downloaded from RecFIN (Melissa Monk, SWFSC).**

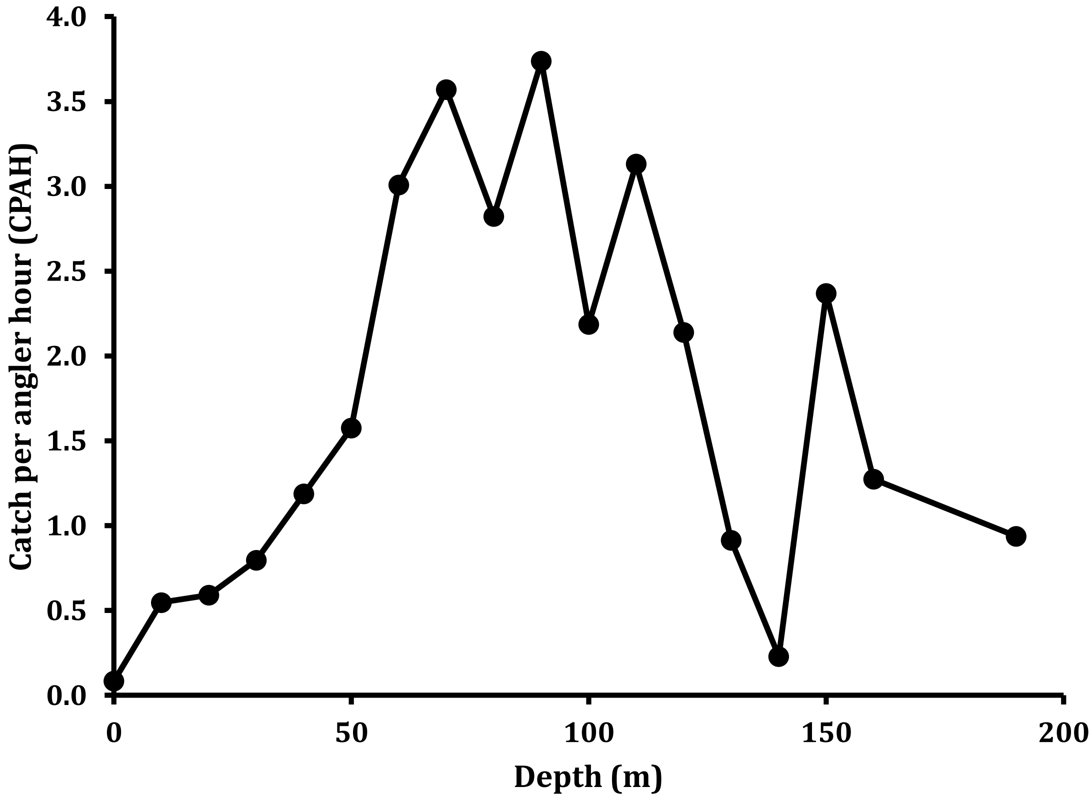



**Figure 45. Plot of average raw recreational catch rates (catch per angler hour) by depth in California waters. Most samples were from south of Santa Barbara. Data with greater than 500 fish encountered were not included in the plot (8 out of 2,873). There were no data from depths greater than 190m. Data were downloaded from RecFIN (Melissa Monk, SWFSC).**

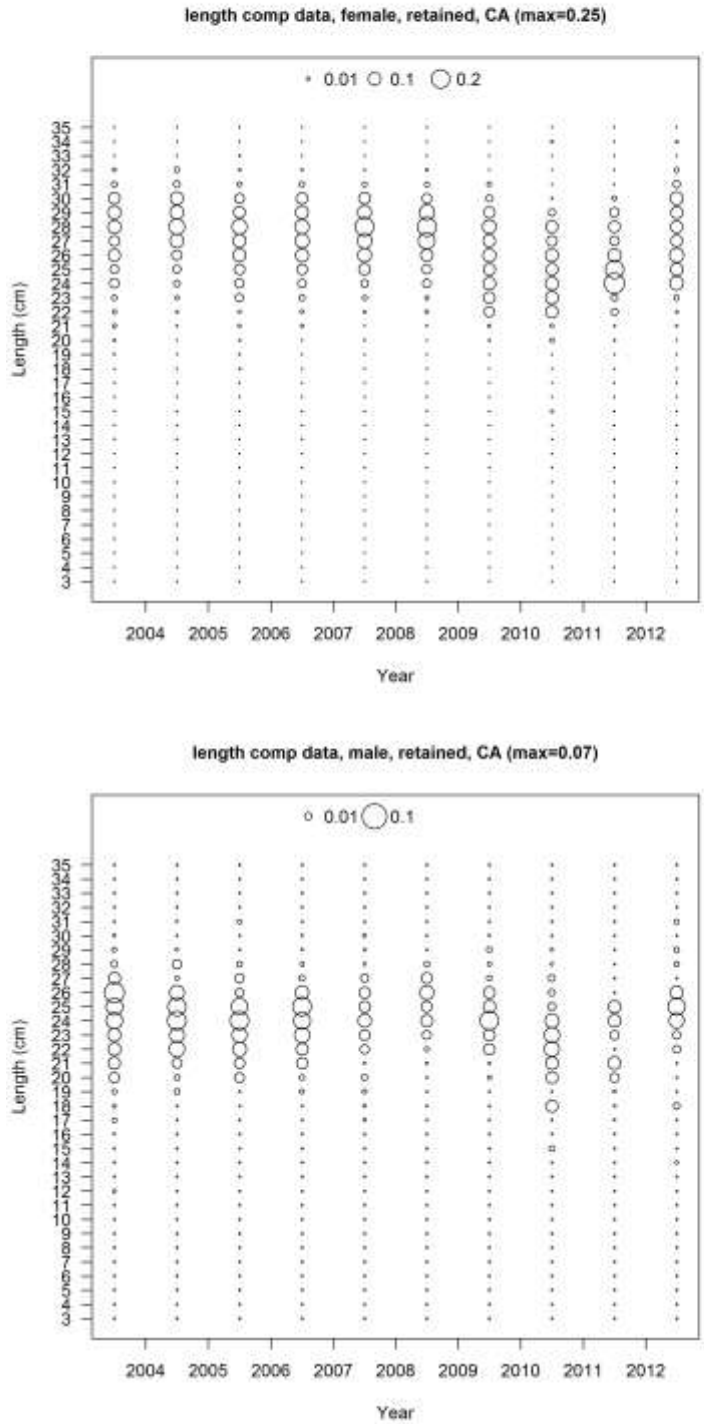



**Figure 46. Length composition data by sex used in the assessment model from retained catches of the California trawl fisheries from 2003 to 2012.**

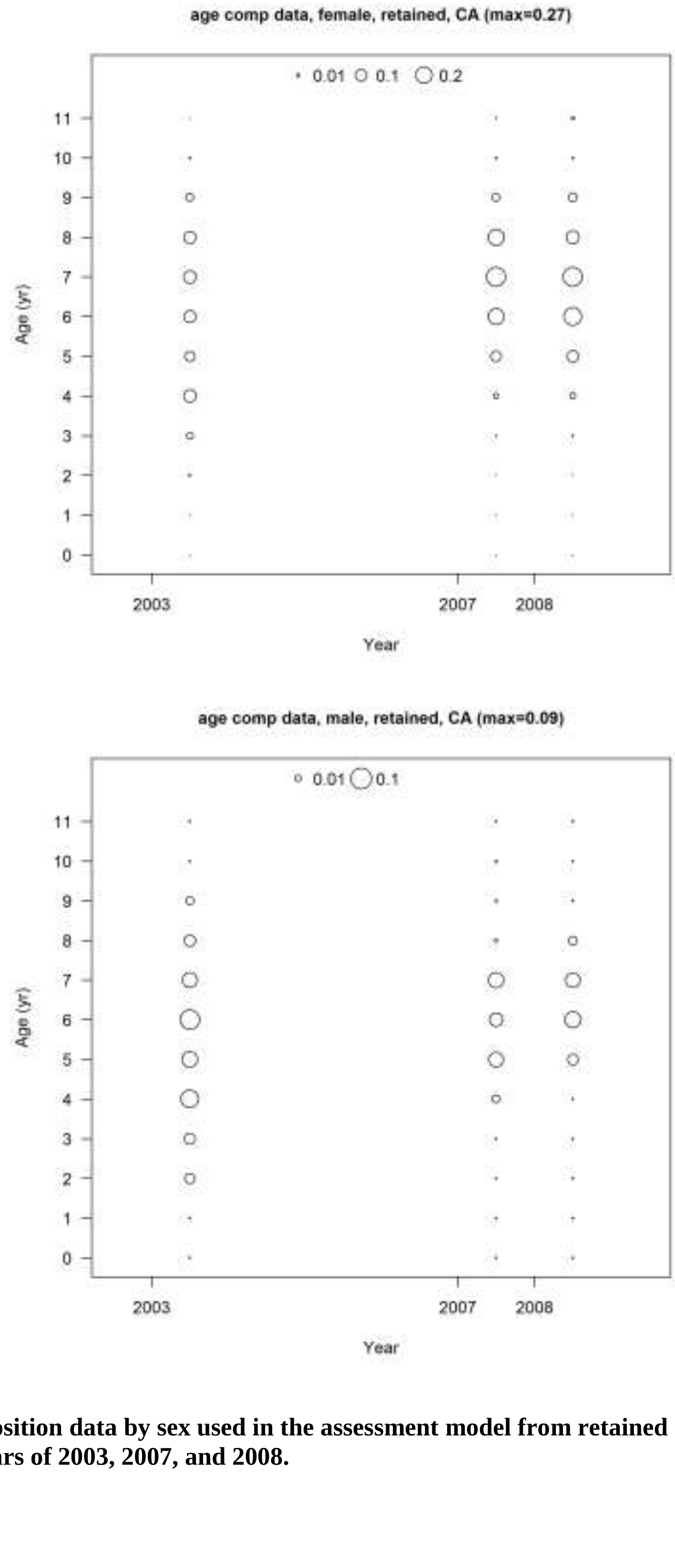



**Figure 47. Age composition data by sex used in the assessment model from retained catches of the California trawl fisheries for years of 2003, 2007, and 2008.**

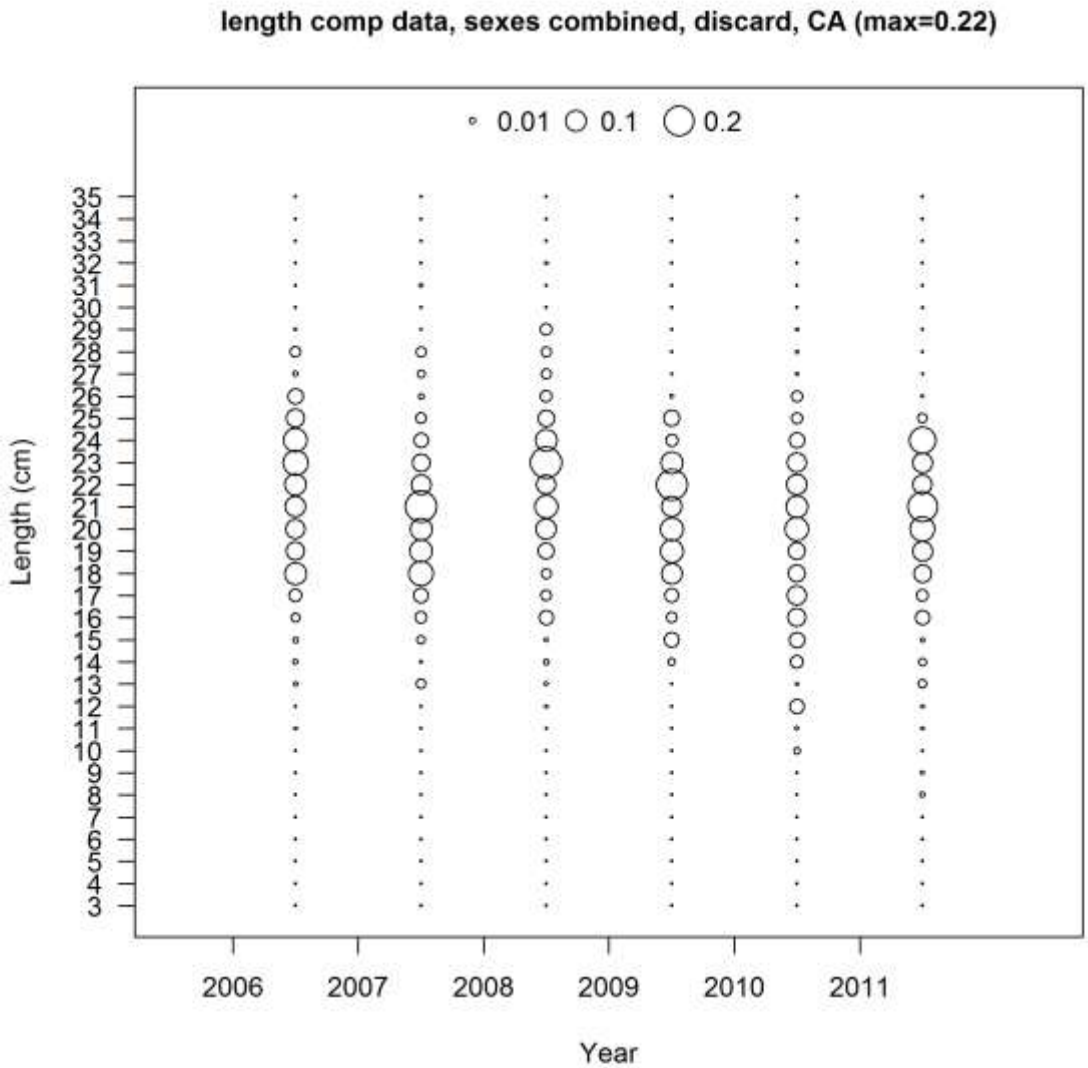
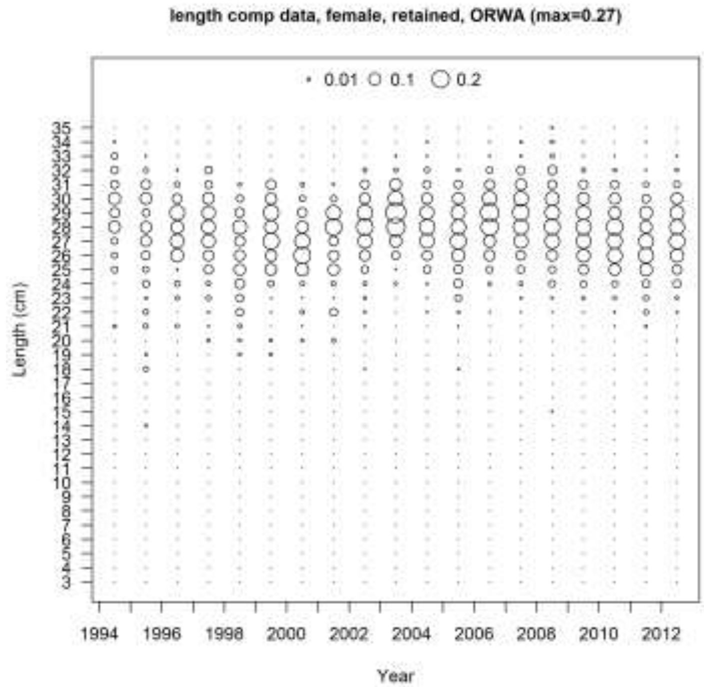



**Figure 48. Length composition plots of discarded catches of combined sexes from the WCGOP program on the CA fishery from 2006 to 2011.**



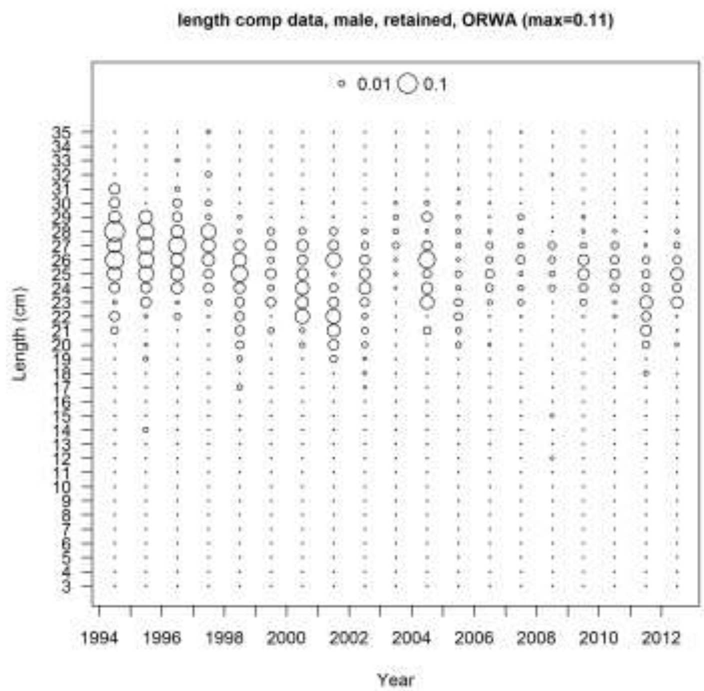




**Figure 49. Length composition data by sex used in the assessment model from retained catches of the Oregon trawl fisheries between 1990 and 2012 (no data in some year).**

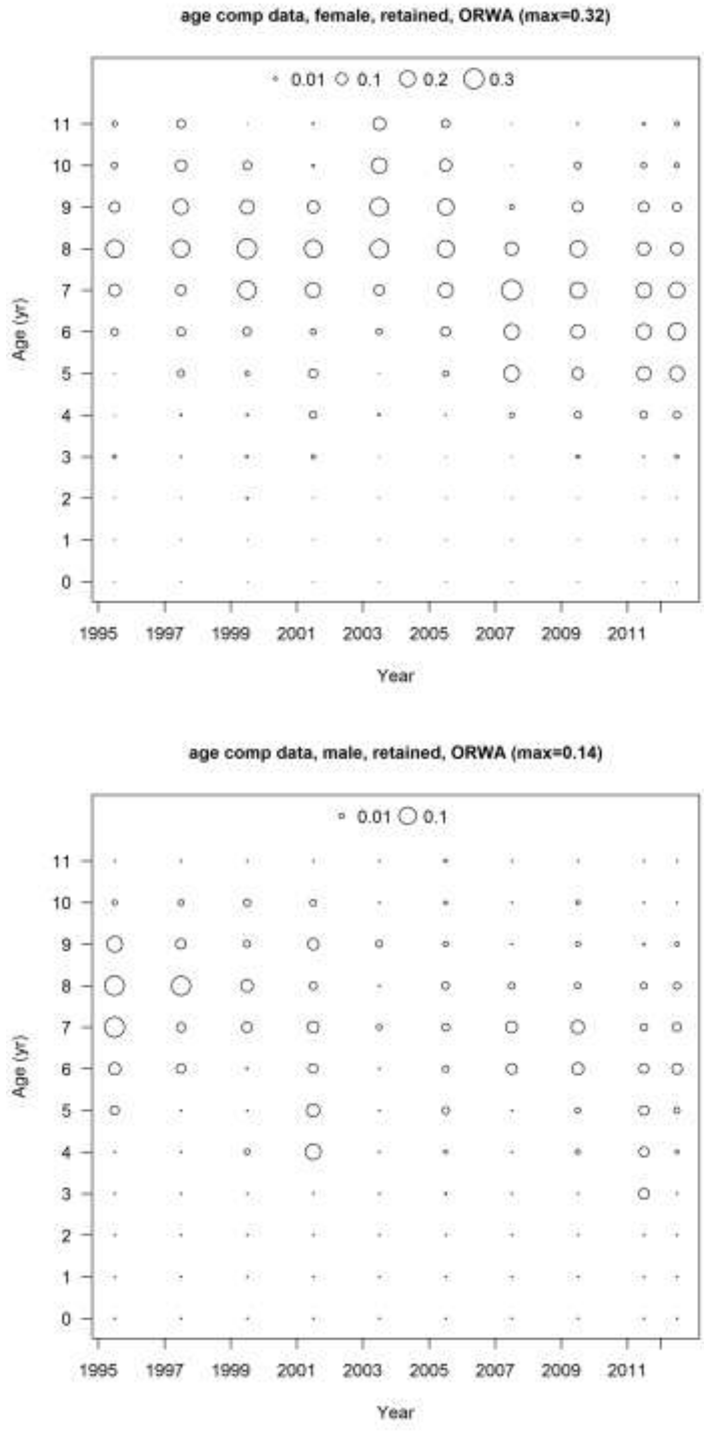
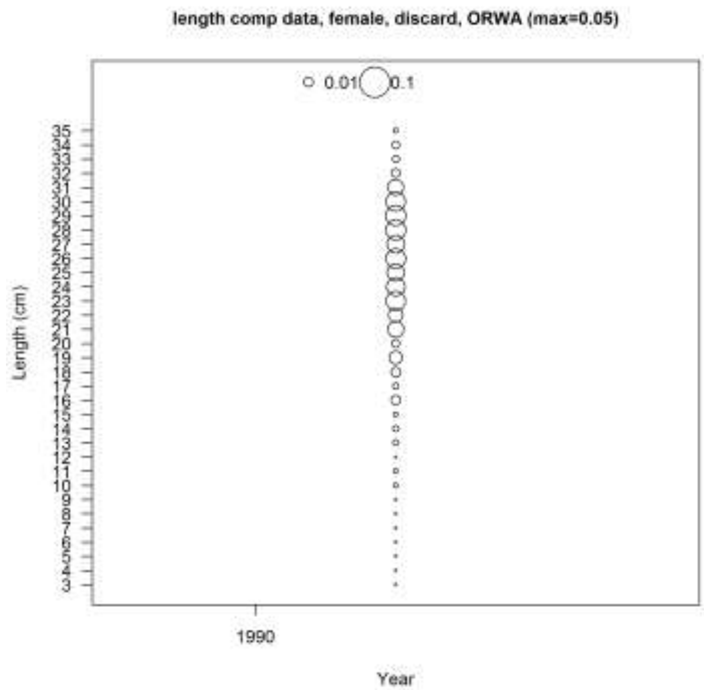



**Figure 50. Age composition data by sex used in the assessment model from retained catches of the Oregon trawl fisheries between 1995 and 2012 (no data in some year).**



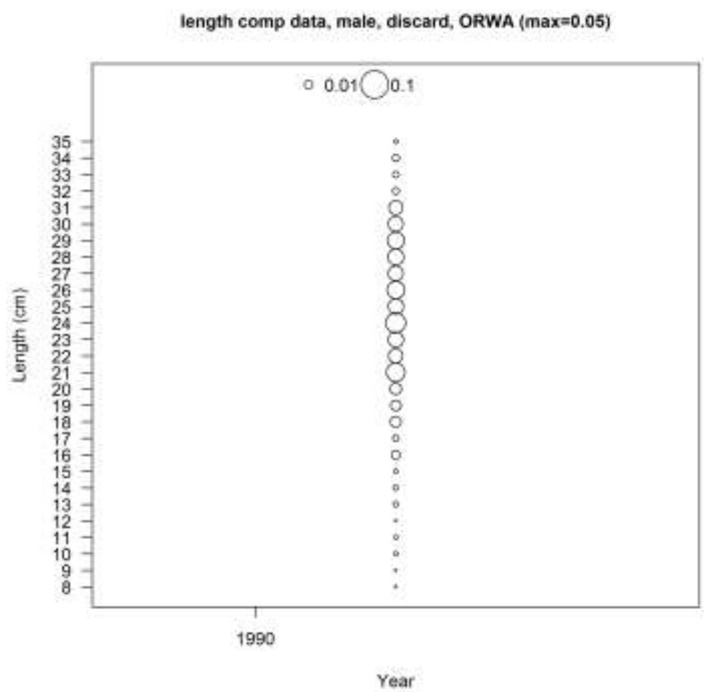




**Figure 51. Length composition plots of discarded catches from the 1990 mesh study for females (top) and males (bottom). The data were used in estimating discarded catches of the Oregon trawl fishery in 1990.**

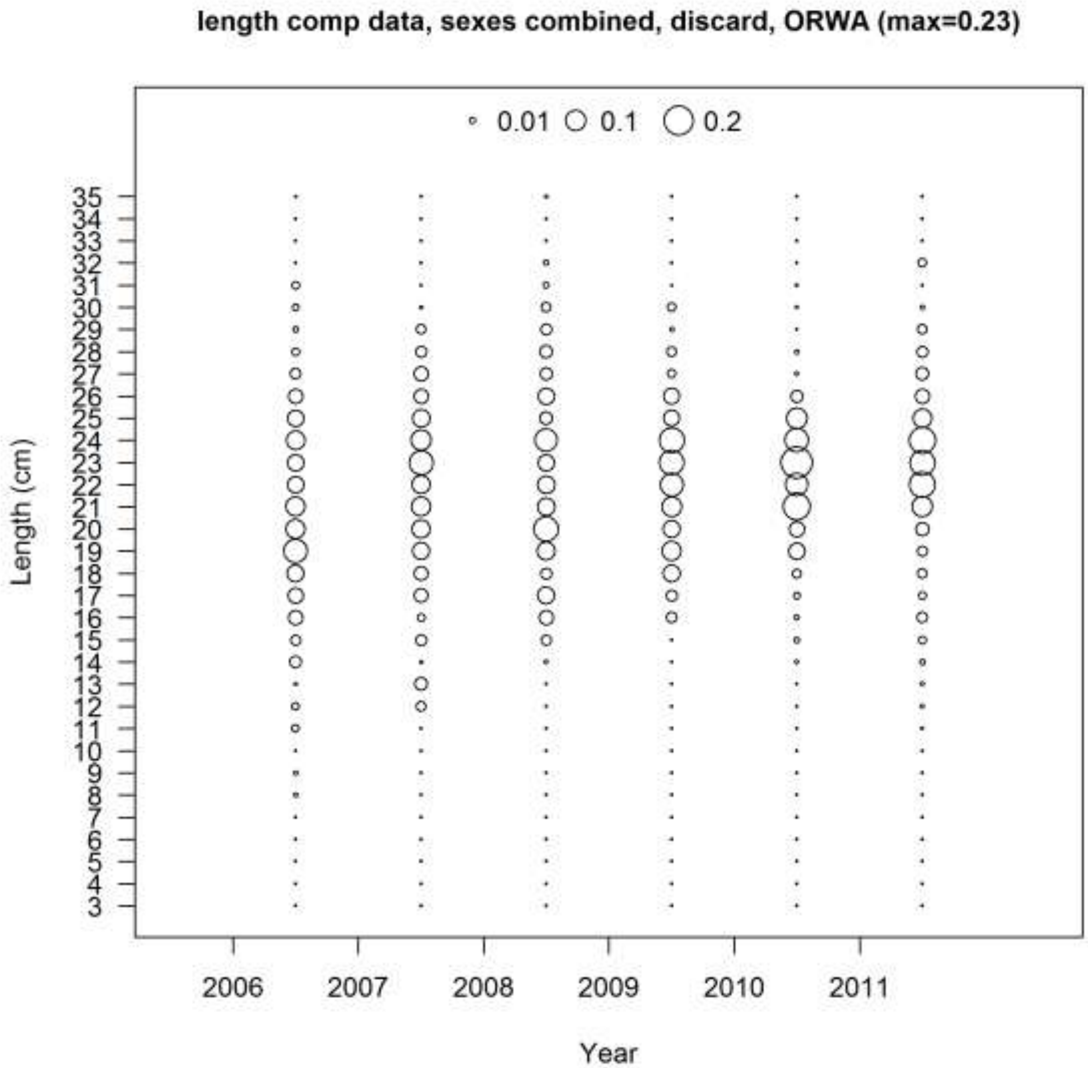



**Figure 52. Length composition plots of discarded catches of combined sexes from the WCGOP program on the OR/WA fishery from 2006 to 2011.**

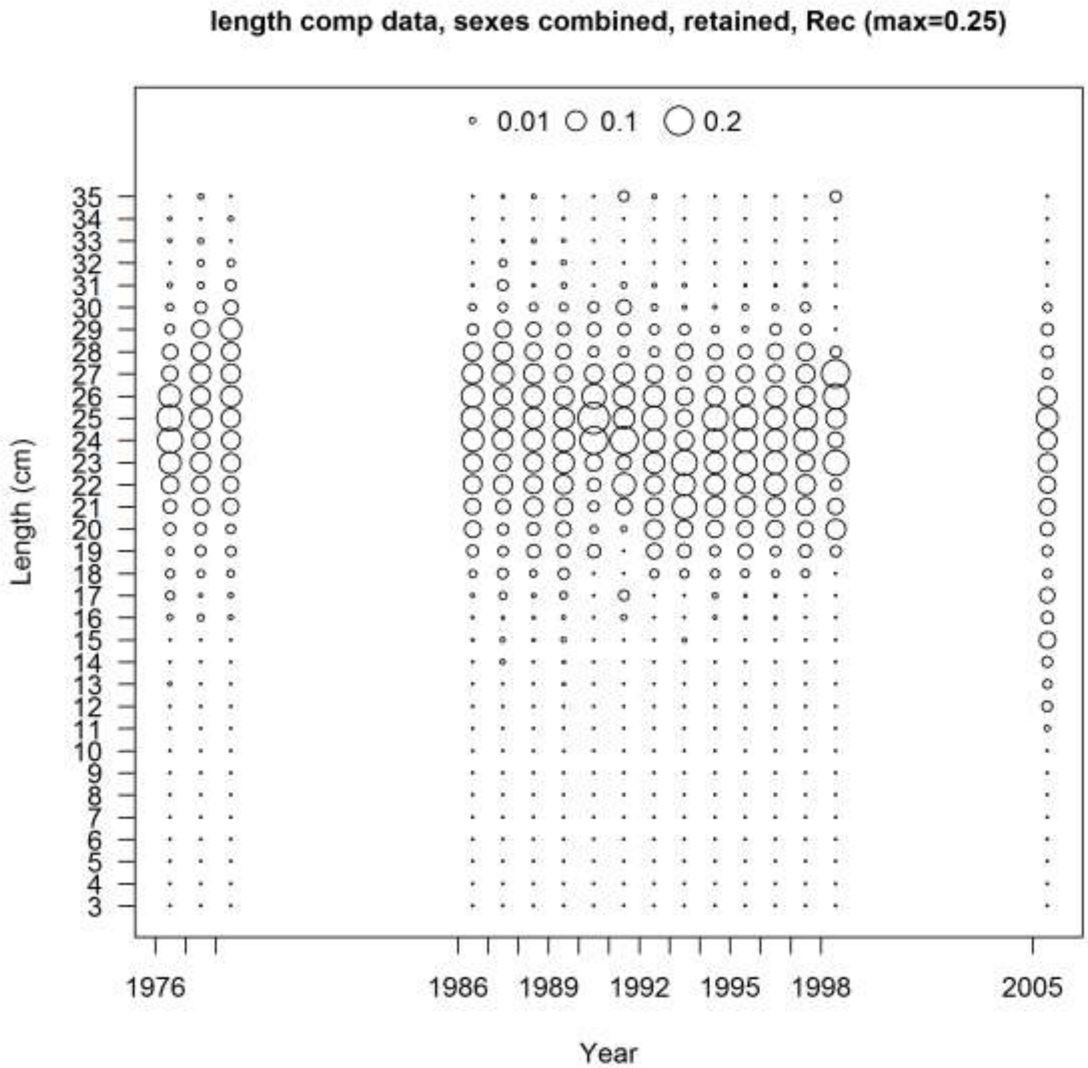



**Figure 53. Length composition plots of recreational fishery catches (sex combined) from the CA CPFC survey.**

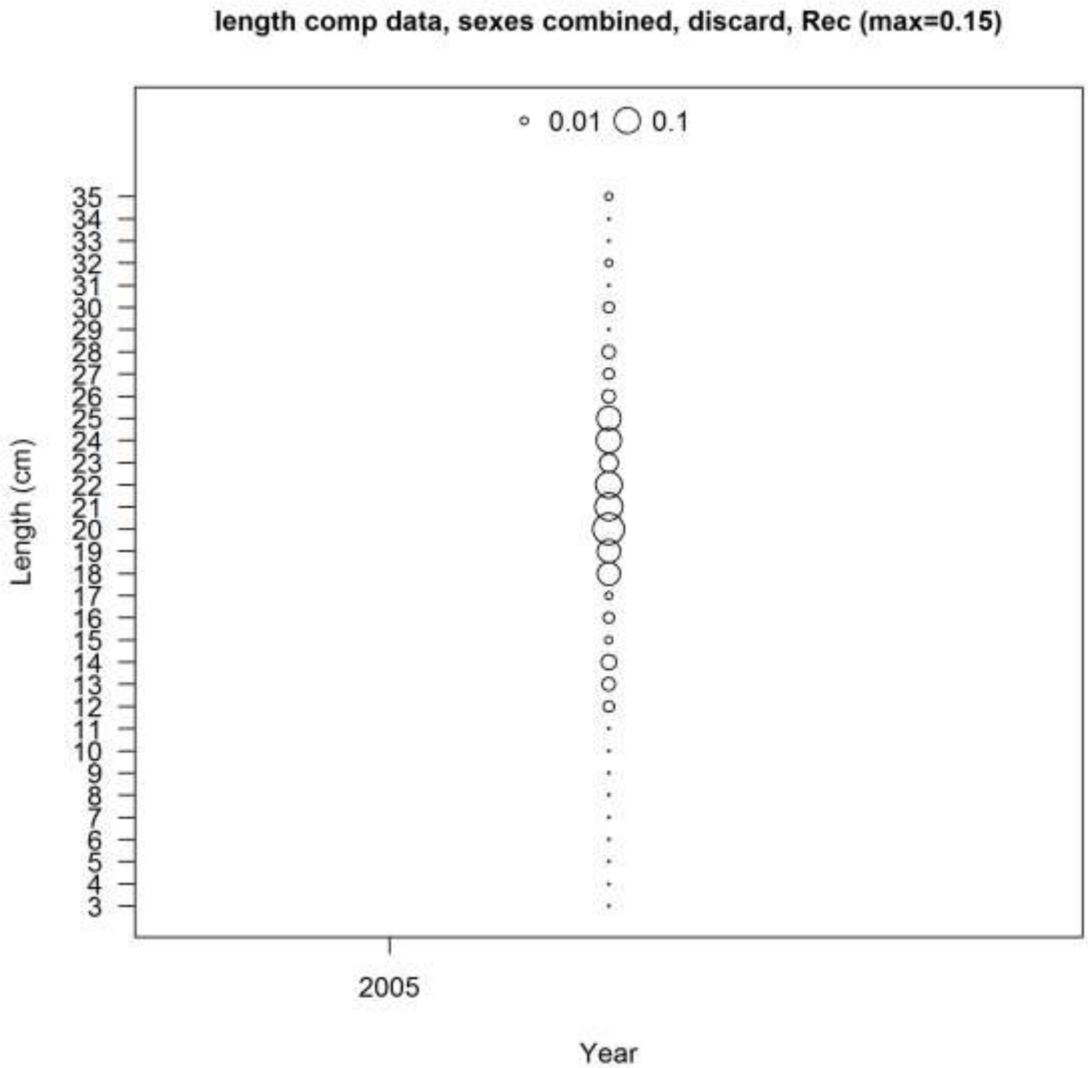



**Figure 54. Length composition plots of discarded catch from the 2005 recreational fishery (sex combined).**

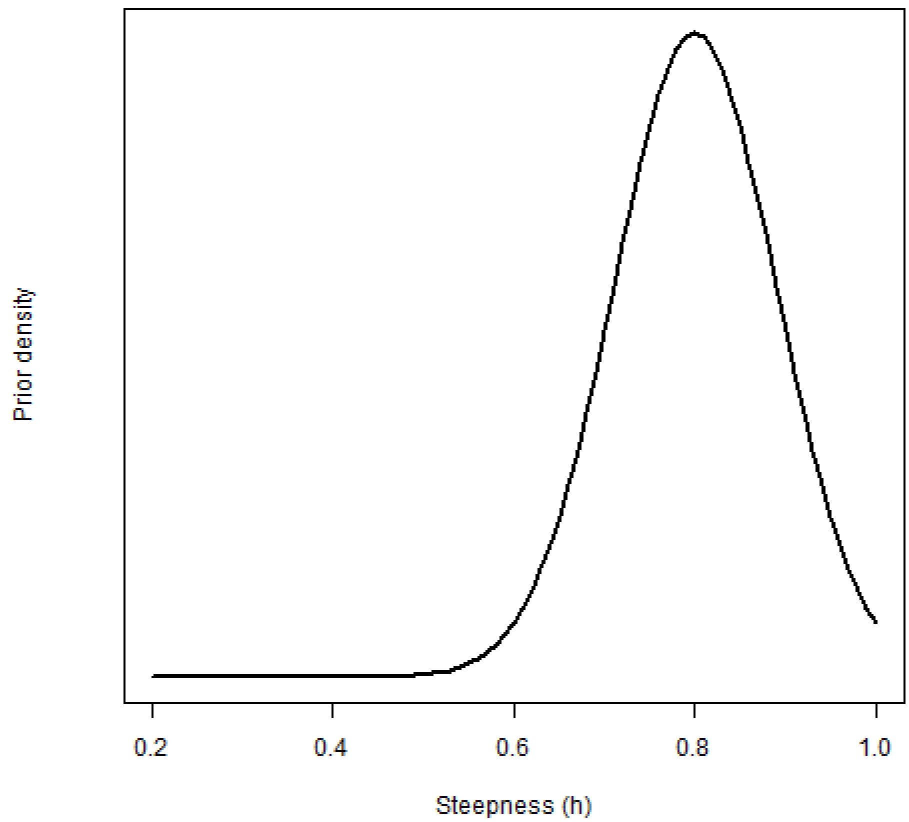



**Figure 55. Priors of stock-recruitment steepness parameter (h) used in this assessment.**

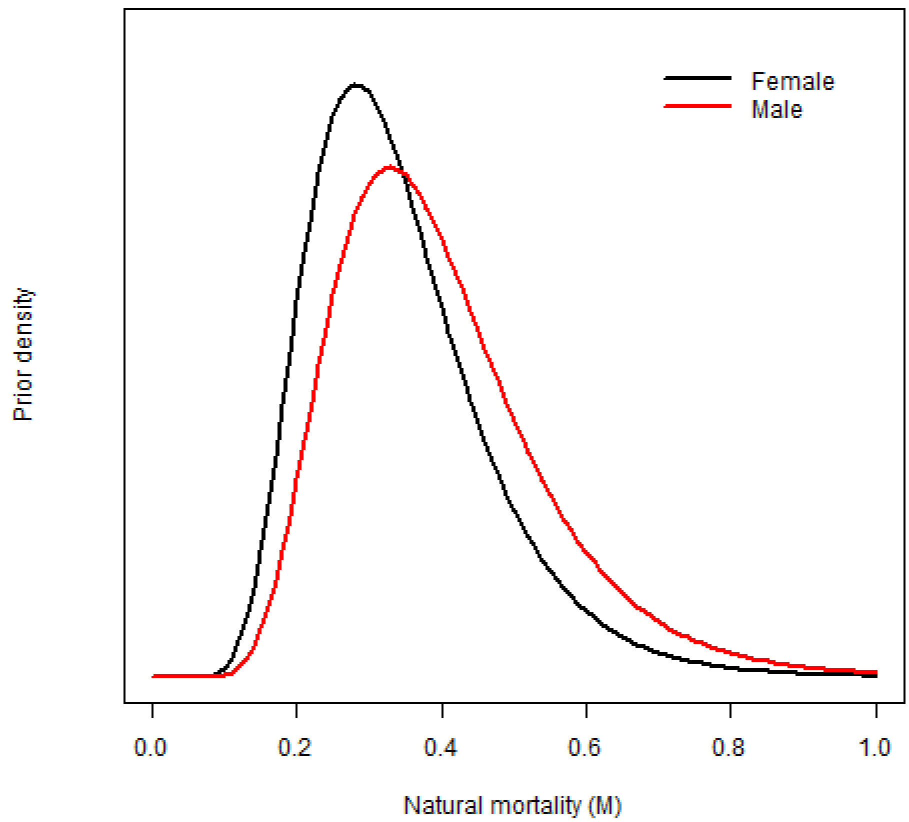



**Figure 56. Priors of natural mortalities for female (black line) and for males (red line) that were used in this assessment.**

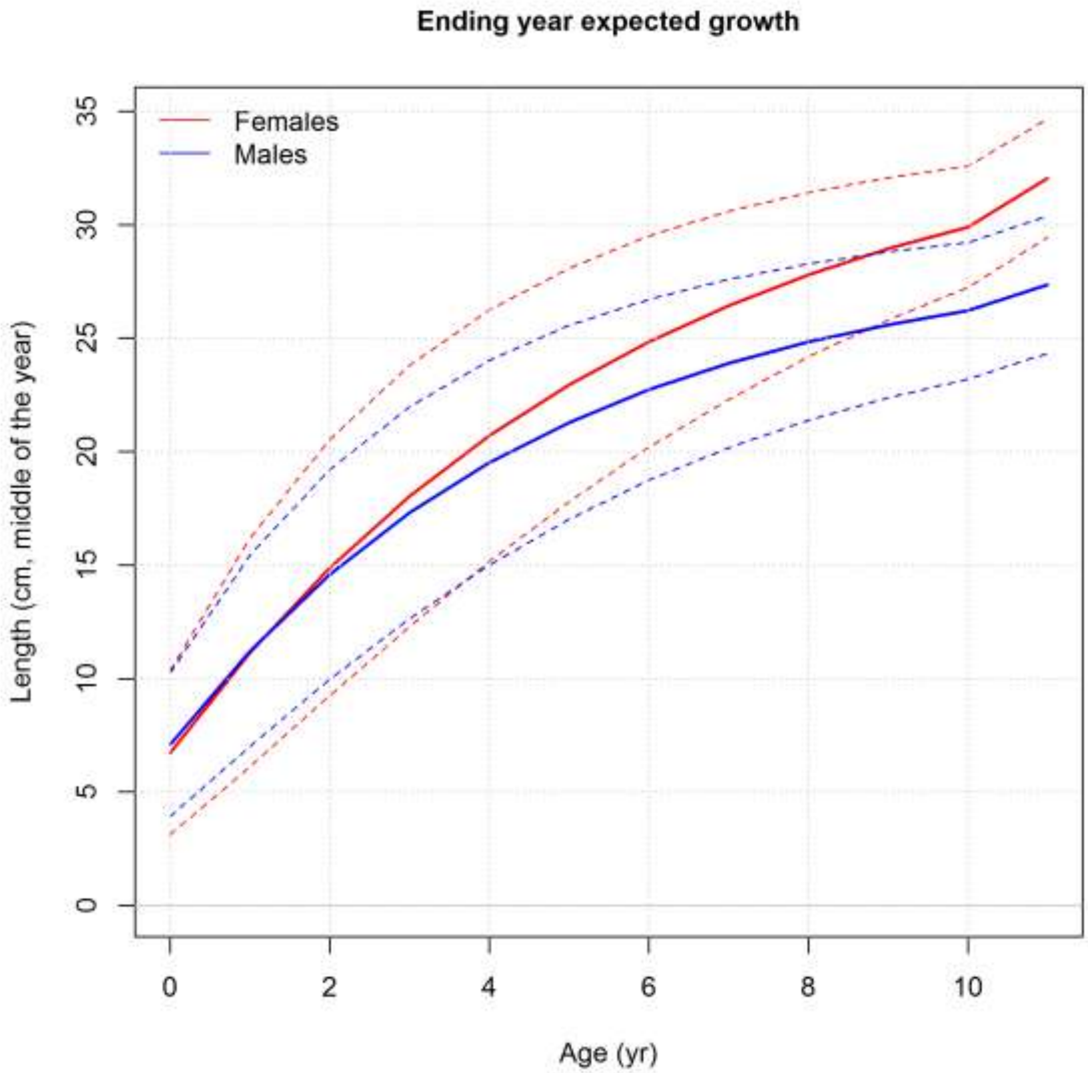



**Figure 57. Estimated growth curves for females (red solid line) and males (blue solid line) with 95% intervals (dashed lines with the same colors).**

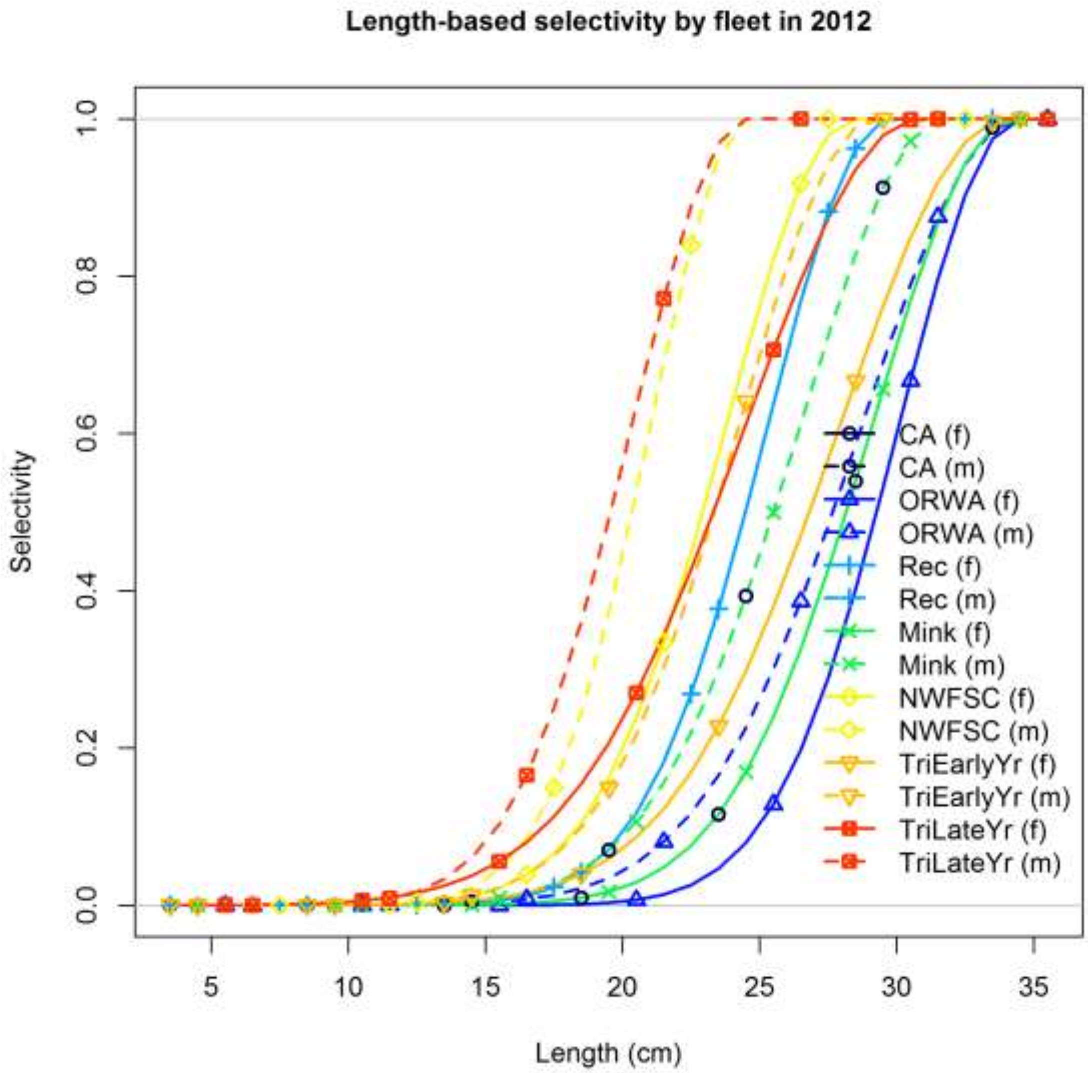



**Figure 58. Estimated length-based selectivity curves by sex for all fleets and surveys. (Selectivity for each fleet and survey, including discards etc, to be included in separated figures)**

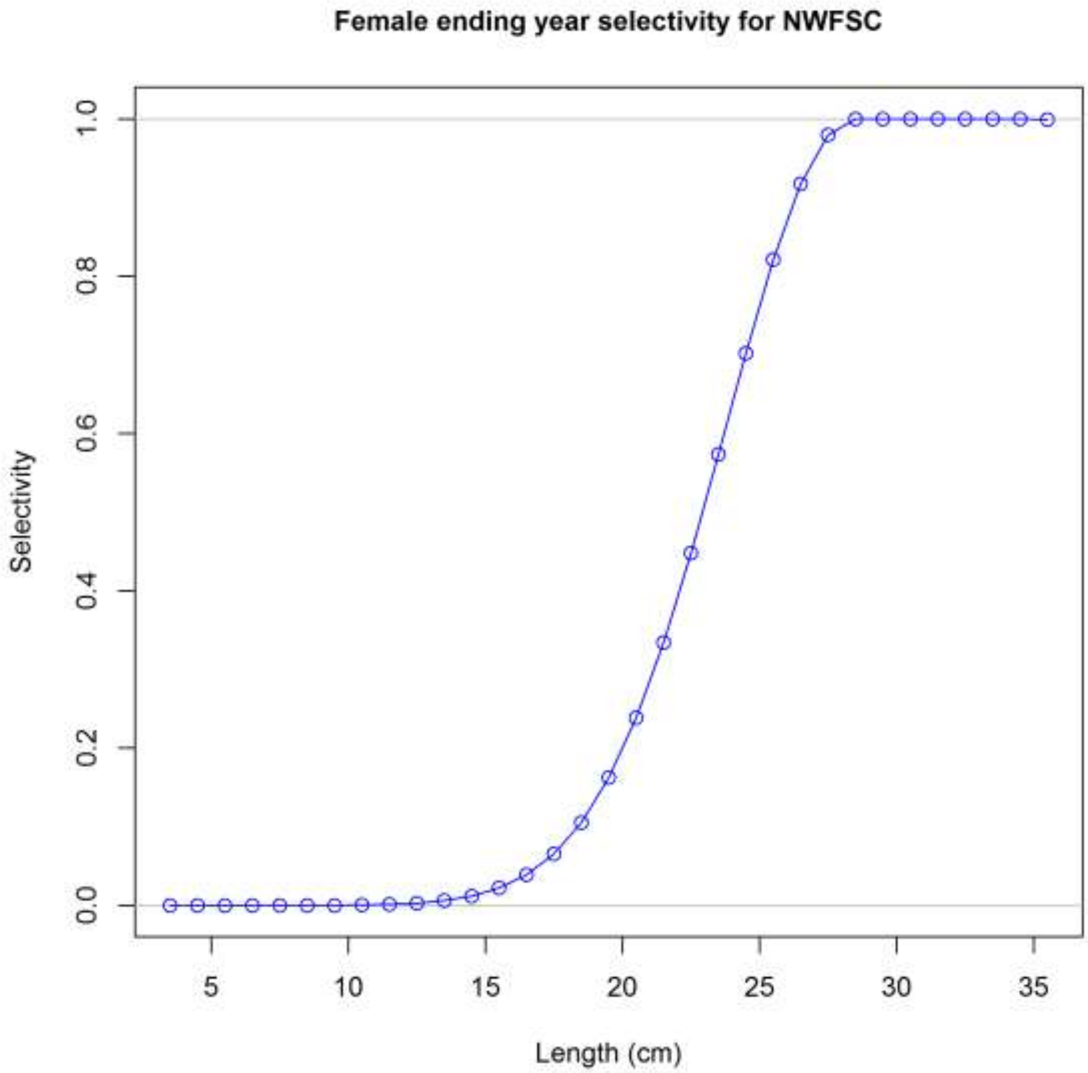



**Figure 59. Estimated length-based selectivity for females for the NWFSC survey.**

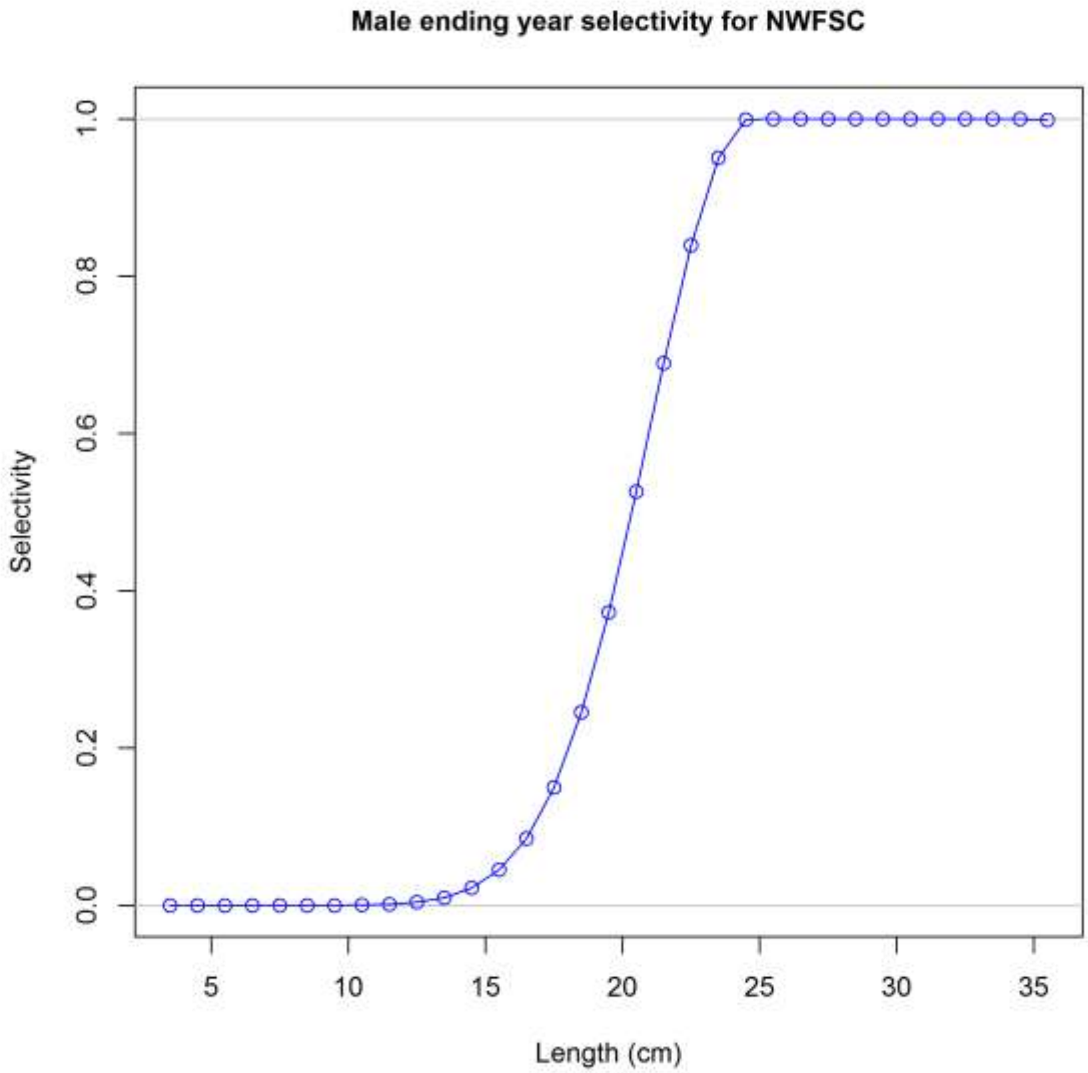



**Figure 60. Estimated length-based selectivity for males for the NWFSC survey.**

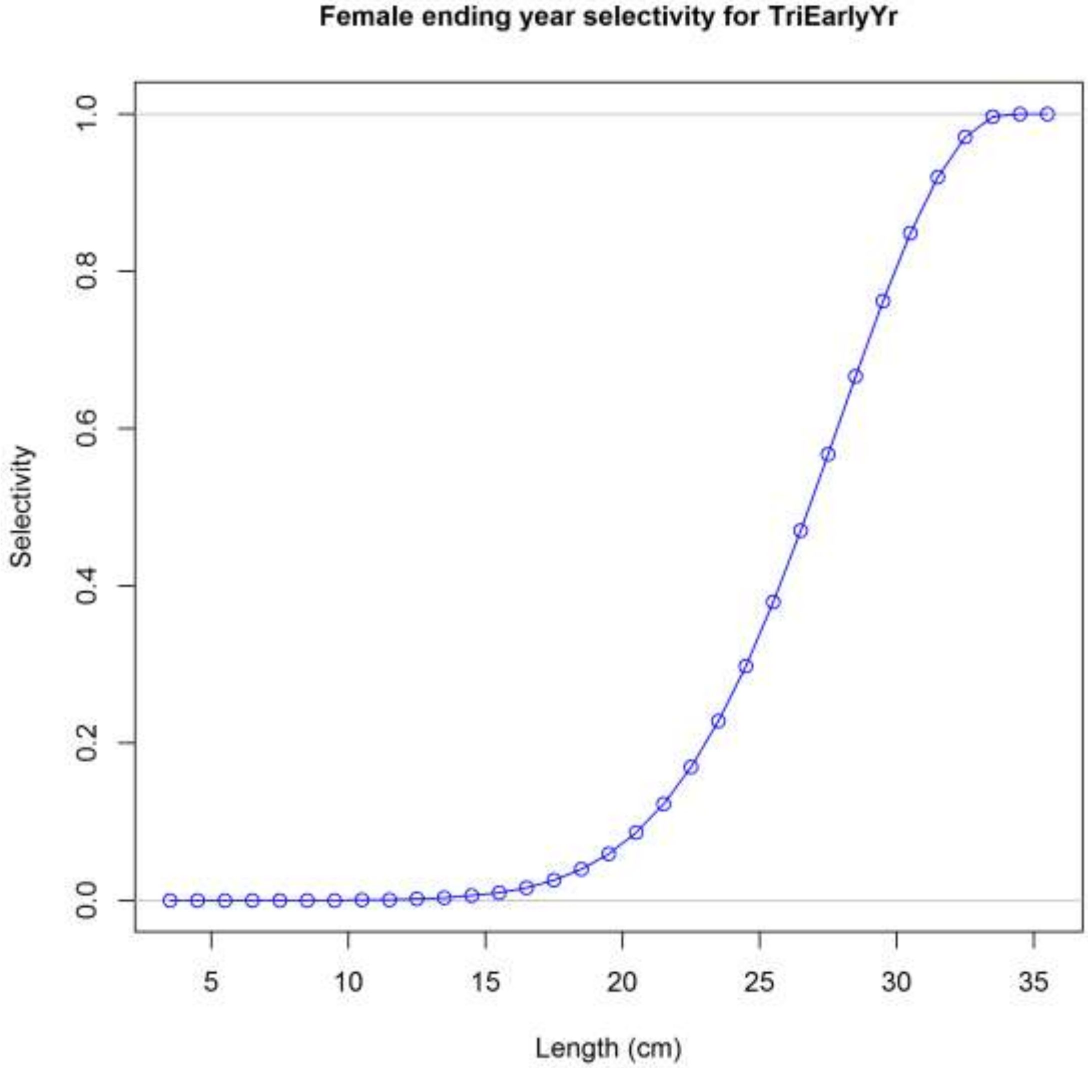



**Figure 61. Estimated length-based selectivity for females for the early year triennial survey.**

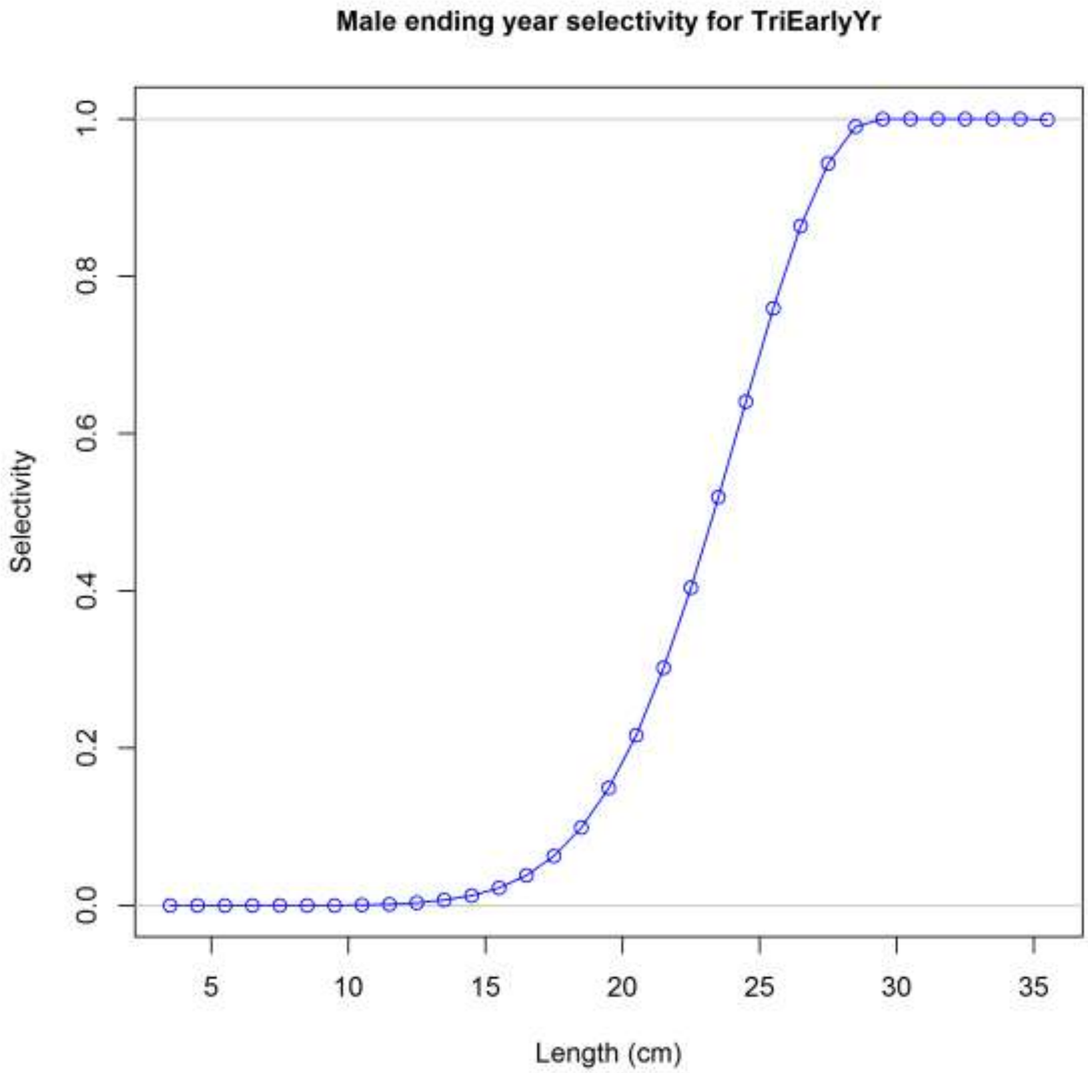



**Figure 62. Estimated length-based selectivity for males for the early year triennial survey.**

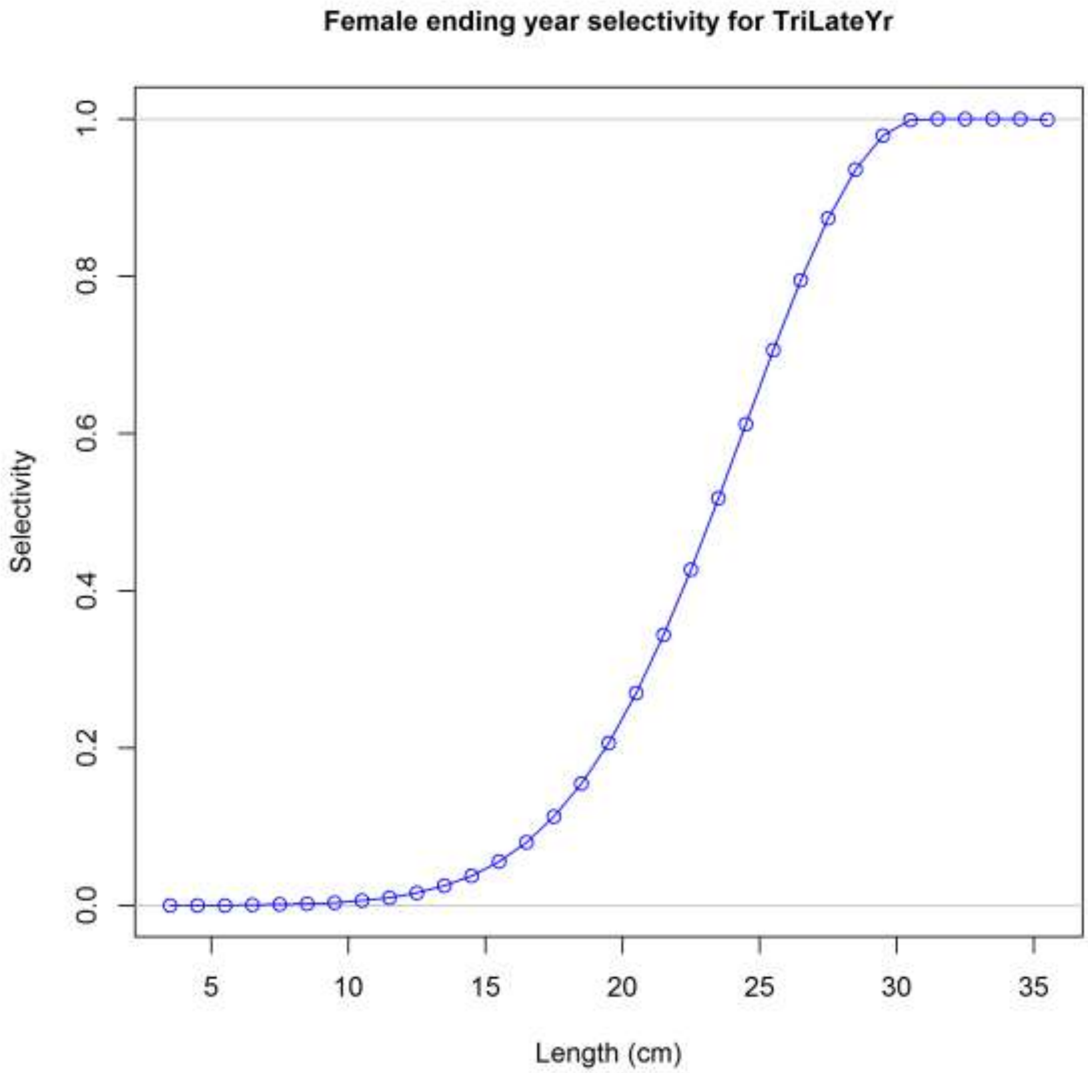



**Figure 63. Estimated length-based selectivity for females for the late year triennial survey.**

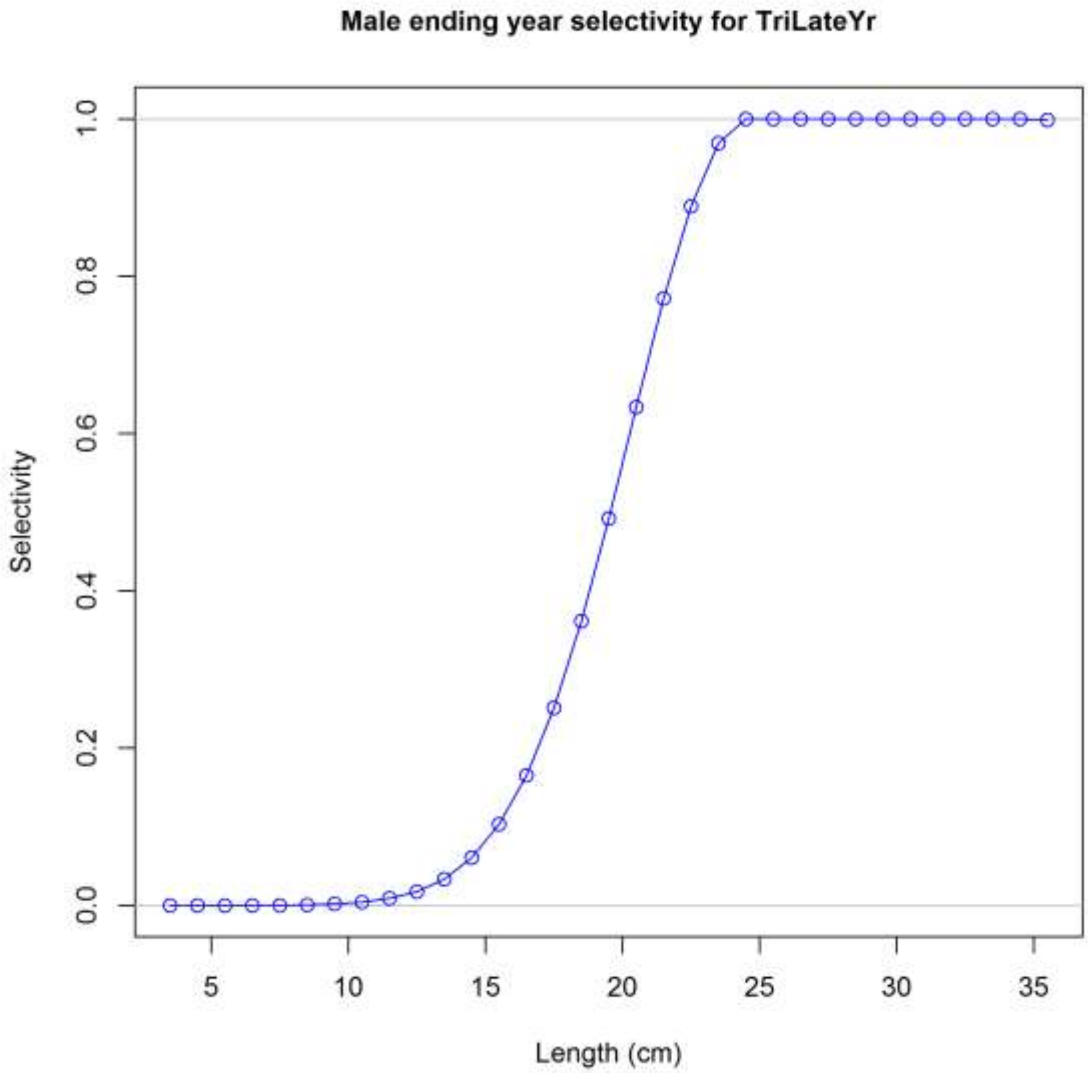



**Figure 64. Estimated length-based selectivity for males for the early year triennial survey.**

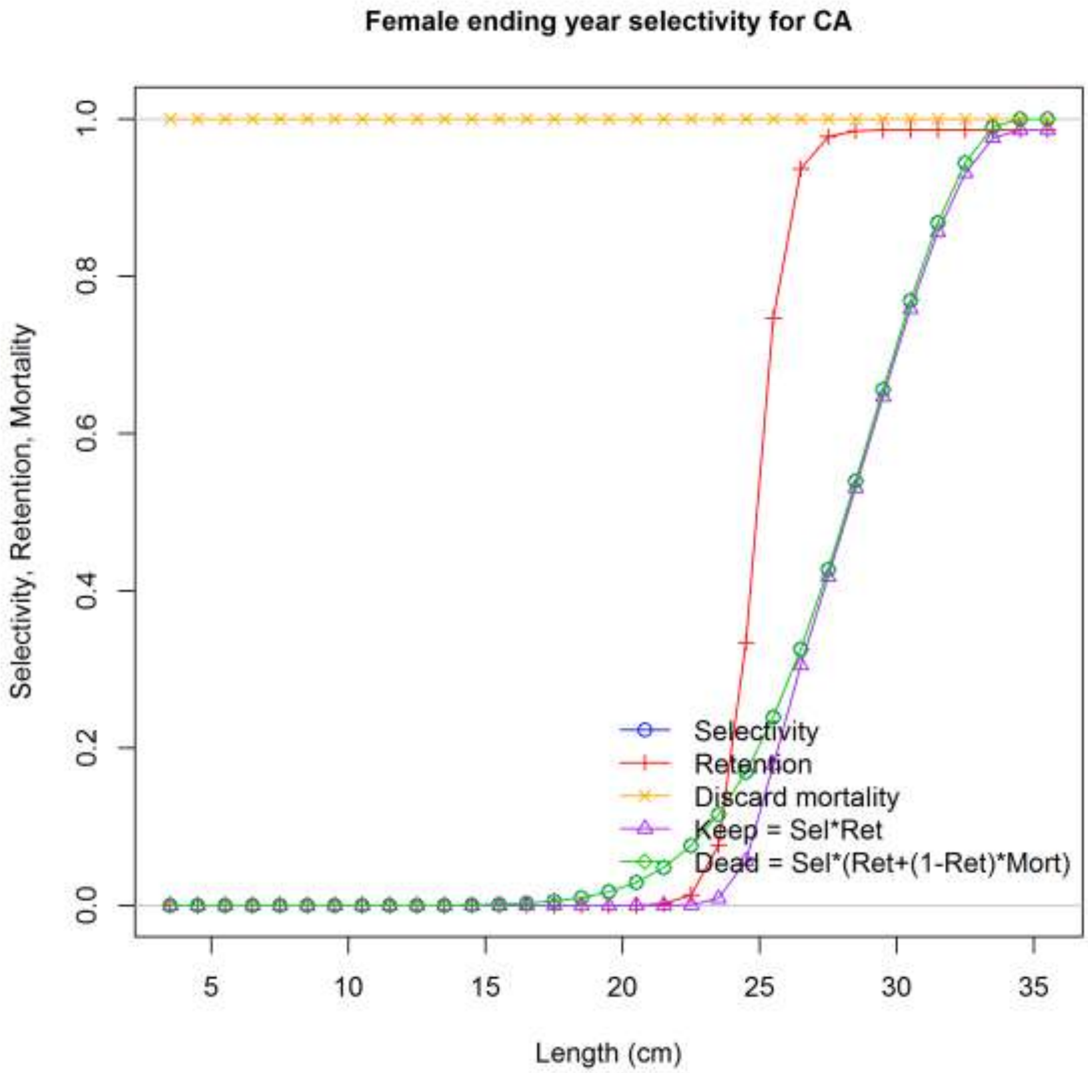



**Figure 65. Estimated length-based selectivity for females for the California fishery.**

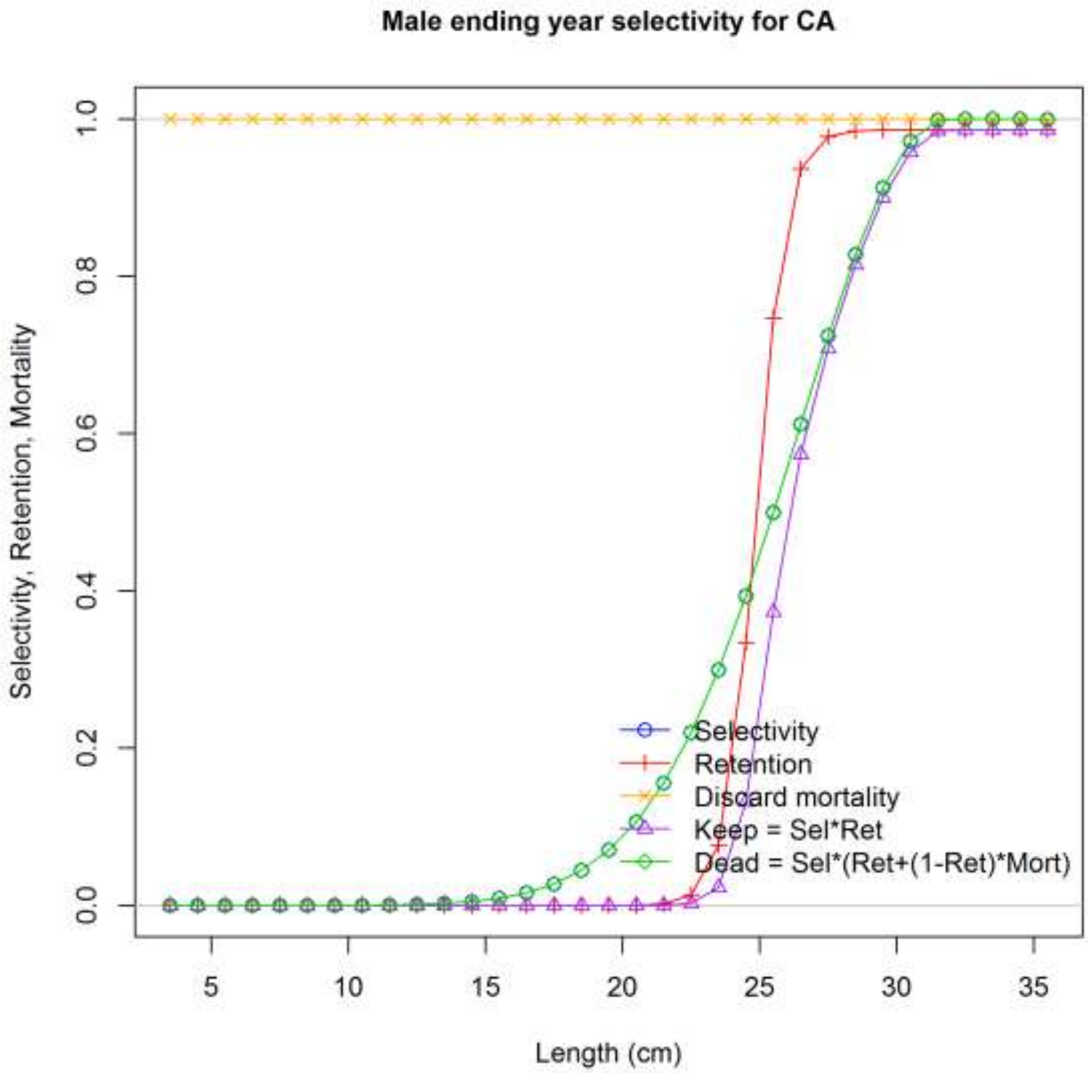



**Figure 66. Estimated length-based selectivity for males for the California fishery.**

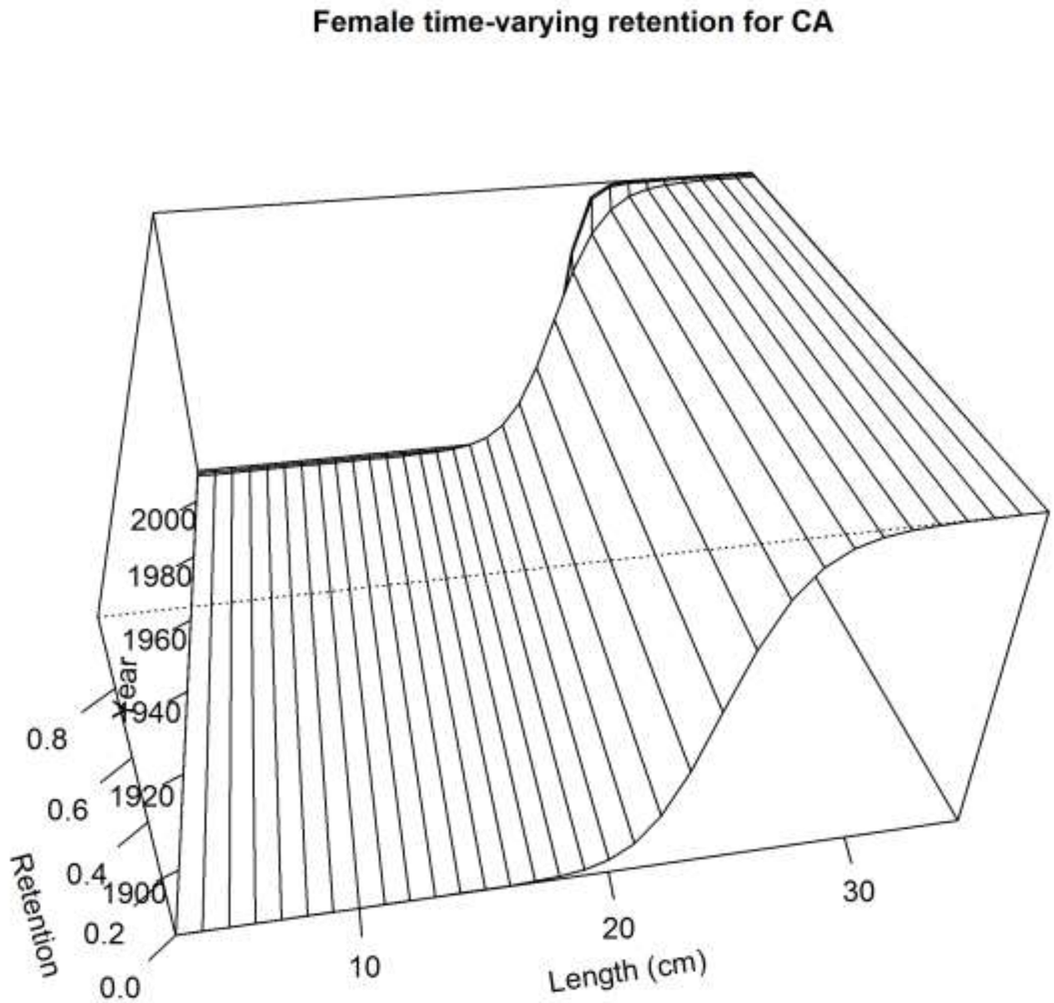



**Figure 67. Estimated time-varying retention selectivity for both sexes for the California fishery (labeled as female time-varying retention).**

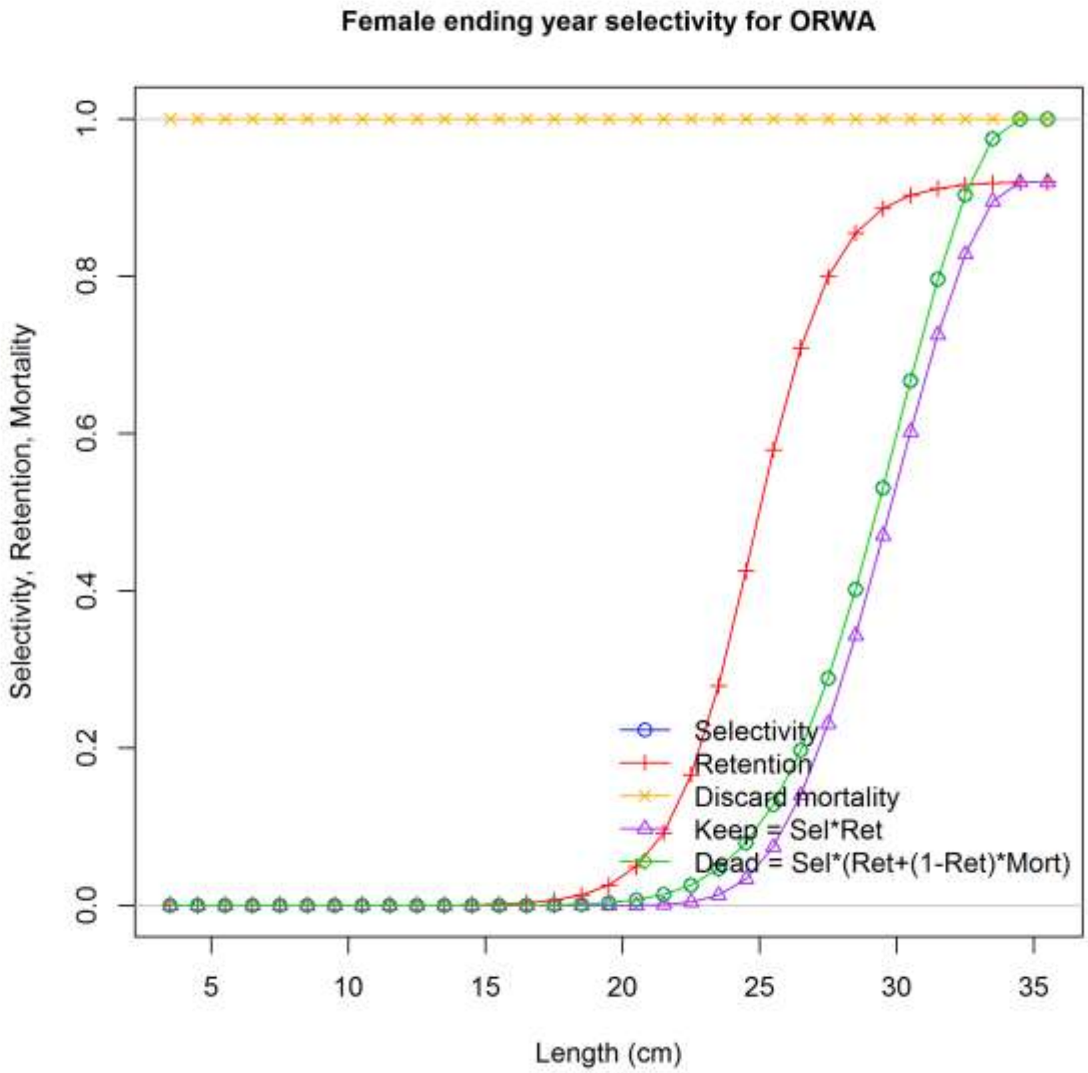



**Figure 68. Estimated length-based selectivity for females for the Oregon/Washington fishery.**

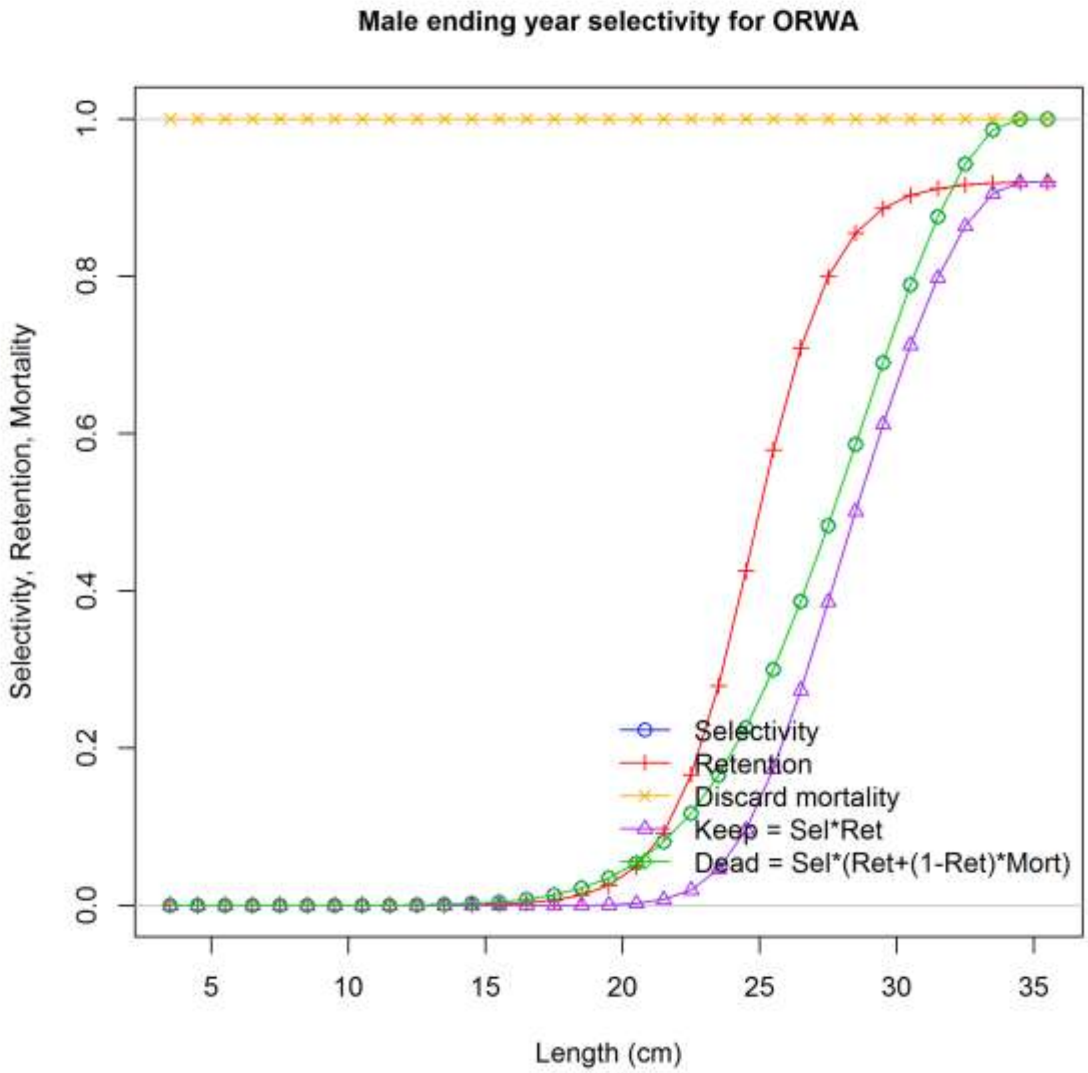



**Figure 69. Estimated length-based selectivity for males for the Oregon/Washington fishery.**

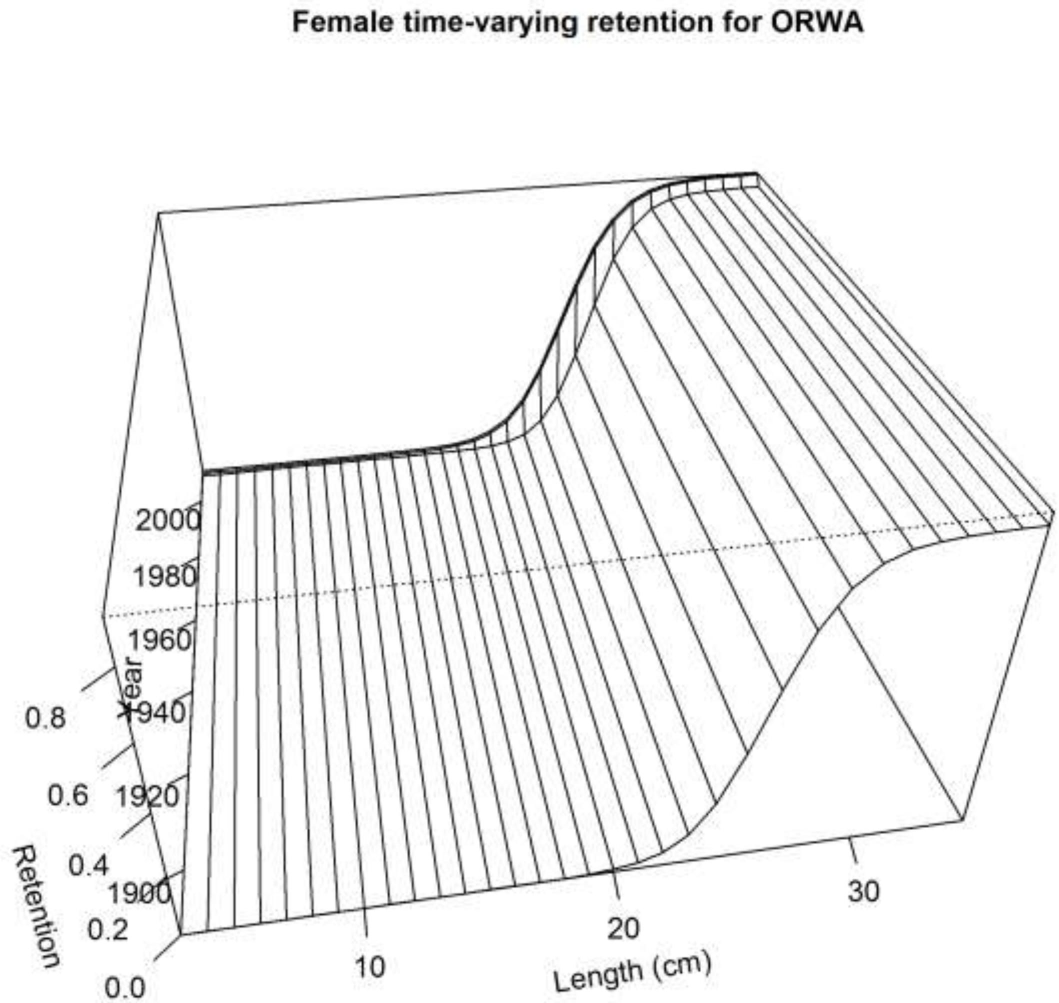



**Figure 70. Estimated time-varying retention selectivity for both sexes for the Oregon/Washington fishery (labeled as female time-varying retention).**

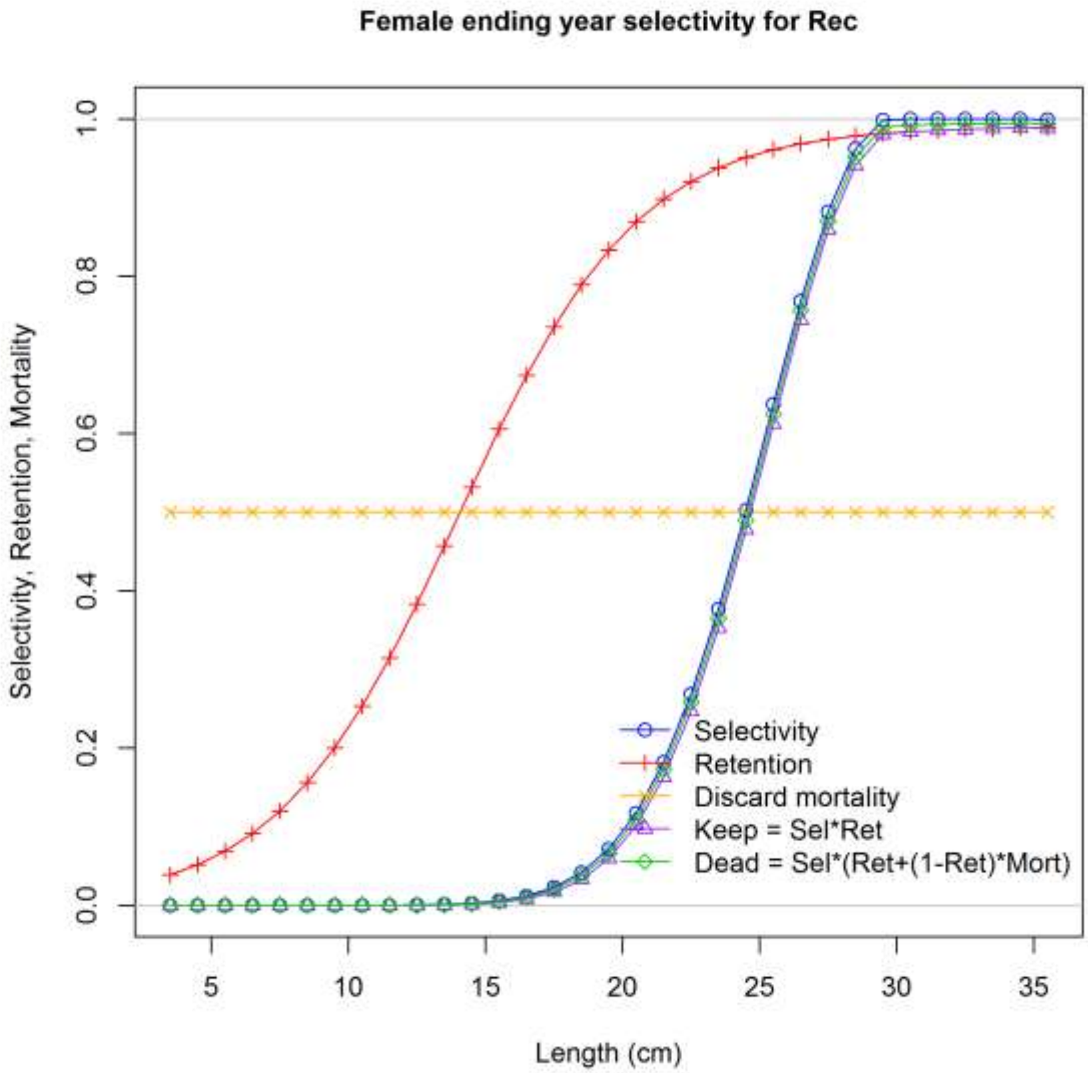



**Figure 71. Estimated length-based selectivity for females for the recreational fishery.**

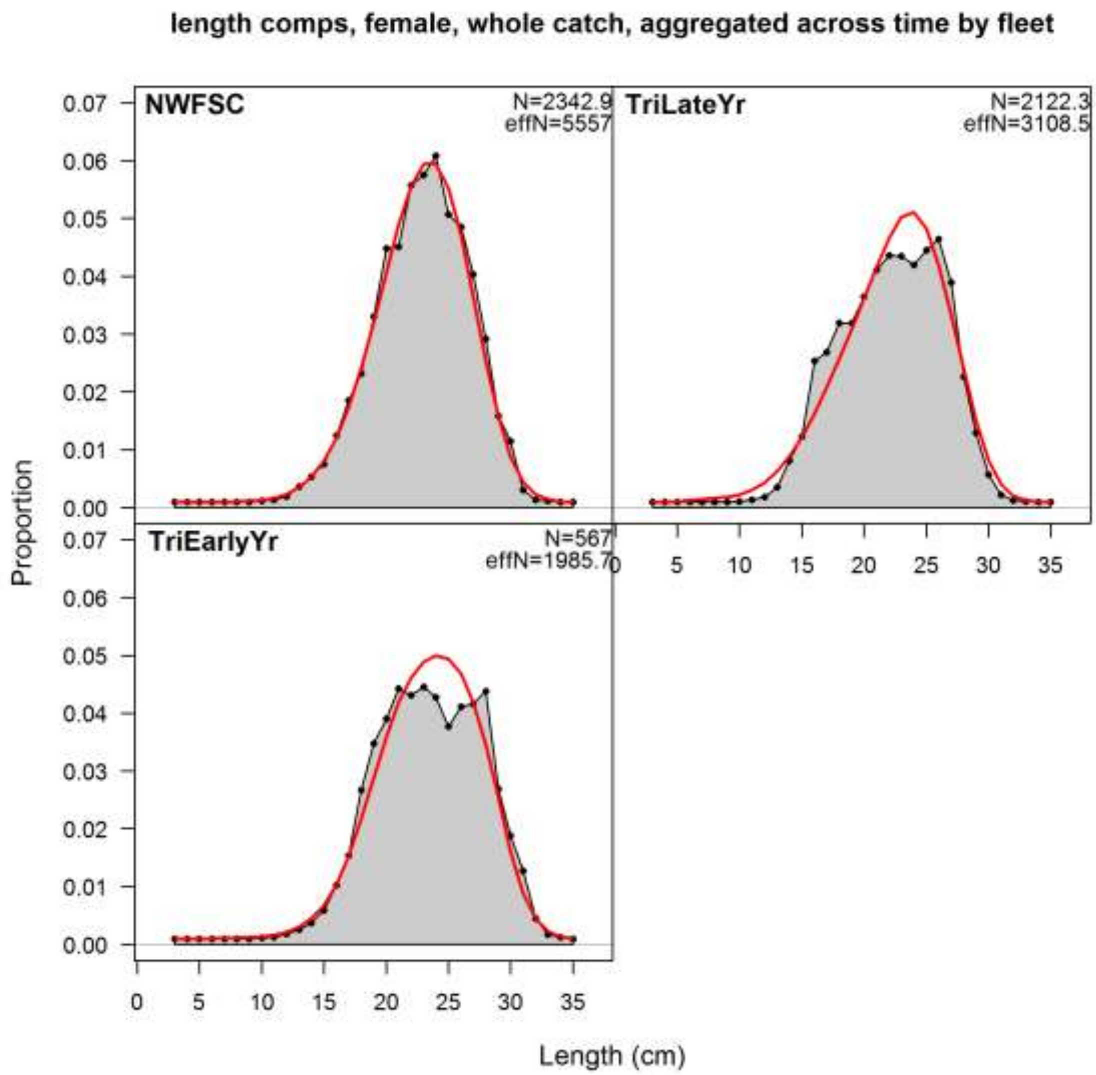



**Figure 72. Fits of base model outputs to the time-aggregated length compositions of females for three fishery-independent surveys.**

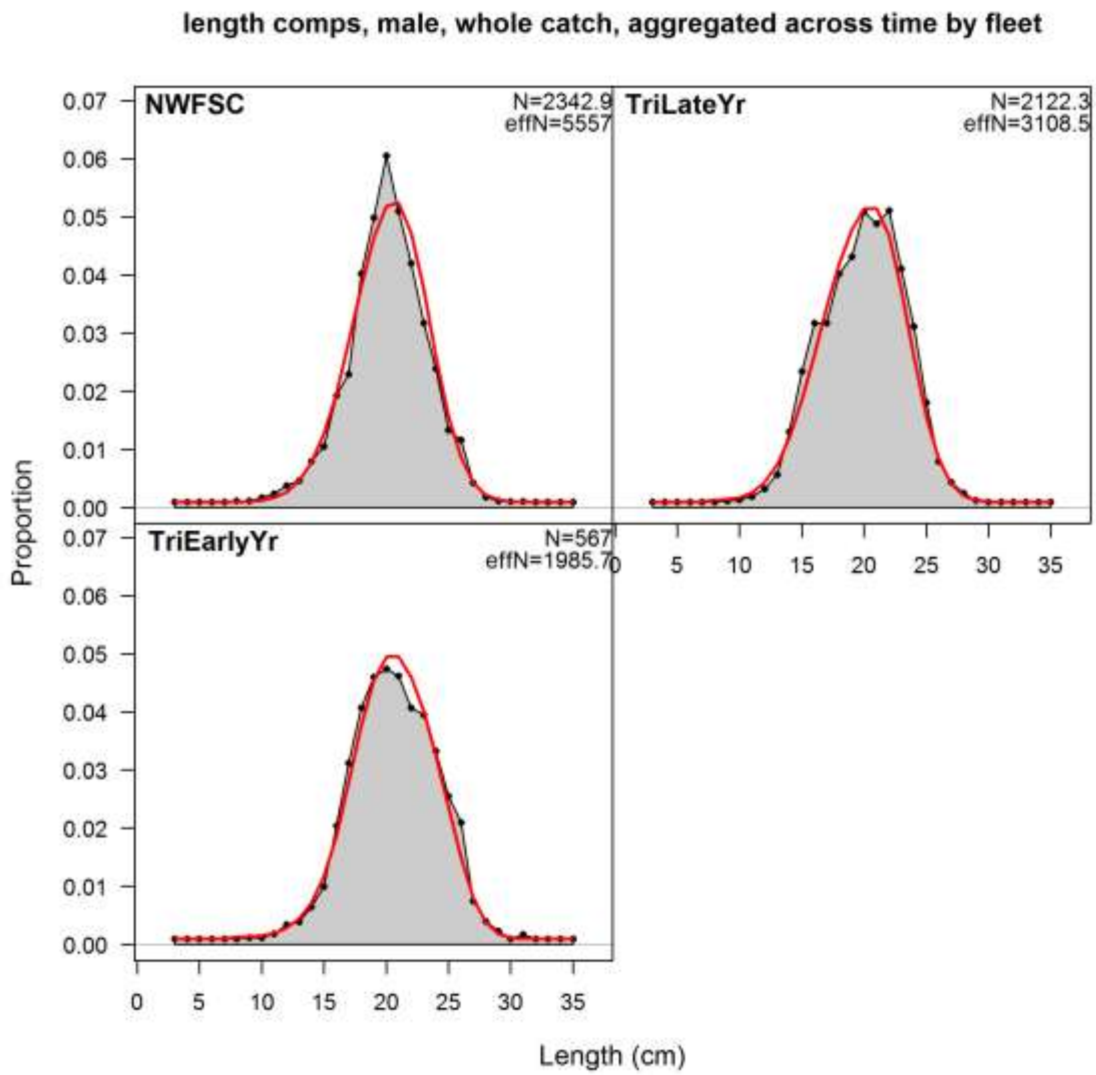



**Figure 73. Fits of base model outputs to the time-aggregated length compositions of males for three fishery-independent surveys.**

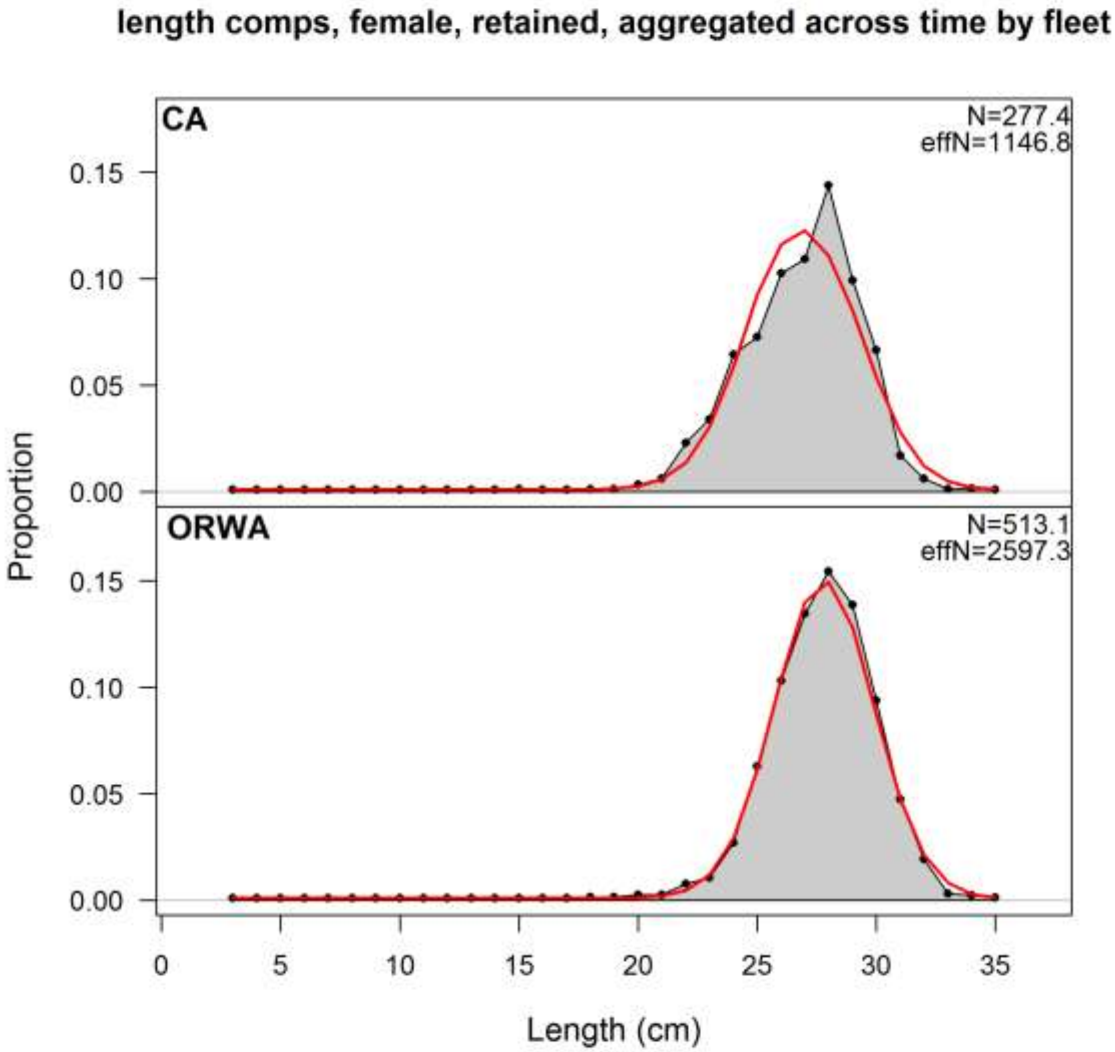



**Figure 74. Fits of base model outputs to the time-aggregated length compositions of females for the CA and OR/WA fisheries.**

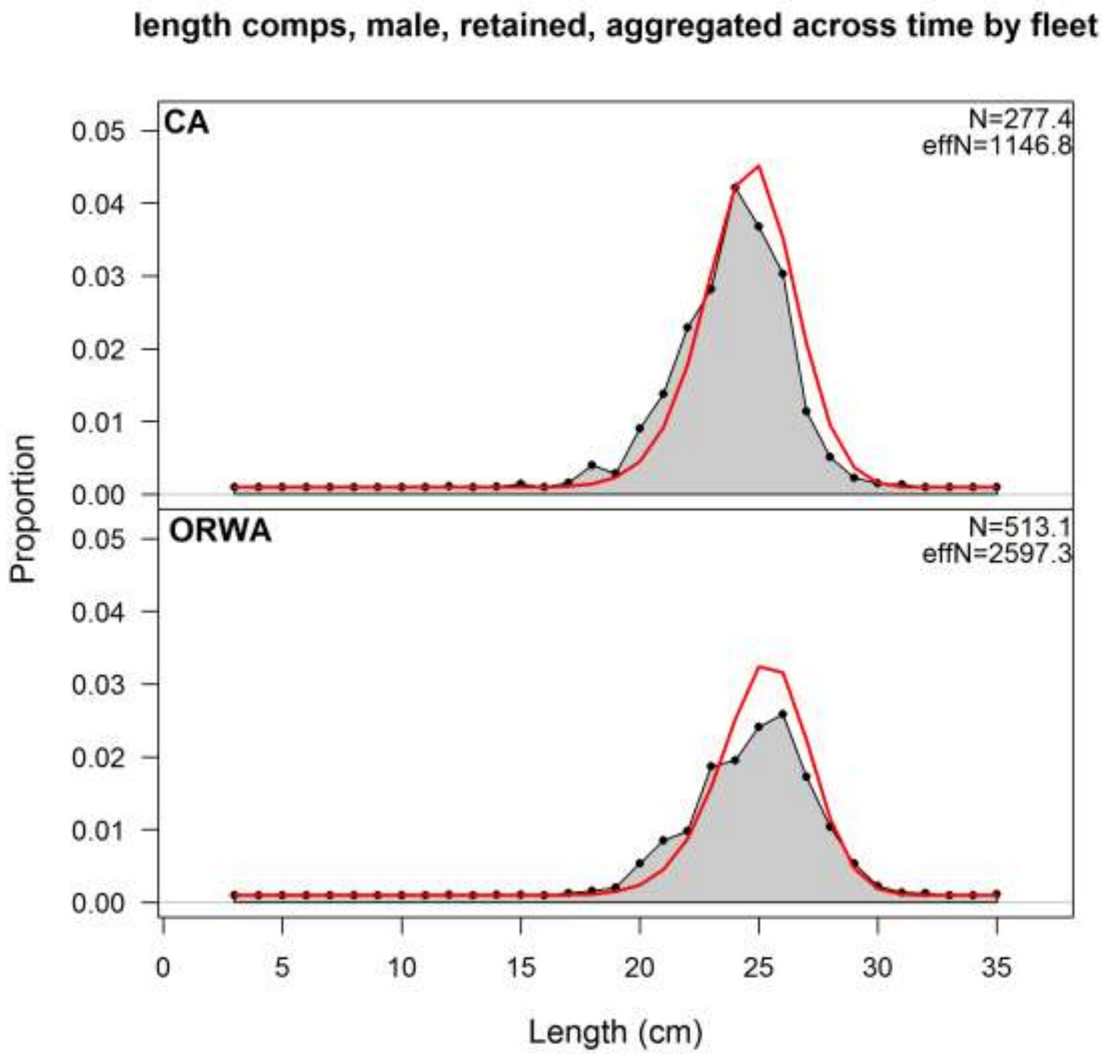



**Figure 75. Fits of base model outputs to the time-aggregated length compositions of males for CA and OR/WA fisheries.**

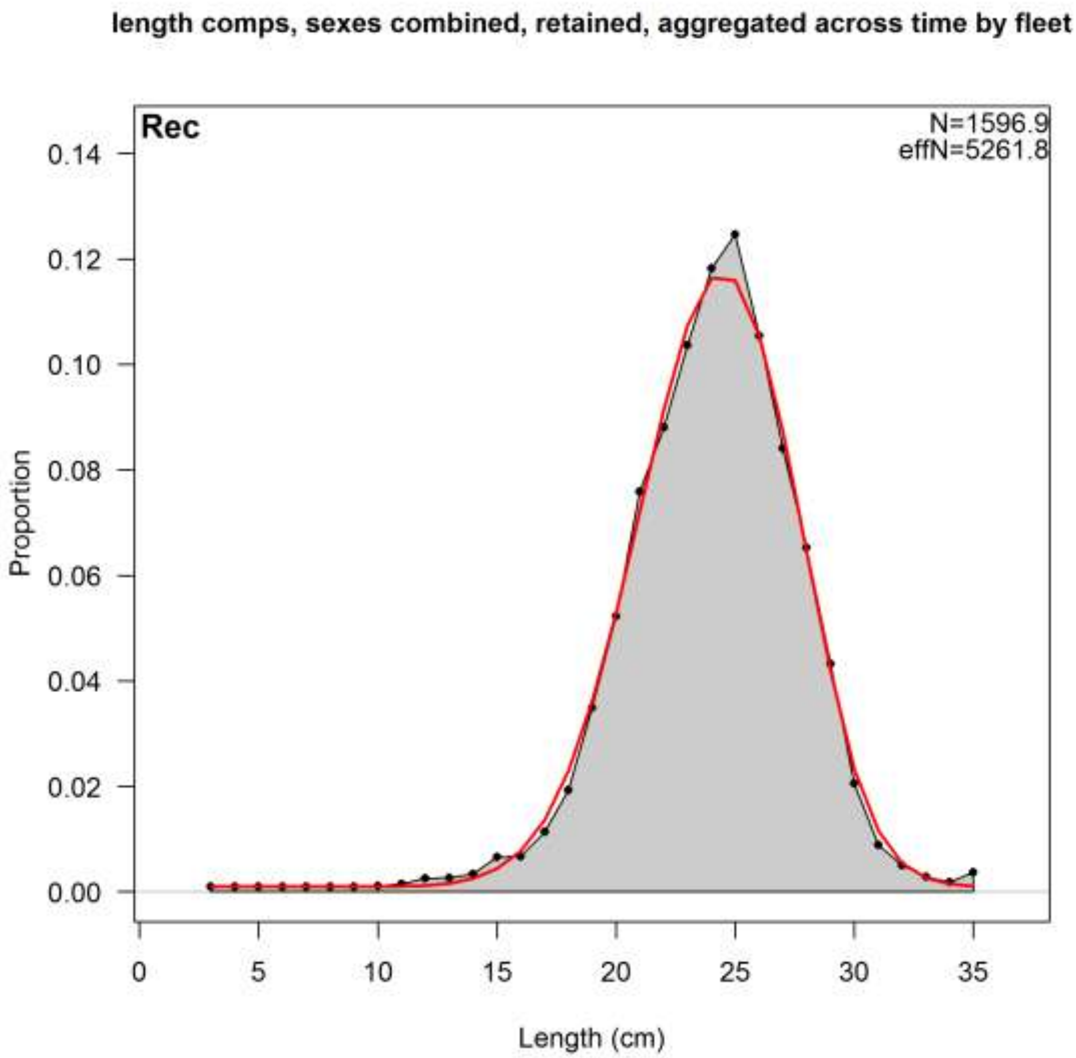



**Figure 76. Fits of base model outputs to the time-aggregated and sex combined length compositions of males for the recreational fishery.**

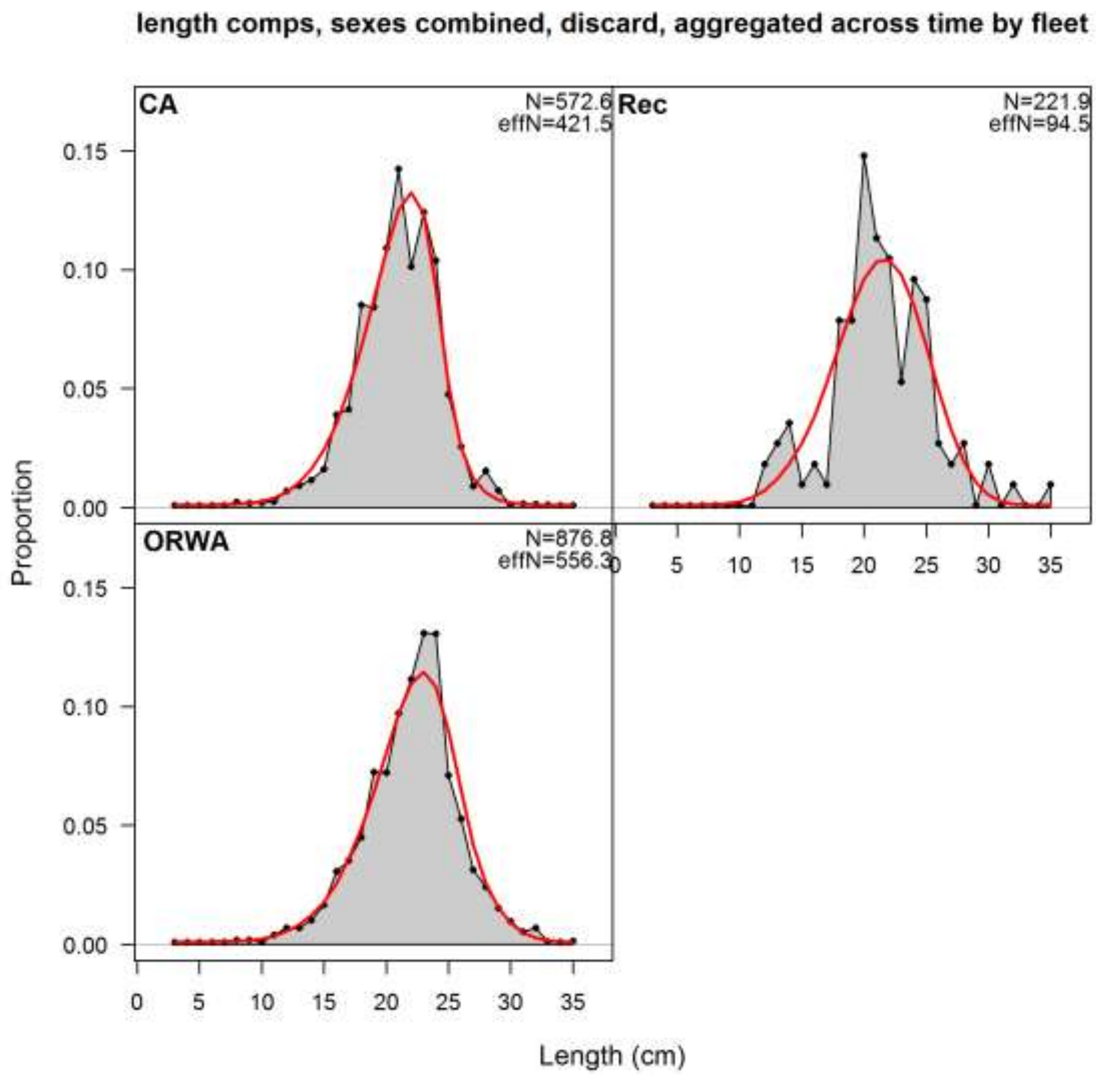



**Figure 77. Fits of base model outputs to the time-aggregated length compositions of combined sexes for three fishing fleets.**

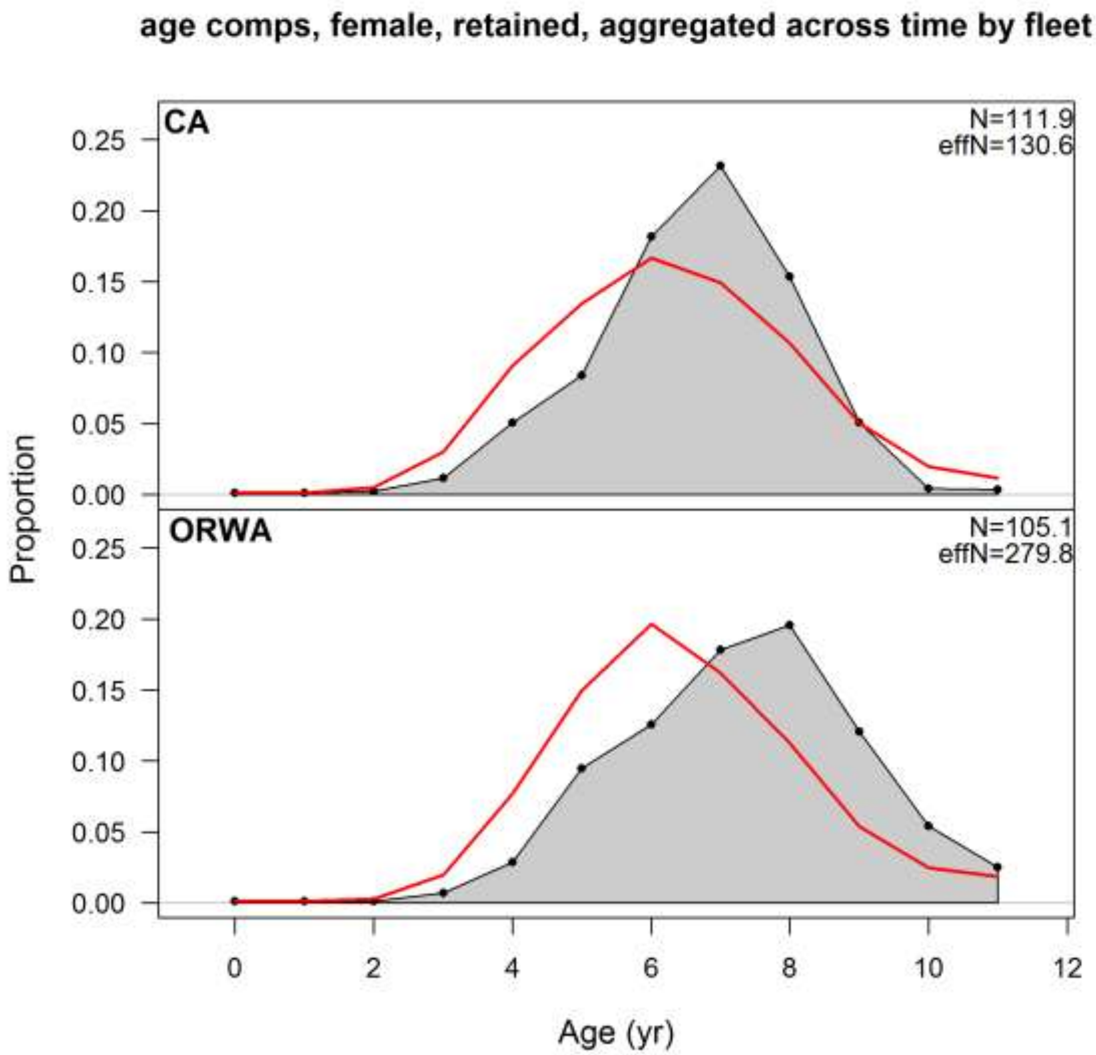



**Figure 78. Fits of base model outputs to the time-aggregated age compositions for females by two fishing fleets.**

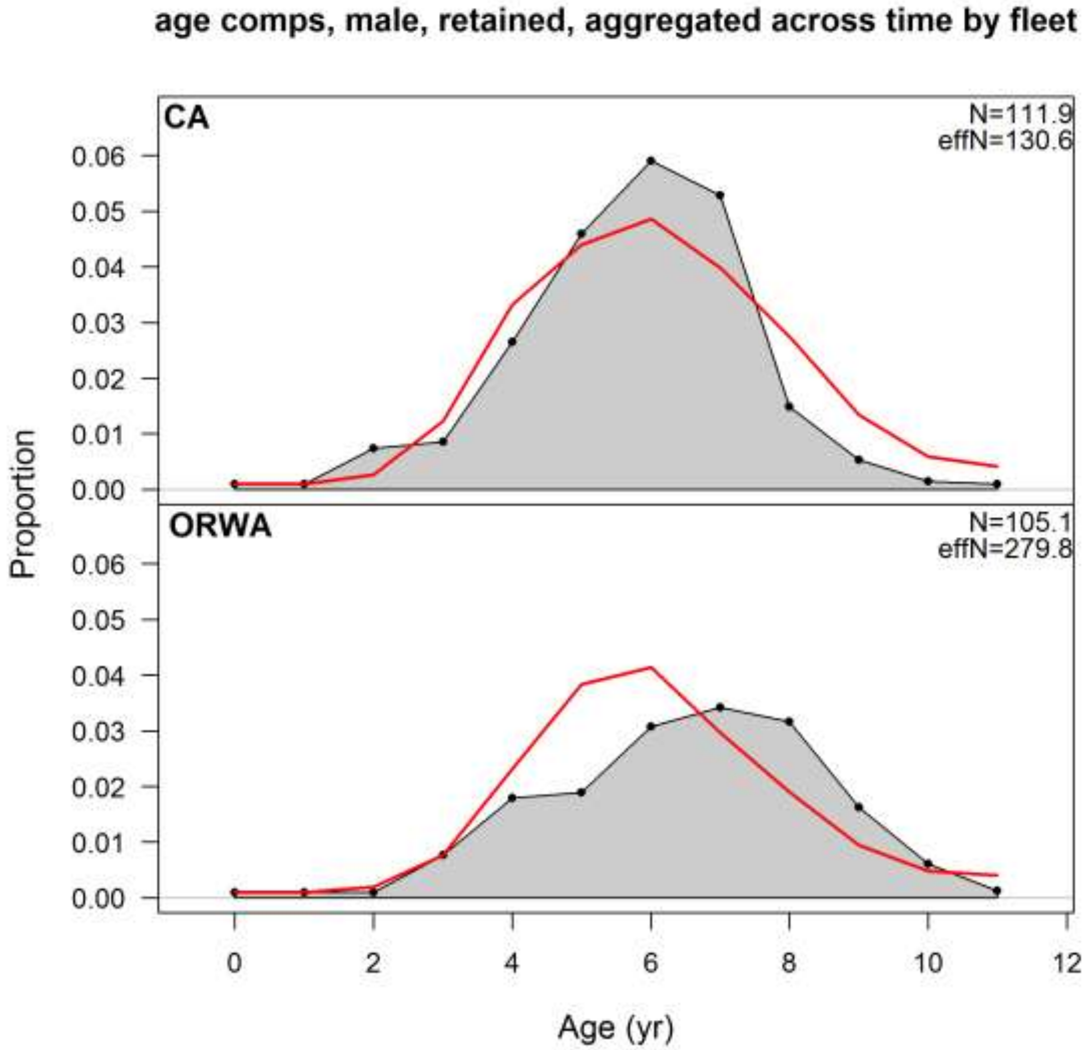



**Figure 79. Fits of base model outputs to the time-aggregated age compositions for males by two fishing fleets.**

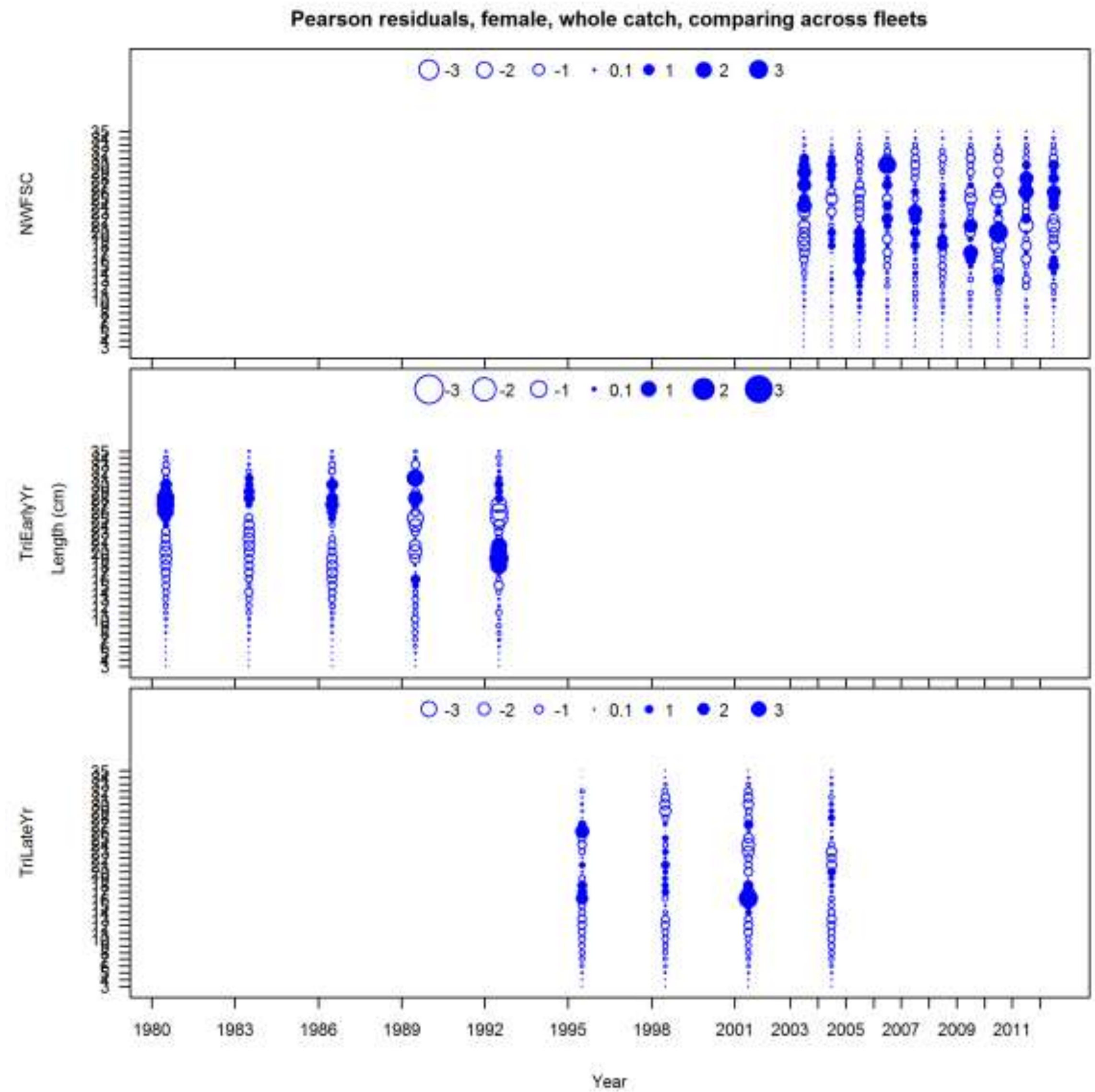



**Figure 80. Pearson residuals for the fits to length frequency data of females from the three fishery-independent surveys.**

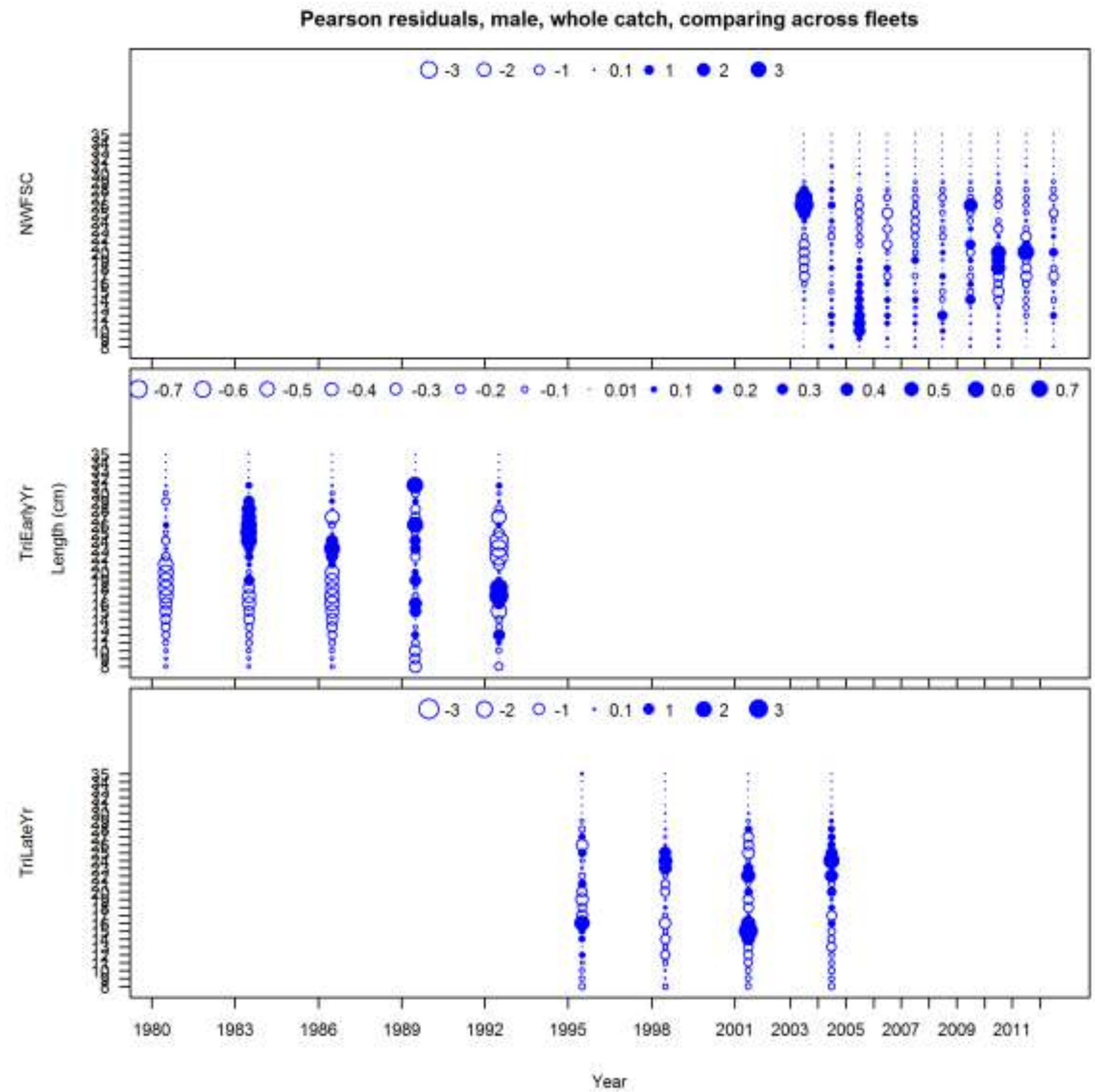



**Figure 81. Pearson residuals for the fits to length frequency data of males from the three fishery-independent surveys.**

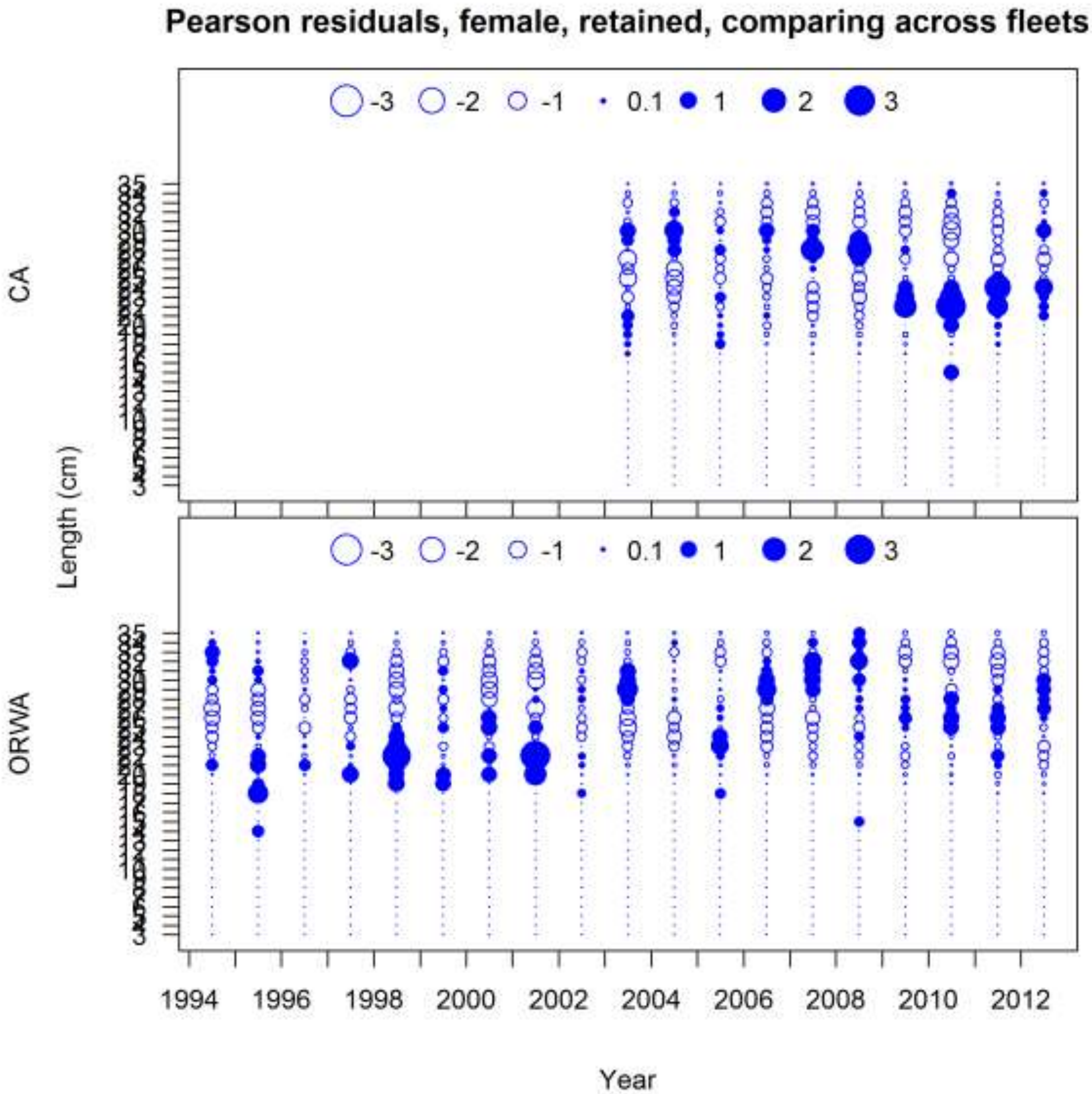



**Figure 82. Pearson residuals for the fits to length frequency data of females from the California and Oregon/Washington trawl fisheries.**

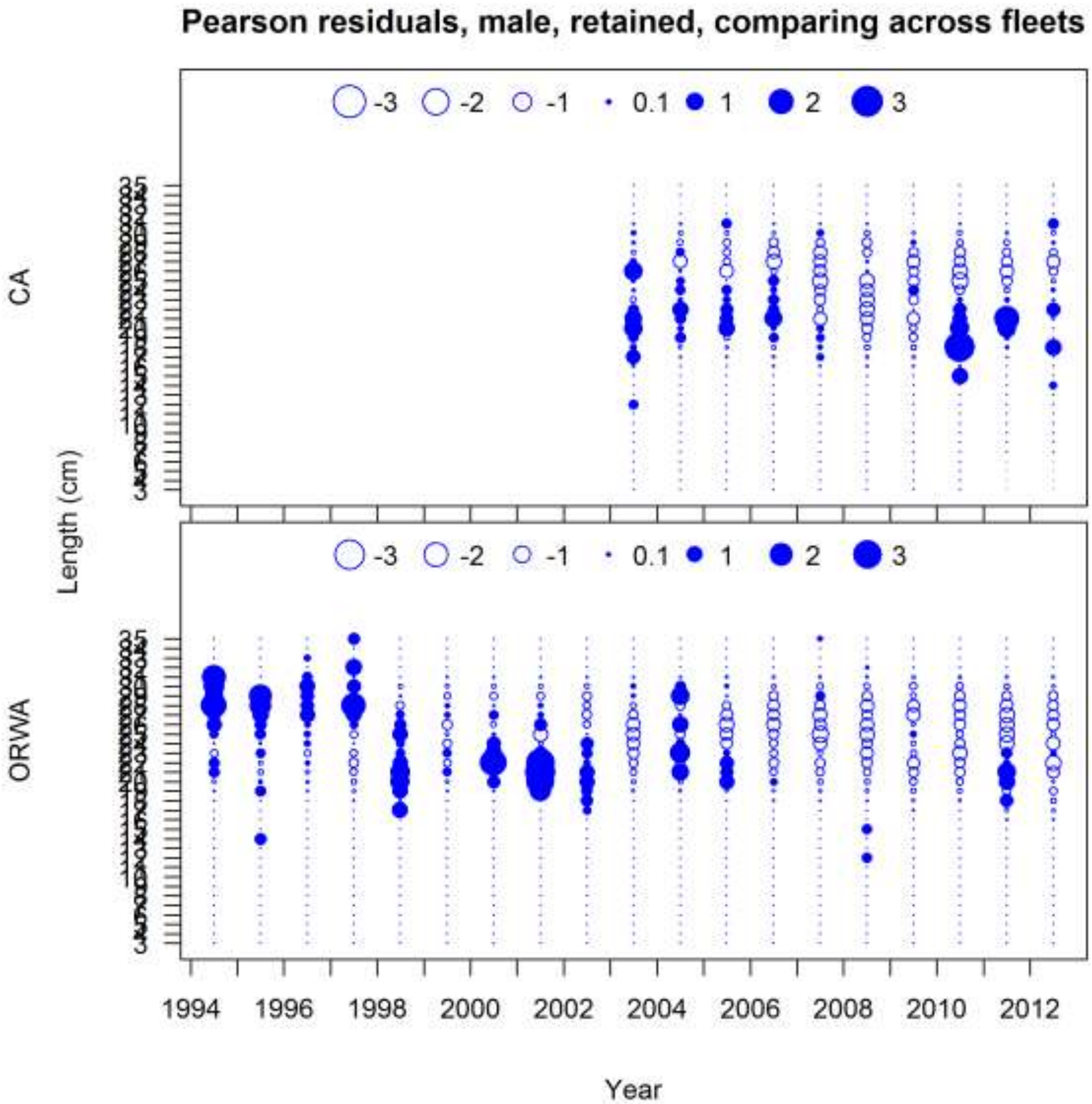



**Figure 83. Pearson residuals for the fits to length frequency data of males from the California and Oregon/Washington trawl fisheries.**

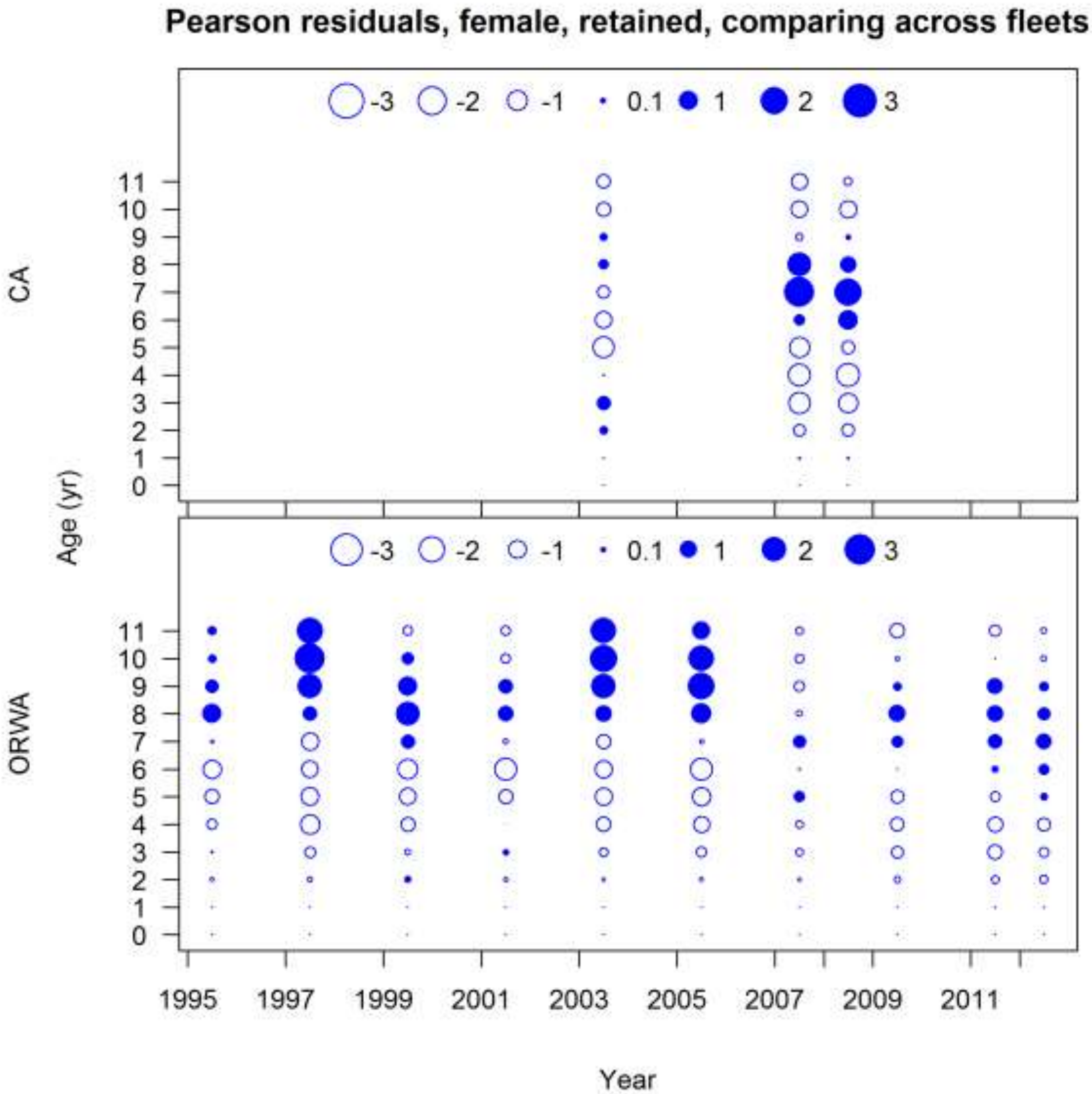



**Figure 84. Pearson residuals for the fits to age frequency data of females from the California and Oregon/Washington trawl fisheries.**

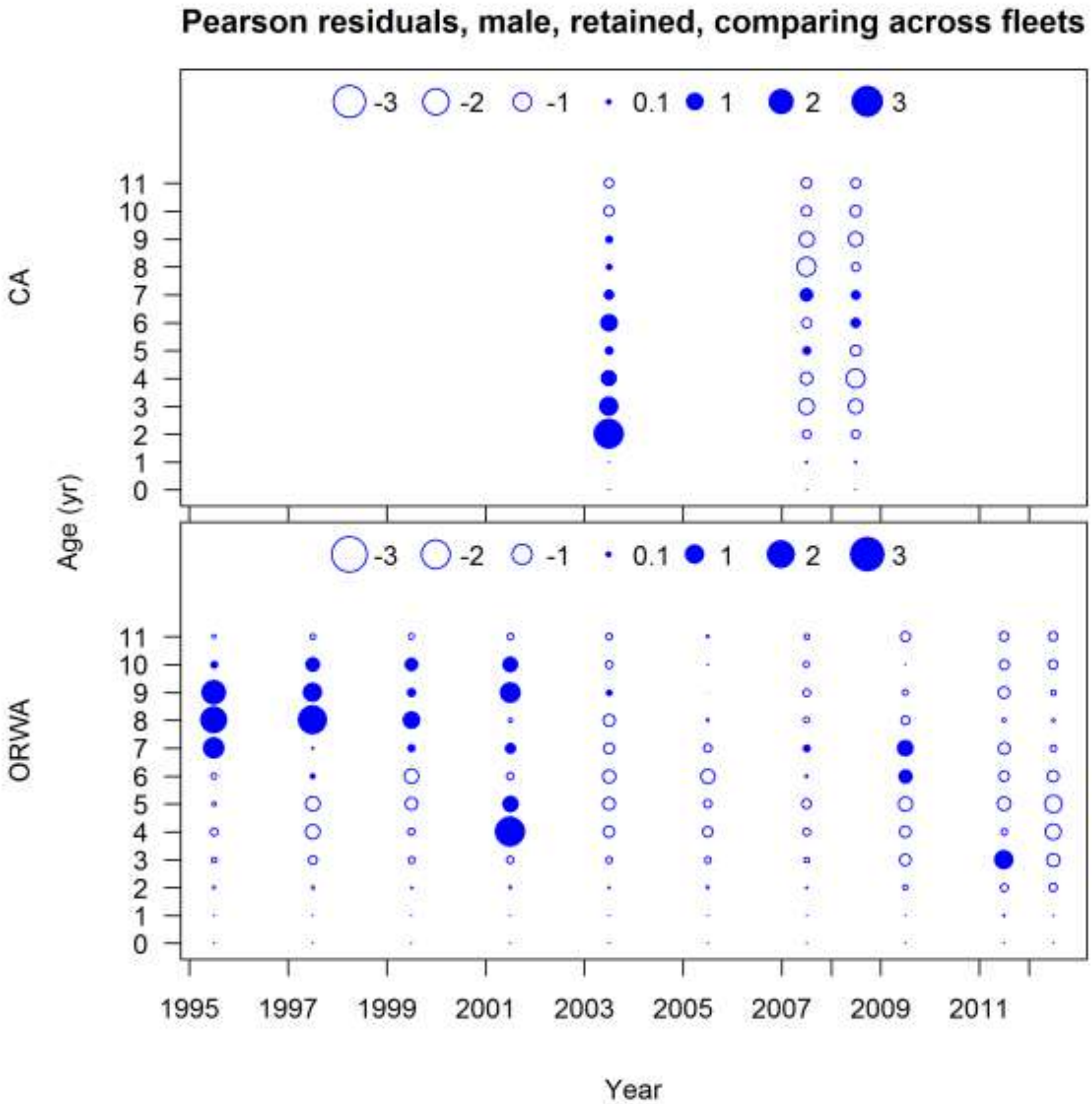



**Figure 85. Pearson residuals for the fits to age frequency data of males from the California and Oregon/Washington trawl fisheries.**

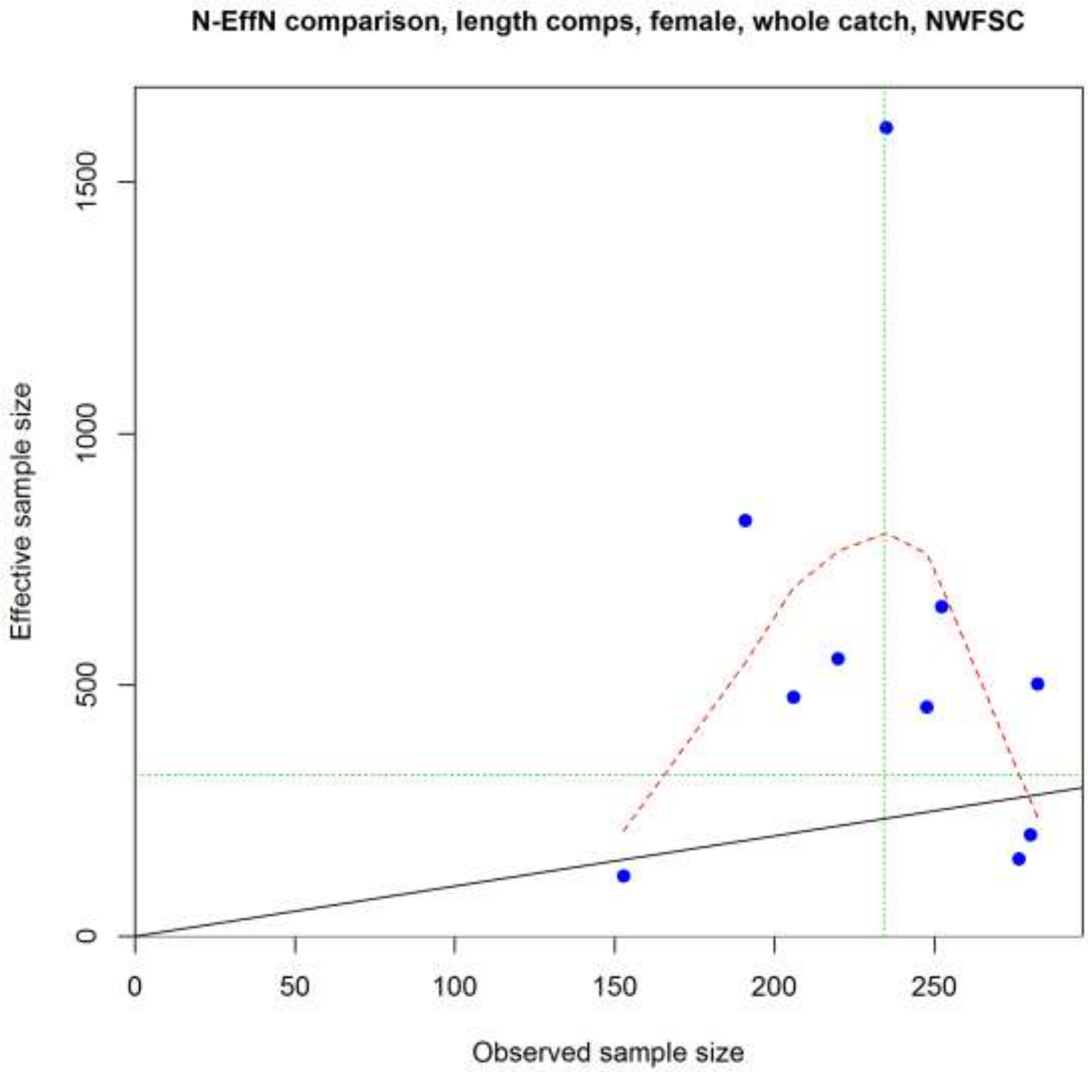



**Figure 86. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the NWFSC survey length frequency data.**

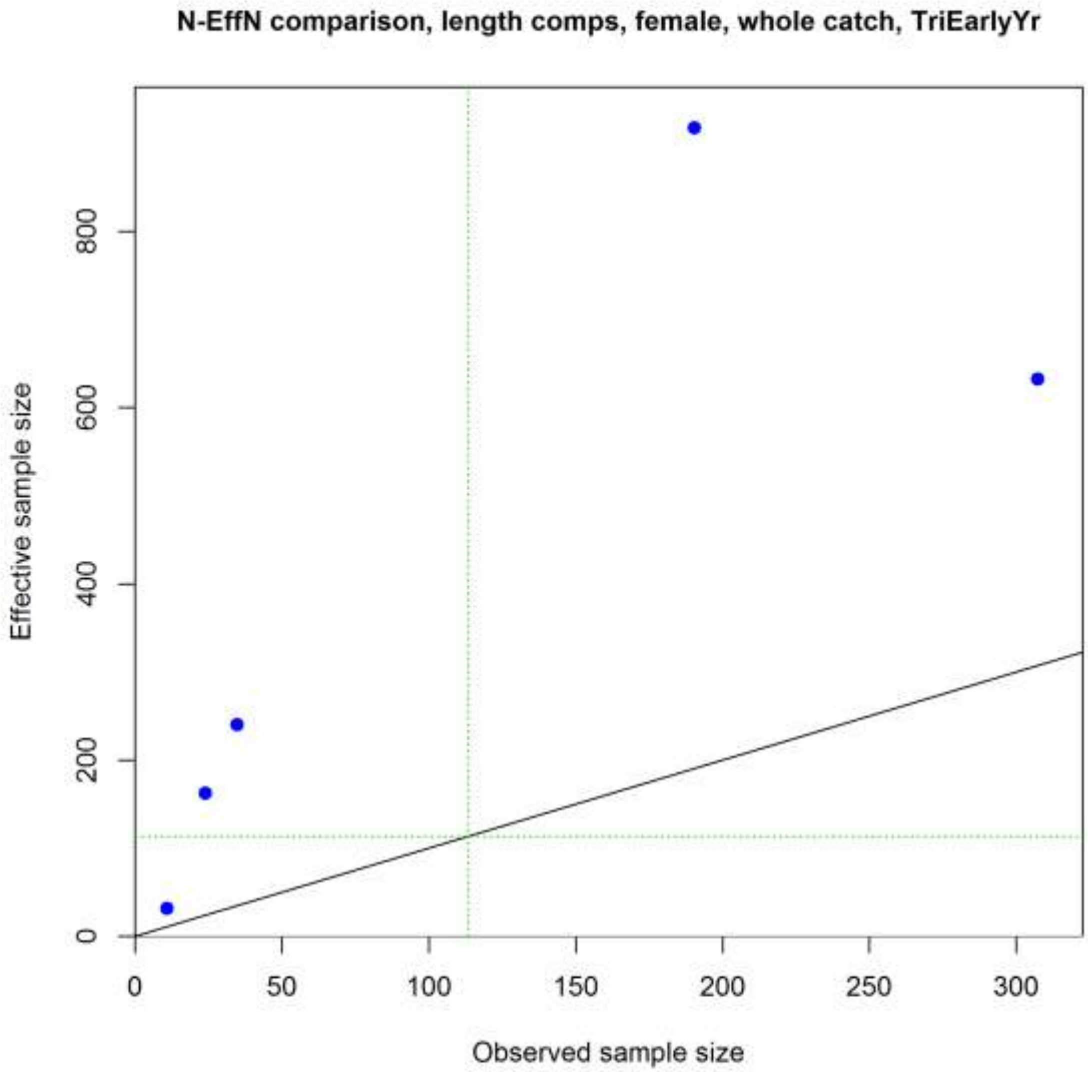



**Figure 87. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the early time period triennial survey length frequency data.**

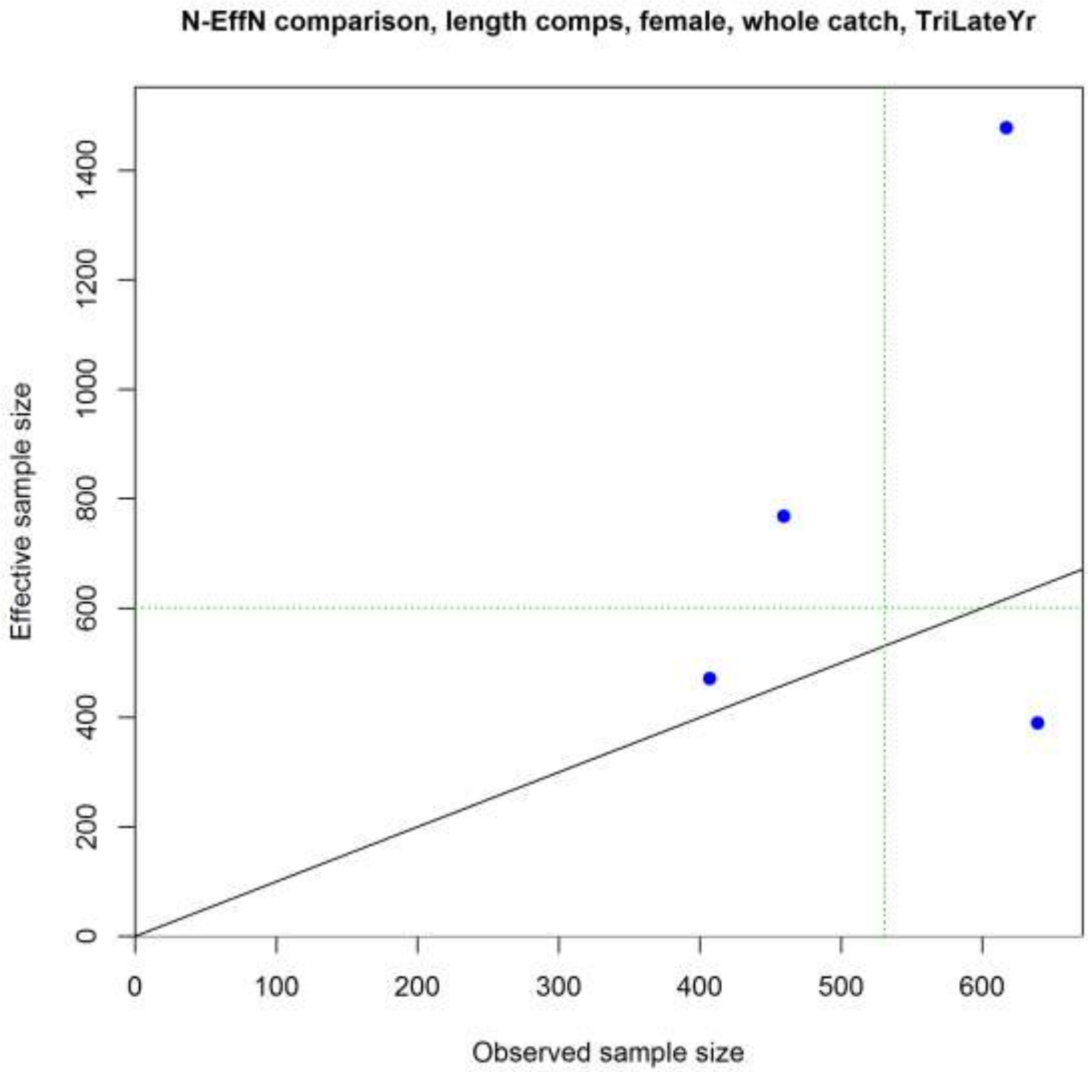



**Figure 88. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the late time period triennial survey length frequency data.**

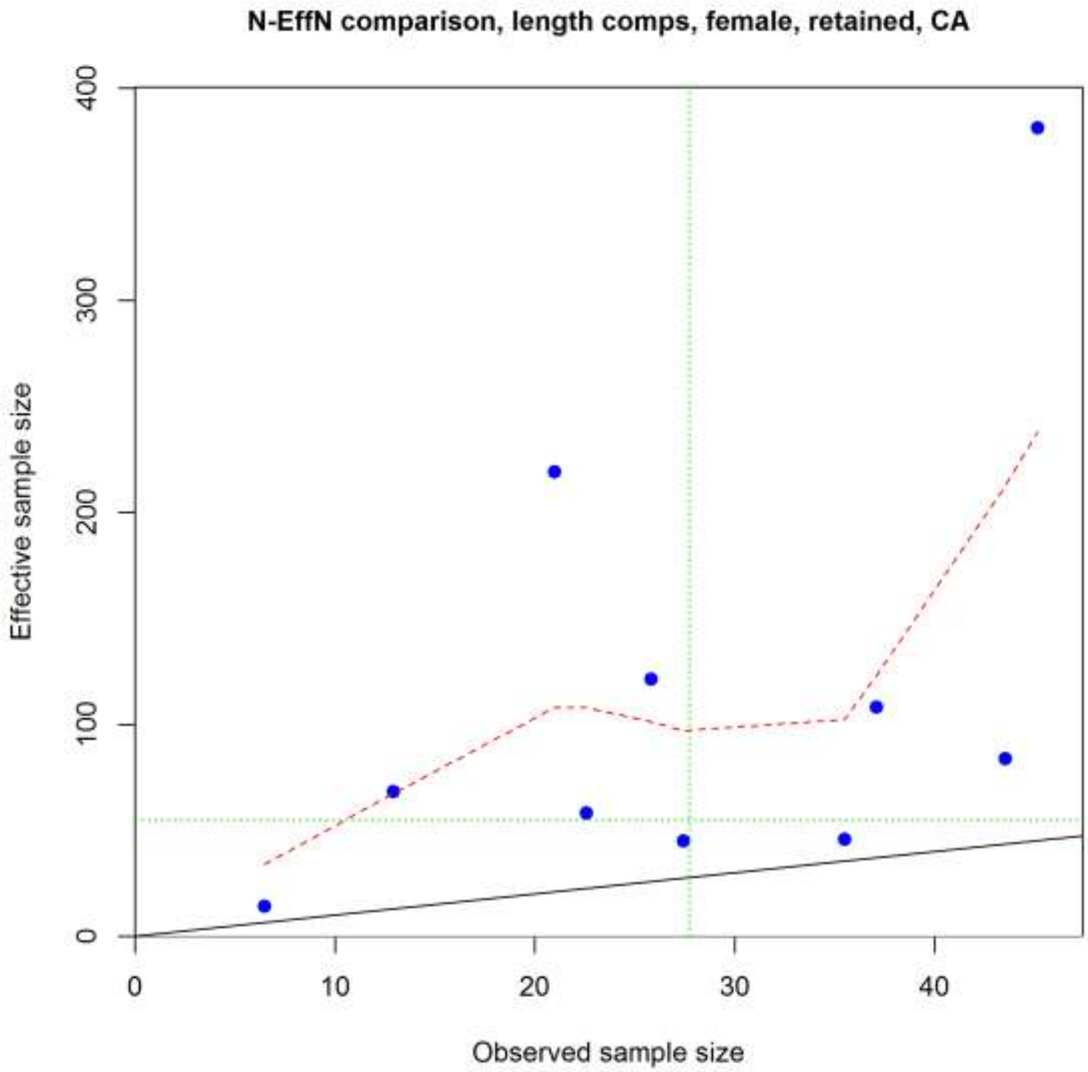



**Figure 89. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the CA retained catches.**

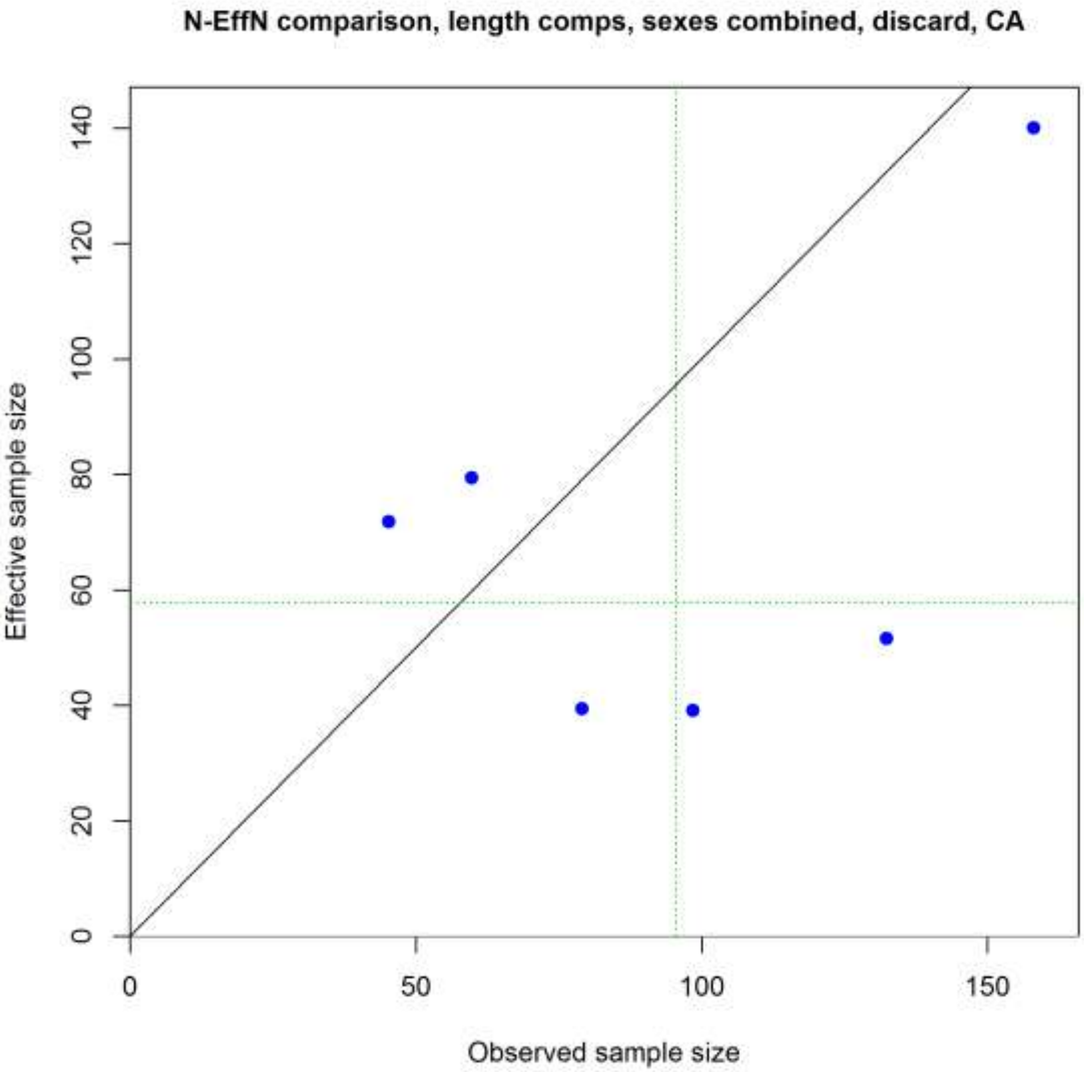



**Figure 90. Observed and effective sample sizes for both sexes for the length frequency data of the CA discarded catches.**

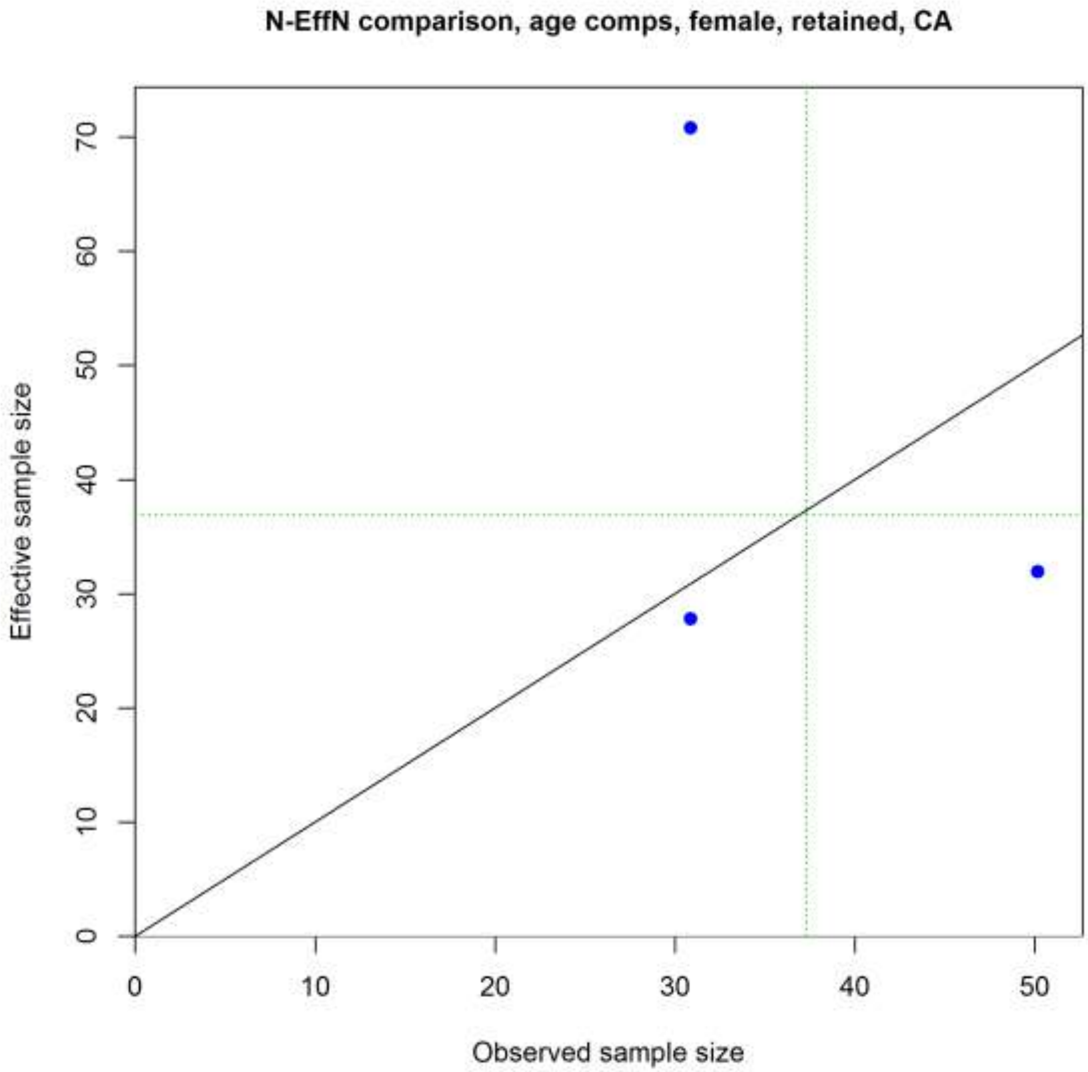



**Figure 91. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the age frequency data of the CA retained catches.**

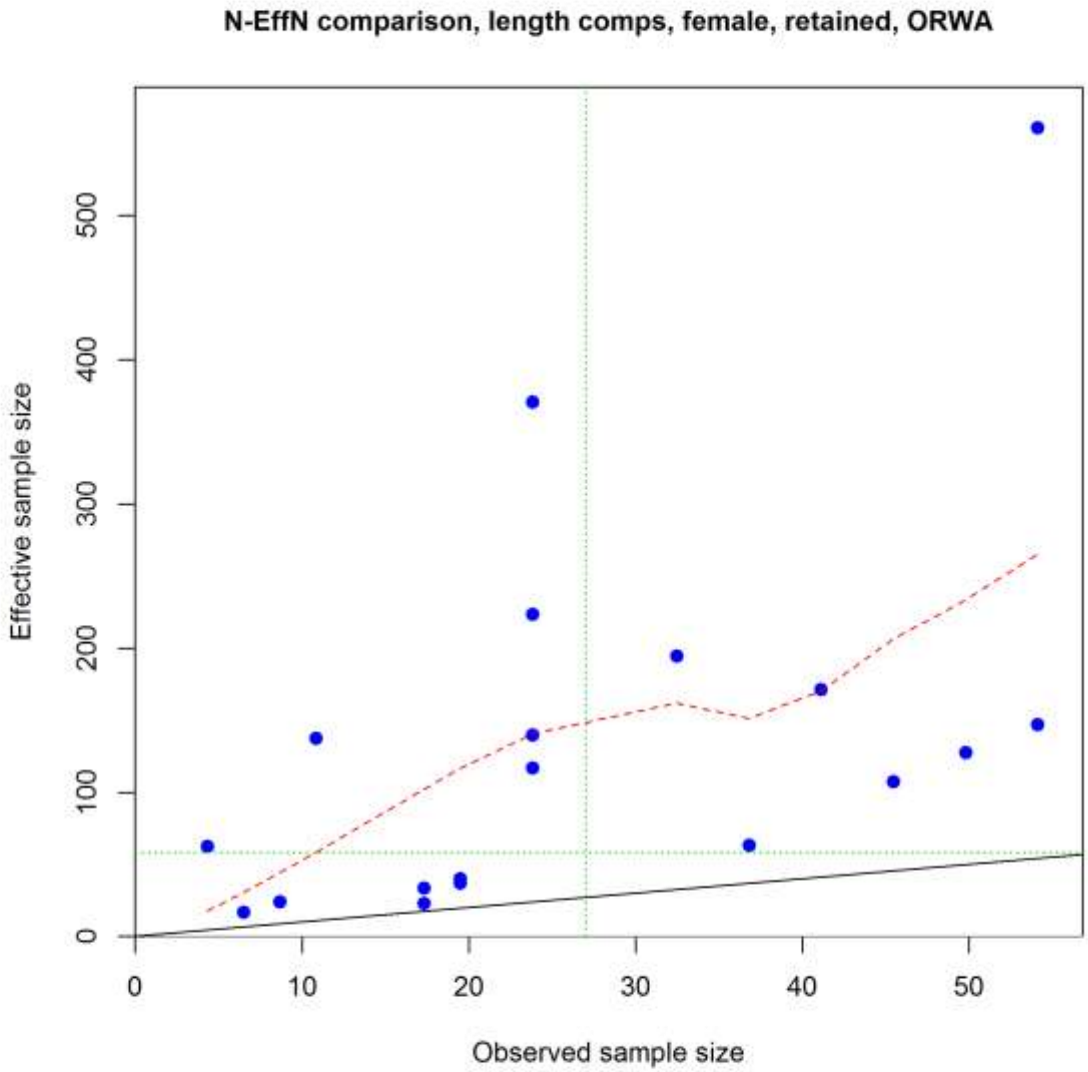



**Figure 92. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the OR/WA retained catches.**

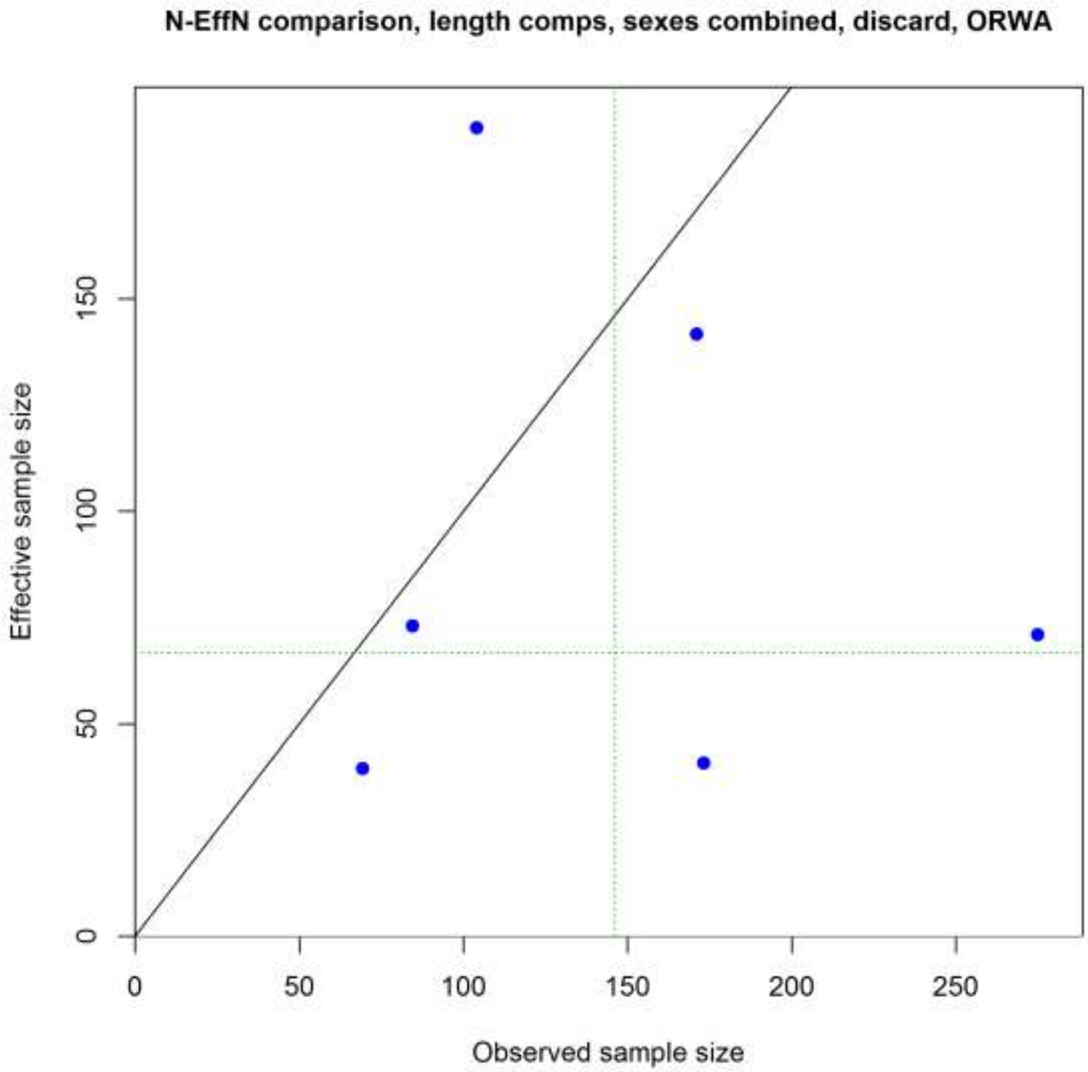



**Figure 93. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the length frequency data of the OR/WA discarded catches.**

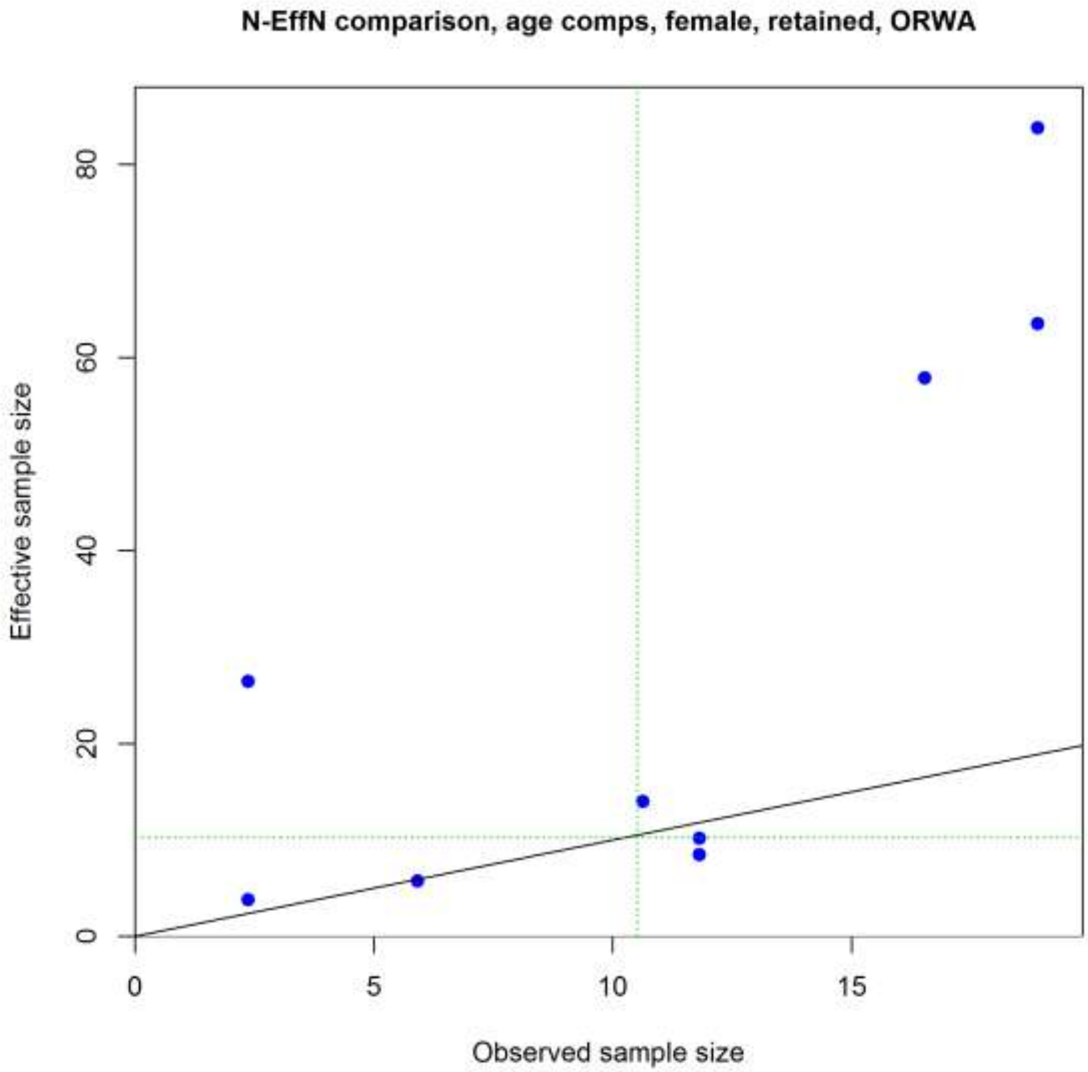



**Figure 94. Observed and effective sample sizes for both sexes (labeled as female on the top of figure) for the age frequency data of the OR/WA retained catches.**

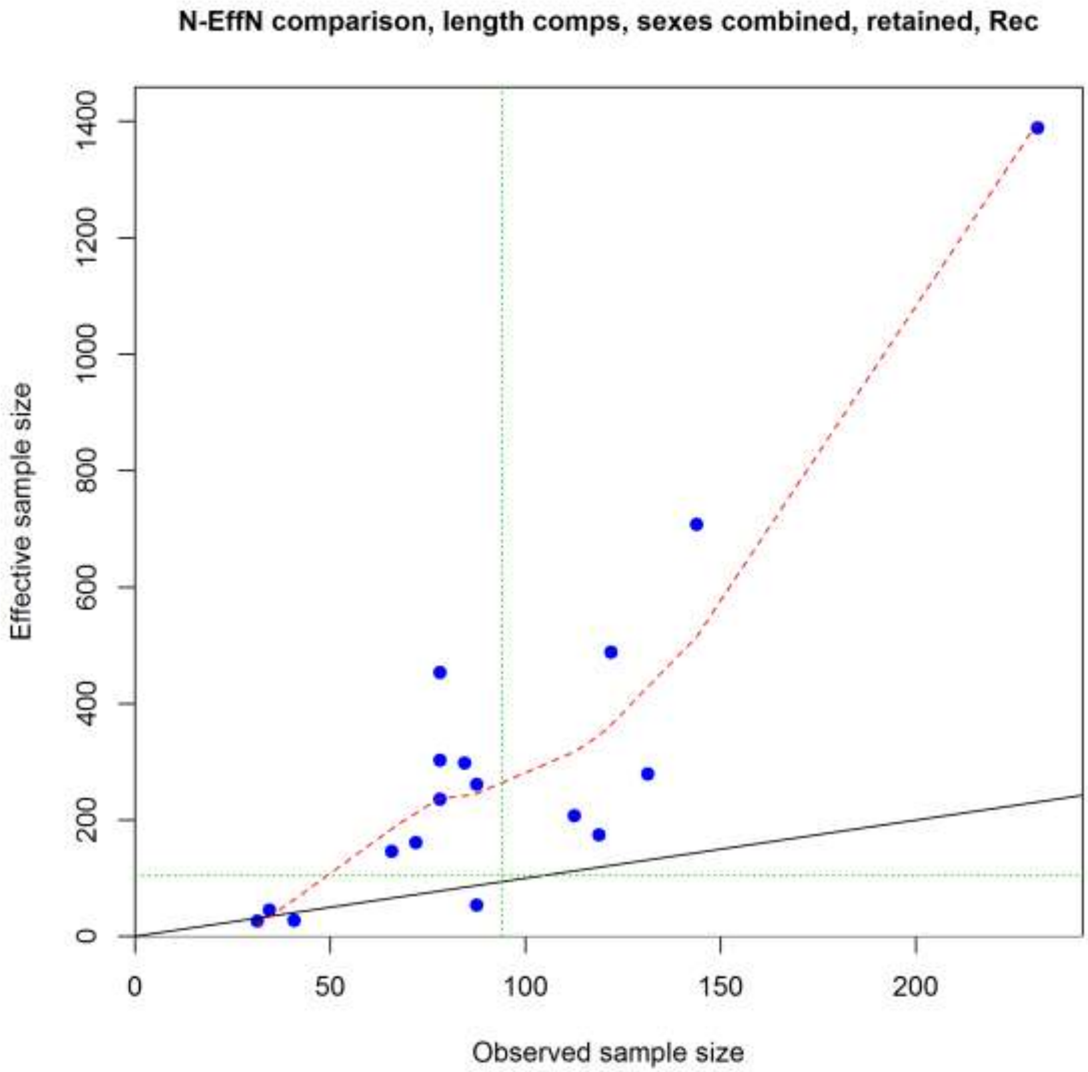



**Figure 95. Observed and effective sample sizes for both sexes for the length frequency data from retained recreational catches.**

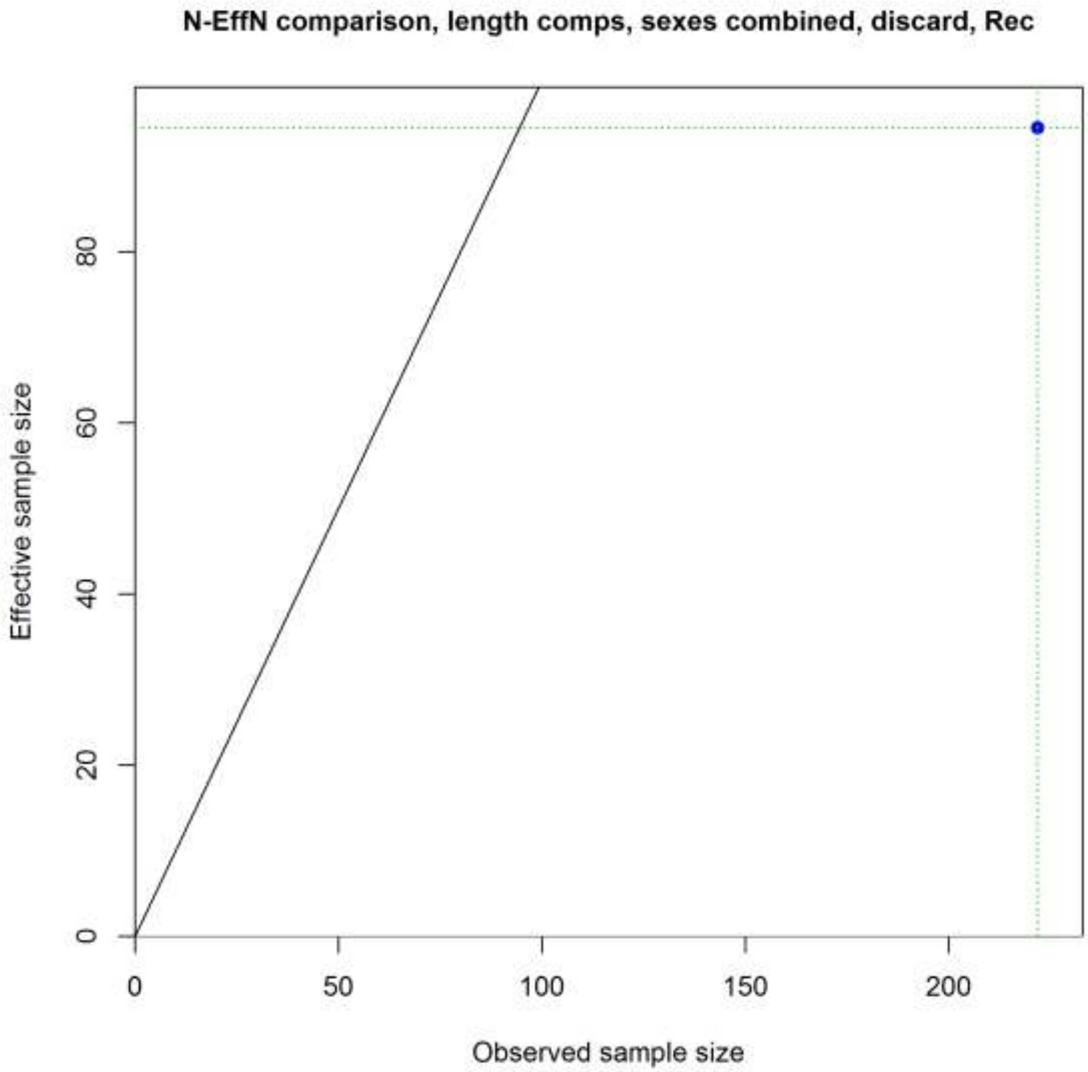



**Figure 96. Observed and effective sample sizes for both sexes for the length frequency data from discarded recreational catches.**

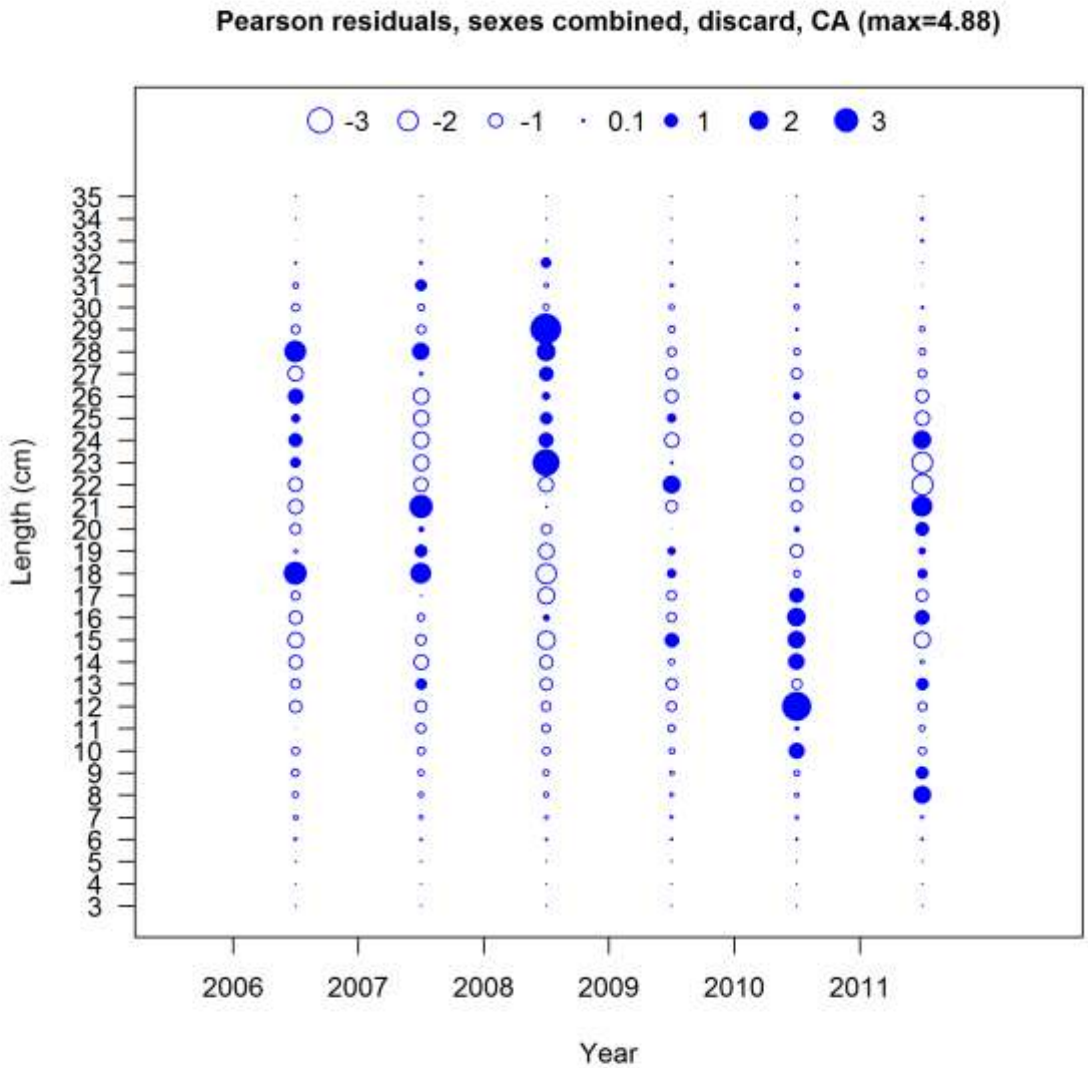



**Figure 97. Pearson residuals of the base model fits to length frequency data from the WCGOP observer data from the California fishery between 2006 and 2011 (sex combined).**

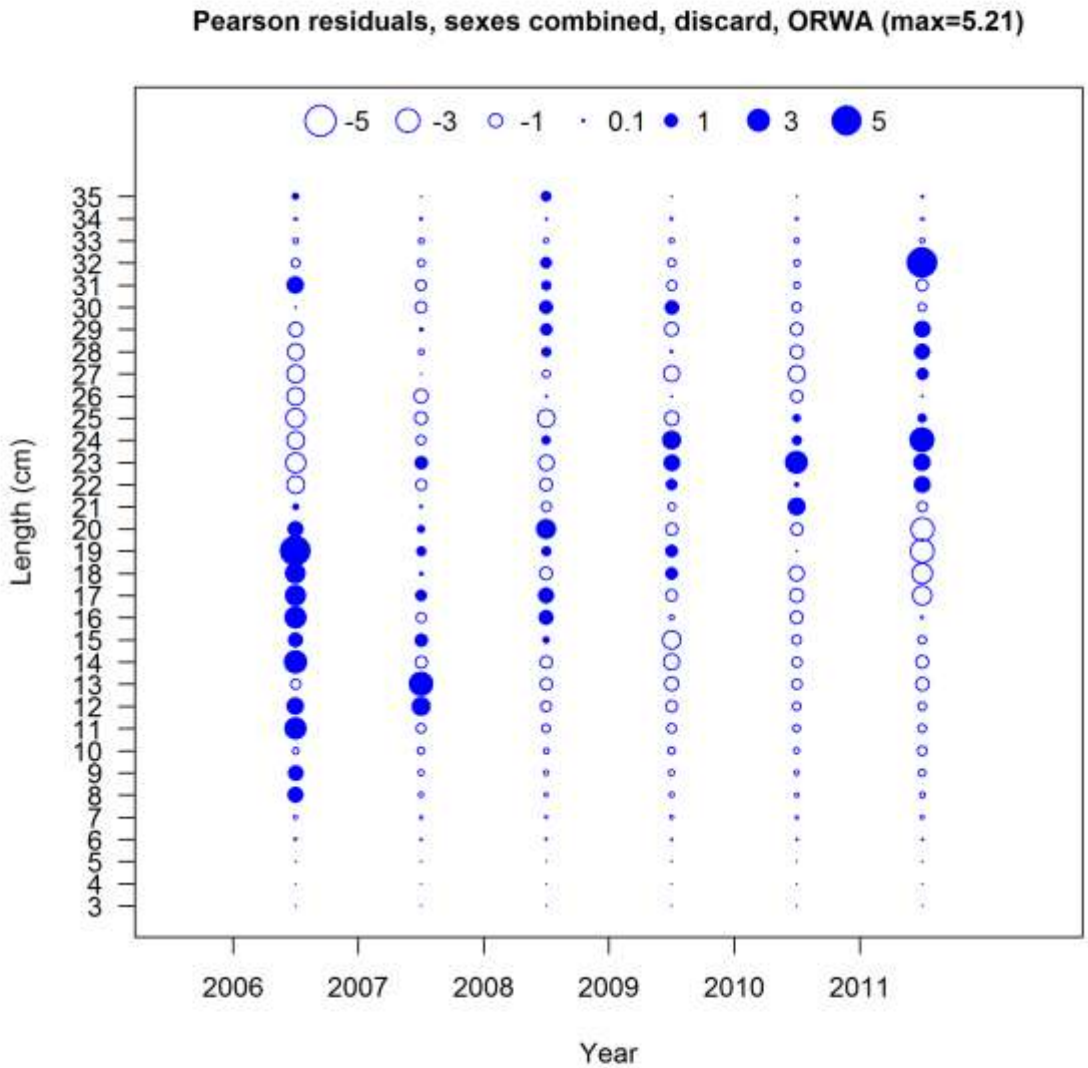



**Figure 98. Pearson residuals of the base model fits to length frequency data from the WCGOP observer data from the OR/WA fishery between 2006 and 2011 (sex combined).**

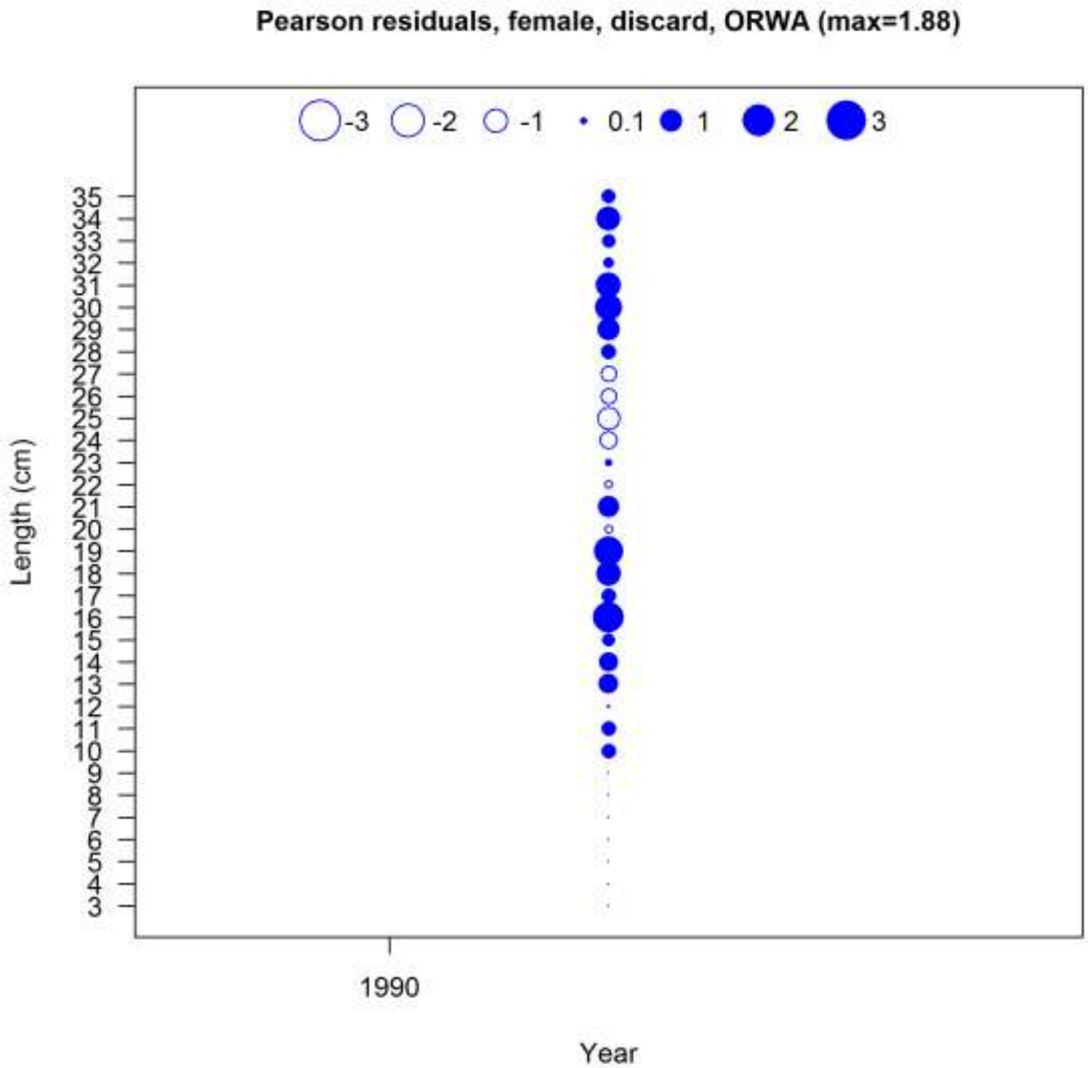



**Figure 99. Pearson residuals of the base model fits to female discard length frequency data from the 1990 Pikitch study of the Oregon fishery.**

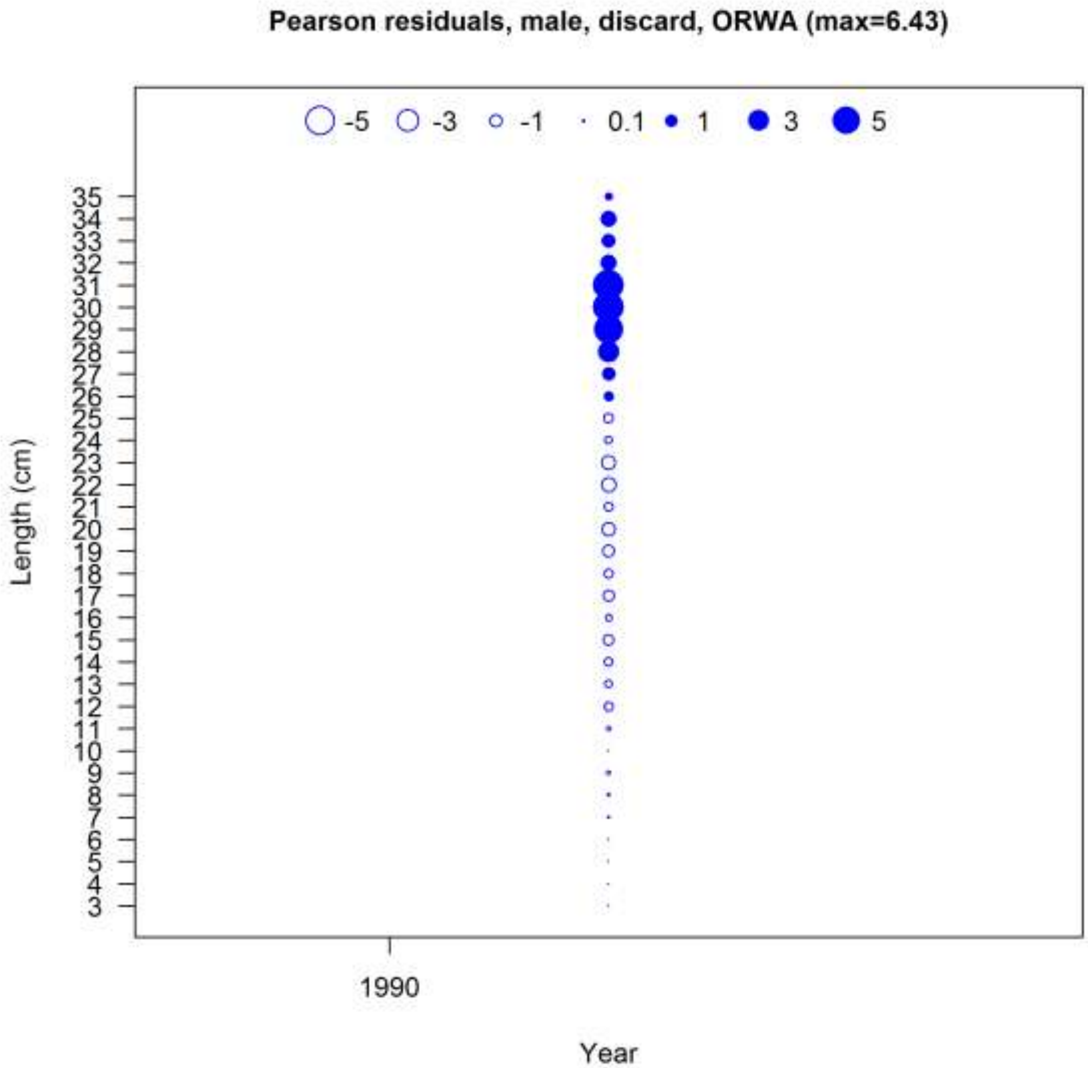



**Figure 100. Pearson residuals of the base model fits to male discard length frequency data from the 1990 Pikitch study of the Oregon fishery.**

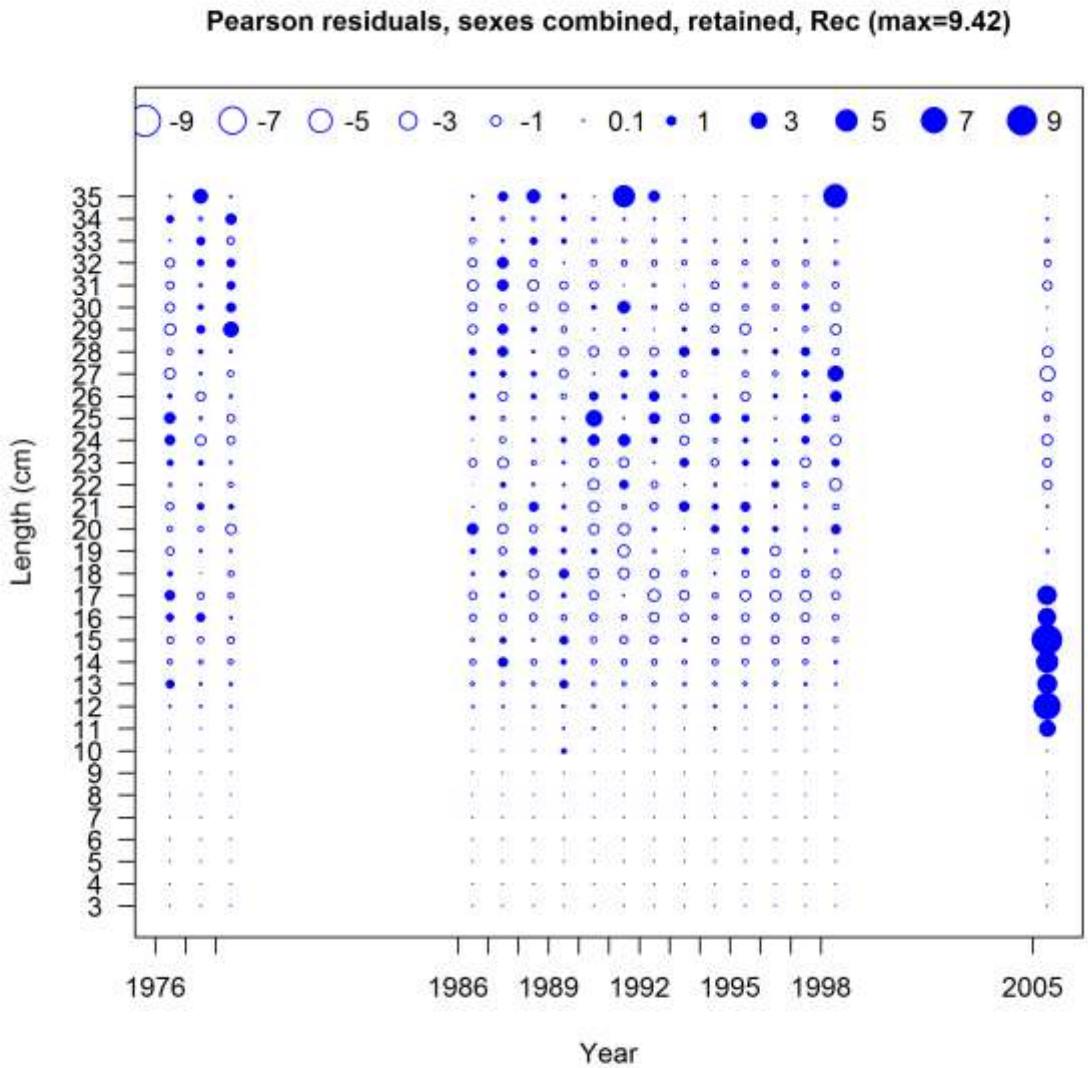



**Figure 101. Pearson residuals of the base model fits to length frequency data from the recreational fishery (sex combined).**

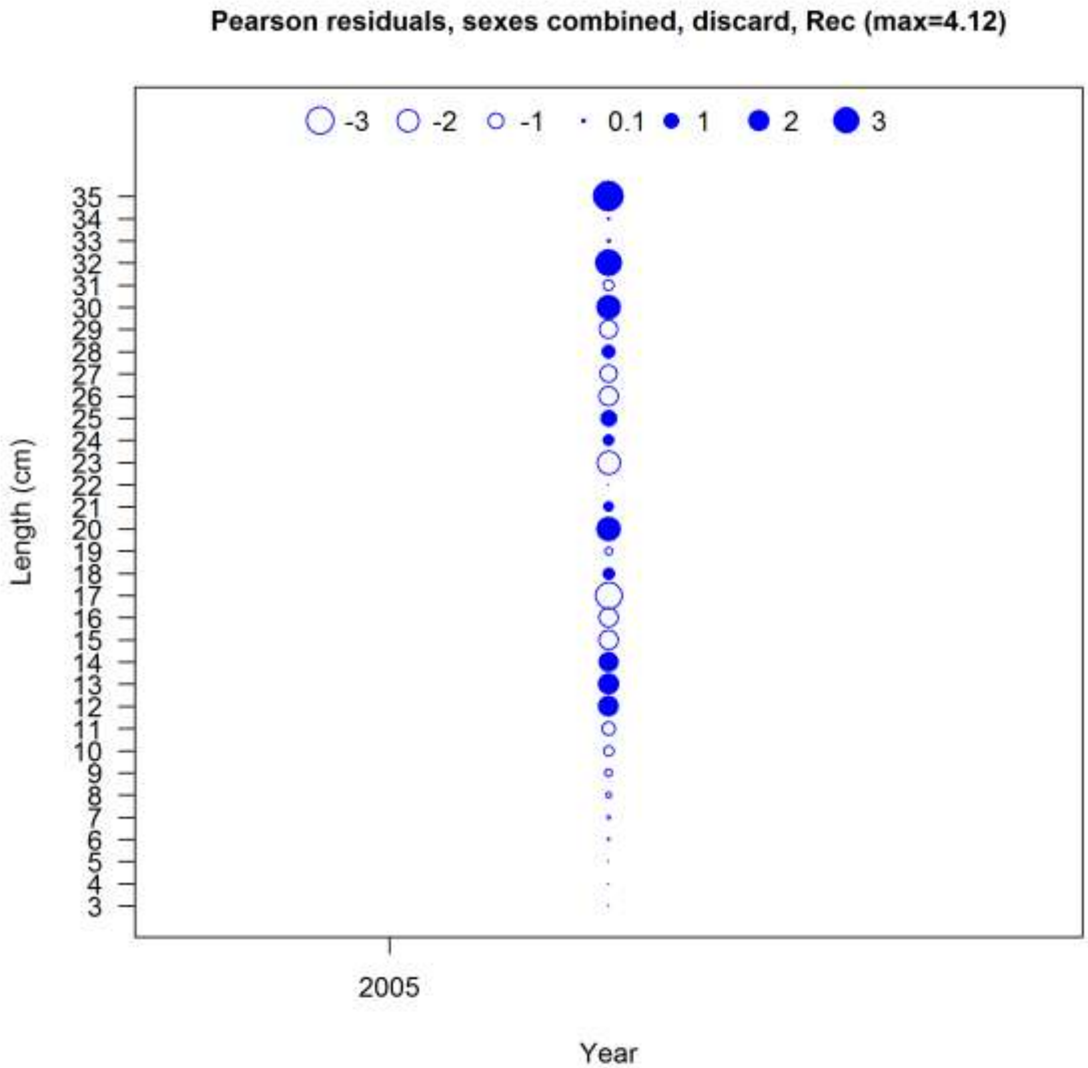



**Figure 102. Pearson residuals of the base model fits to length frequency data from the 2005 recreational fishery (sex combined).**

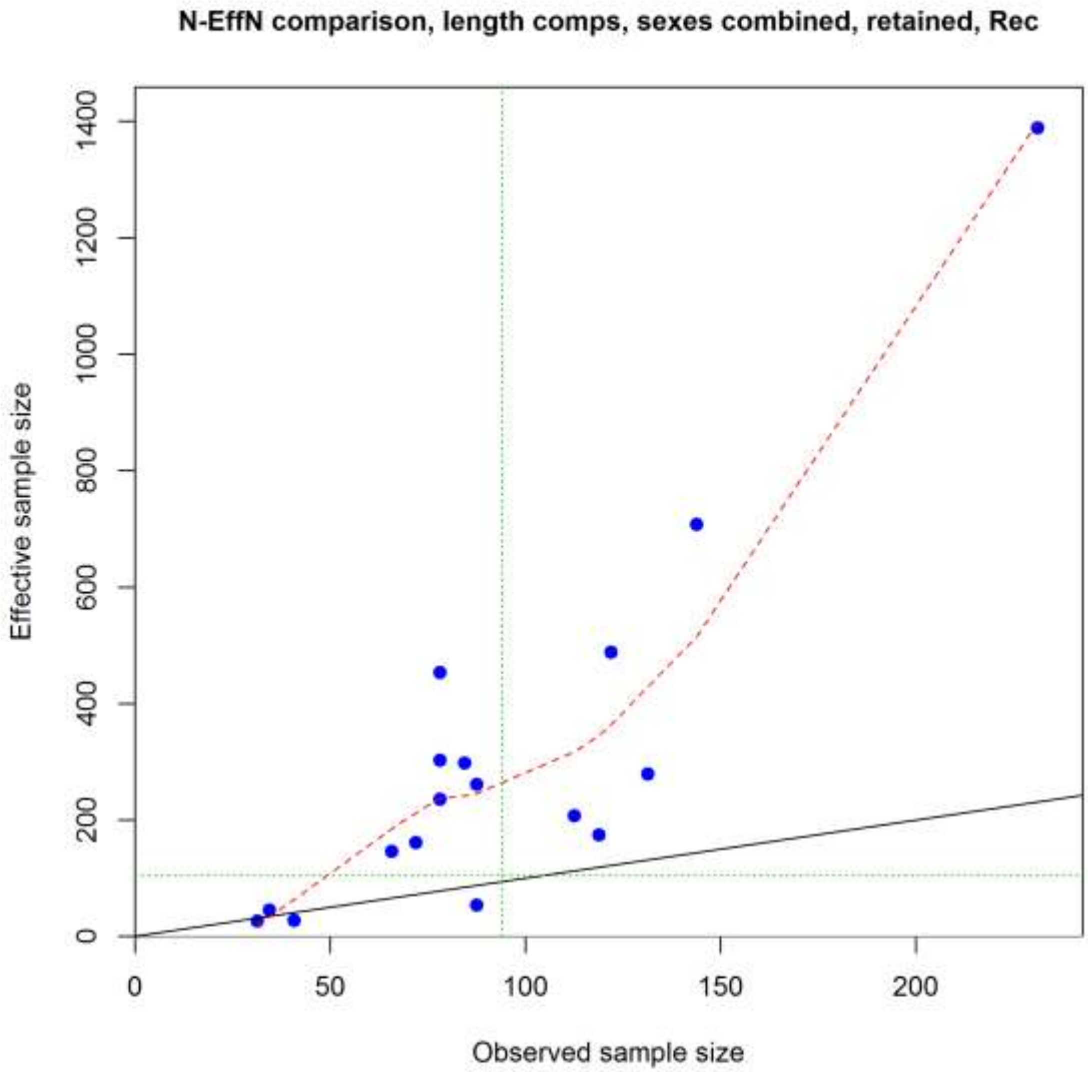



**Figure 103. Observed and effective sample sizes for the length frequency distributions for the recreational fishery (retained catches and sexes combined).**

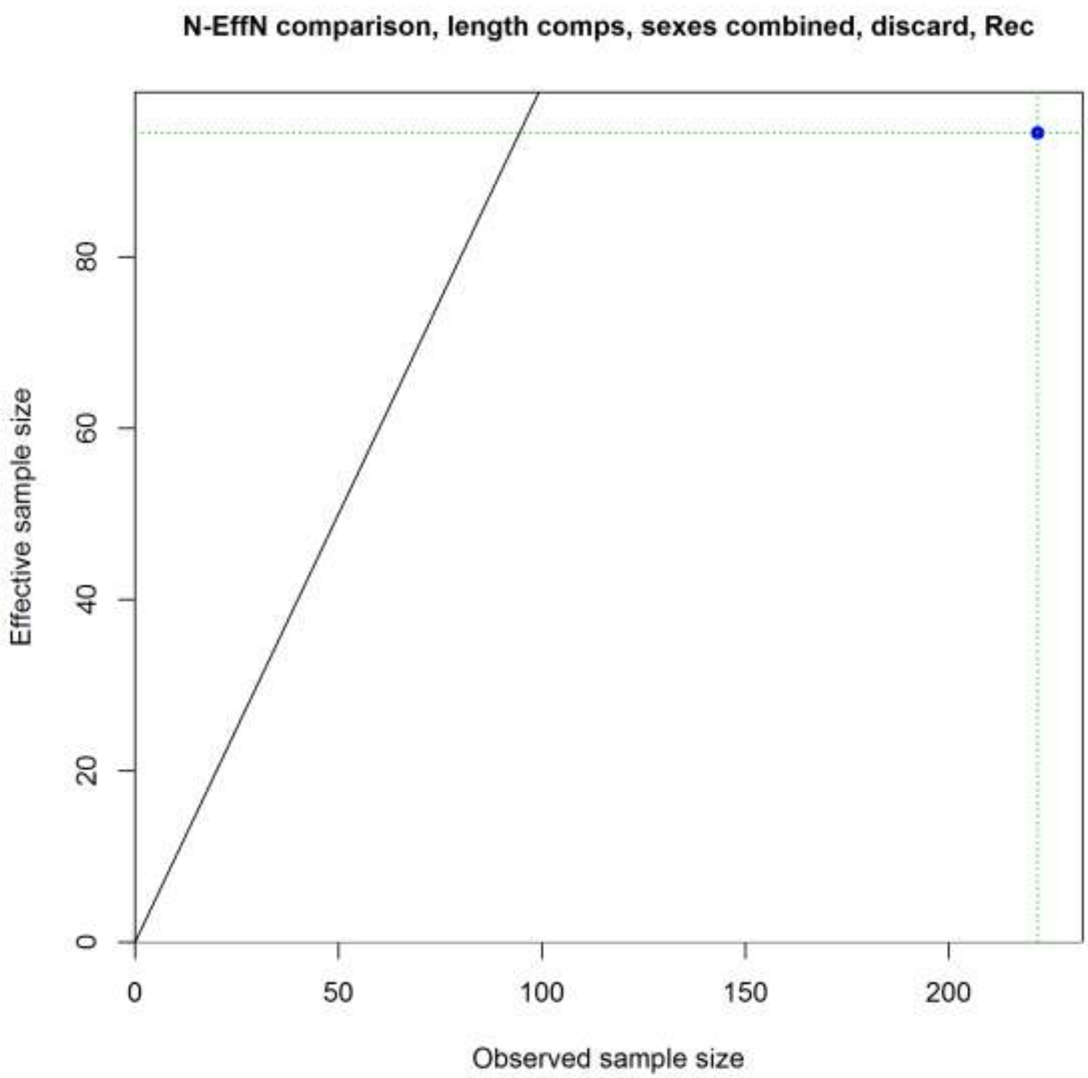



**Figure 104. Observed and effective sample sizes for the length frequency distributions for the recreational fishery (discarded catch and sexes combined). Only one year data in 2005 were available.**

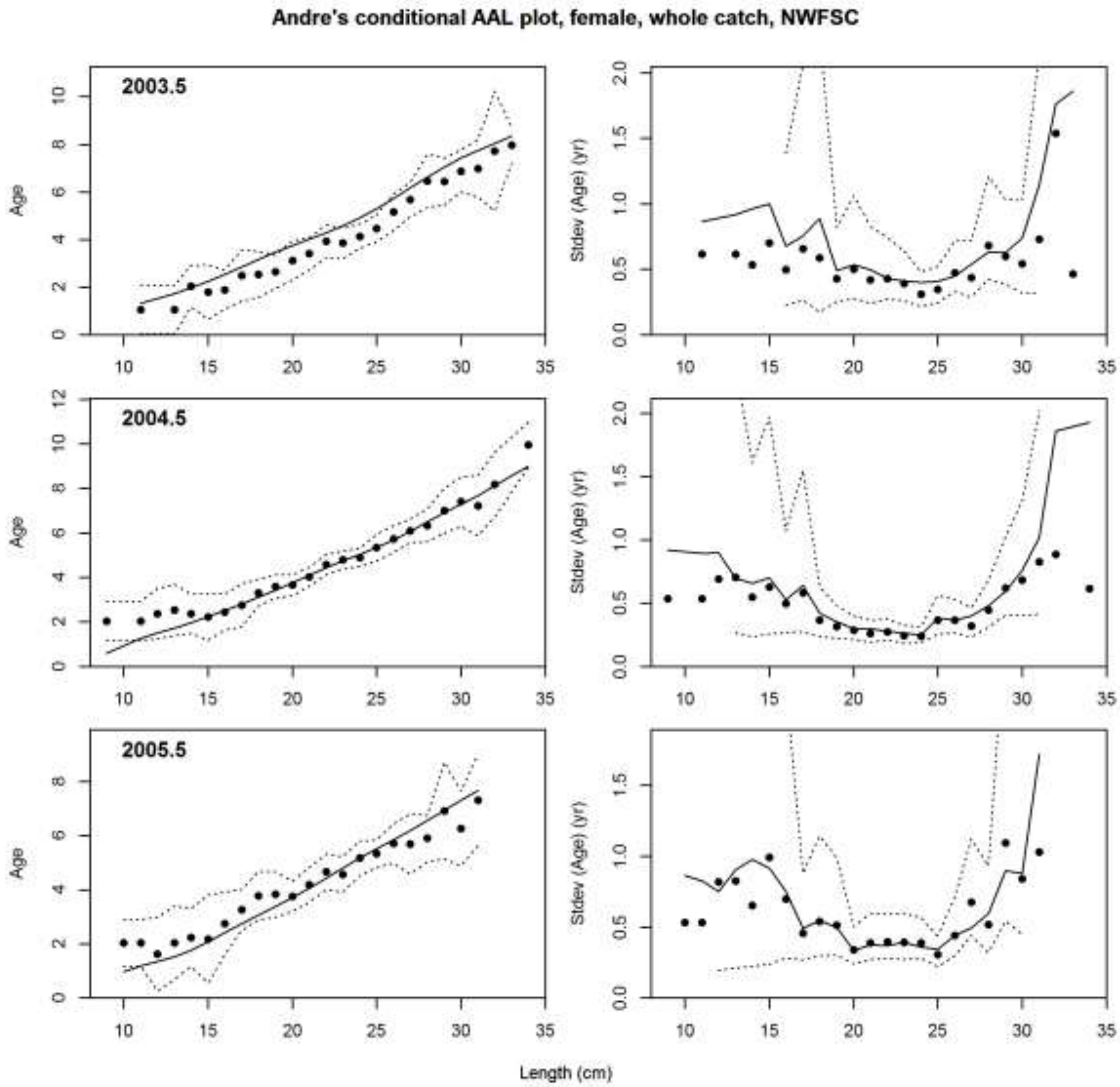



**Figure 105. Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 1 of 6).**

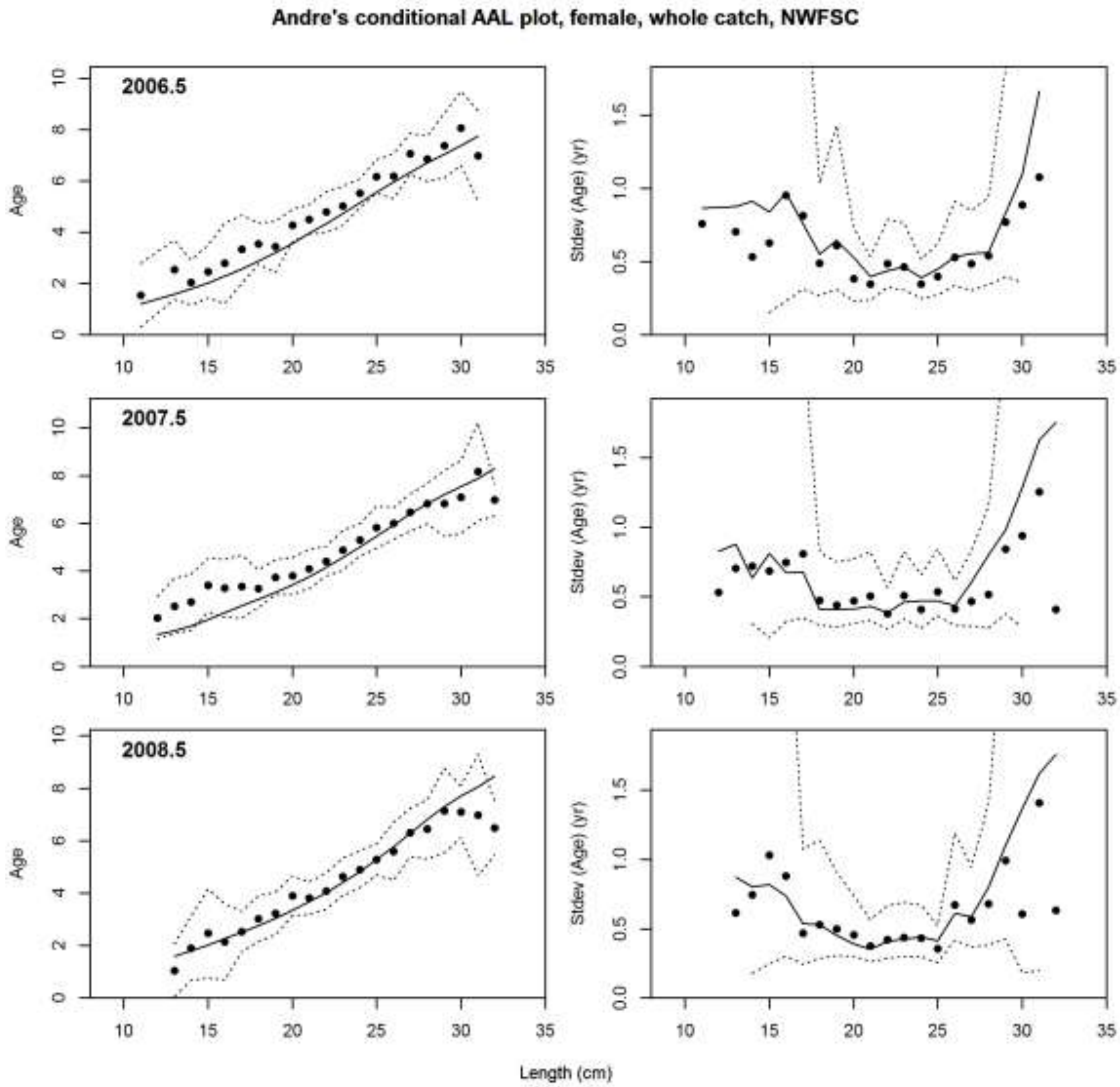



**Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 2 of 6).**

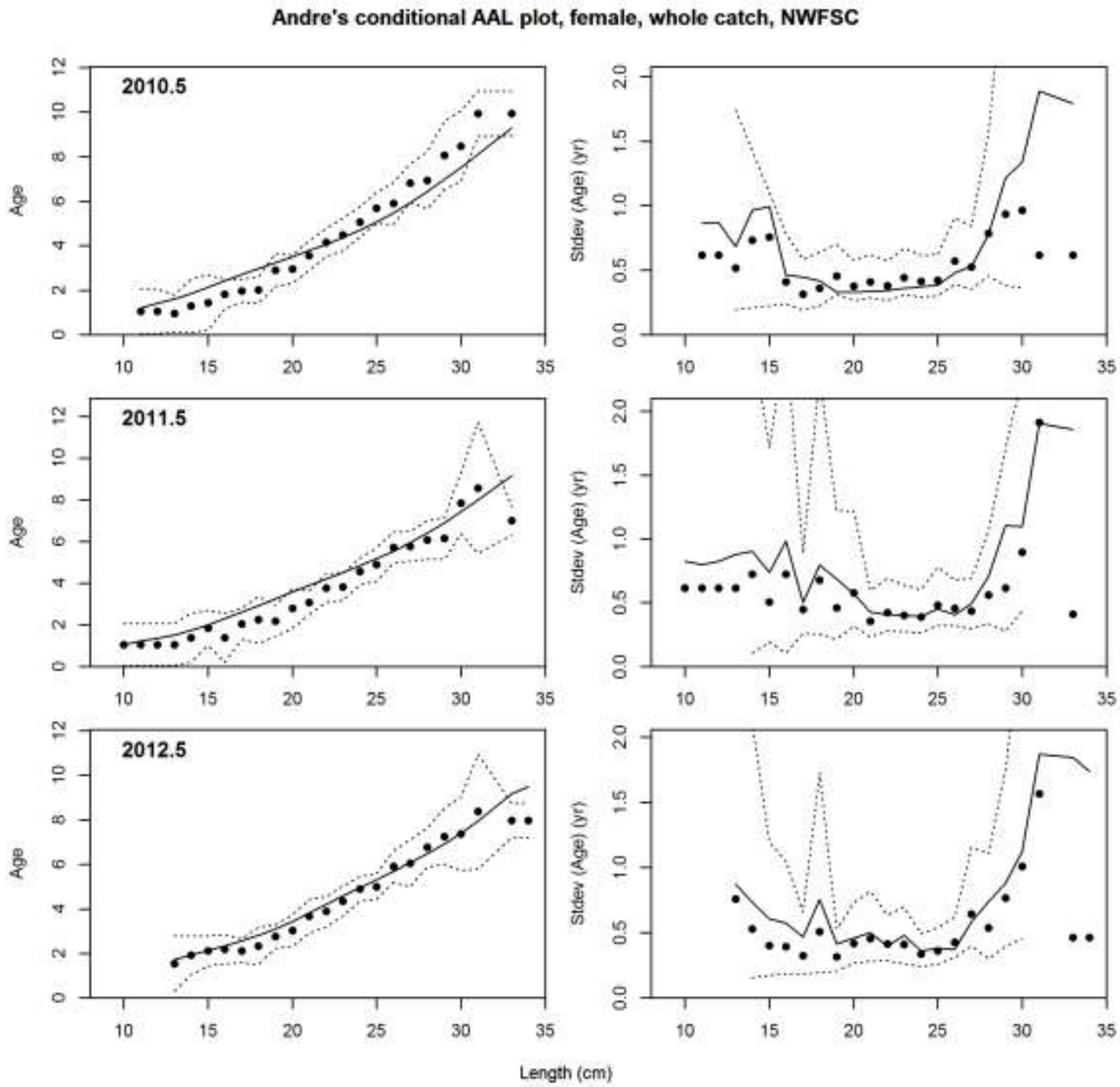



**Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 3 of 6).**

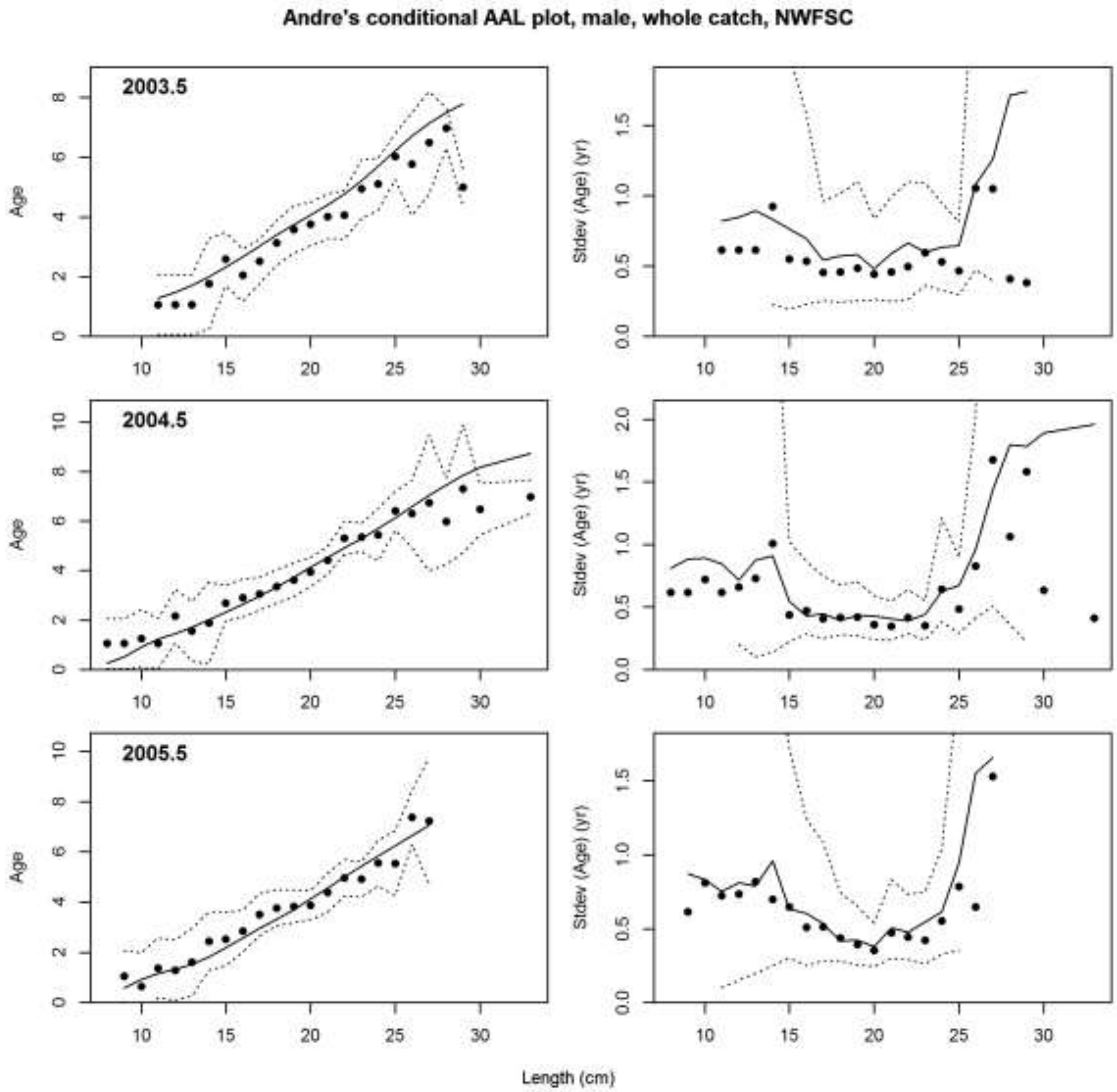



**Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 4 of 6).**

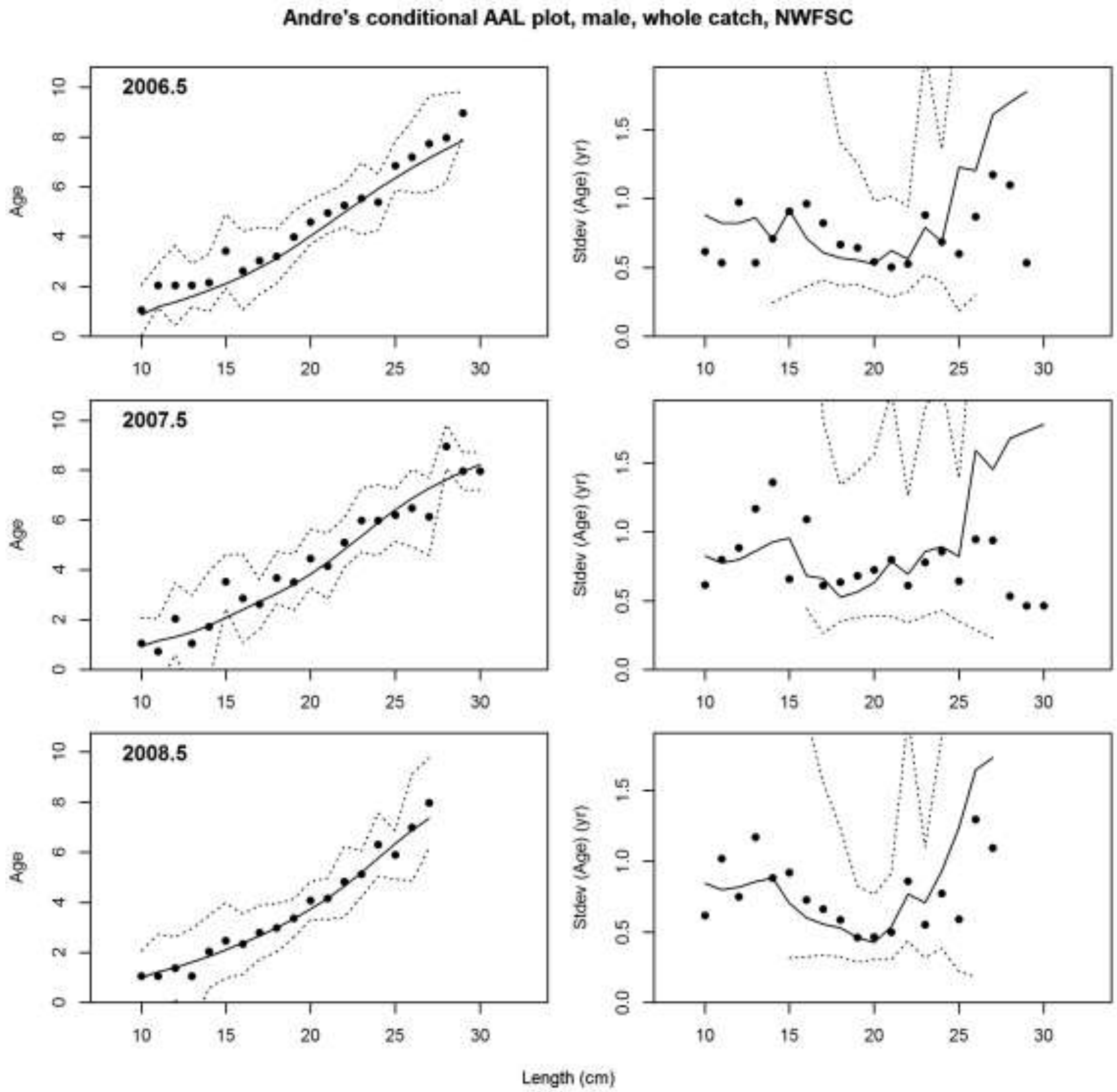



**Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 5 of 6).**

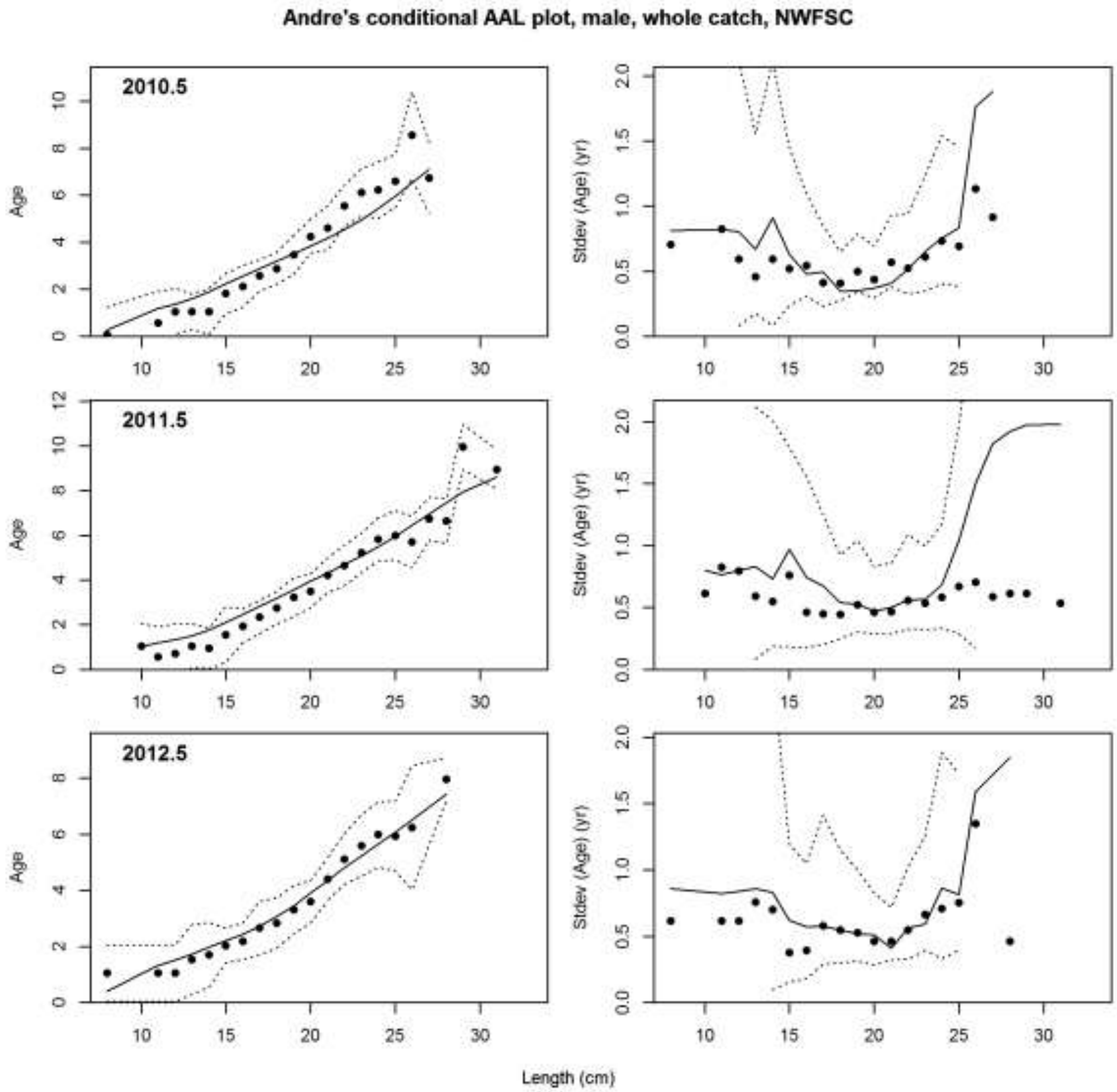



**Figure (continued). Conditional age-at-length and their standard deviations by year and by sex for the NWFSC survey data (page 6 of 6).**

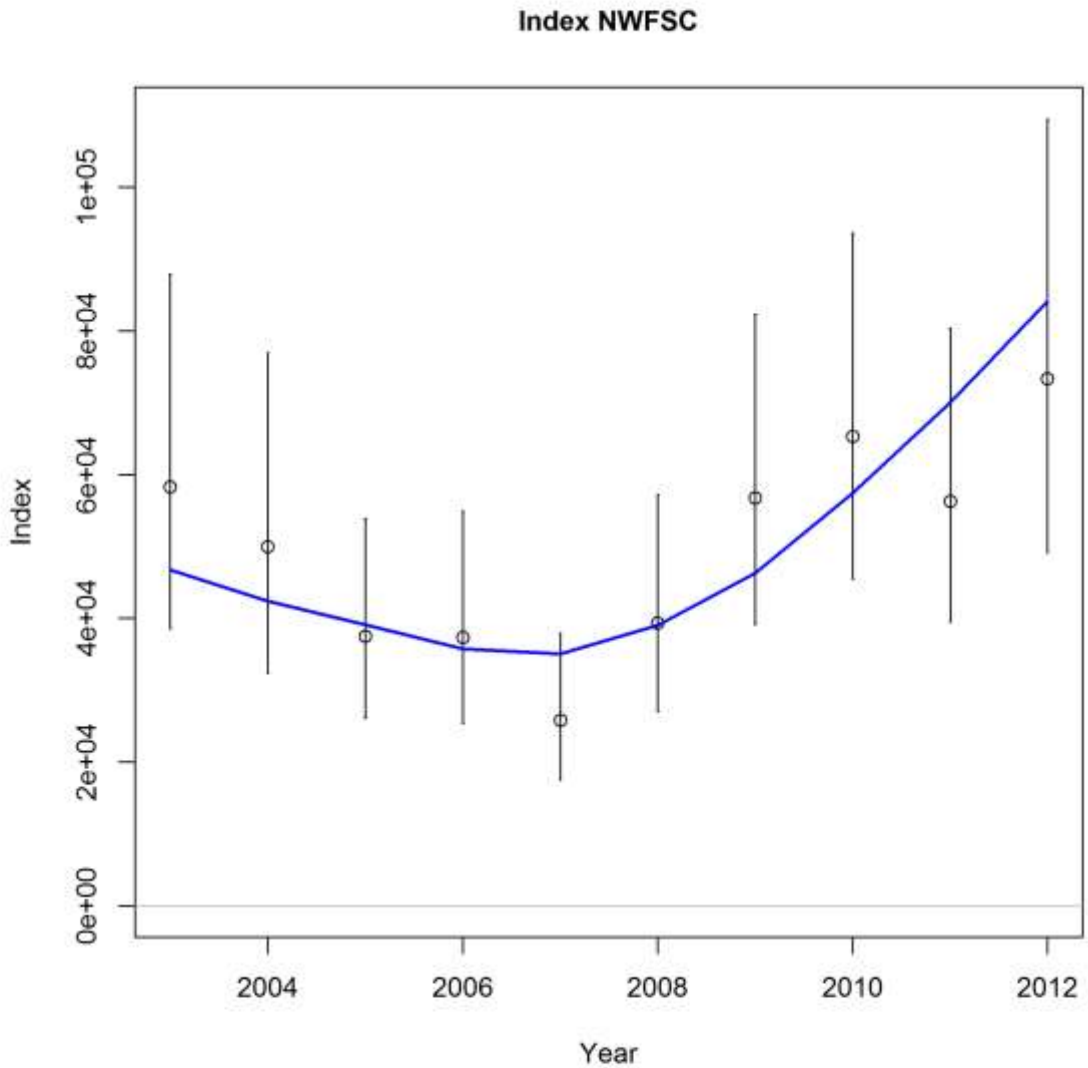



**Figure 106. Fits of base model outputs to the NWFSC survey.**

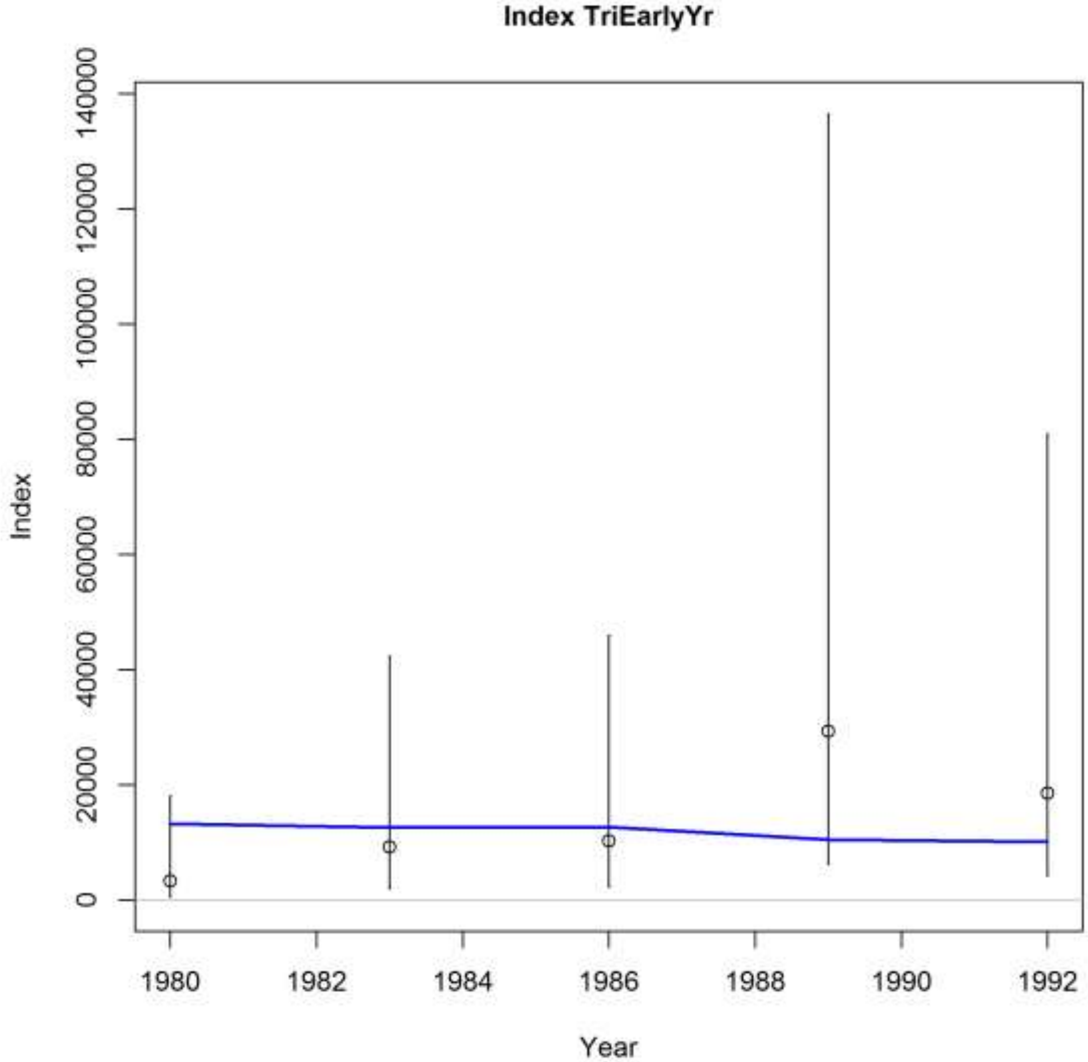



**Figure 107. Fits of base model outputs to the early period of the triennial trawl survey.**

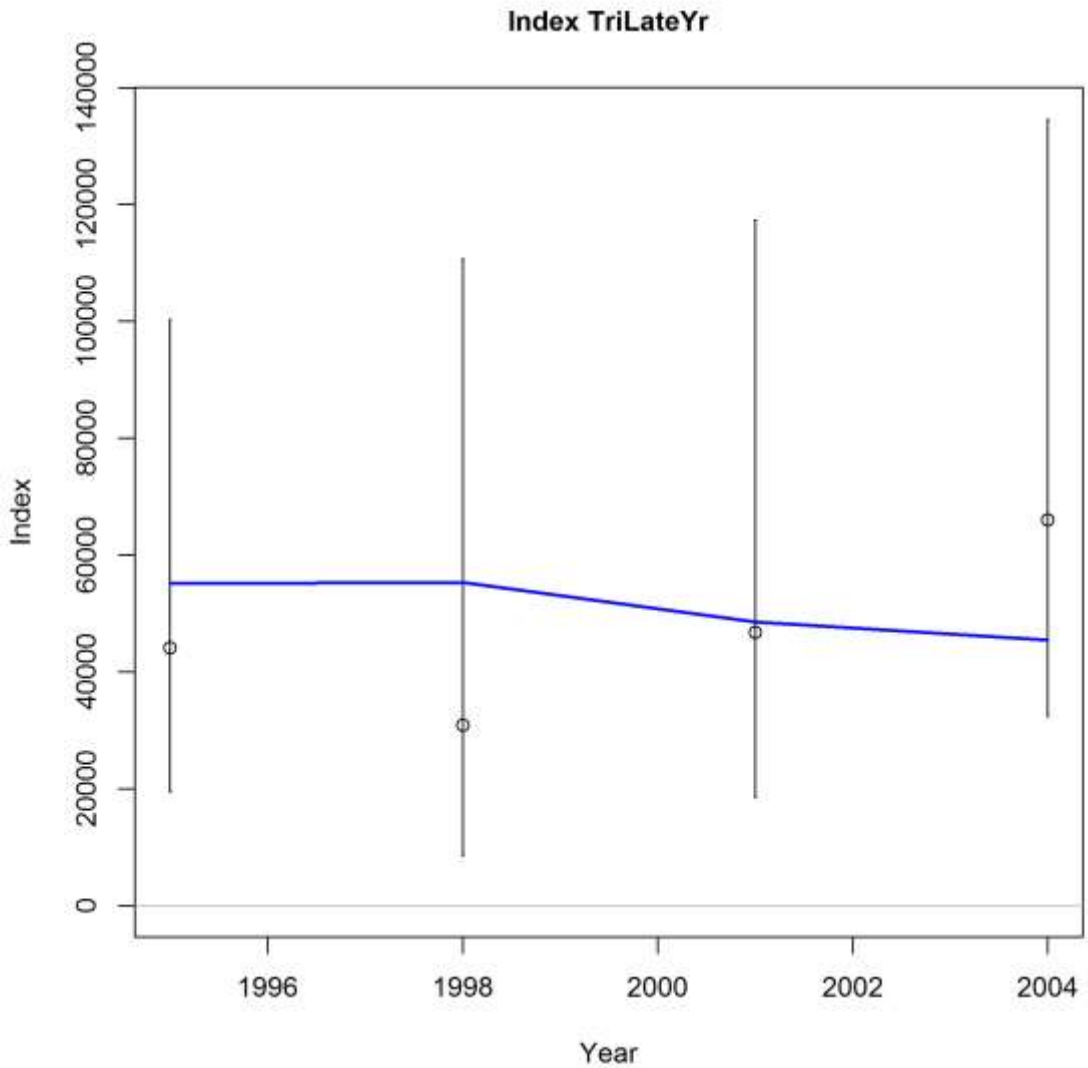



**Figure 108. Fits of base model outputs to the late period of the triennial trawl survey.**

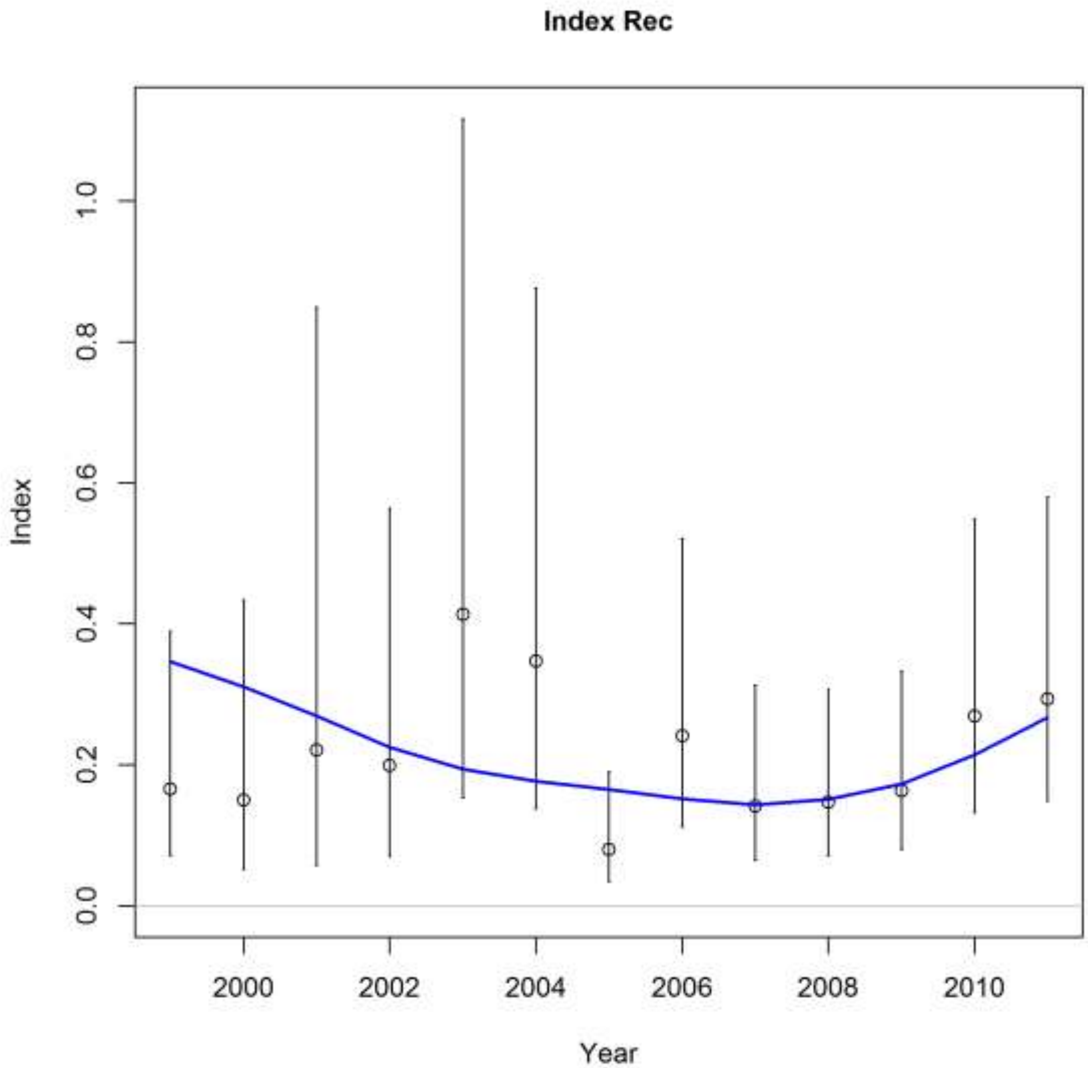



**Figure 109. Fits of base model outputs to the recreational survey.**

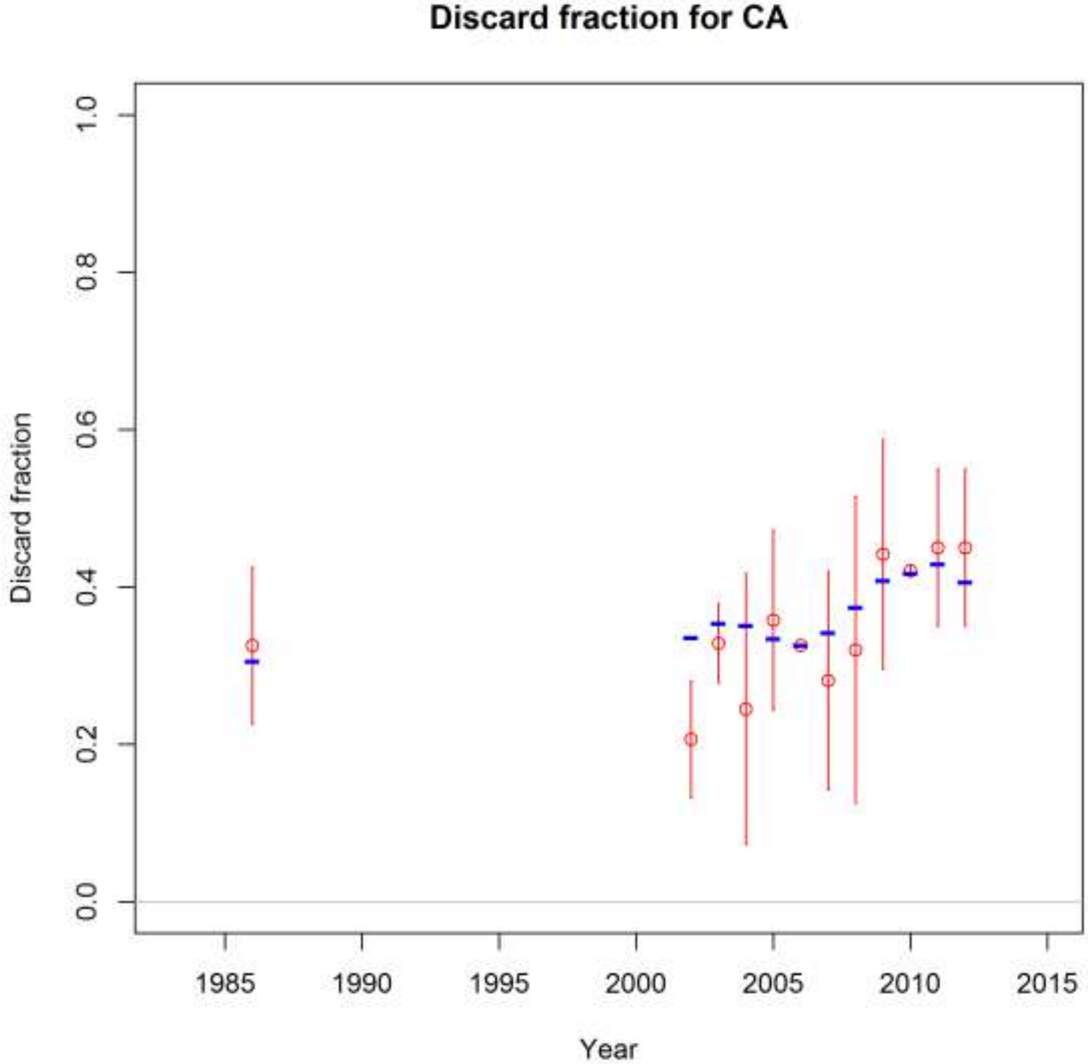



**Figure 110. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the CA fishery.**

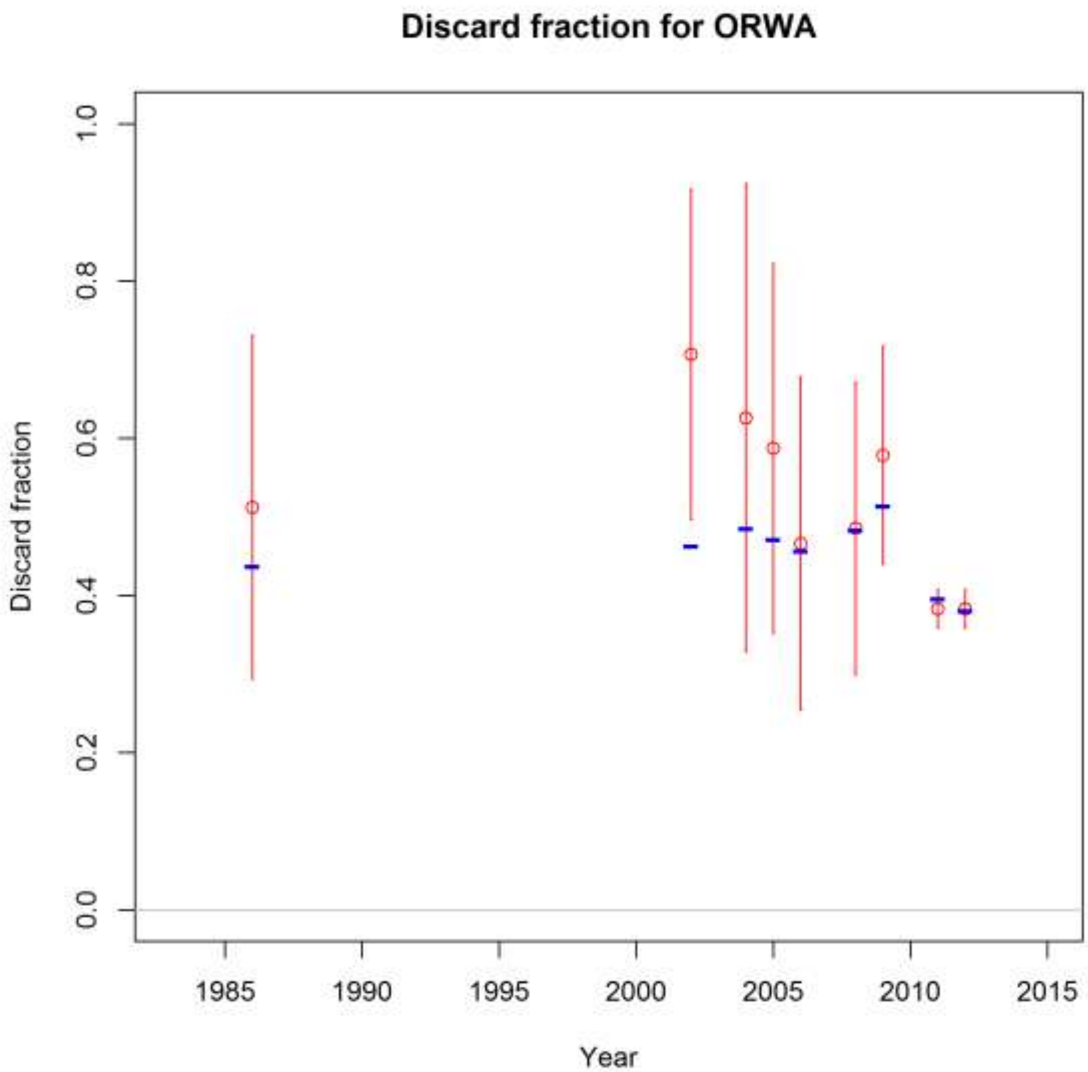



**Figure 111. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the OR/WA fishery.**

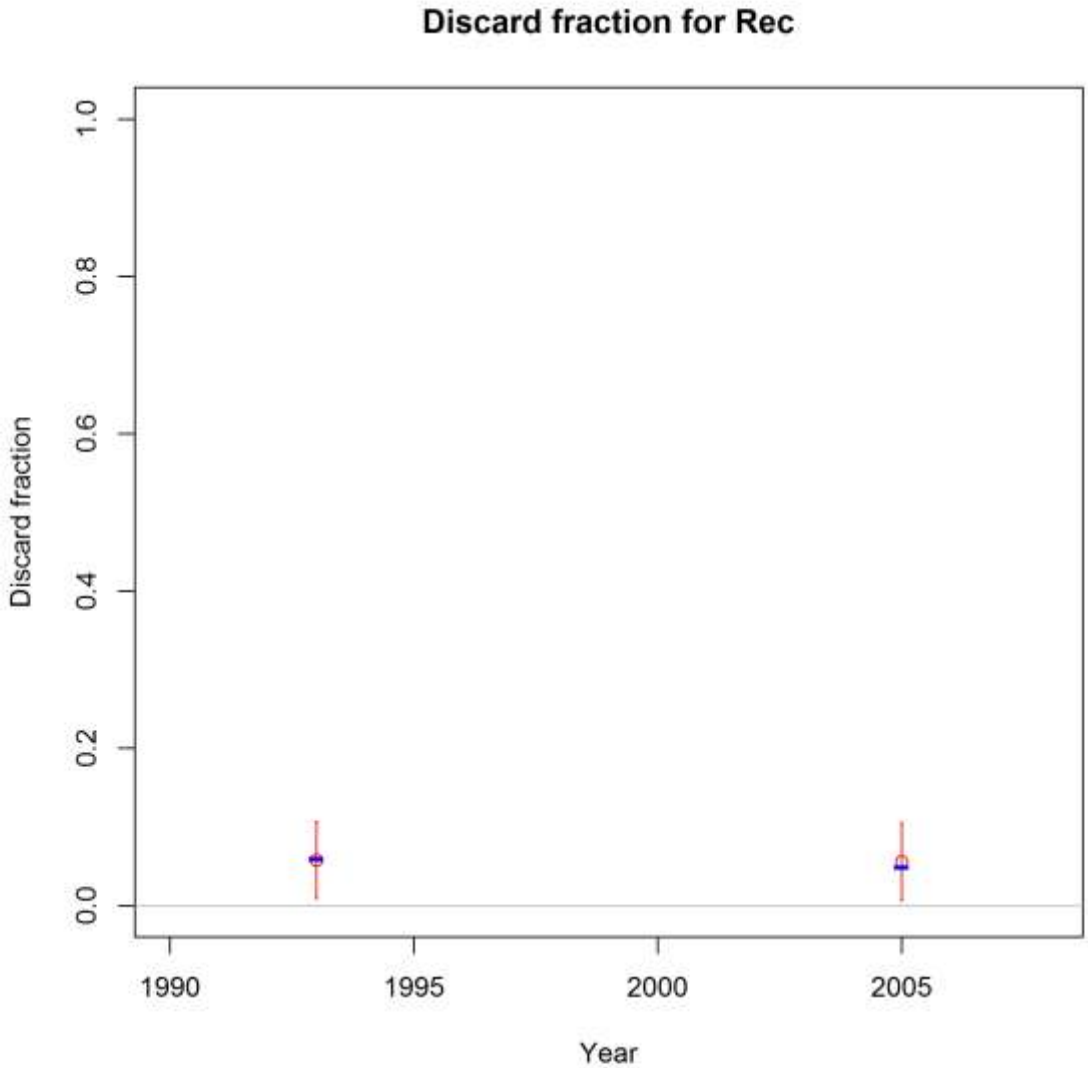



**Figure 112. Fits of base model estimates of discard ratios (blue) to inputted values and standard deviations (red circle and line) for the recreational fishery.**

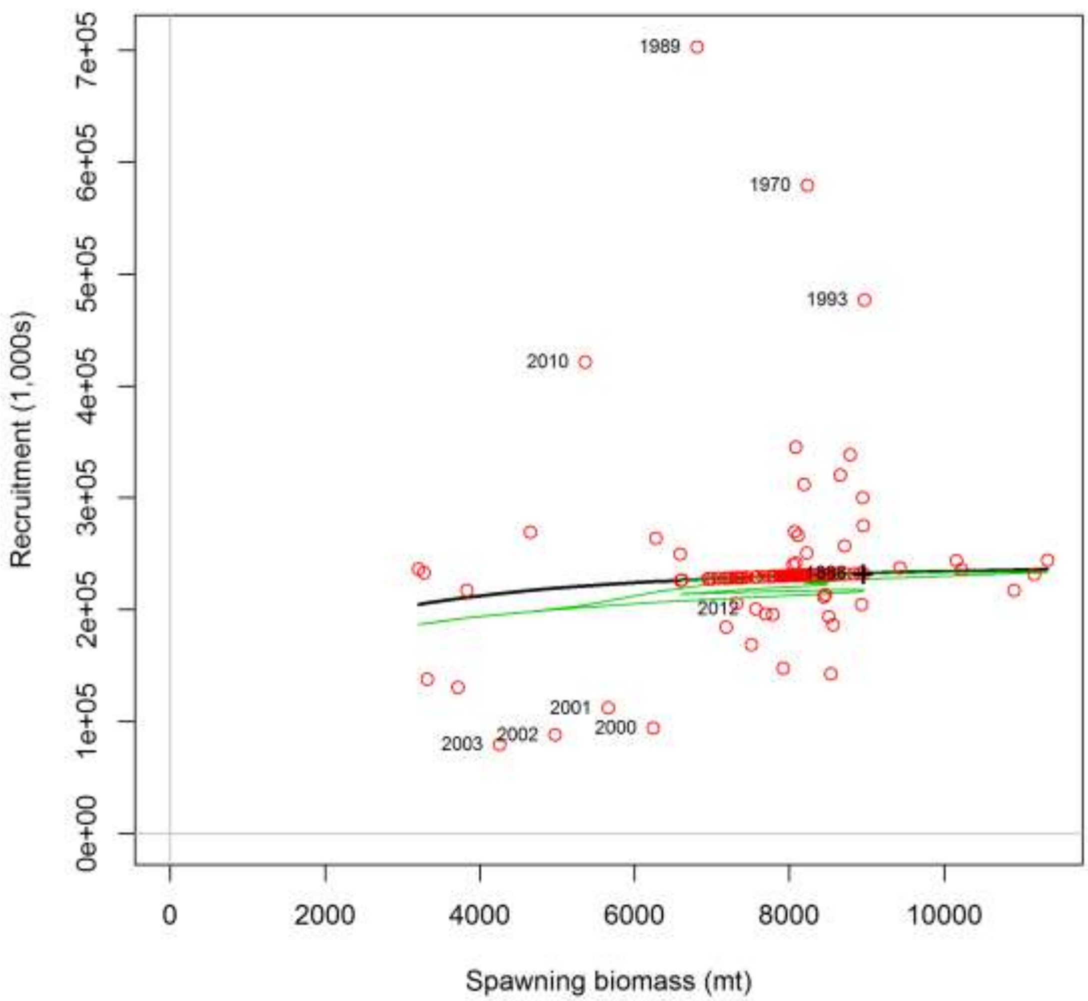



**Figure 113. Estimated stock-recruit function (black line) with predicted annual recruitments (red circle), and bias-corrected recruitment expectations (green line).**

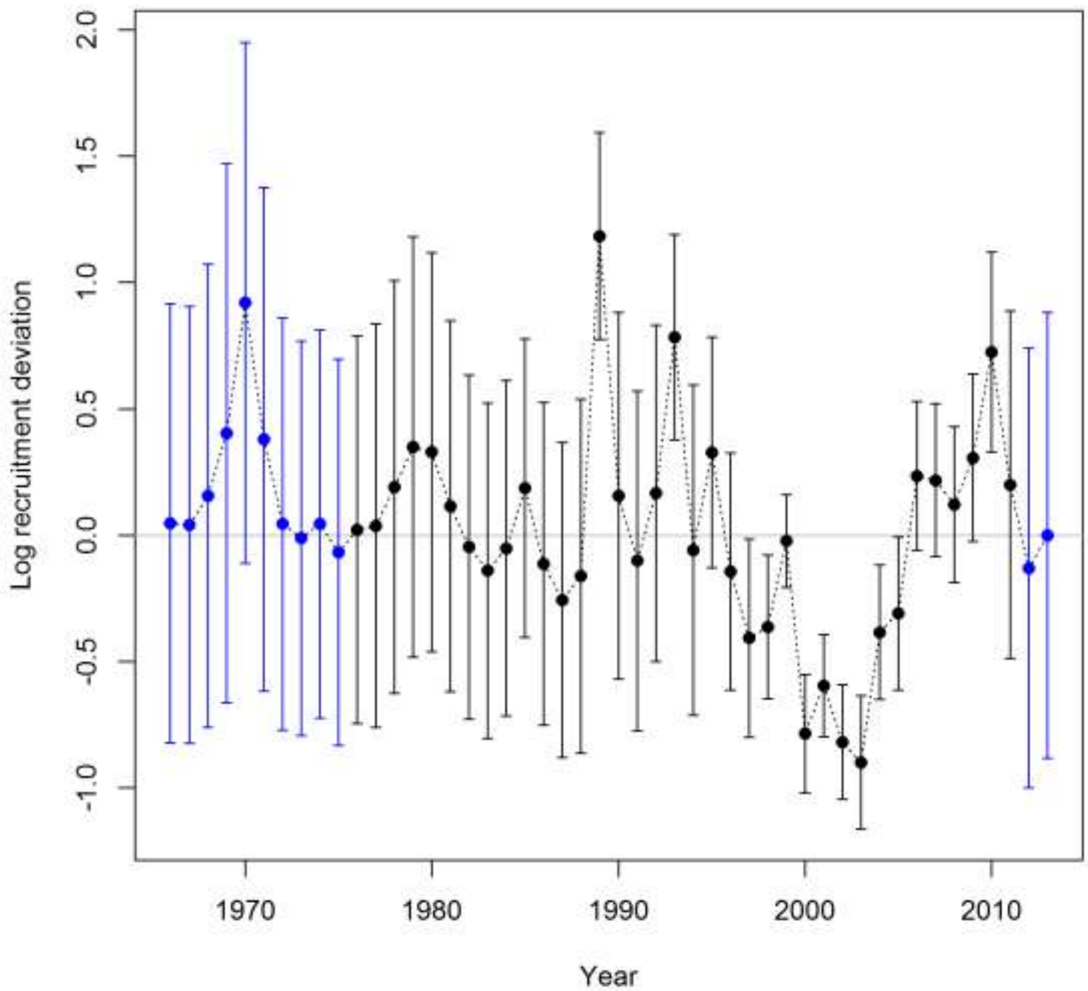



**Figure 114. Estimated annual recruitment deviations and their standard deviations from the base model. Black dots and bars were for the main recruitment period (1980 to 2011), and blue dots and lines were for the early and late periods, respectively.**

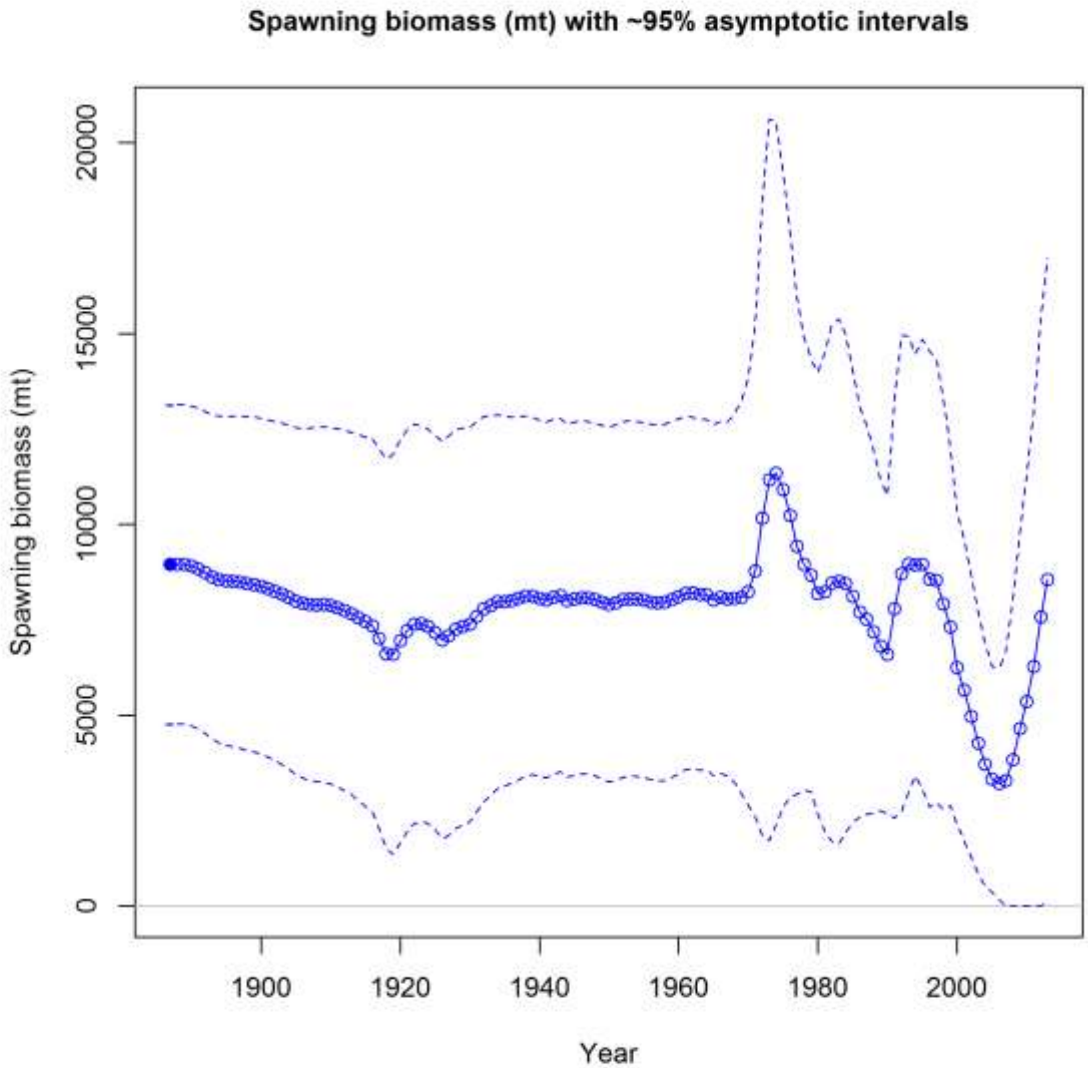



**Figure 115. Estimated time series of annual spawning biomass from the base model (open circle and solid line) with approximate asymptotic 95% confidence intervals (dashed lines).**

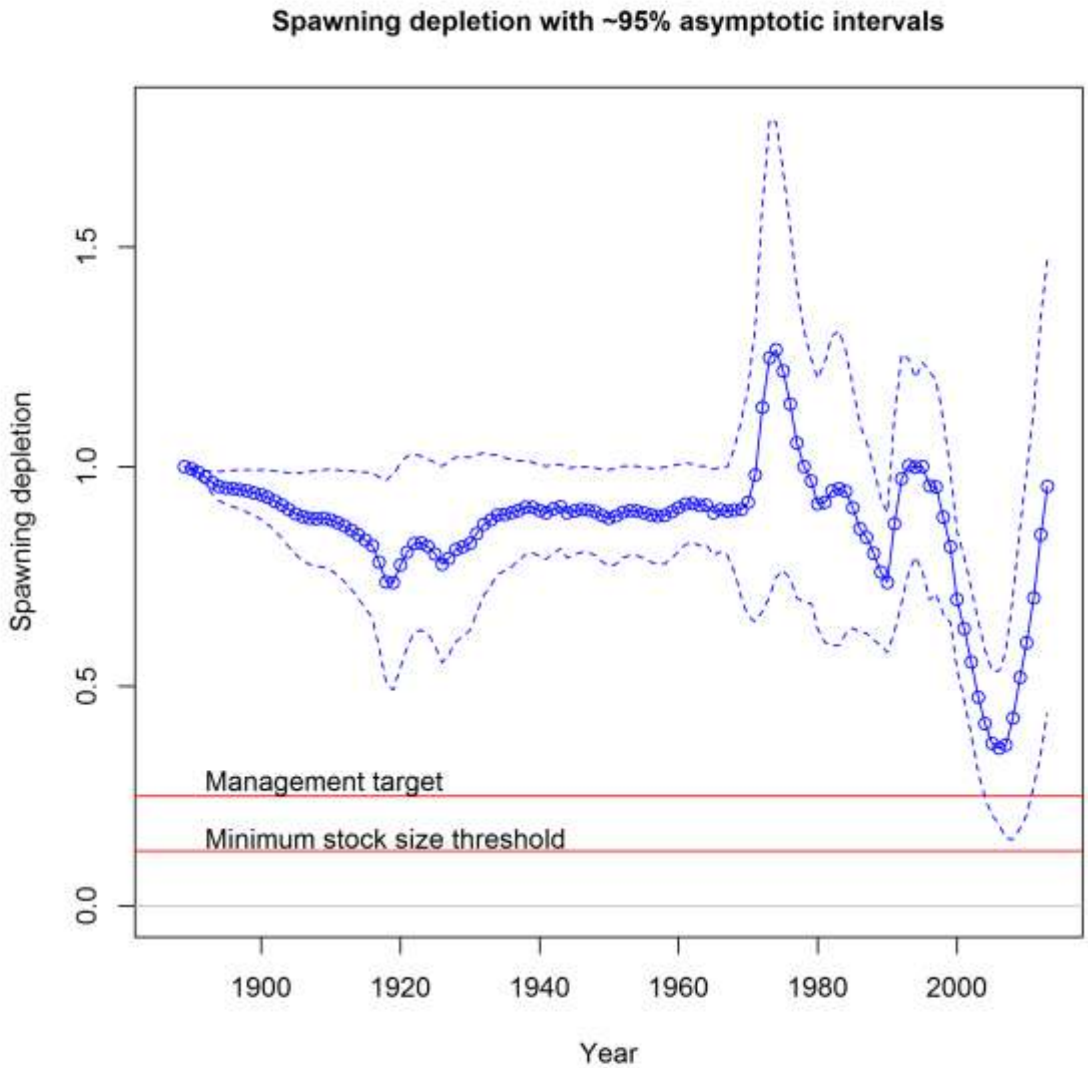



**Figure 116. Estimated time series of annual stock depletion (open circle and solid line) from the base model with approximate asymptotic 95% confidence intervals (dashed line). Levels of management target (0.25) and minimum stock threshold (0.125) are also shown (solid red lines).**

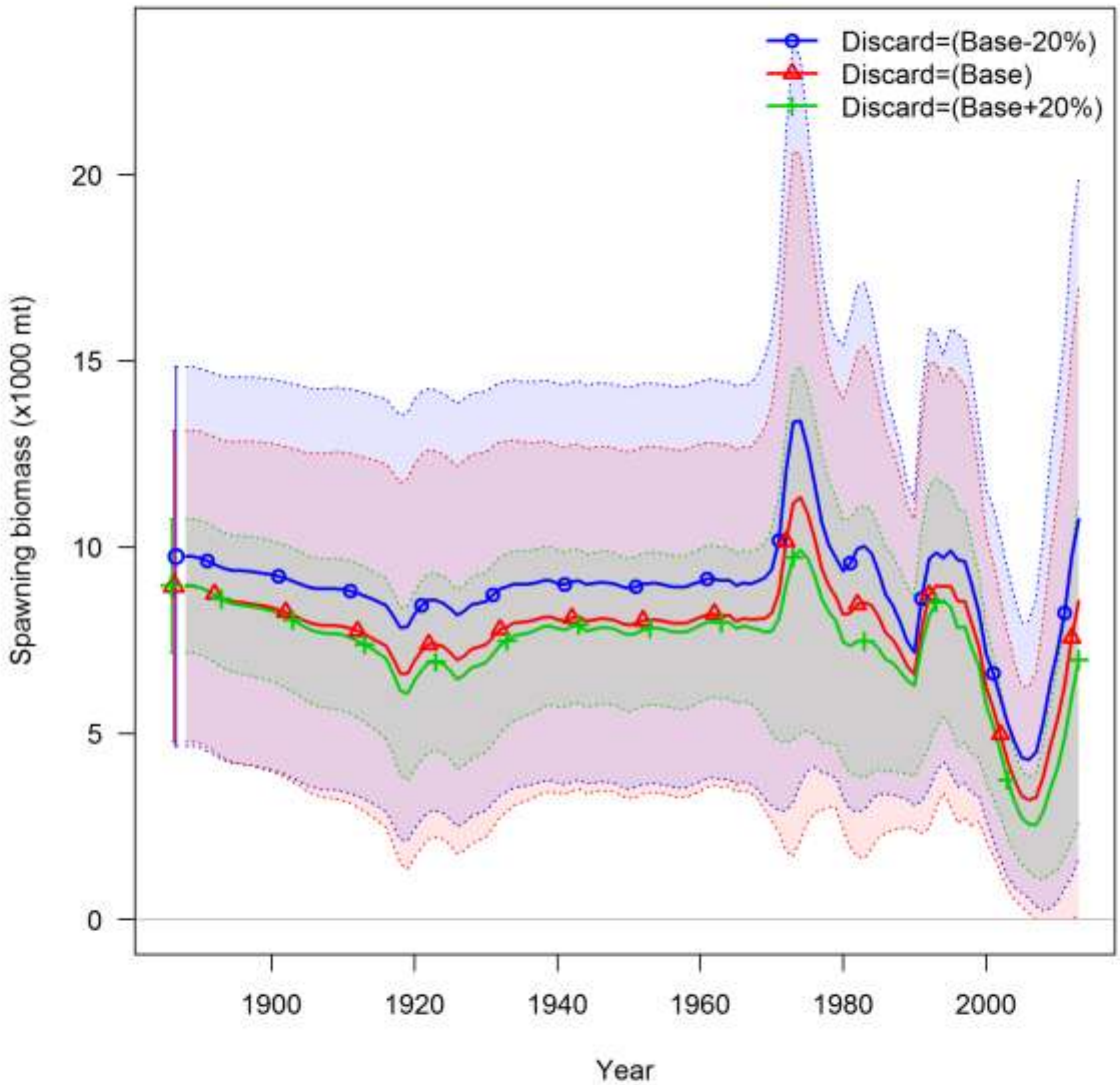



**Figure 117. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on inputted fishery discard rates. Outputs from three model runs were compared: (1) Discard rates reduced by 20% (blue circle and line); (2) Discard rates used in the base model (red circle and line); and (3) Discard rates increased by 20% (green circle and line).**

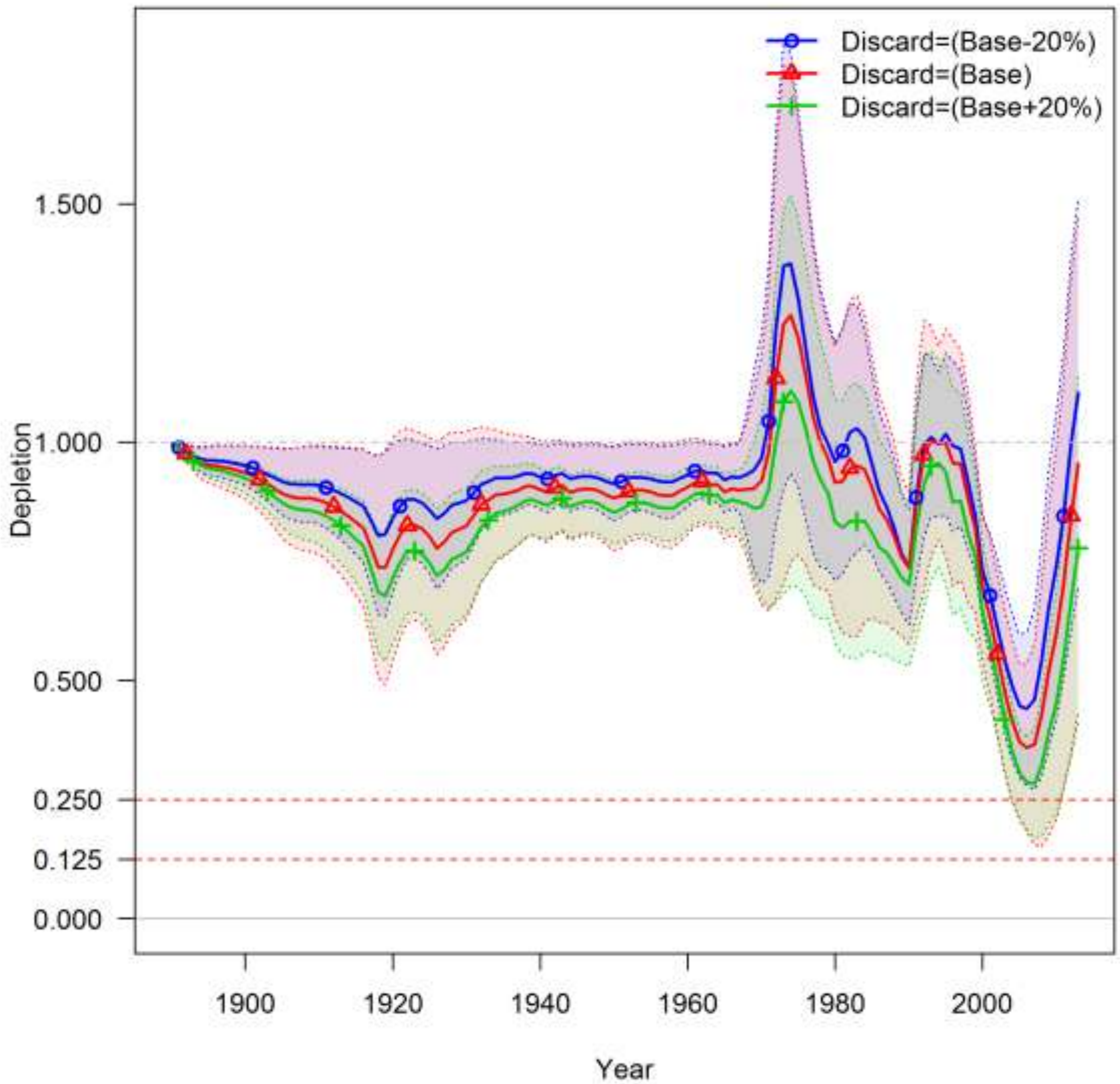



**Figure 118. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on inputted fishery discard rates. Outputs from three model runs were compared: (1) Discard rates reduced by 20% (blue circle and line); (2) Discard rates used in the base model (red circle and line); and (3) Discard rates increased by 20% (green circle and line).**

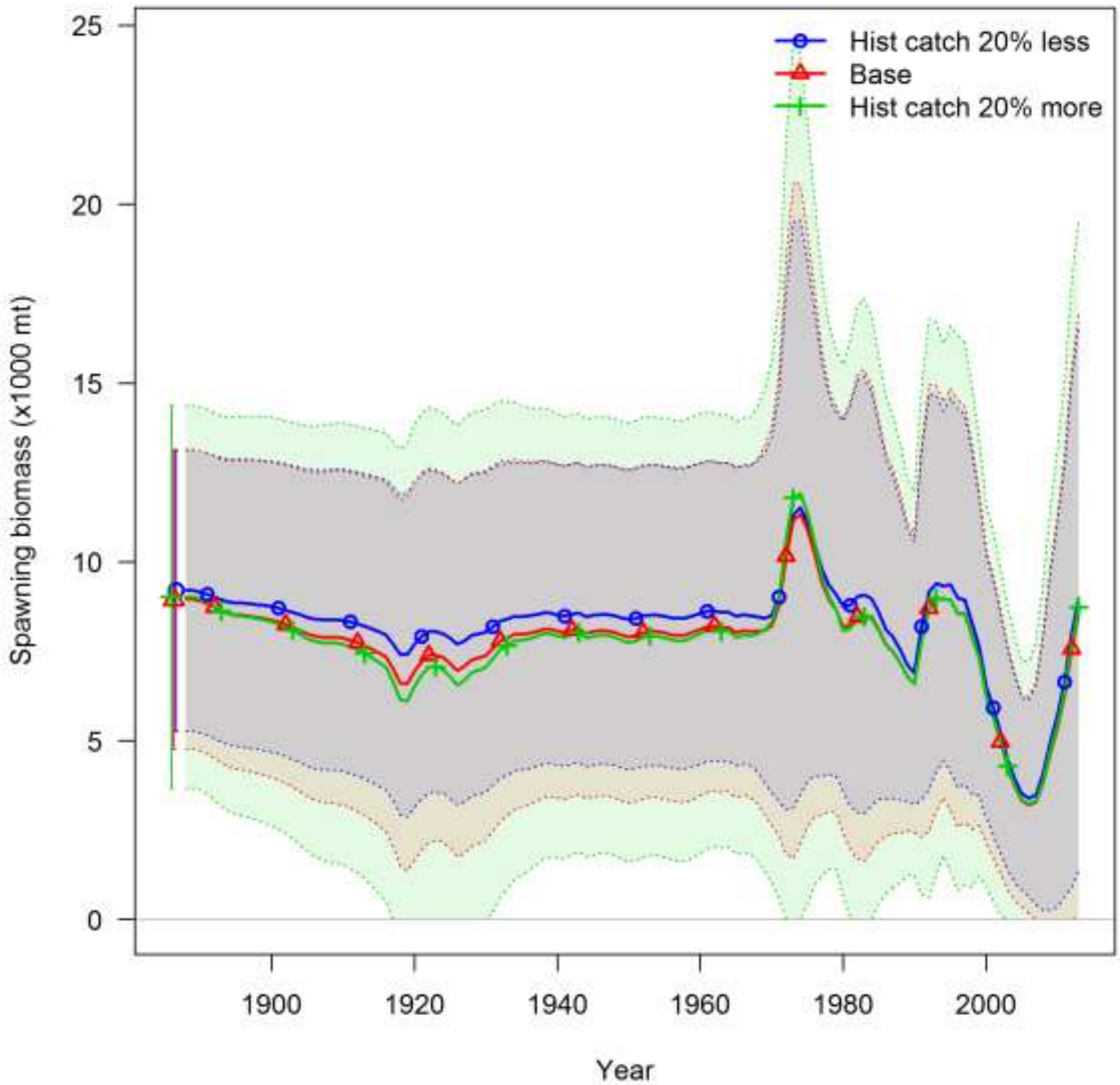



**Figure 119. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on three levels of historical catch data. Historical catch data were referred to all catch data before 1980.**

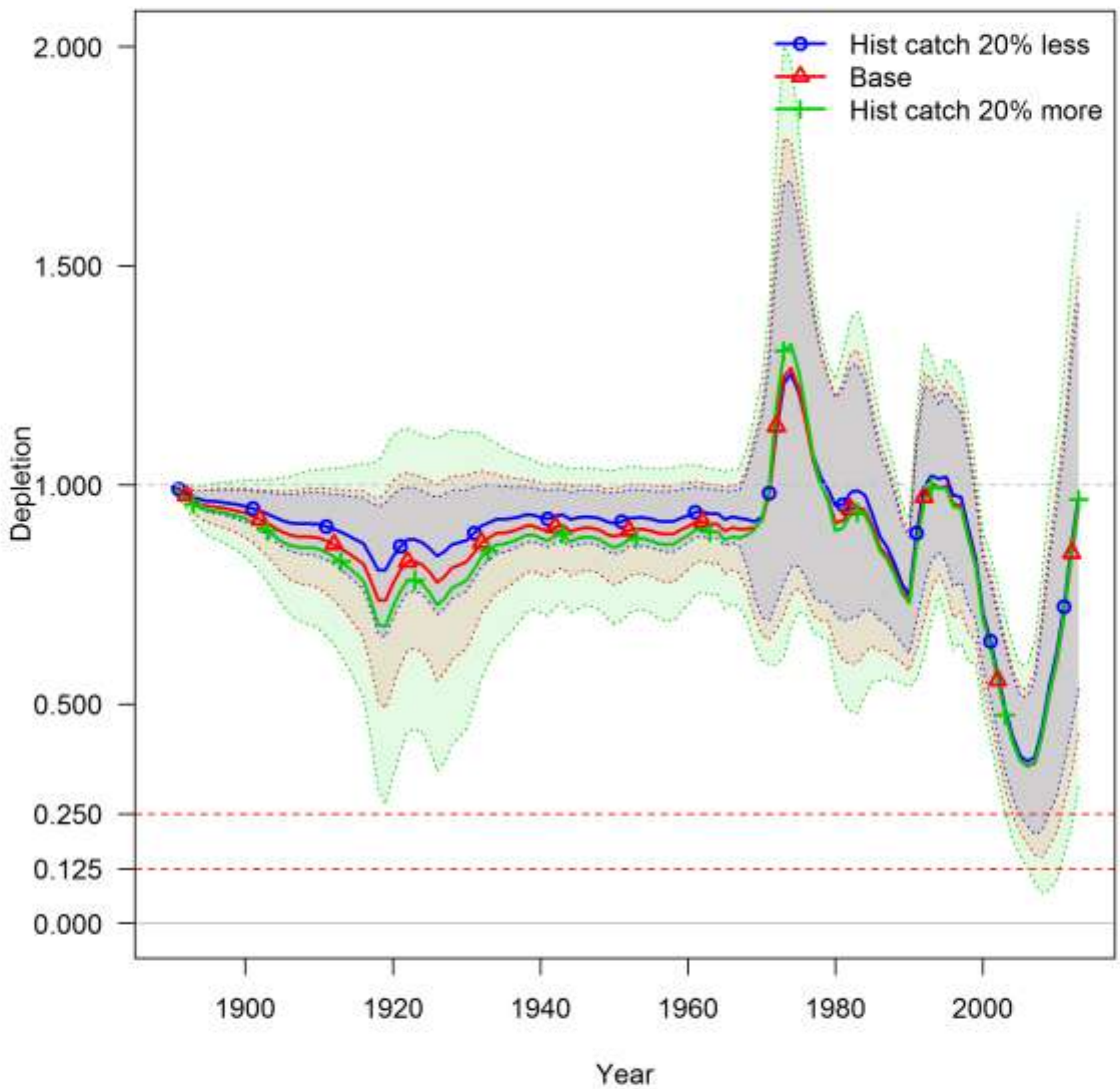



**Figure 120. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three levels of historical catch data. Historical catch data were referred to all catch data before 1980.**

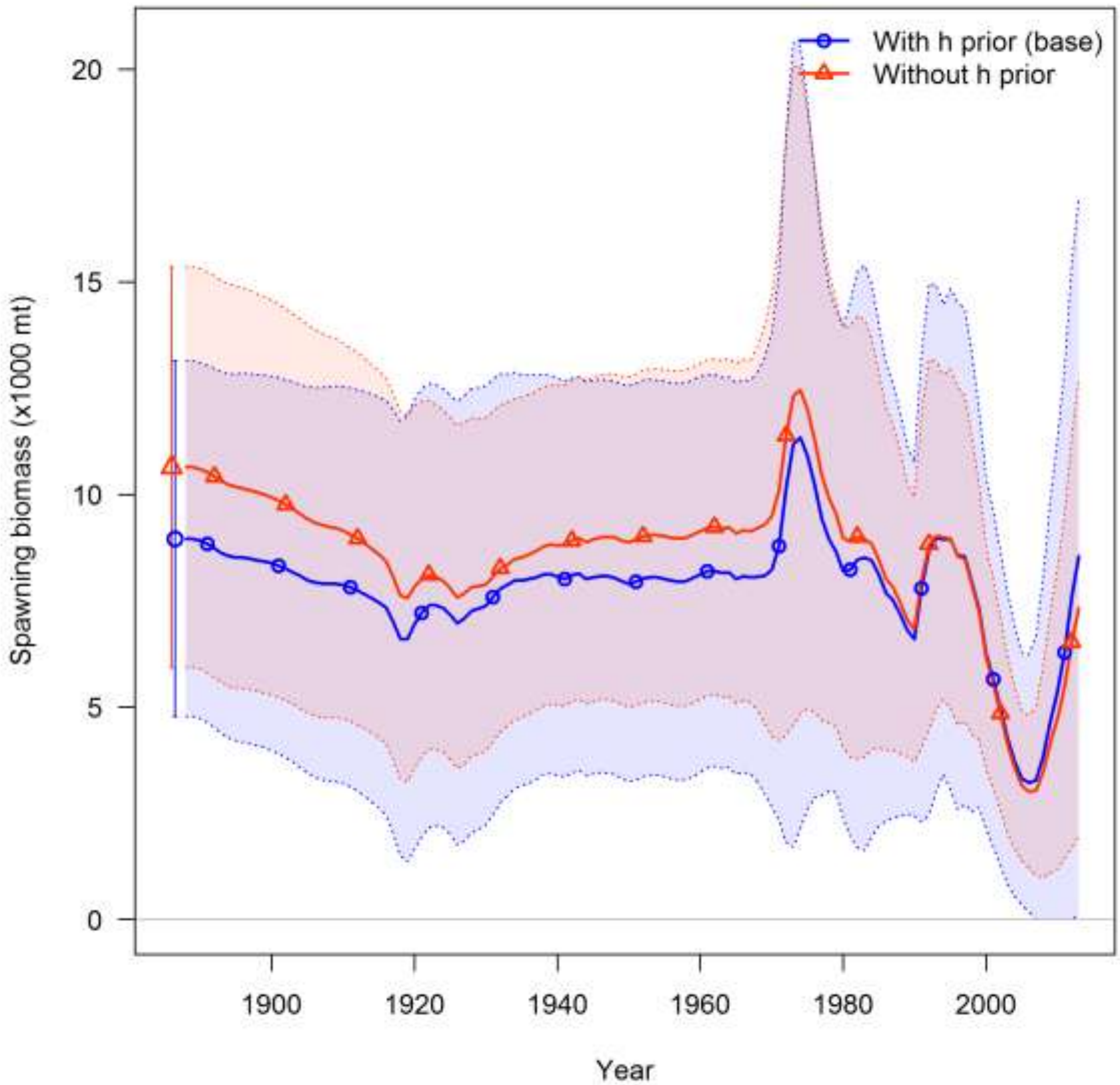



**Figure 121. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on with and without steepness (*h*) prior.**

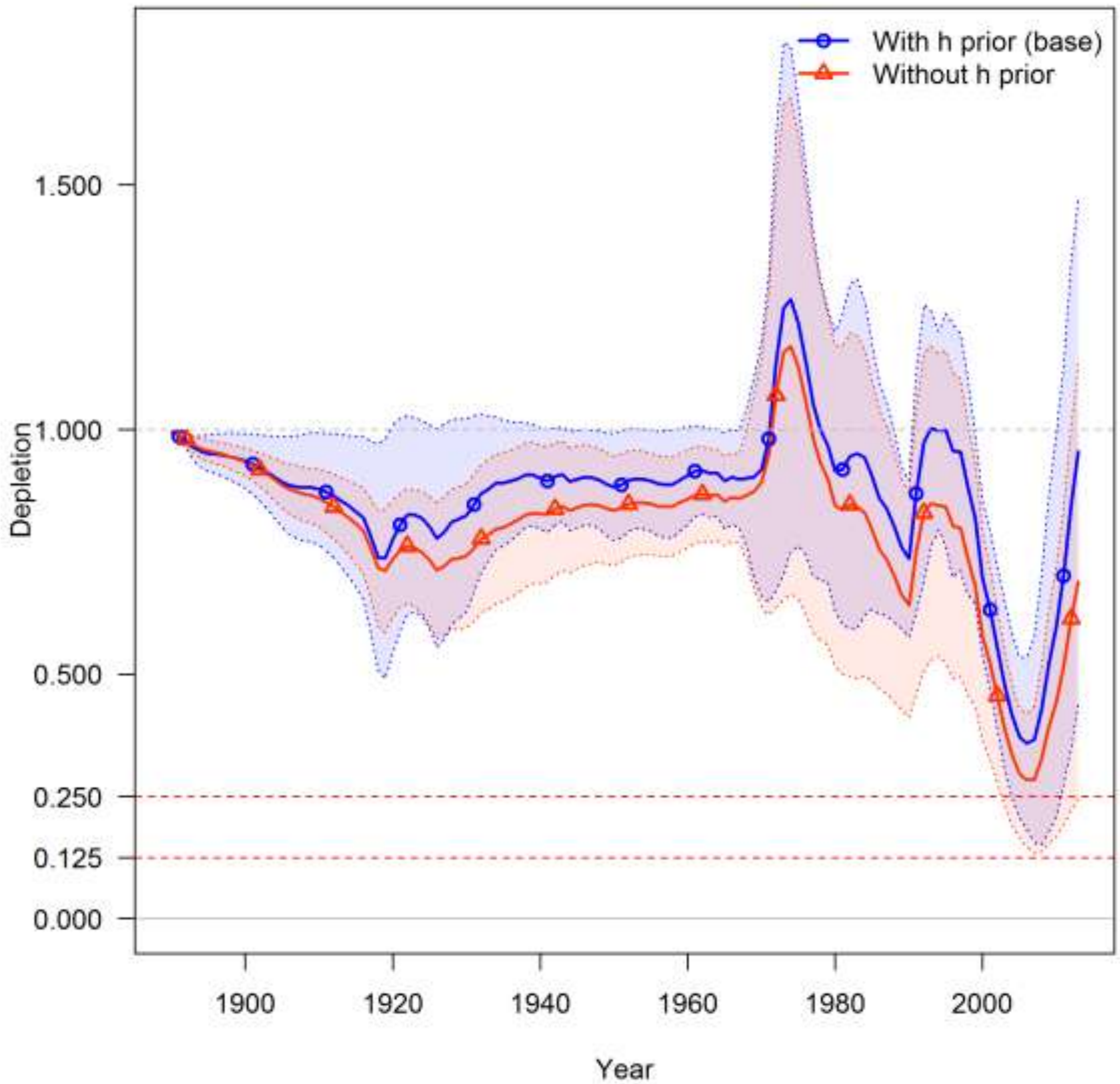



**Figure 122. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on with and without steepness (*h*) prior.**

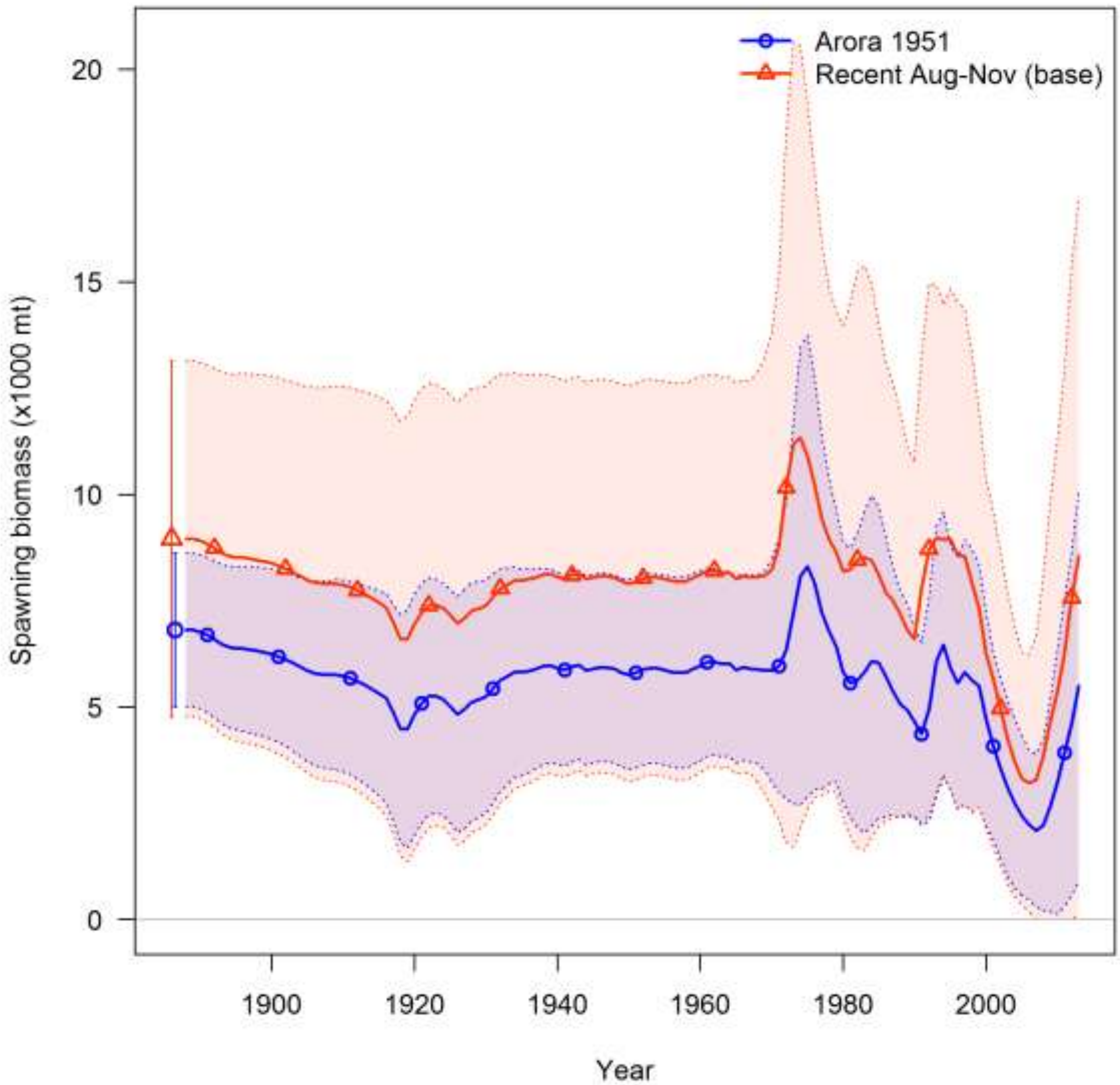



**Figure 123. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.**

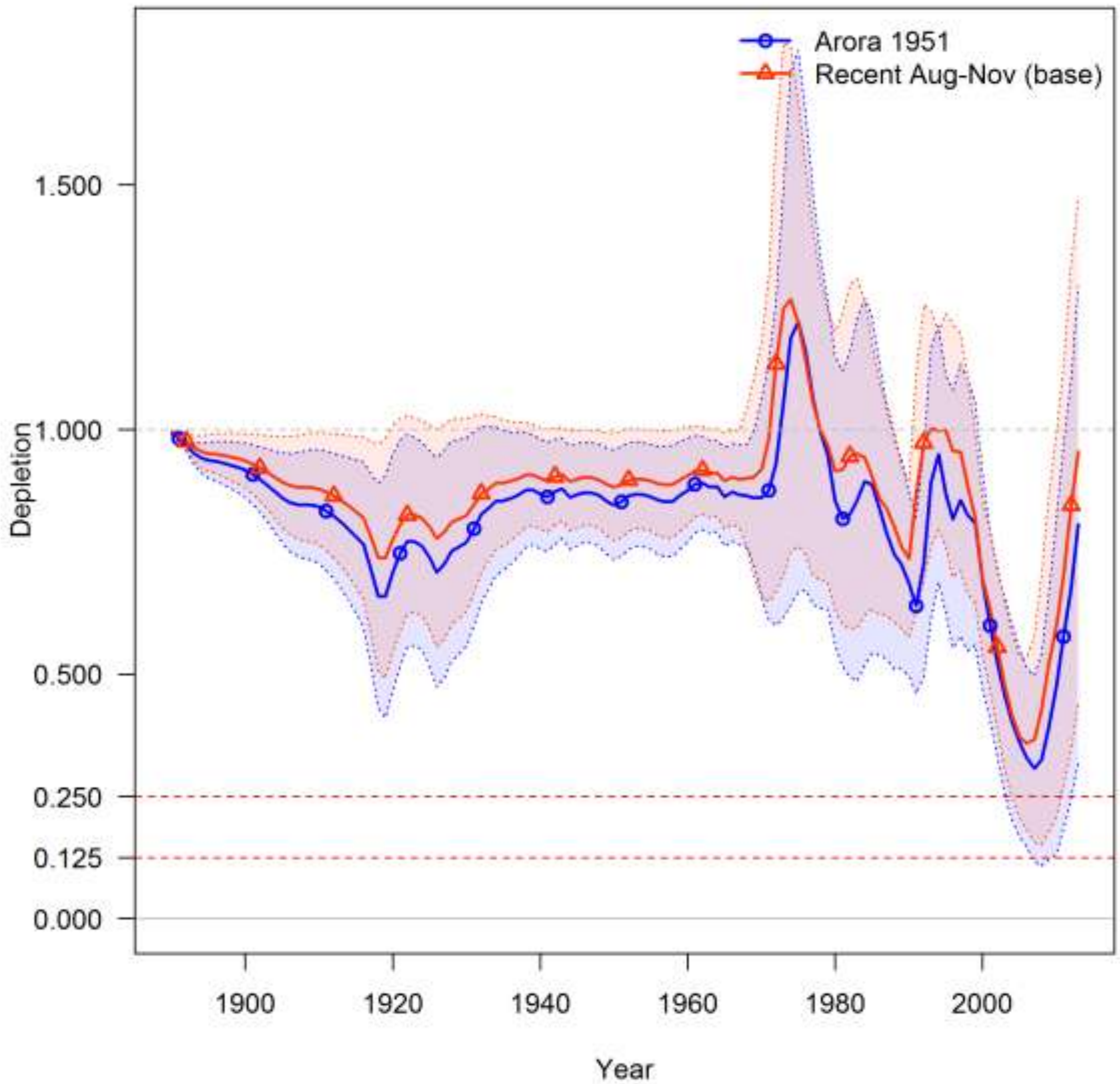



**Figure 124. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.**

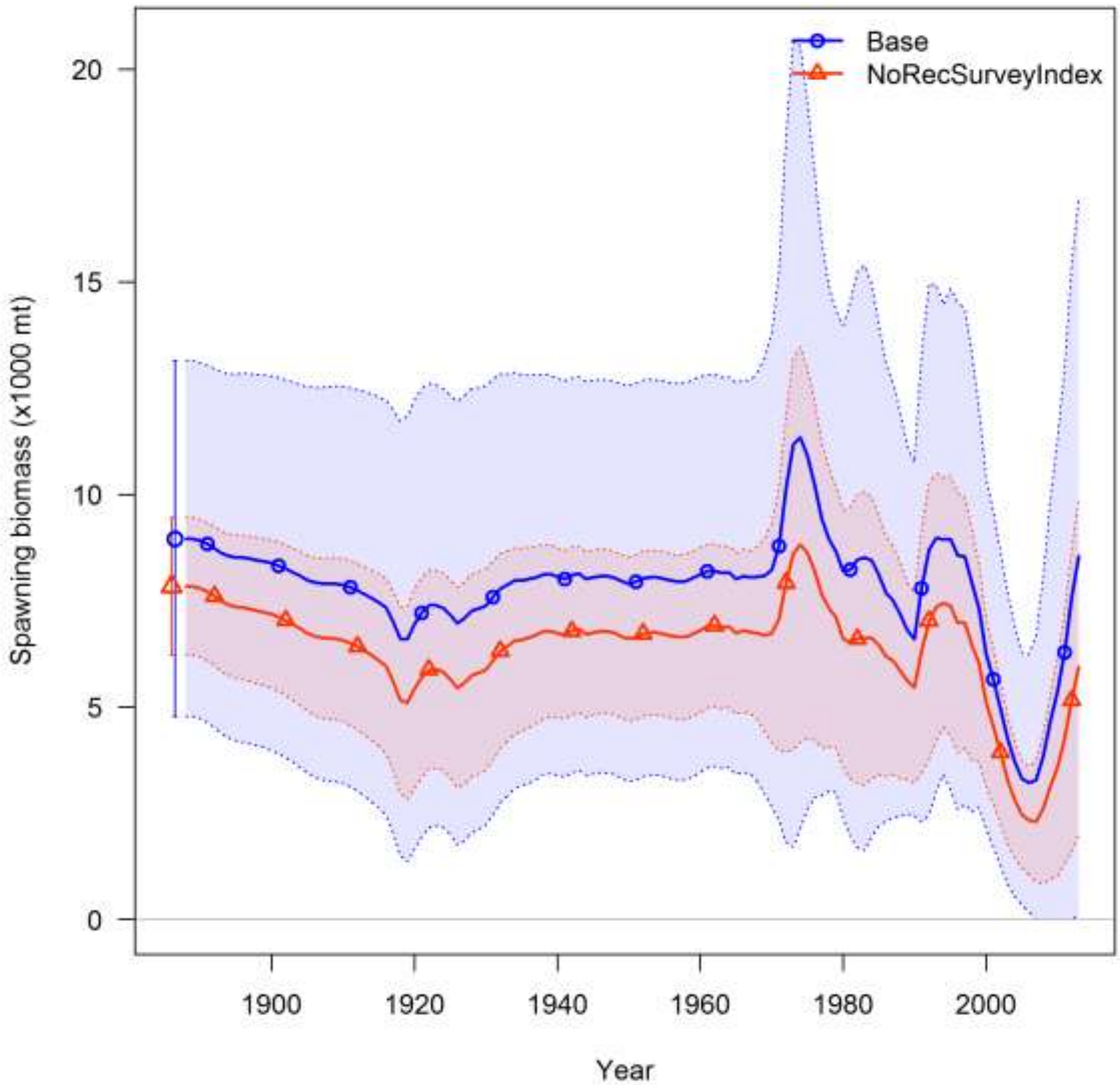



**Figure 125. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on two maturity schedules.**

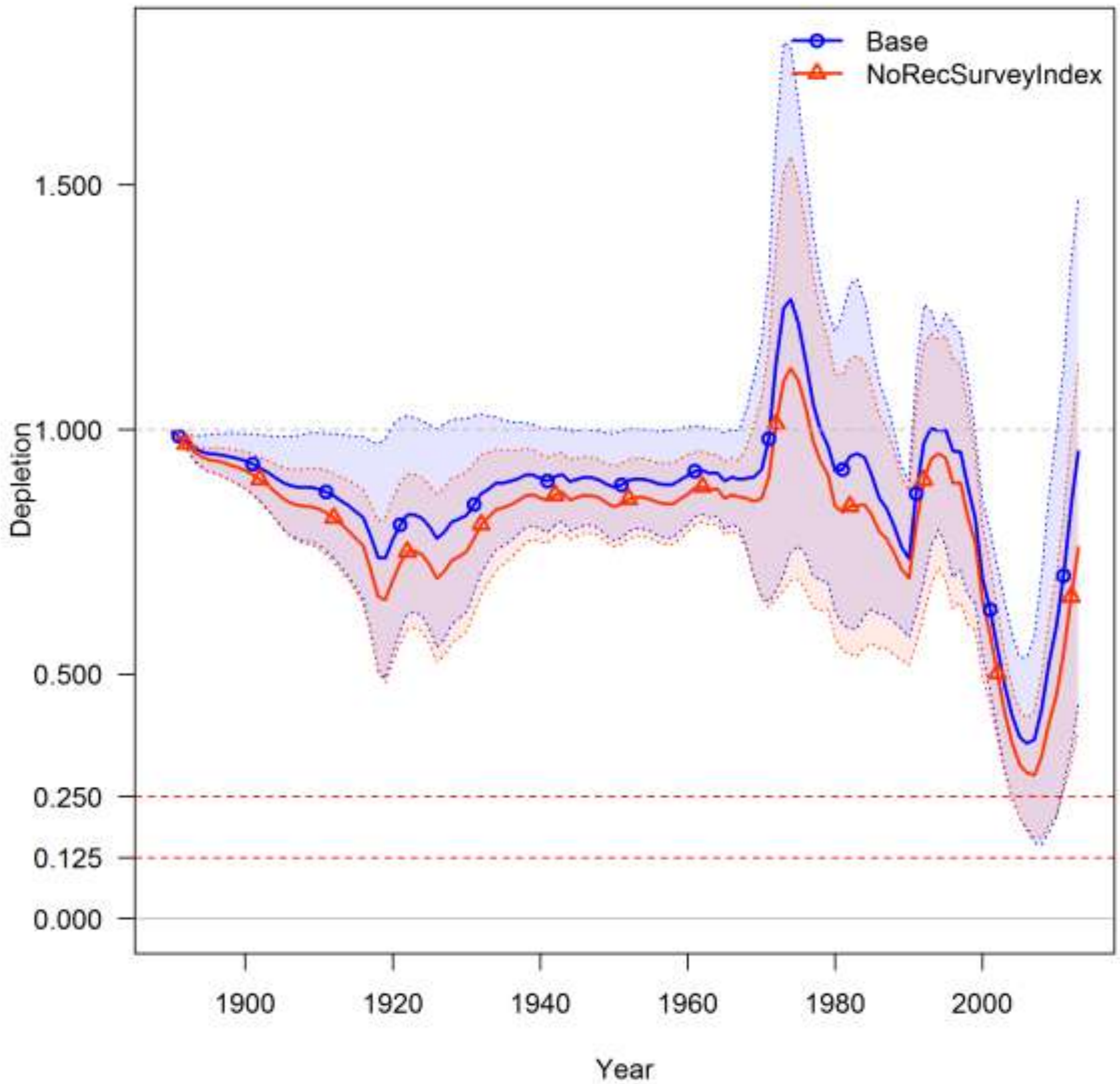



**Figure 126. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on two maturity schedules.**

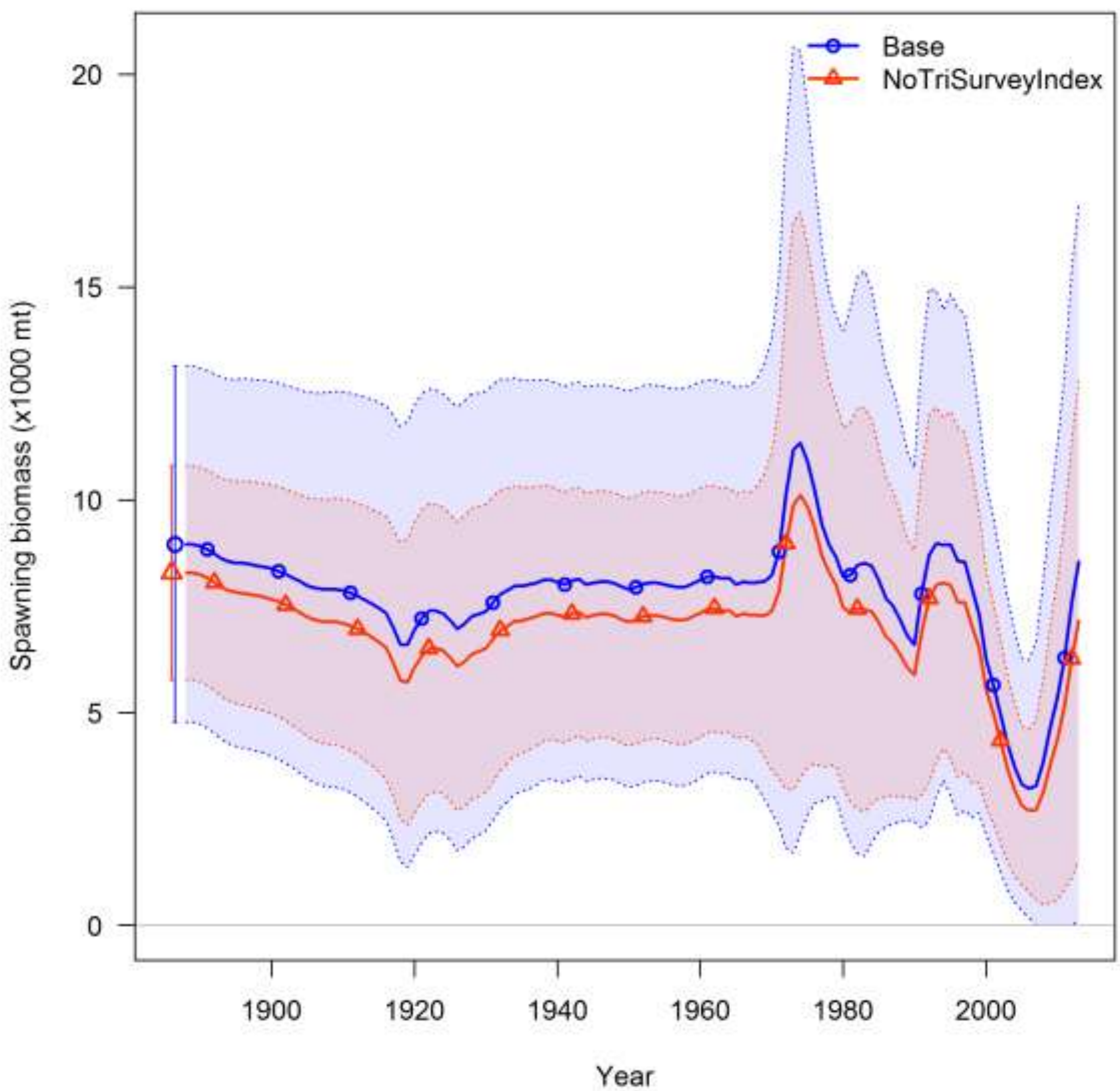



**Figure 127. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.**

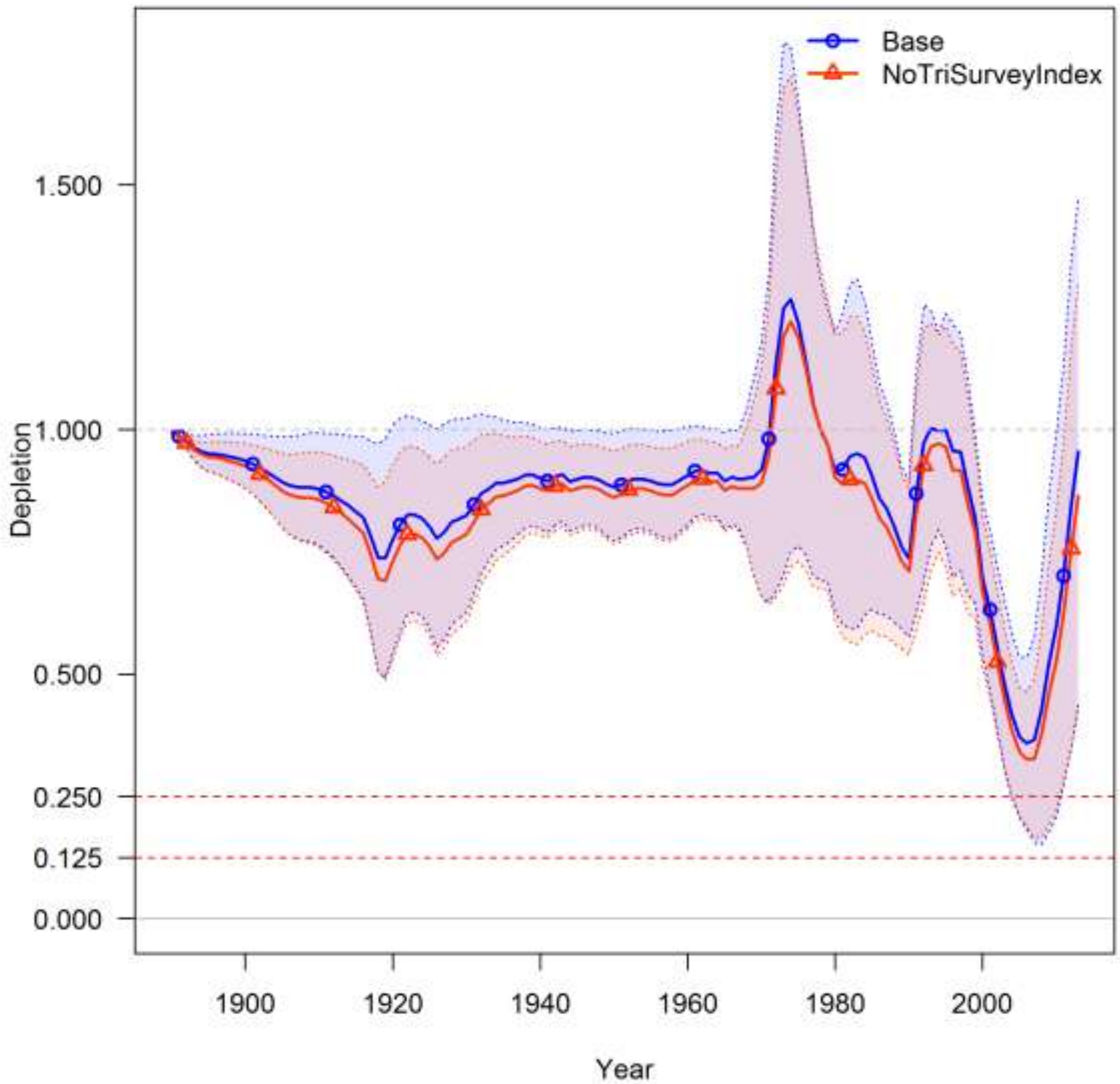



**Figure 128. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on three maturity schedules.**

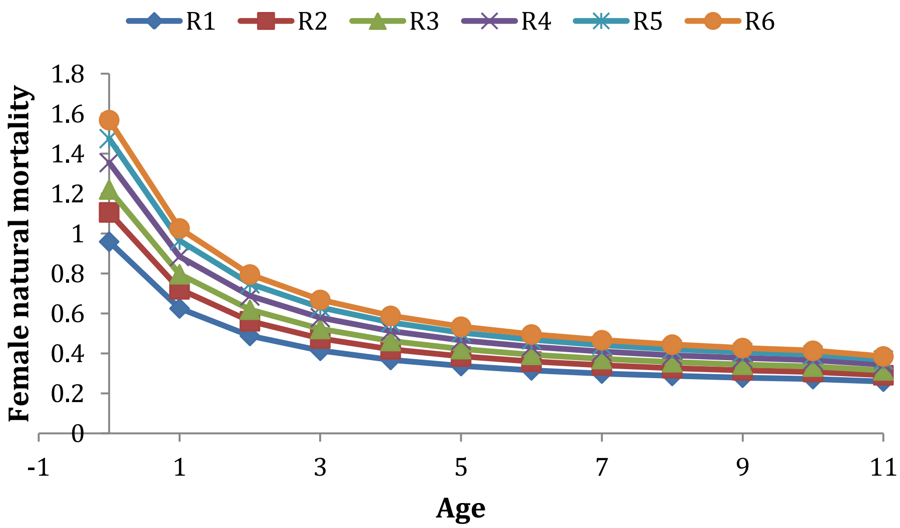



**Figure 129. Estimated female natural mortality by age using the Lorenzen function for natural mortality for six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6).**

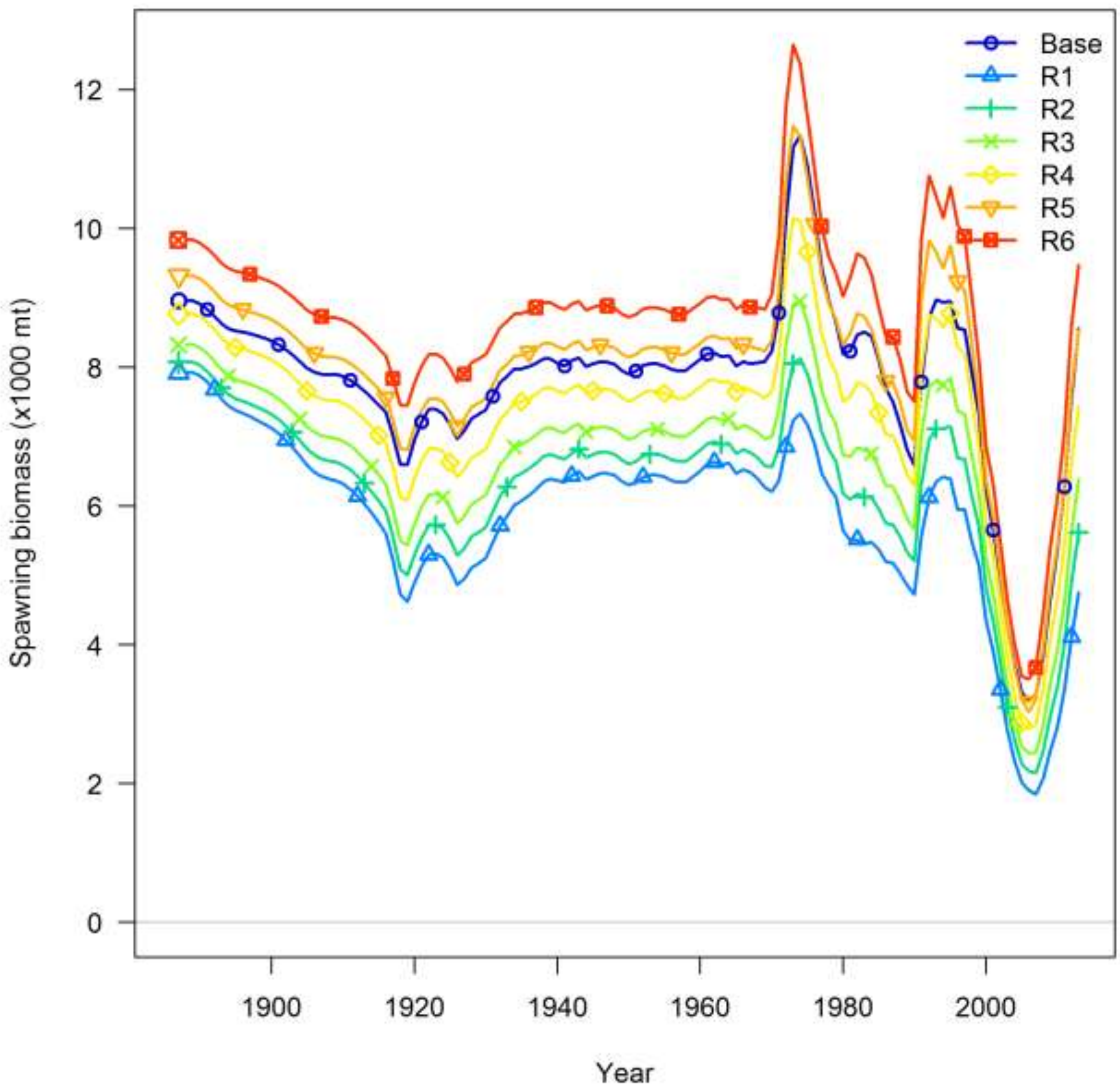



**Figure 130. Estimated time series of spawning biomass from sensitivity runs on using the Lorenzen function for natural mortality at six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

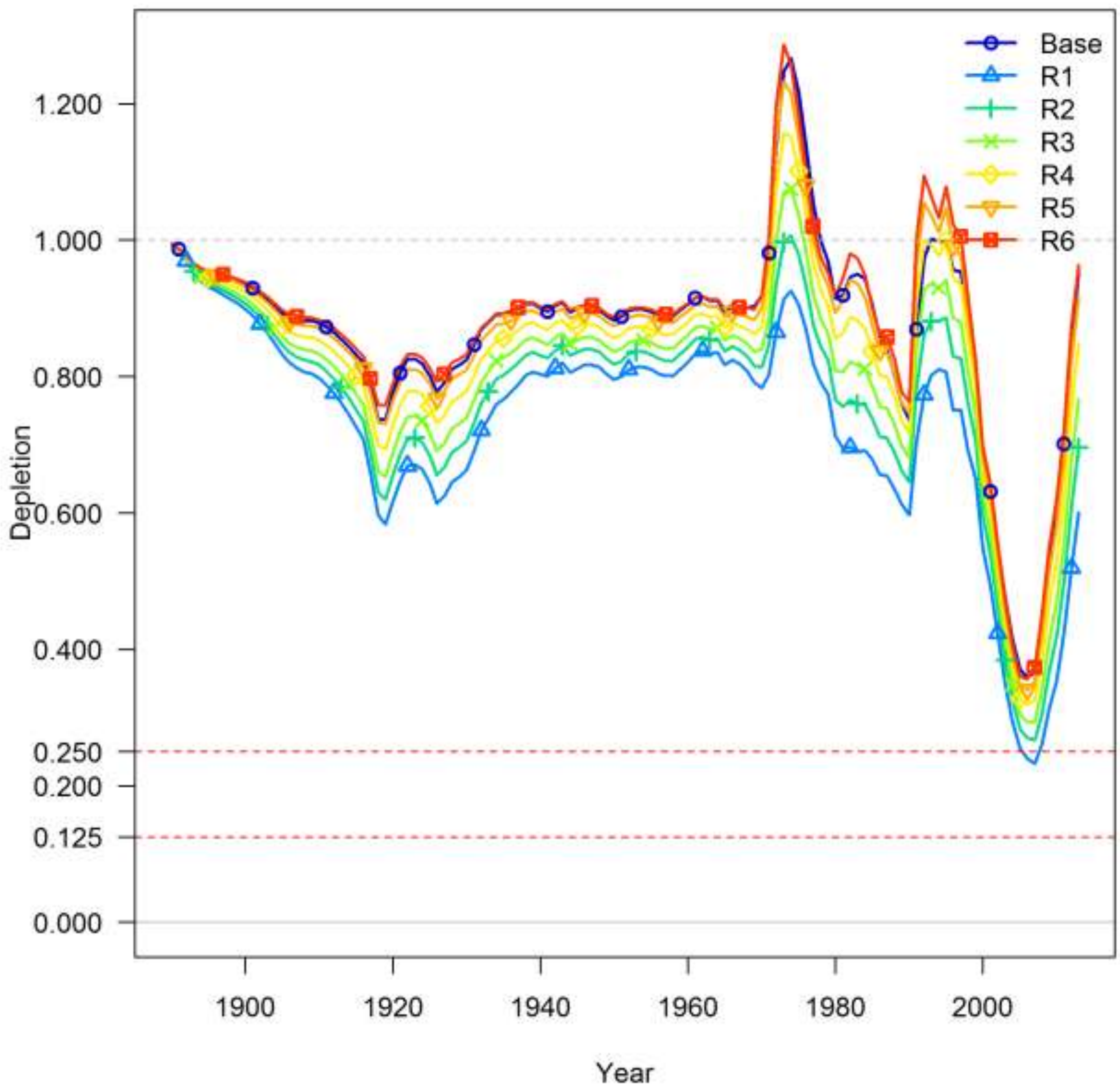



**Figure 131. Estimated time series of stock depletion from sensitivity runs on using the Lorenzen function for natural mortality at six reference ages (R1 = age 1, R2 = age 2, R3 = age 3, R4 = age 4, R5 = age 5, and R6 = age 6). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

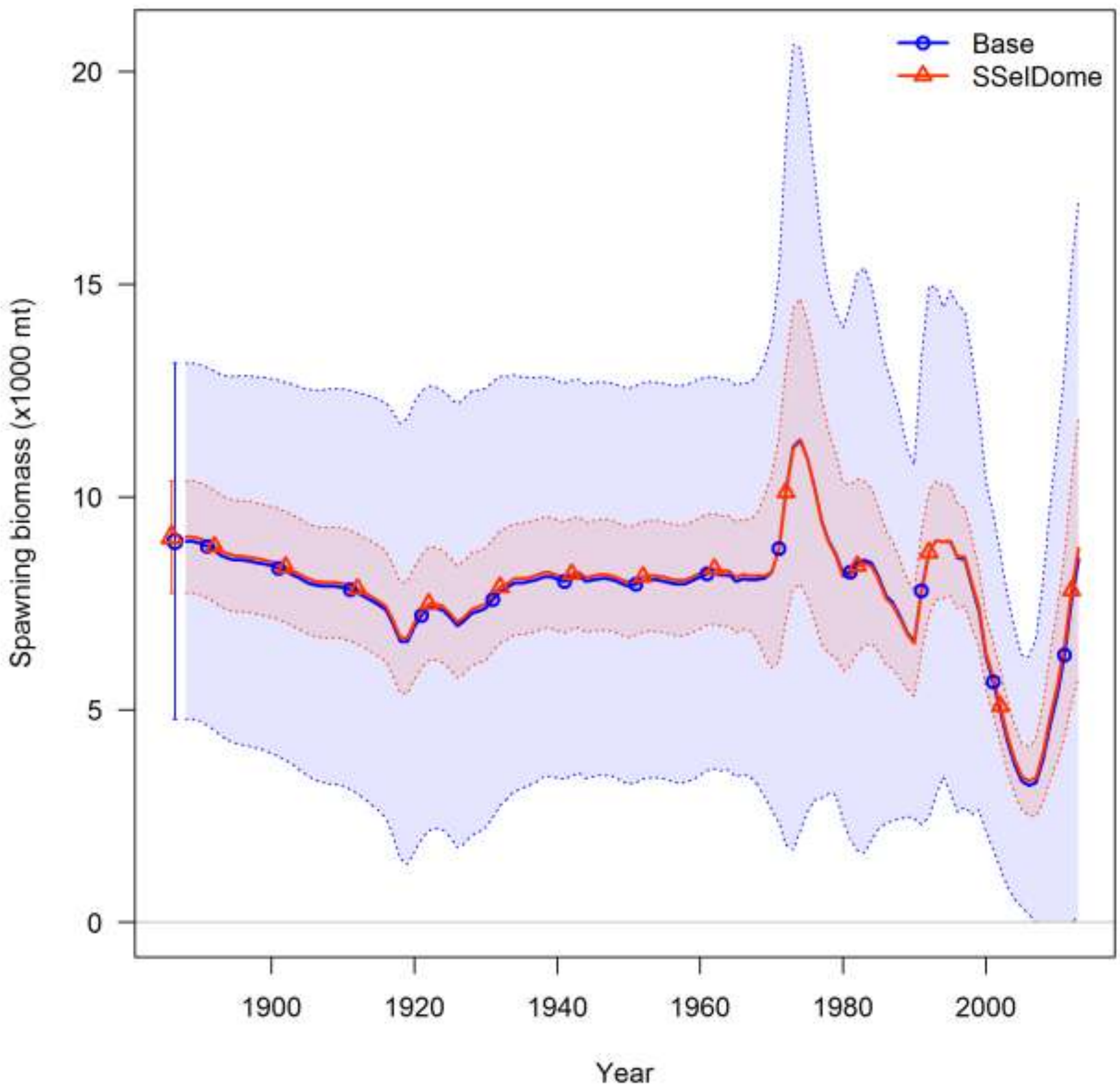



**Figure 132. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on applying dome-shaped selectivity function on all surveys. Selectivity functions for all fisheries are still asymptotic.**

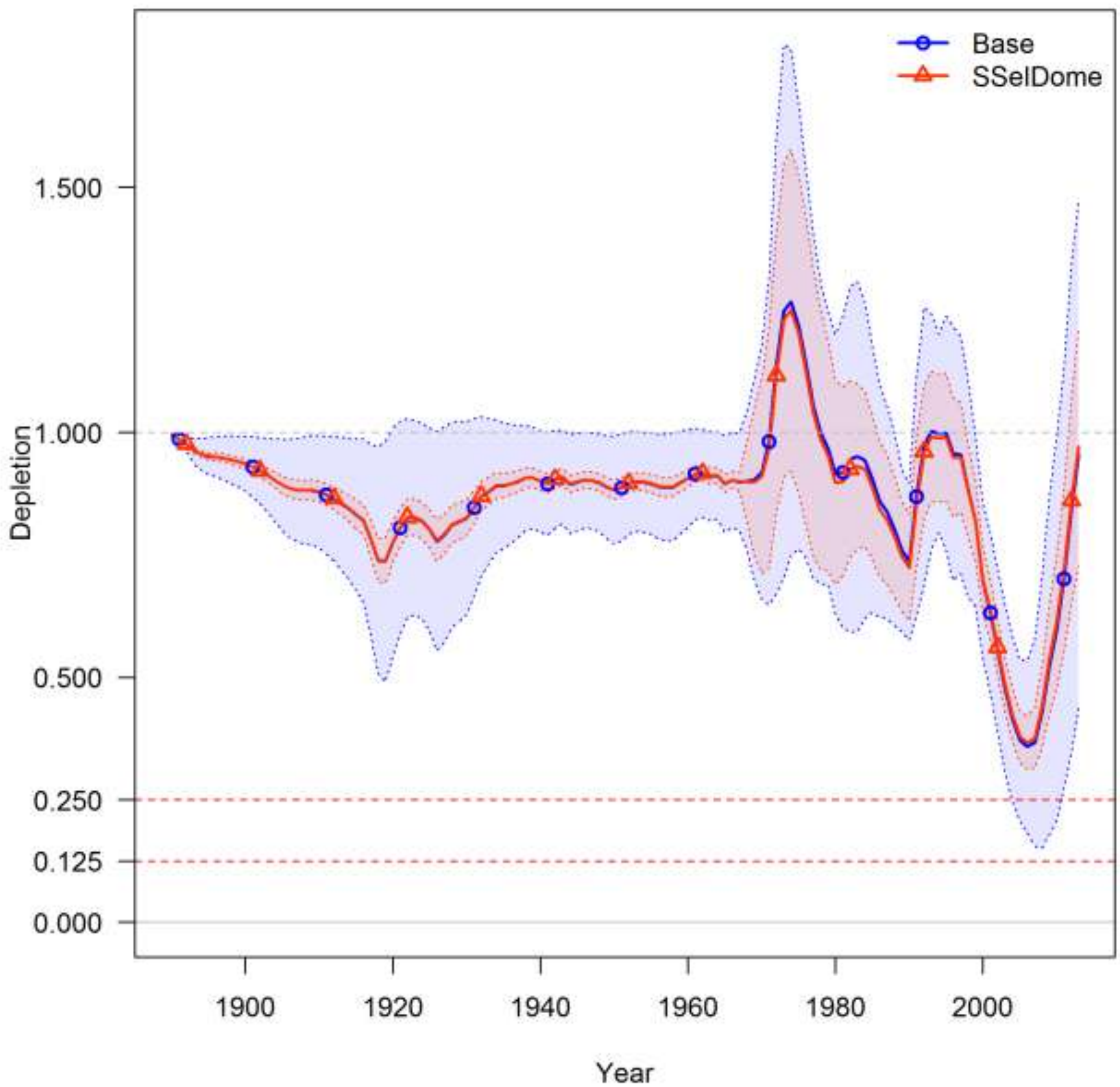



**Figure 133. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on applying dome-shaped selectivity function on all surveys. Selectivity functions for all fisheries are still asymptotic.**

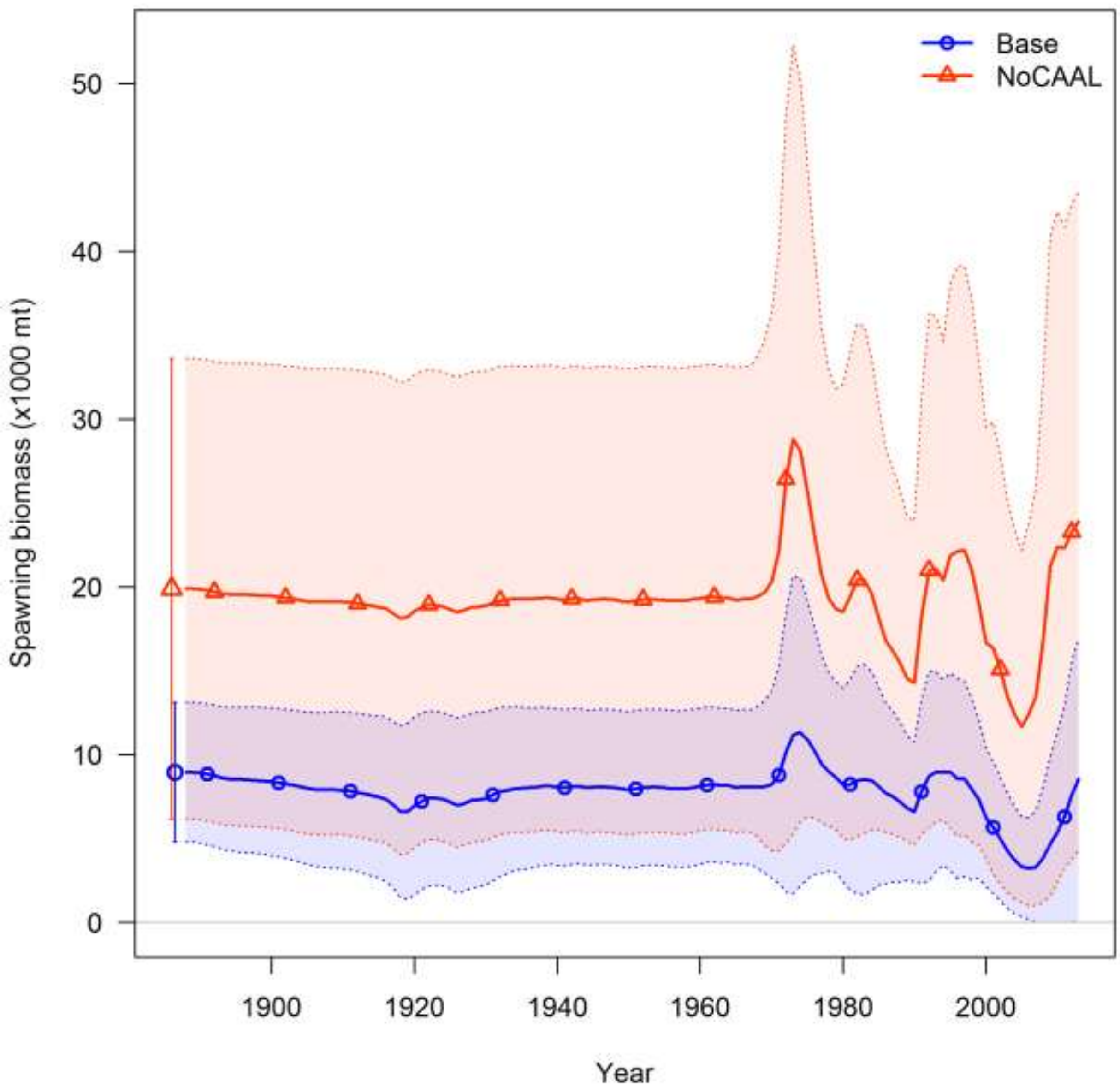



**Figure 134. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from sensitivity runs on not using the conditional age-at-length (CAAL) data. Growth parameters were fixed before the CAAL data were removed.**

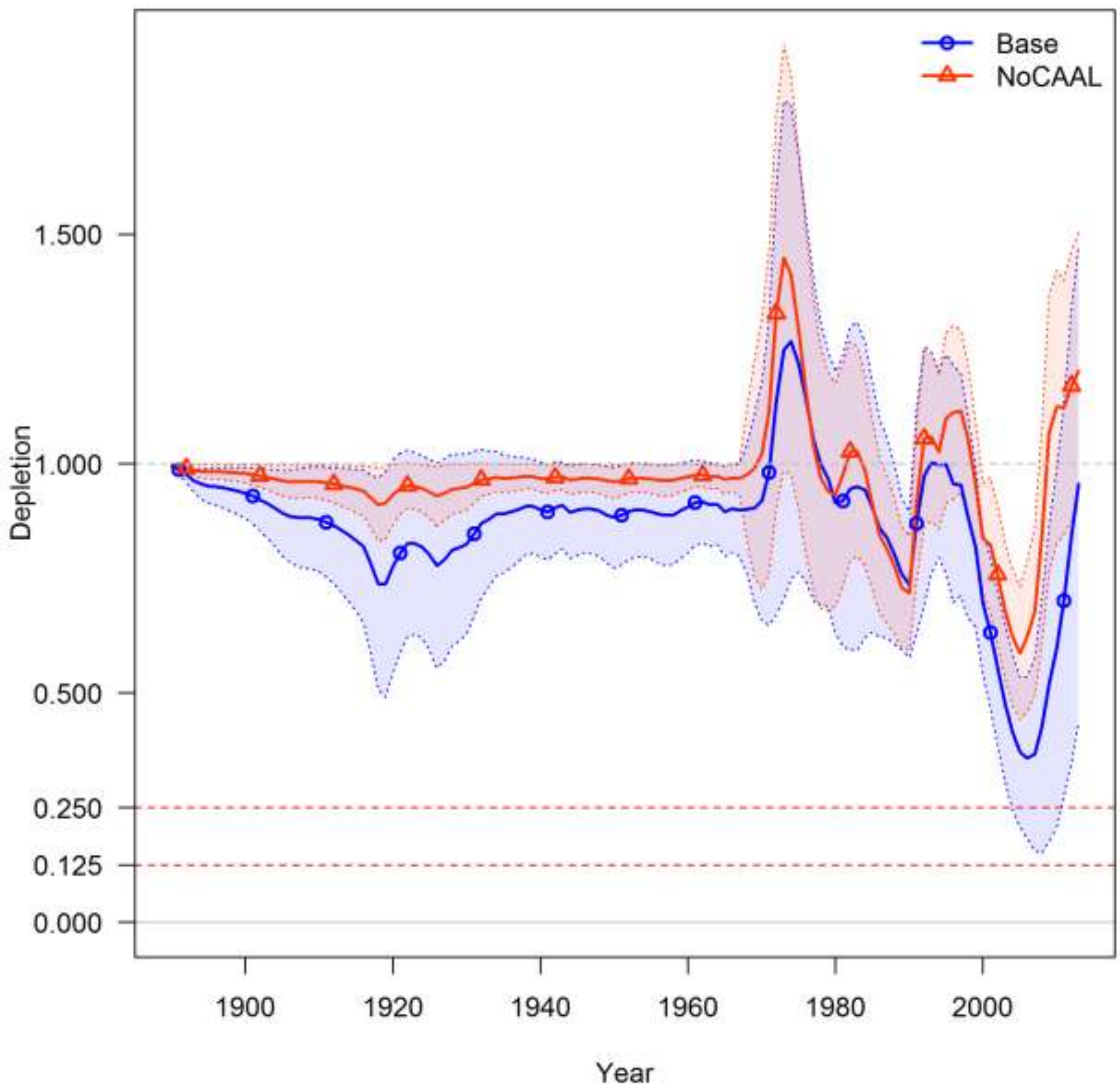



**Figure 135. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from sensitivity runs on not using the conditional age-at-length (CAAL) data. Growth parameters were fixed before the CAAL data were removed.**

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**Figure 136. Likelihood profile for stock-recruit steepness (*h*), ranged from 0.3 to 1.0 at interval of 0.025.**

**Figure 137. Estimated time series of spawning biomass from a profile run on steepness (*h*=0.3 to *h*=1.0 at interval of 0.025).  Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

**Figure 138. Estimated time series of stock depletion from a profile run on steepness (*h*=0.3 to *h*=1.0 at interval of 0.025). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

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**Figure 139. Likelihood profile for virgin recruitment (*LN(R₀)*).**

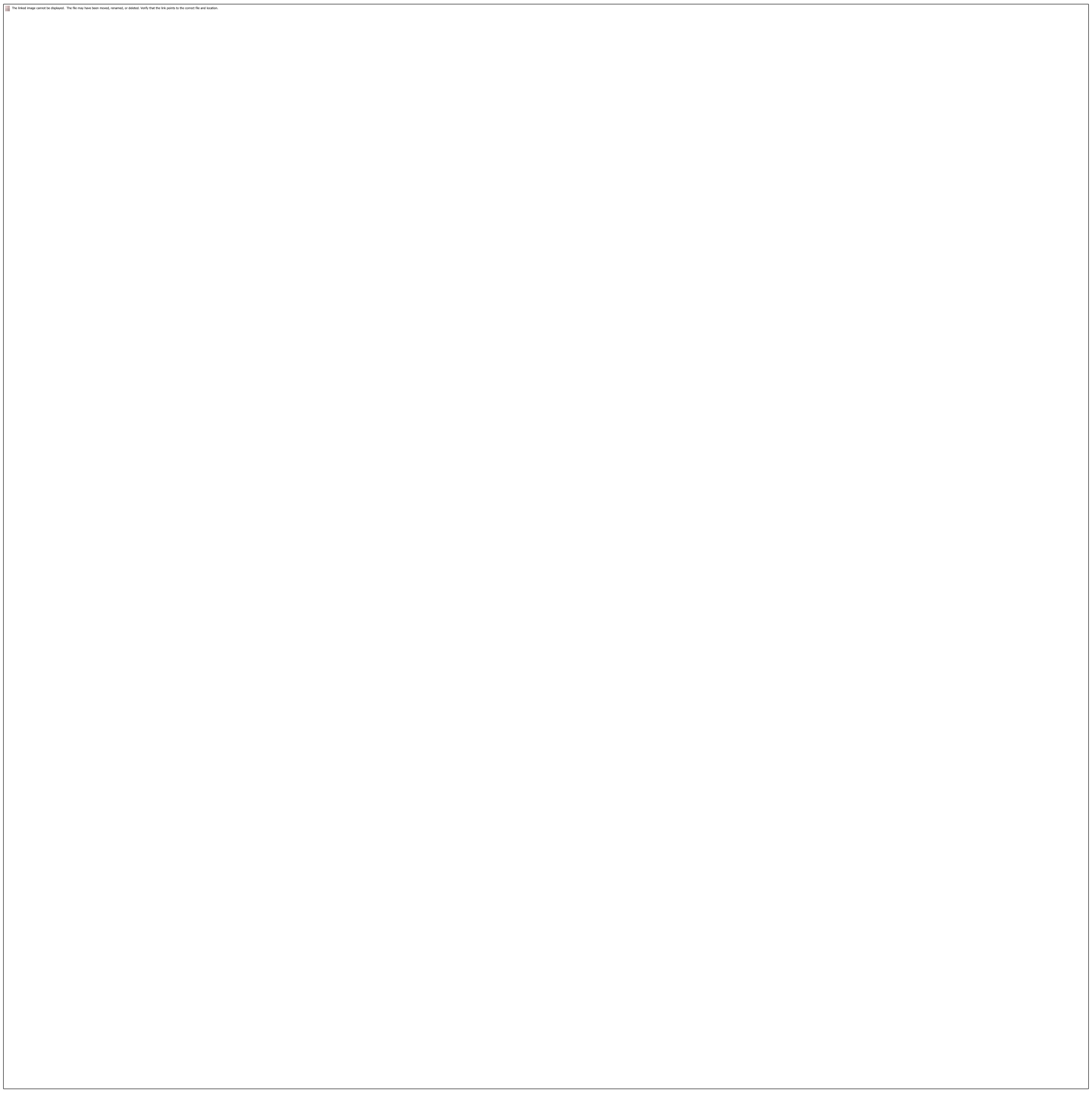


**Figure 140. Estimated time series of spawning biomass from a profile run on virgin recruitment (*$LN(R_0)$*). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

**Figure 141. Estimated time series of stock depletion from a profile run on virgin recruitment (*$LN(R_0)$*). Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

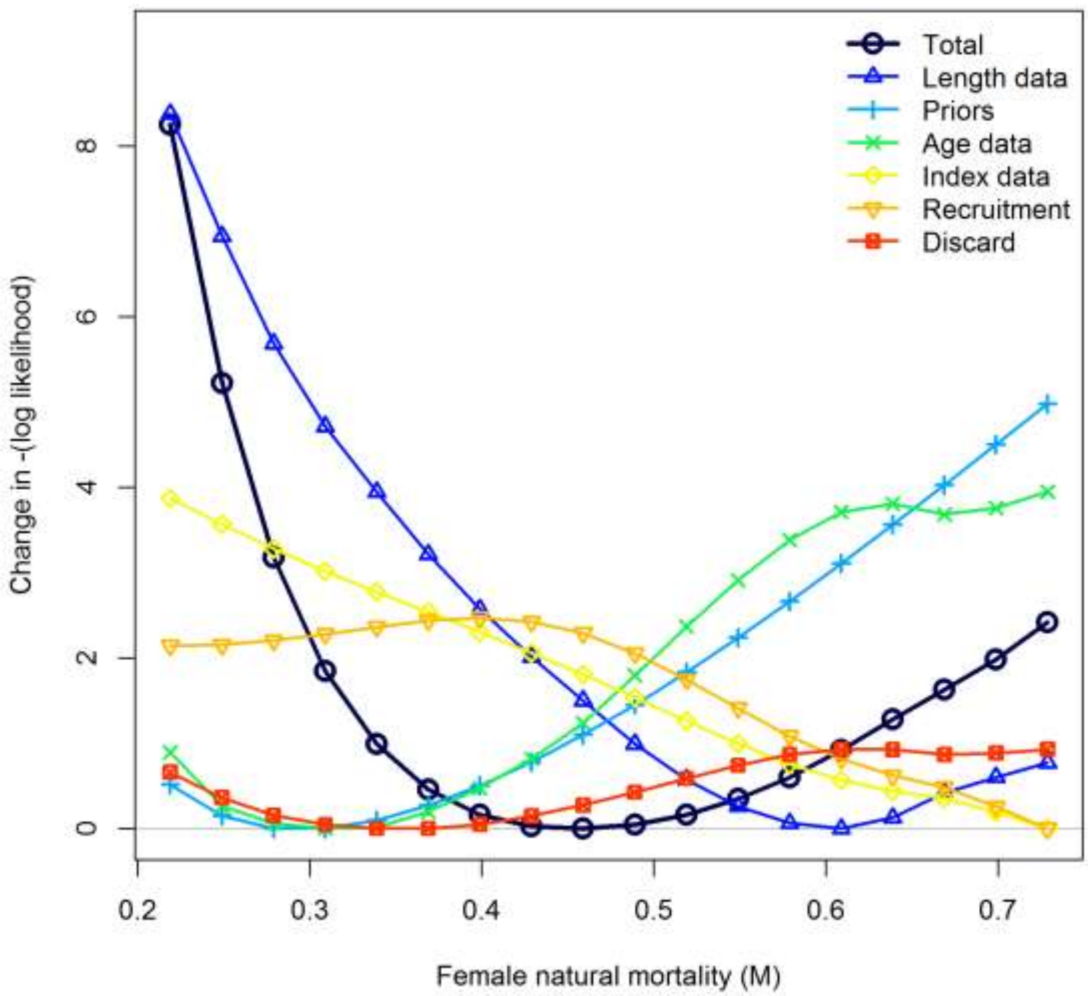


**Figure 142. Likelihood profile for female natural mortality (M), ranged from 0.20 to 0.44. Male natural mortalities were changed in the same increment.**

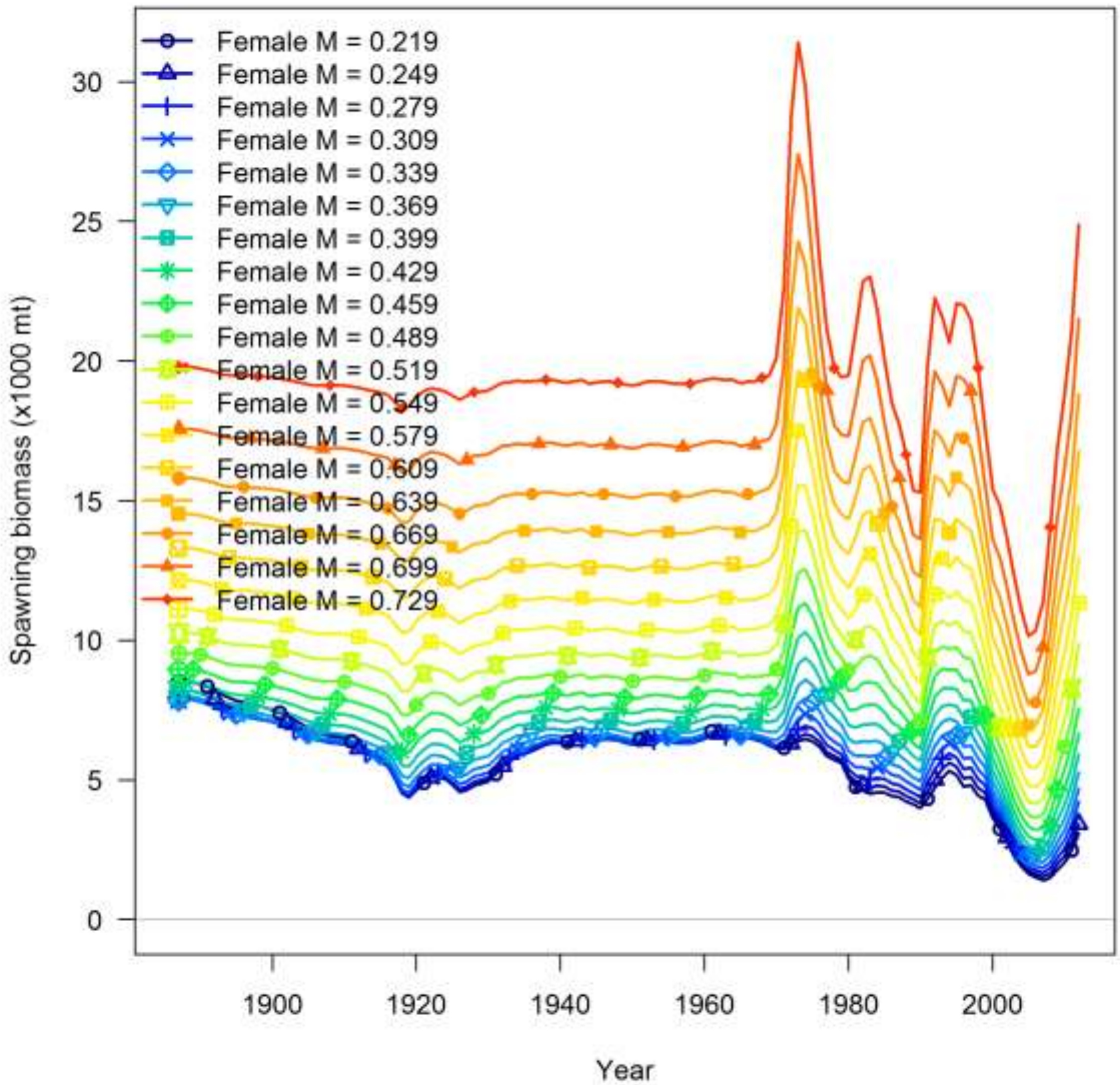


**Figure 143. Estimated time series of spawning biomass from a profile run on female natural mortality (*M*=0.20 to *M*=0.44 at interval of 0.02). Male natural mortalities were changed in the same increment. Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

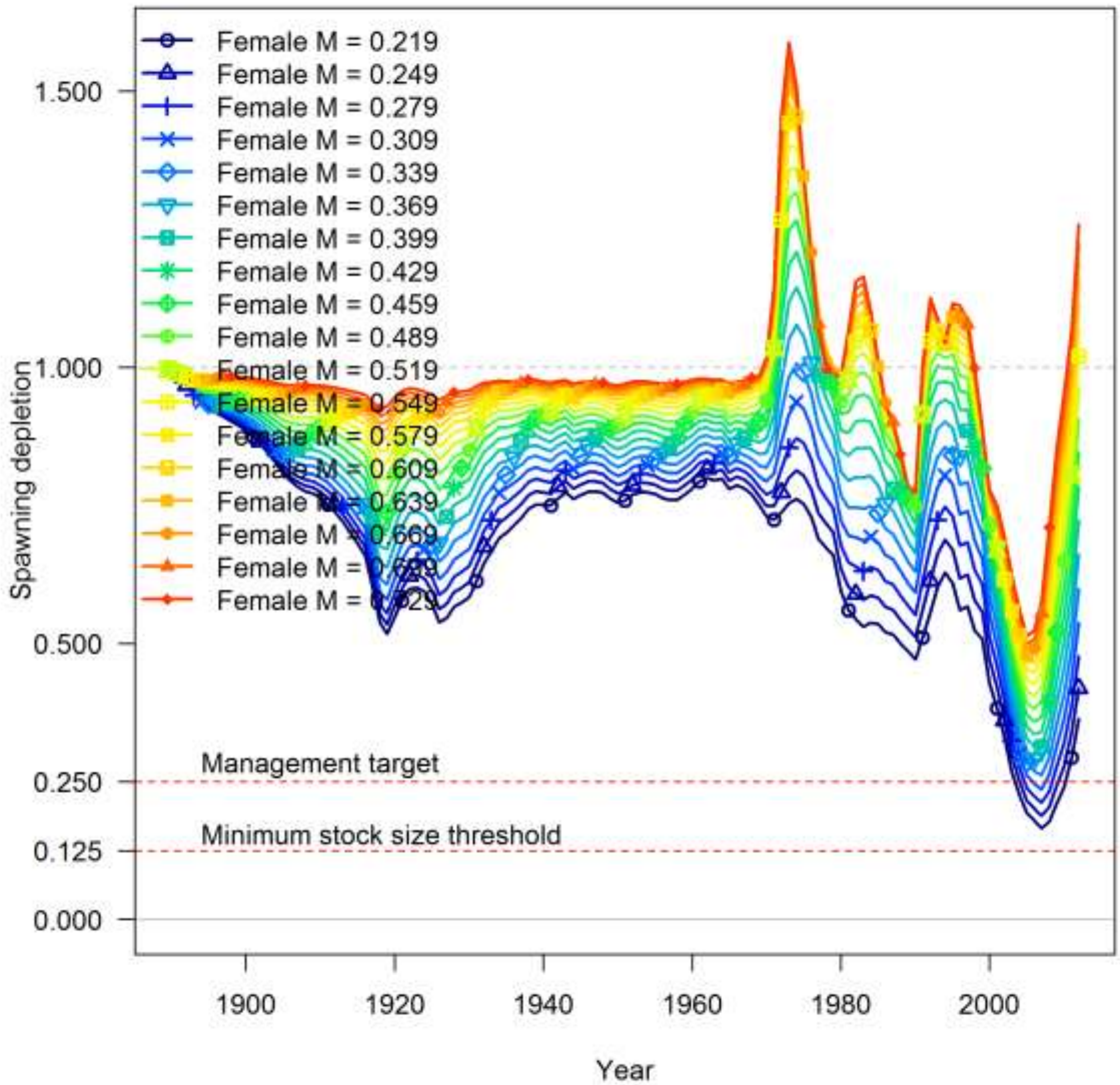


**Figure 144. Estimated time series of stock depletion from a profile run on female natural mortality (*M*=0.20 to *M*=0.44 at interval of 0.02). Male natural mortalities were changed in the same increment. Asymptotic 95% confidence intervals for these runs were not shown to increase graphic clarity.**

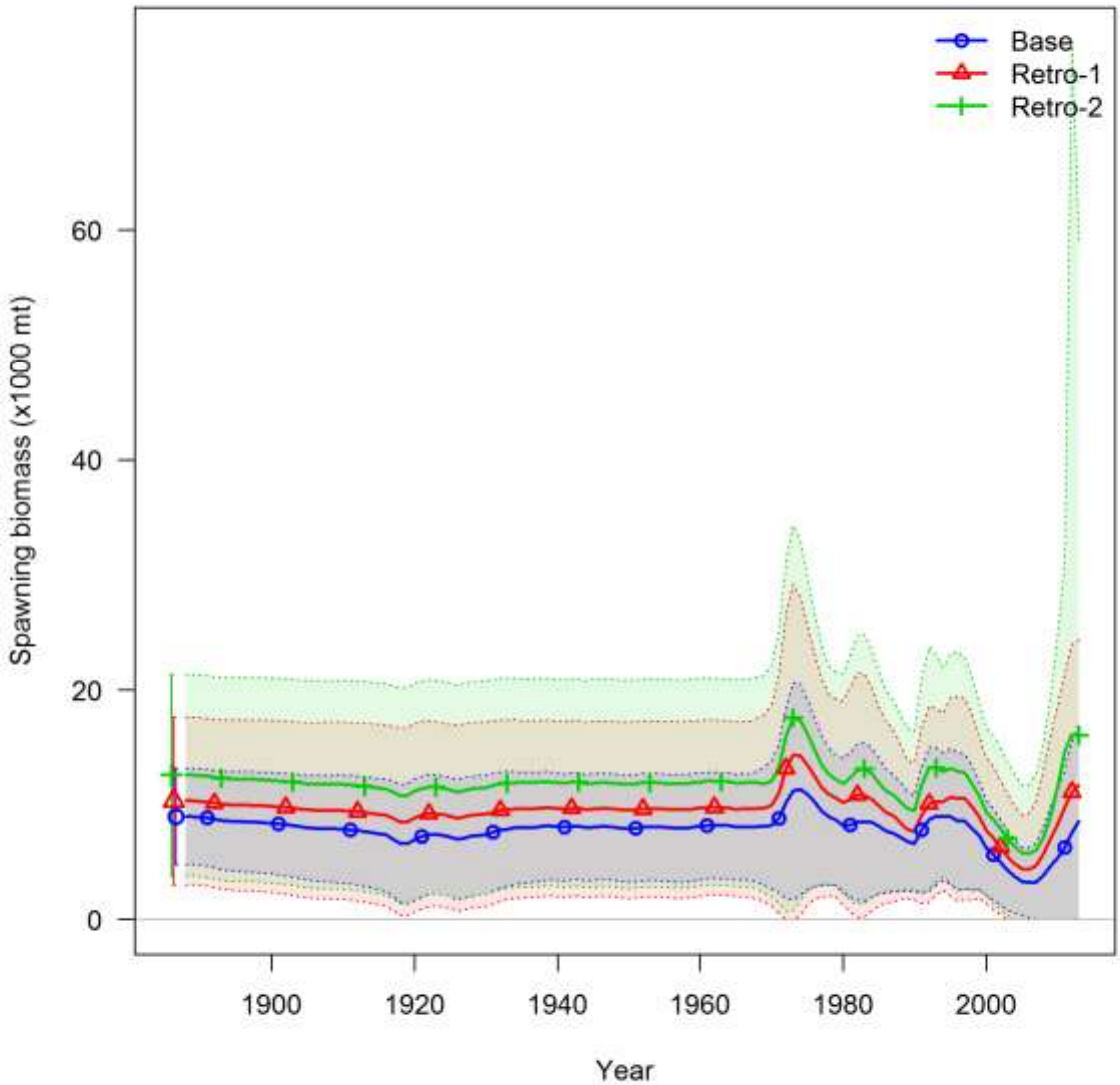


**Figure 145. Estimated time series of spawning biomass with approximate asymptotic 95% confidence intervals from retrospective analysis of 0 to 3 years.**

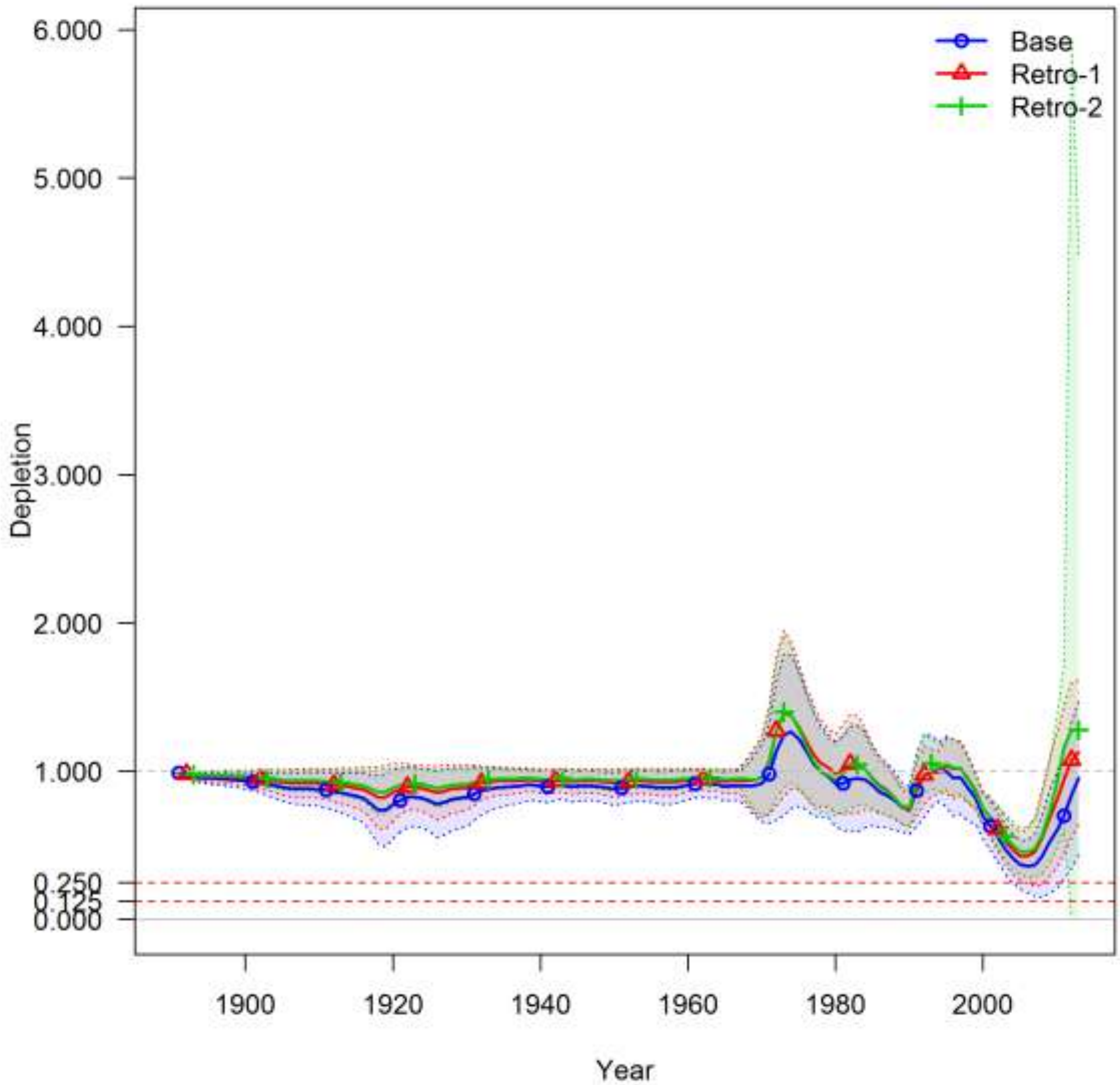


**Figure 146. Estimated time series of stock depletion with approximate asymptotic 95% confidence intervals from retrospective analysis of 0 to 3 years.**

# Appendix A. History of Management Measures Affecting the Pacific Sanddab Fishery

Pacific sanddabs have been managed in the Other Flatfish complex of species since implementation of the Groundfish FMP in 1982.

Pacific sanddabs have historically been taken by bottom trawls, commercial and recreational hook-and-line gear, and gillnets before that gear was prohibited. The vast majority of the take of Pacific sanddab has been with bottom trawls. Trawl discards of Pacific sanddabs have been relatively high although some targeting of the stock has occurred. For example, Scottish seine gear, which is legal trawl gear, has been deployed to selectively harvest Pacific sanddabs off central California (Steve Fitz, personal communication). Trawl fleet distribution and fishing behavior changed dramatically in 2011 with implementation of the trawl rationalization program where the shoreside trawl sector (i.e., those vessels delivering to shore-based processors) is managed under a system of individual fishing quotas (IFQs). Prior to 2011, trawl landings of species managed in the Other Flatfish complex were managed with cumulative landing limits (Table A1). With the advent of the trawl IFQ program, a trawl sector allocation of Other Flatfish was apportioned to trawl-endorsed permits based on permit catch history. These permit quotas or IFQs can be fished at any time during the season and traded to other IFQ participants. Since all catch, both landed and discarded (there is 100% observer requirement to track discards under the IFQ program), are counted against quota, any marketable catch is landed if there is room onboard the vessel to retain the catch. This has changed discard rates for many species caught in bottom trawls under the IFQ program. While it is assumed that most of the historical discarding prior to the IFQ program was market-based, there may have been some regulatory-induced discarding due to landing limits (Table A1).

To facilitate implementation of the trawl rationalization program, a formal allocation of stocks important to the trawl fishery was decided under Amendment 21, which decided trawl:non-trawl sector allocations. The trawl sector allocation of the non-tribal fishery harvest guideline (fishery HG or the available harvest guideline for non-tribal sectors) for the Other Flatfish species is 90% of the fishery HG (species in the Other Flatfish complex are trawl-dominant or primarily caught by trawl gears).

In 1992, the minimum mesh size of commercial trawls was increased from 3 in. to 4.5 in. This may have changed the selectivity of Pacific sanddabs to commercial trawls.

The trawl Rockfish Conservation Area (RCA) was implemented by emergency regulation in September 2002 south of 40º10' N lat. and coastwide in annual regulations implemented since 2003. While the bounds of the RCA have changed seasonally to achieve management objectives (i.e., allow attainment of healthy target species' catch limits while minimizing the mortality of overfished species), the core closed area has limited access to Pacific sanddabs. Despite that, there are continued trawl catches of Pacific sanddabs, mostly shoreward of the RCA. Washington does not allow commercial fishing in their state waters (0-3 nm) and California does not allow trawling in their state waters (with few designated zones south of Pt. Conception that are open).

Prior to 2000, there was no trawl limit on Other Flatfish species (Table A1). Also in 2000, trawls with small footropes (≤8 in. diameter) were required to land Other Flatfish species. Starting in 2001, there were differential limits specified for large and small footrope trawls with larger limits for the latter gear type. Beginning in 2005, selective flatfish trawl that were less efficient at catching rockfish and more efficient at catching flatfish, were required when fishing shoreward of the RCA north of 40º10' N lat. (small footrope trawl are required when fishing shoreward of the RCA south of 40º10' N lat.).

While Pacific sanddabs are trawl-dominant, there is non-trawl catch and some targeting of Pacific sanddabs by line gears.  This catch is controlled by cumulative landing limits and area restrictions in the commercial non-trawl fisheries (Table A2) and daily bag limits, area restrictions, depth restrictions, and gear restrictions in recreational fisheries.  Commercial access using non-trawl sectors to Other Flatfish species was not limited by regulations prior to 1999 for the open access sector and prior to 2002 for the limited entry fixed gear sector (Table A2).  The non-trawl RCA was implemented by emergency regulation in September 2002 south of 40º10’ N lat. and coastwide in annual regulations implemented since 2003.  However, hook-and-line gear restrictions were implemented beginning in 2003 for efforts targeting Pacific sanddab south of 40º10’ N lat. and for all waters off California beginning in 2005 (i.e., the Pacific sanddab hook-and-line fishery was not subject to RCA restrictions provided the gear specified in Table A2 was used).

Recreational catches of Pacific sanddabs are controlled by state-specific management measures such as bag limits, season restrictions, gear restrictions, depth restrictions, and other area restrictions (see Table A3 for 2013 recreational management measures affecting Pacific sanddabs).  The California recreational fishery, where most of the recreational catch of Pacific sanddabs occurs, uses a similar gear restriction as the hook-and-line commercial sector to gain access Pacific sanddabs in areas otherwise closed to groundfish fishing (Table A3).

**Table A1. Limited entry trawl cumulative landing limits for species in the Other Flatfish complex, including Pacific sanddabs, 1982-2010.**

| Year | Area | Gear | Period | Cumulative Landing Limits |
|---|---|---|---|---|
| 2010 | N of 40º10’ | Large FR and small FR | 1&6 | 110,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole |
| | | Sel. FF & multiple bottom trawl gears a/ | 1 | 90,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole |
| | | | 2-6 | 60,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole |
| | S of 40º10’ | All trawl gears | 1&6 | 110,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 9,500 lb/2 mo. of which may be petrale sole |
| 2009 | N of 40º10’ | Large FR and small FR | 1&6 | 110,000 lbs/2 mo. |
| | | | 2 | 110,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole |
| | | | 3-5 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | Sel. FF & multiple bottom trawl gears a/ | 1&6 | 90,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole |
| | | | 2-5 | 90,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole |
| | S of 40º10’ | All trawl gears | 1&6 | 110,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| 2008 | N of 40º10’ | Large FR and small FR | 1&6 | 110,000 lbs/2 mo. |
| | | | 2 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | | 3-5 | 110,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | Sel. FF & multiple bottom trawl gears a/ | 1 | 70,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole |
| | | | 2 | 70,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole |
| | | | 3 | 50,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole |
| | | | 4 | 80,000 lbs/2 mo., no more than 18,000 lb/2 mo. of which may be petrale sole |
| | | | 5 | 80,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 80,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole |
| | S of 40º10’ | All trawl gears | 1&6 | 110,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |

| Year | Area | Gear | Period | Cumulative Landing Limits |
|---|---|---|---|---|
| 2007 | N of 40º10' | Large FR and small FR | 1 | 110,000 lbs/2 mo. |
| | | | 2 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | | 3-4 | 110,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 5 | 150,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 150,000 lbs/2 mo., including arrowtooth flounder |
| | | Sel. FF & multiple bottom trawl gears a/ | 1 | 90,000 lbs/2 mo., no more than 16,000 lb/2 mo. of which may be petrale sole |
| | | | 2 | 90,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole |
| | | | 3-4 | 70,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 5 | 70,000 lbs/2 mo., no more than 15,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 30,000 lbs/2 mo. (including arrowtooth flounder), no more than 8,000 lb/2 mo. of which may be petrale sole |
| | S of 40º10' | All trawl gears | 1 | 110,000 lbs/2 mo. |
| | | | 2 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | | 3-4 | 110,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole |
| | | | 5 | 150,000 lbs/2 mo., no more than 25,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 150,000 lbs/2 mo., including arrowtooth flounder |
| 2006 | N of 40º10' | Large FR and small FR | 1 | 55,000 lbs/2 mo. |
| | | | 2-5 | 90,000 lbs/2 mo., no more than 28,000 lbs/2 mo. of which may be petrale sole |
| | | | 6 | 110,000 lbs/2 mo. |
| | | Sel. FF & multiple bottom trawl gears a/ | 1 | 45,000 lbs/2 mo. |
| | | | 2 | 90,000 lbs/2 mo., no more than 25,000 lbs/2 mo. of which may be petrale sole |
| | | | 3-5 | 90,000 lbs/2 mo., no more than 28,000 lbs/2 mo. of which may be petrale sole |
| | | | 6 | 90,000 lbs/2 mo. |
| | S of 40º10' | All trawl gears | 1 | 55,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 110,000 lbs/2 mo. |

| Year | Area | Gear | Period | Cumulative Landing Limits |
|---|---|---|---|---|
| 2005 | N of 40º10’ | Large FR and small FR | 1 | 110,000 lbs/2 mo. |
| | | | 2 | 110,000 lbs/2 mo., no more than 42,000 lb/2 mo. of which may be petrale sole |
| | | | 3-5 | 110,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 80,000 lbs/2 mo., no more than 60,000 lb/2 mo. of which may be petrale sole |
| | | Sel. FF & multiple bottom trawl gears a/ | 1 | 100,000 lbs/2 mo., no more than 25,000 lbs/2 mo. of which may be petrale sole |
| | | | 2 | 100,000 lbs/2 mo., no more than 35,000 lbs/2 mo. of which may be petrale sole |
| | | | 3-5 | 90,000 lbs/2 mo., no more than 35,000 lbs/2 mo. of which may be petrale sole |
| | | | 6 | 75,000 lbs/2 mo., no more than 15,000 lbs/2 mo. of which may be petrale sole |
| | S of 40º10’ | All trawl gears | 1&6 | 110,000 lbs/2 mo. |
| | | | 2-5 | 110,000 lbs/2 mo., no more than 42,000 lb/2 mo. of which may be petrale sole |
| 2004 | N of 40º10’ | Large FR | 1-3&6 | 100,000 lbs/2 mo. |
| | | | 4-5 | 100,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | Small FR | 1-2 | 30,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole |
| | | | 3 | 80,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | | 4-5 | 80,000 lbs/2 mo., no more than 26,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 100,000 lbs/2 mo. |
| | S of 40º10’ | All trawl gears | 1 | 100,000 lbs/2 mo. |
| | | | 2 | 100,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 3-5 | 120,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 120,000 lbs/2 mo., no more than 100,000 lb/2 mo. of which may be petrale sole |
| 2003 | N of 40º10’ | Large FR | 1&6 | 100,000 lbs/2 mo. |
| | | | 2-5 | 100,000 lbs/2 mo., no more than 30,000 lb/2 mo. of which may be petrale sole |
| | | Small FR | 1&6 | 100,000 lbs/2 mo. |
| | | | 2-5 | 20,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole |
| | S of 40º10’ | All trawl gears | 1&6 | 70,000 lbs/2 mo. |
| | | | 2-5 | 70,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |

| Year | Area | Gear | Period | Cumulative Landing Limits |
|---|---|---|---|---|
| 2002 | N of 40º10’ | Small FR | 1 | 15,000 lbs/2 mo. |
| | | | 2 | 35,000 lbs/2 mo. |
| | | | 3 | 30,000 lbs/2 mo., no more than 10,000 lb/2 mo. of which may be petrale sole |
| | | | 4 | 40,000 lbs/2 mo., no more than 15,000 lb/2 mo. of which may be petrale sole |
| | | | 5 | 50,000 lbs/2 mo., no more than 20,000 lb/2 mo. of which may be petrale sole |
| | | | 6 | 50,000 lbs/2 mo. |
| | S of 40º10’ | Small FR | 1-2&6 | 70,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be Pacific sanddabs |
| | | | 3-5 | 70,000 lbs/2 mo., no more than 40,000 lb/2 mo. of which may be Pacific sanddabs, no more than 15,000 lb/2 mo. of which may be petrale sole |
| 2001 | N of 40º10’ | Large FR | 1-6 | 1,000 lbs/trip |
| | | Small FR | 1,2&6 | No limit |
| | | | 3-5 | 30,000 lb/mo. for all flatfish except Dover sole |
| | S of 40º10’ | Large FR | 1-6 | 1,000 lbs/trip |
| | | Small FR | 1-6 | No limit |
| 2000 | Coastwide | Small FR | 1-6 | No limit - only small footrope gear can be used to take and retain flatfish other than Dover sole, petrale sole, rex sole, or arrowtooth flounder during various periods |
| 1982-1999 | Coastwide | All trawl gears | Year-round | No limit - for flatfish other than Dover sole, petrale sole, rex sole, or arrowtooth flounder during various periods |

a/ If a vessel has both selective flatfish gear and large or small footrope gear on board during a cumulative limit period (either simultaneously or successively), the most restrictive cumulative limit for any gear on board during the cumulative limit period applies for the entire cumulative limit period.

**Table A2. Limited entry fixed gear and open access cumulative landing limits for species in the Other Flatfish stock complex, including Pacific sanddabs, 1982-2012.**

| Year | Area | Sector | Period | Cumulative Landing Limits | Other Regulations |
|---|---|---|---|---|---|
| 2005-2012 | Coastwide | LEFG | Year-round | 5,000 lbs/mo. | South of 42º N lat. (i.e., waters off CA), when fishing for Other Flatfish, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| 2004 | N of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | RCAs |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| | S of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | When fishing for Other Flatfish, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| 2003 | N of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | RCAs |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| | S of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | When fishing for Pacific sanddabs, vessels using hook-and-line gear with no more than 12 hooks per line, using hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to the RCAs |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| 2002 | N of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | None |
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| | S of 40º10’ | LEFG | Year-round | 5,000 lbs/mo. | Closed deeper than 20 fm in periods 4-6 |

| Year | Area | Sector | Period | Cumulative Landing Limits | Other Regulations |
|---|---|---|---|---|---|
| | | OA | Year-round | 3,000 lb/mo., no more than 300 lb of which may be species other than Pacific sanddabs | |
| 1999-2001 | Coastwide | LEFG | Year-round | No limit | None |
| | | OA | Year-round | 300 lb/mo. | |
| 1982-1998 | Coastwide | All a/ | Year-round | No limit | None |

a/ Non-trawl sector designations were implemented in 1994 with the designation of limited entry and open access sectors. Limited entry participants, based on the fishing history of qualifying vessels, were further divided with permits endorsed for one or more of three gear types (trawl, longline, and pot/trap).

**Table A3. 2013 recreational management measures affecting Pacific sanddabs by state.**

| State | Daily Bag Limit | Depth Restrictions | Other Area Restrictions | Special Gear Restrictions for Flatfish |
|---|---|---|---|---|
| CA | None | None | No fishing in federal and state MPAs | When fishing for Other Flatfish, vessels using hook-and-line gear with hooks no larger than "Number 2" hooks, which measure 11 mm (0.44 inches) point to shank, and up to two 1 lb (0.45 kg) weights per line are not subject to depth or season restrictions |
| OR | 25 fish limit per day for all flatfish, excluding Pacific halibut, but including all soles, flounders and Pacific sanddabs, | Closed >40 fm seasonally | No fishing in federal MPAs and YRCAs | None |
| WA | 12 bottomfish, including sanddabs, per day | Closed >20 fm seasonally in Marine areas 3 and 4 and closed >30 fm seasonally in Marine area 2 | No fishing in federal YRCAs and state MPAs; seasonal restrictions | None |

# Appendix B. Summaries of Field and Laboratory Studies on Reproductive Biology of Pacific Sanddab

Lyndsey Lefebvre
Fisheries Ecology Division
SWFSC, Santa Cruz, CA
June 2013

## Introduction

Data on the reproductive ecology of Pacific sanddab, *Citharichthys sordidus*, are limited. Arora (1951) described the ovarian cycle based on measurements of eggs from the ovaries of females collected by otter trawl from Pt. Reyes to San Francisco, CA. The spawning season was stated to last from July through early-September, as egg diameters reached maximum values and no females with spent ovaries were collected during this time period. Arora suggested sanddabs were capable of spawning multiple times a season, due to the occurrence of multiple modes of maturing eggs in the ovaries, but was unable to test this hypothesis. It was estimated that 50% of females were mature at 190 mm total length (TL) with nearly all mature by 220 mm TL, corresponding to an age of 3 years.

To estimate the spawning season, Chamberlain (1979) used descriptions of gross morphological changes to the ovary as well as finer scale histological descriptions of oocyte development from Pacific sanddab collected between December 1969 and June 1972 between Santa Barbara and San Diego, CA. Chamberlain suggested initial oocyte development (vitellogenesis) started in February and that females were in spawning condition by June. The spawning season continued through September as the first fish with spent ovaries were collected in October. A maturity curve was not provided; however, the smallest mature female reported was 160 mm TL. Chamberlain made no mention of the possibility of sanddab being batch spawners.

Both Arora (1951) and Chamberlain (1979) provide insight into Pacific sanddab reproductive biology but fail to provide data important in assessing population status, such as spawning frequency and fecundity. Additionally, Pacific sanddab larvae and metamorphic-stage fish were collected year-round off the coast of central and southern California by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) from 1954-1960 and 1984 (Moser et al. 2001). While sanddab have a long larval and metamorphic-stage duration (up to 9 months [Sakuma and Larson 1995; Donohoe 2000]) and size and the stage of fish were not provided by the CalCOFI data, the year-round collection suggest spawning may be occurring outside of the time period proposed by Arora and Chamberlain.

In order to determine spawning season; describe the female reproductive cycle; and estimate size and length at maturity, fecundity, and spawning frequency of females, Pacific sanddab were collected via hook-and-line from the Monterey Bay during 13 sampling trips between March 2012 and April 2013. Additional Pacific sanddab were collected opportunistically from mid-water trawl and live trap surveys conducted in the same region. Ovarian tissue from a subset of females collected was examined histologically to microscopically describe the reproductive cycle and estimate spawning frequency of wild Pacific sanddab. Additional studies of captive fish provided information on biological capabilities for reproduction in sanddab.

## Materials and Methods

### Collections and General Reproductive Biology

Collections of Pacific sanddab have been ongoing since March 2012. The majority of fish were collected by hook-and-line; 13 individuals from May and early June 2012 were collected in a mid-water trawl and 17 individuals from early August were caught in a live trap, all in the same area as hook-and-line fishing occurred in the southern Monterey Bay. In March and July fishing occurred in the northern Monterey Bay off of Santa Cruz in the 70-90 m depth range. In May and June 2012 and from August onward, all fish were collected from the southern portion of Monterey Bay, off of the Monterey Peninsula and Point Piños, in the 50-70 m depth range. Female sanddab were targeted but a random sampling of males was made during each collection.

Total length, total body weight, liver weight, and sex were recorded and saggital otoliths were removed for aging when possible. For all females gonads were excised, weighed, and macroscopically staged for maturity (Table B1) and a latitudinal cross-section collected from the middle portion of one ovarian lobe was fixed in 10% neutral buffered formalin for histological analysis. When weights were available, the gonadosomatic index (*GSI*) was calculated as:

$$GSI = \left(\frac{ow}{ofbw}\right) * 100$$

where $ow$=ovary weight (g) and $ofbw$=ovary-free body weight (g). T-tests were performed to compare monthly GSI values with significance levels of p=0.05. When ovaries with hydrated oocytes (HO) were encountered, two weighed subsamples of ovarian tissue were preserved in 10% neutral buffered formalin for fecundity analysis. for comparison to histological phases described in the next section, females with mature ovaries were further classified as “inactive”, “developing”, or “active” (Table B1) based on their macroscopic stage. Inactive females were those incapable of spawning in the near future; developing females were those capable of spawning in the near future; and active females were those capable of spawning in the immediate future or that had spawned recently. Male gonads were examined for maturity did not remain intact upon removal.

**Histology**

A subset of ovarian tissues from each sampling day was selected for histological processing by standard techniques (Humason 1972). Briefly, after at least 24 hours of fixation, tissues were rinsed in freshwater and stored in 70% ethanol. Tissues were taken through a graded series of ethanol before being infiltrated and embedded in paraffin; sectioned to a thickness of 4-6 µm using a rotary microtome; mounted on glass slides; and stained and counterstained using Hematoxylin and Eosin-y. Histology sections were examined at 100x and 250x magnification using a compound microscope, and each was assigned an ovarian maturity phase (Table B2). Ovarian phases were based on descriptions of teleost oocyte development by Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). Mature females were further classified as “inactive”, “developing”, or “active” (Table B2) based on the ovarian phase assigned, level of atresia, and presence or absence of postovulatory follicles (POFs). Inactive females were those incapable of spawning in the near future or lacking evidence of recent spawning activity. Developing females had ovaries that were capable of proceeding to the spawning capable phase in the near future. Active females were capable of spawning in the immediate future, were actively spawning, or showed evidence of a recent spawn. POFs were assigned an approximate age according to descriptions of POF degradation in Hunter and Macewicz (1985a) and Ganias et al. (2007) and based on observations from a laboratory study described in the “spawning frequency” section.

**Fecundity**

Fecundity was estimated using the hydrated oocyte method (Hunter et al. 1985); each weighed subsample of ovarian tissue from female sanddabs with ovaries macroscopically staged as ripe (HO present in ovary but not in oviduct) were placed onto gridded Petri dishes, viewed under a dissection microscope, and HO enumerated. Absolute batch fecundity (ABF; the number of oocytes released per spawning event) for each subsample was calculated as:

$$ABF = \left(\frac{c_x}{ss_x}\right) * ow$$

where $c_x$=count of HO in subsample $x$, $ss$=weight (g) of subsample $x$, and $ow$=ovary weight (g). The ABF for each female was calculated as the mean of the ABF of the two subsamples. To remove the effect of fish size on fecundity, relative batch fecundity (RBF) was calculated as:

$$RBF = \frac{ABF_x}{ofbw}$$

where $ABF_x$=absolute batch fecundity of subsample $x$ and $ofbw$=ovary-free body weight (g). The RBF for each female was calculated as the mean of the RBF of the two subsamples. Linear regressions were performed to examine length-specific changes in ABF and RBF.

**Spawning Frequency**

To examine spawning frequency, male and female Pacific sanddab were collected from the Monterey Bay in July, August, and September and brought into aquariums maintained at the Fisheries Ecology Division, SWFSC/NMFS. Fish were initially kept in one large (diameter=183 cm, height=127 cm) circular tank with approximately 3-4 cm of 16 grit sand on the bottom. As experiments progressed fish were separated into 10 smaller tanks (diameter=85 cm, height=127 cm), each filled with 3-4 cm of 16 grit sand. Ambient temperature seawater pumped directly from the ocean was filtered through 2 sand filters (10-100 µm) and passed through a UV sterilizer before mixing with chilled seawater. Tank temperatures fluctuated between 8 and 13˚C (primarily between 9.5-12.5˚C). Each tank had separate inflowing and outflowing standpipes. Water was constantly flowed into the tanks at a rate of 100 mL/s, and the net motion of the surface water was circular. Outflowing water was filtered through an egg collector lined with 333 µm mesh netting. All tanks were covered by black tarps; however, some light made it into the tanks at the inflow standpipes. Fish were exposed to ambient light regimes until October 31, 2012 when a 16 hour light, 8 hour dark regime was established for a separate experiment. Fish were fed to satiation a diet of mixed fish and market squid three days per week. An aliquot (0.2-0.9 ml settled volume) of eggs collected from the large tank on 5 different days was placed in a petri dish, and all the eggs were counted twice to get the average number of eggs per ml.

In late August five male-female pairs were segregated into individual tanks. The volume of eggs collected was measured and the stages of egg development were recorded daily (Mon-Fri) when eggs were present. If volumes of eggs collected on Monday were at least double the volume from individual spawns the week before, the fish was estimated to have spawned twice. The number of spawns recorded was a minimum value since spawning activity was not monitored over weekends and holidays; therefore, there may have been additional unrecorded spawns. When egg collectors overflowed, a spawn was recorded if eggs were present and the stage of development could be determined, though no volumes were available. The spawning frequency for each female was calculated as the quotient of the total number of days in isolation and the minimum number of spawns. The average batch fecundity for each female was calculated by summing the recorded volumes of spawns from the date of isolation to November 30, 2012, multiplying by the average number of eggs per ml, and dividing the total number of eggs by the minimum number of spawns.

To establish guidelines for aging POFs in histological sections of ovaries from wild-caught fish, male-female pairs were placed into the remaining five individual tanks, and females were sacrificed at post-spawning intervals (4 hour intervals to 24 hours post-spawning and 8 hour intervals thereafter to 48 hours). A cross section from the middle portion of one ovarian lobe of each female was collected and processed histologically as described in the histology section. Slides were examined and POFs were described for each 24-hour time.

## Results and Discussion

### Collections and General Reproductive Biology

Three hundred seventy-two (312 females; 60 males) Pacific sanddab were collected over twenty-two sampling days between March 2012 and April 2013. Sanddab were sexually dimorphic, with females reaching larger total length (TL) than males (Fig. B1). Females ranged in size from 110 to 290 mm TL (90% were 130-240 mm); males ranged in size from 120 to 230 mm TL (90% were 140-200 mm). Ages of females ranged from 0 to 8 years while males collected ranged from 1 to 6 years of age.

Macroscopic examination of testes from male Pacific sanddab suggested that all males collected were mature. Testes from all males were opaque and tan in color. Testes appeared similar throughout the year with no detectable changes in appearance during the reproductive season

Macroscopic staging of ovaries (Fig. B2a) showed an increasing proportion of females with developing ovaries through the late winter and early summer. By June ovaries were near spawning condition. In August all of the females collected were actively spawning, and the majority of females remained in the actively spawning stages through at least November (no collection was made in December). Immature females were easily distinguished from mature females between August and November due in large part to most mature individuals having hydrated oocytes (HO) visible during this time. HO, which are evidence of an imminent spawn, were readily distinguished from maturing oocytes based on their large size and translucent appearance. In individuals from October and November that had finished spawning for the season, oocytes were still visible in mature individuals whereas immature ovaries were translucent.

GSI values were available for 257 female Pacific sanddab from all sampling months except May and June and mirrored trends in macroscopic staging (Fig. B2a). Mean GSI values were significantly lower (1.74-2.41) through the winter and early summer (February through July) than the rest of the year. GSI peaked in August (mean=6.70) and decreased slightly in September (mean=4.80), remaining at a level that was not significantly different through November. The mean GSI value decreased significantly again in January (mean=3.13). The gross staging of ovaries and GSI values suggest that Pacific sanddab have a protracted spawning season extending from August through at least November. This season is similar to that reported by both Arora (1951) and Chamberlain (1979); however the season lasts longer than either previous study reported.

### Histology

A subsample of 97 ovarian tissues from females collected in all months sampled, except for February and April, have been processed and staged (as of May 2013). The fish were chosen to represent the size range and macroscopic maturity stages of fish collected at each time period. An additional 60 samples are being processed to obtain representative histology samples from February, March, and April 2013 and to fill in underrepresented sampling months. General histological trends mirror macroscopic trends (Fig. B2b), and all histological phases were encountered (Figs. B3 and B4). The majority of female sanddab collected between January and May had inactive ovaries, indicating that they were between spawning seasons. By July most fish were in or nearing spawning condition. The majority of females remained active through November, though some spawning activity persisted until January.

Histological examination of tissues allows for viewing of cellular structures (e.g., POFs and oocytes in initial stages of oocyte maturation [OM]) not visible to the naked eye, thereby allowing for refinement of the reproductive cycle. The finer scale histological phases show a more nuanced trend in the annual reproductive cycle of sanddab (Fig. B3) and that the reproductive season extended from July through January, with a peak of activity from August through November. Oocyte development is rapid with the first vitellogenic oocytes found in May and the first actively spawning ovaries found in July. In August all females collected had previously spawned and were nearing another spawning event. The first spent ovaries were found in September (as found by Arora [1951]), but the majority of females remained in the spawning capable phase through November. During the peak of spawning activity, all stages of oocytes were found in ovaries from actively spawning females, indicating oocyte development is asynchronous, oocyte recruitment is continuous, and fecundity is indeterminate in Pacific sanddab (Murua and Saborido-Rey 2003; Korta et al. 2010). By January the majority of females had ovaries in the regressing phase and had ceased spawning activity; only one female in the regressing phase had POFs, suggesting spawning activity had ended at least several days prior to collection. Chamberlain (1979) had suggested that vitellogenesis began as early as February but his lack of samples between November and February, when fish may still have been spawning, may have led him erroneously to this conclusion. More likely the early vitellogenic oocytes he found were from the previous spawning season and had not yet undergone atresia.

Oocytes in the initial stages of OM, the hormonally controlled "point-of-no-return" which ultimately results in ovulation and spawning of mature eggs, were found in sanddab ovaries that also had HO. Laboratory held sanddabs mostly spawned in the early morning hours (0200-0800 hrs), before the typical sampling time of wild fish; however, HO were found in wild-caught females collected 0800-1200 and as well as 1600-1800 hrs. The histological and field evidence suggests OM is not a rapid event in Pacific sanddab. OM, like other physiological processes, is influenced by temperature; the duration of hydration (the final stage of OM) took 20 hours at 9˚C but less than 5 hours at 20˚C in Japanese flounder, *Paralichthys olivaceus* (Kurita et al. 2011). Even longer durations of hydration, from 35 to 54 hours, have been found in deep-dwelling Atlantic halibut, *Hippoglossus hippoglossus* (Finn et al. 2002). Water temperatures at the time of collection were not available but Pacific sanddab are reported to be tolerant of waters between 5-13˚C (Love 2011), and it is presumed temperatures were within this range. It is plausible that hydration could last 20-24 hours in Pacific sanddab, with the next batch of oocytes destined to be spawned initiating OM 24 hours prior to the onset of hydration.

The lack of immature females in histological samples from March, May, and June and the comparatively high proportion from macroscopic staging during the same time period (Fig. B2) illustrates how misclassification of immature, mature, and resting ovaries outside of the reproductive season is an issue for indices of maturity relying on macroscopic data (West 1990). Macroscopically, the immature ovary, which only contains early growth oocytes (late primary growth and early cortical alveolar) and has no atretic oocytes, appears similar to the regenerating ovary, which has similar stages of oocytes but pronounced atresia as well. Similarly, while nearly half the females collected in January were macroscopically staged as having developing ovaries, histological examination of five of these revealed that the oocytes visible to the naked eye were atretic, being resorbed as part of the end of the season "cleanup" that occurs in regressing and regenerating ovaries. Because of these issues, the growth curve for female sanddab (Fig. B5) was constructed utilizing macroscopic stages of ovaries from fish collected only during the peak reproductive period, August through November (n=154). Compared to Arora (1951), who used maturity data collected from 227 female Pacific sanddab collected in August, females in the current study reached maturity at a much smaller size. In the current study, no fish were mature below 120 mm TL, 50% maturity occurred before 130 mm, and 100% maturity occurred at 150 mm TL. In contrast, Arora (1951) showed first maturity around 170 mm, 50% around 185 mm, and 95% around 200 mm TL. Though no females smaller than 150 mm were available in his August collections, Arora did collect females as small as 95 mm as part of his other life history work. The differences in the two growth curves may be attributable in part to regional differences or interannual variability; however, fishing-induced evolution can result in fish maturity at smaller sizes (Rijnsdorp et al. 2010; van Walraven et al. 2010).

**Fecundity**

Fecundity subsamples were collected from 100 females during the spawning season. Data collection is ongoing; however, as of May 2013, fecundity estimates have been made from 50 females. Average batch fecundity (ABF) values ranged from 810 to 17,400 (mean=6,350 ± 610) eggs spawned per batch and increased linearly with TL (Fig. B6a; $R^2$=0.55). Relative batch fecundity (RBF) values ranged from 15 to 115 (mean=61 ± 4) eggs per gram ovary-free body weight and showed no significant relationship with length (Fig. B6b; $R^2$=0.06). Not all ovarian samples from females for which fecundity was estimated were examined histologically, and it is therefore possible that the reported values may be biased low: without histological examination to look for new POFs, it is impossible to say whether or not a particular female had ovulated and spawned a portion of the batch of eggs. Despite the potential for fecundity values to be underestimates, these data provide novel information on the minimum reproductive output of Pacific sanddab.

Fecundity data are limited on flatfish species, especially other Paralichthyids, and, more generally, fish with indeterminate spawning strategies due to the difficulty in obtaining sufficient data (Murua et al. 2003; Fitzhugh et al. 2012). Two other Paralichthyid species, Patagonian flounder (*Paralichthys patagonicus*) and yellowfin sole (*Limanda aspera*) have much larger batch fecundities, 80,380 on average for the former (Militelli 2011) and between 2,400 and 408,000 for the latter (Nichol and Acuna 2001). Relative batch fecundity was similar, however, in the Patagonian flounder (means of 71-93 HO per gram OFBW; Militelli 2011). Batch fecundity in captive yellowtail flounder (*Limanda ferruginea*), a Pleuronectid, was also higher, falling between 10,000 and 20,000 eggs spawned (Manning and Crimm 1998). Relative batch fecundity in captive Dover sole, *Microstomus pacificus* (Pleuronectidae), was even lower than that estimated for Pacific sanddab, decreasing from 10 oocytes per gram OFBW early to 5 oocytes per gram late in the spawning season (Hunter et al. 1992). However, comparisons between Pacific sanddab and the other species mentioned should be made cautiously as yellowfin sole, Dover sole, and yellowtail flounder have determinate fecundity and fecundity type in Patagonian flounder was not explicitly stated.

**Spawning Frequency**

Pacific sanddab collected from Monterey Bay and brought into the laboratory acclimatized well: spawning often occurred the night fish were collected and brought into the lab. On average there were 2,012 eggs per ml of eggs collected from the large group tank. The 5 male-female pairs began spawning within one or two days of being isolated (Table B3), and females often spawned on successive days throughout the time period. The ABF for these 5 captive female sanddab ranged from 3,026 to 5,961 eggs. The ABF in captive females is within the range of ABF estimated from wild females but may be less than the average for several reasons. Firstly, all but one of the captive females were smaller than 200 mm TL; ABF from wild-caught females above 200 mm TL were generally greater than 6,000 eggs/batch and contributed to the high average. Secondly, it is possible that not all the eggs spawned made it into the egg collectors: sanddab eggs are positively buoyant but unfertilized or non-viable eggs sink (Smith et al. 1999). Lastly, a female may not ovulate and release all HO at once (Burt et al. 1988). Additionally, the actual batch fecundity of captive females may be even lower than initial estimates due to unrecorded spawns. Captive female sanddab spawned every 1.6 days on average (i.e., an individual would be expected to spawn twice every three days), though this is likely an underestimate due to lack of monitoring of spawning activity over weekends and holidays.

Four of the original five pairs of sanddab are still isolated: one pair was euthanized in March 2013 due to injuries. Spawning continued regularly in all tanks until a rapid drop in temperature from 10.5 to 8.5 ˚C in December, at which time spawning volumes dropped in four tanks and ceased all together in one. Spawning resumed in four tanks once temperatures were adjusted upwards. In February an additional two females ceased spawning activity. Spawning activity in the two remaining tanks remained fairly regular, with spawning frequency decreasing to around once every three days, from December through March. In April the females began to spawn daily the majority of the time. Sporadic spawning in the two tanks with females that had stopped in February began again in early May as temperatures rose from 9.5-10.0ºC to 11.5-12.5ºC. Other examples of species in which individual females are capable of spawning daily include New Zealand snapper, *Pagrus auratus* (Scott et al. 1993); yellowfin tuna, *Thunnus albacores* (Schaeffer 1998); and Japanese flounder (Kurita et al. 2011). However, in Japanese flounder, while the population-level spawning period lasts 5 months, an individual female only spawns 2-3 months (Kurita et al. 2011). While the tank conditions are completely artificial compared to environmental conditions wild fish encounter, female Pacific sanddab are biologically capable of prolonged reproductive activity.

Histology samples from 36 females sacrificed at known intervals post-spawning were examined. Because most spawning occurred between midnight and 0800 hrs in the lab and the majority of wild fish were collected between 0800-1200 hrs, day 1, day 2 and day 3+ POFs were considered those 0-12, >12 to 36, and >36 hours old, respectively (Fig. B7). POFs were distinguishable from other atretic material (atretic oocytes and late-stage atresia of oocytes and POFs) for at least 2 days (48 hrs); POF persistence beyond that time is unknown since no females were held in experimental tanks past 48 hours post-spawning. Based on the morphology of the 48-hour old POFs and presence of multiple "modes" of POFs present in ovaries examined, they likely remain distinguishable beyond that time. POFs persisted as long as 58 hours in Mediterranean sardine, *Sardina pilchardus sardine* (Ganias et al. 2003) and up to 3-4 days in northern anchovy, *Engraulis mordax* (Hunter and Macewicz 1985b). Kurita et al. (2011), however, found that POFs in Japanese flounder were no longer evident 16 hours after spawning at 9˚C.

Spawning in the laboratory occurred most frequently between 0200 and 0800 hrs and most sampling of wild Pacific sanddab occurred from 0800 to 1200 hrs; therefore, Day 0, day 1, and day 2+ POFs were considered to be 0-12, >12-36, and >36 hours old, respectively. In Day 0 POFs, the cells of the granulosa layer were cuboidal in shape with prominent nuclei and formed a convoluted shape in the lumen of the empty follicle. Day 1 POFs were further condensed often with less space in the lumen and the granulosa layer began to form a single layer within the lumen by the end of the stage. Day 2+ POFs were smaller and triangular in shape with a very small, single layer of granulosa cells and a thickened layer of thecal cells. In the oldest discernible POFs, the granulosa layer was nearly absent and the thecal layer was thicker.

Due to a restricted space to set up more spawning tanks and a lack of diel synchronicity in spawning of captive sanddab, it was impossible to get a sufficient number of samples from all post-spawning time periods in order to fully examine the degradation of POFs over time. Temperature significantly effects the rate of degradation of POFs in other species (Kurita et al. 2011), and the fluctuating temperatures in experimental tanks over the course of spawning further precluded solidification of precise criteria to establish age of POFs. Additionally, as spawning activity of females prior to their isolation was unknown, most of the histological sections had POFs from multiple spawns complicating interpretation. The experiment did help establish a general idea of new, recent, and older POFs which, while not applicable for accurately establishing spawning frequency in wild sanddab, assisted with histological staging.

## Conclusions

Pacific sanddab in the Monterey Bay are indeterminate spawners with asynchronous oocyte development and are capable of spawning many times throughout a protracted reproductive season extending from July through January. While histological evidence was unable to allow for population level spawning frequency estimates of wild fish, it does suggest that females are capable of spawning on successive days. Biologically, female sanddab are capable of spawning daily for at least several days in a row, as evidenced by the spawning activity of captive fish. If a wild female is assumed to exhibit a similar spawning frequency to laboratory held fish during the peak spawning months of August through November and an average batch fecundity of 6,350 eggs, that female could potentially spawn 76 times during the peak, producing up to 4.8 million eggs. Sanddab appear to be maturing at significantly smaller sizes and younger ages from fish collected off the California coast in the 1930s and 1940s (Arora 1951). Whether the change in size and age at maturation was induced by fishing related evolution or was due to spatial and/or temporal variability is unknown but the change is compelling and has significant repercussions on estimates of spawning stock biomass.

Fecundity and spawning frequency results presented here are introductory, and further sample processing and research would allow us to examine other aspects of the reproductive ecology of Pacific sanddab. For example, in other indeterminate spawning teleosts, batch fecundity has been shown to vary between the beginning and end of the spawning season (Ruchon et al. 1993; Militelli and Macchi 2004).

More importantly, while relative fecundity appears to be unrelated to female size in our initial analysis, maternal age and/or size may still be relevant to other aspects of the spawning ecology of Pacific sanddab. Maternal age or size has been shown to influence the quality of eggs and larvae in several species (Berkeley 2004; Sogard 2008). The duration of spawning season and frequency often differs between fish of different age and size categories (Lowerre-Barbierri et al. 2011), most often with older, larger females spawning for longer and more frequently than younger, smaller females (Fitzhugh et al. 2012). When this is failed to be accounted for in stock assessment models, the result is an overestimate of biological reference points that are used in setting harvest rates (Fitzhugh et al. 2012). Collection of additional fecundity samples and closer examination of spawning frequency of wild-caught fish may allow us to determine if there are age and size differences in the reproductive ecology of these fish and what effects the reduced size at maturity may have on the population of Pacific sanddab along the Central California coast.

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Table B1.  Macroscopic stages of maturity for Pacific sanddabs.

| **Stage** | **Visual description** | **Gross Maturity Category** |
|---|---|---|
| Immature | Ovaries thin; no oocytes visible; translucent.  As approaching maturity, lamellae are faintly visible. | Immature |
| Developing | Oocytes visible, giving ovary a granular appearance; ovary vascularized; ovary opaque peach in color | Mature--Developing |
| Ripe | Hydrated oocytes (clear) visible in ovary, but not in oviduct or lumen; the rest of the ovary looks like the "Developing" ovary | Mature--Active |
| Running | Hydrated oocytes loose in lumen and/or oviduct; additional hydrated oocytes may be visible in ovarian tissue; rest of the ovary looks like the "Developing" ovary | Mature--Active |
| Regressing | Ovary bright red/pink (well vascularized) & flaccid; oocytes visible but not throughout ovary and not patterned; ovary has a  loose and gelatinous texture | Mature--Active |
| Regenerating or Early Developing | Ovaries small and mostly translucent; lamellae/early oocytes visible creating track- or maze-like pattern in ovary | Mature--Inactive |

Table B2. Histological phase criteria and descriptions for Pacific sanddab. Phases were based on descriptions of teleost development in Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). PG=primary growth; CA=cortical alveolar; Vtg=vitellogenic; POF=postovulatory follicle; HO=hydrated

| **Phase** | **Subphase** | **Description** | **Gross Maturity Category** |
|---|---|---|---|
| Immature | | Only oogonia and PG oocytes present, though early CA oocytes may be present towards the end of the phase; no atresia; no prominent blood vessels or muscle bundles; tissue organized | Immature |
| Developing | Early Developing | Oogonia, PG, and CA oocytes present; tissue organized; little to no atresia present | Mature--Inactive |
| | Maturing (mid-maturation) | Vitellogenic (VTG) 1 and Vtg2 are the most advanced oocytes; minor atresia may be present | Mature--Developing |
| Spawning Capable | Late Developing | Vtg3 oocytes are the most advanced oocyte present; minor atresia may be present; evidence of recent spawning (POFs) | Mature--Active |
| | Gravid | HO are the most advanced oocytes; no evidence of recent spawning (POFs) | Mature--Active |
| | Recent spawn | Day 0 and Day 1 POFs present; older POFs may also be present; rest of ovary resembles the "Maturing", "Late Developing", or "Gravid" ovary; moderate delta and gamma atresia may be present | Mature--Active |
| | Past spawn | Day 2+ POFs present and readily distinguishable from older atresia; rest of ovary resembles the "Maturing", "Late Developing", or "Gravid" ovary; moderate delta and gamma atresia may be present | Mature--Active |
| Regressing | | Majority of Vtg and/or HO oocytes are undergoing alpha and/or beta atresia; lamellae appear loose and disorganized; some non-atretic Vtg and CA may be present; POFs may or may not be distinguishable from other atretic material | POFs visible: Mature--Active POFs not visible: Mature--Inactive |
| Regenerating | | Oogonia and PG oocytes dominate, though CA oocytes may be present; lamellae appear more organized compared to "Regressing" ovary; some beta atresia may be present but delta and gamma atresia dominate; muscle bundles, blood vessels, and connective tissue often prominent | Mature--Inactive |

Table B3. Average batch fecundity and spawning frequency of laboratory held Pacific sanddab. For each female, the number of days used to estimate spawning frequency was the total days from the date isolated until November 30, 3012. The average batch fecundity was estimated by first multiplying the total volume of eggs spawned from date of isolation until November 30, 2012 by 2,012 (the number of eggs per ml), then dividing by the minimum number of spawns.

| Tank # | Date Isolated | Date of First Spawn | Minimum # of spawns | Average batch fecundity | Spawning frequency |
|---|---|---|---|---|---|
| 1 | 8/21/2012 | 8/23/2012 | 62 | 4,851 | 1.6 |
| 2 | 8/29/2012 | 8/30/2012 | 62 | 3,329 | 1.5 |
| 3 | 8/27/2012 | 8/28/2012 | 75 | 3,085 | 1.3 |
| 4 | 8/29/2012 | 8/31/2012 | 54 | 5,961 | 1.7 |
| 5 | 8/22/2012 | 8/23/2012 | 59 | 3,026 | 1.7 |

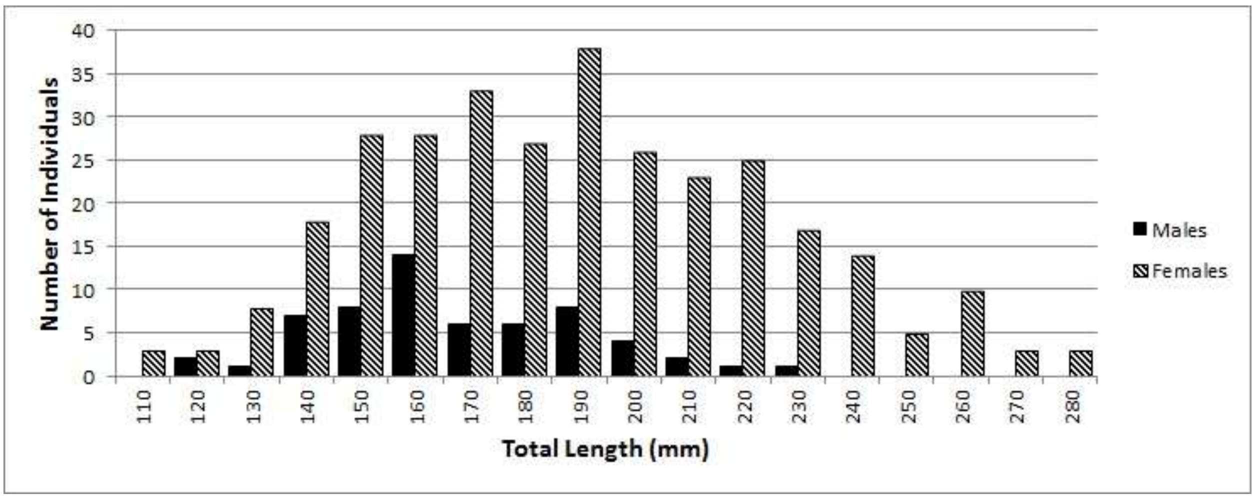
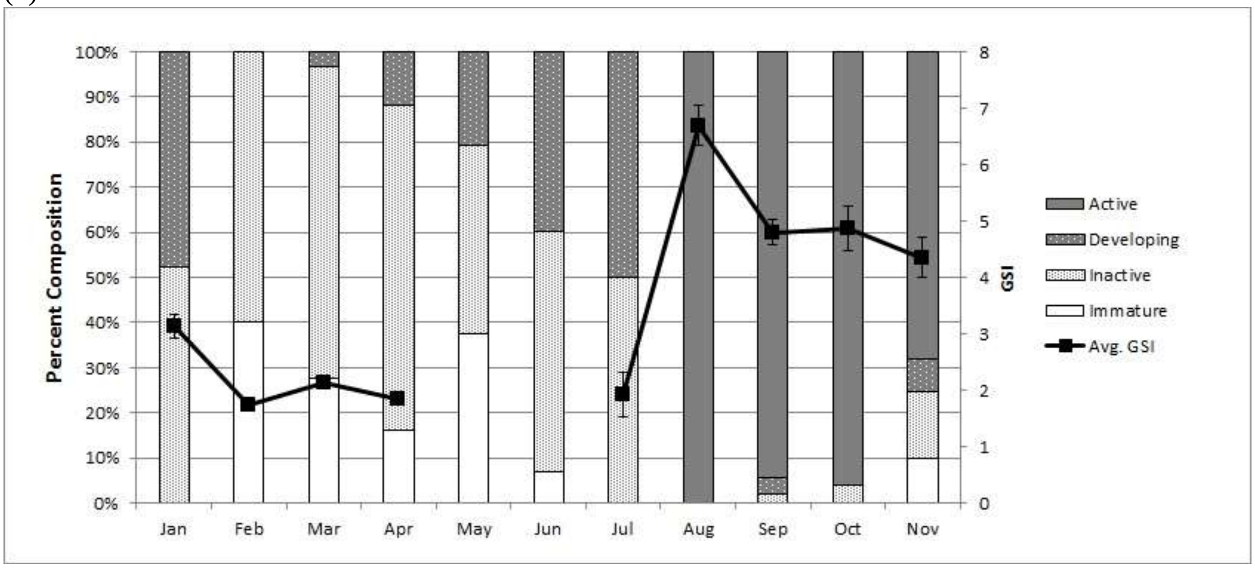



**Figure B1.** Size distribution of Pacific sanddab (*Citharichthys sordidus*) collected from the Monterey Bay, California, between March 2012 and April 2013.

(**a**)




(**b**)

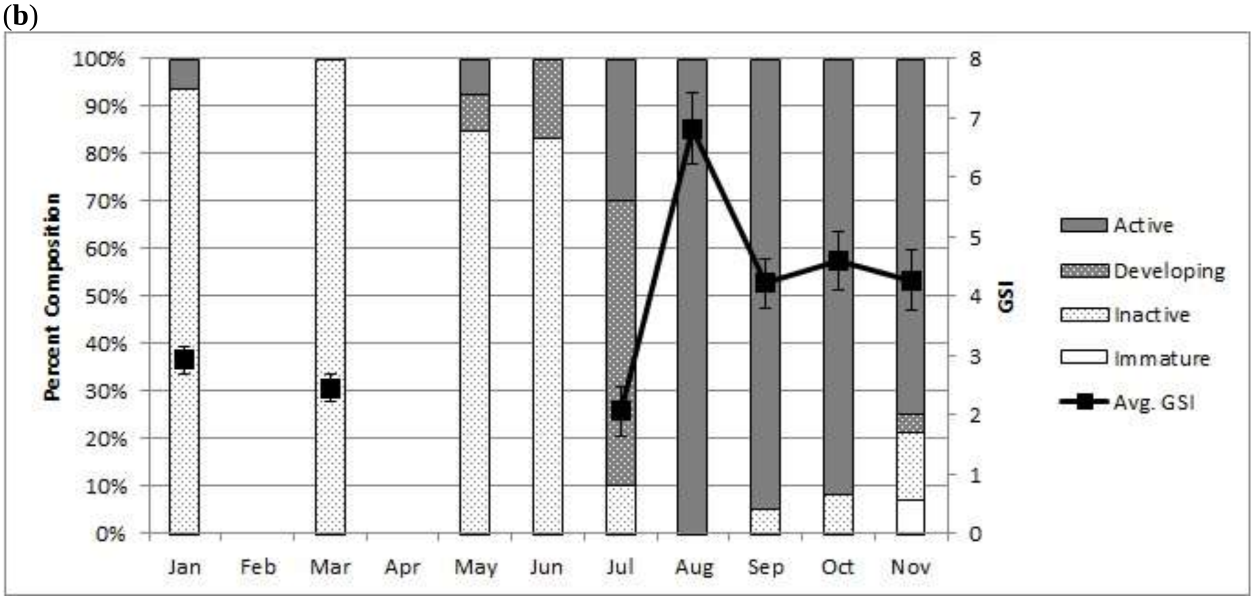



**Figure B2.** Percent composition of females in gross maturity categories and average GSI values for Pacific sanddab (*Citharichthys sordidus*) collected March 2012-April 2013 for **(a)** all females collected (n=312), with gross maturity based on macroscopic staging and **(b)** females examined histologically (n=97).

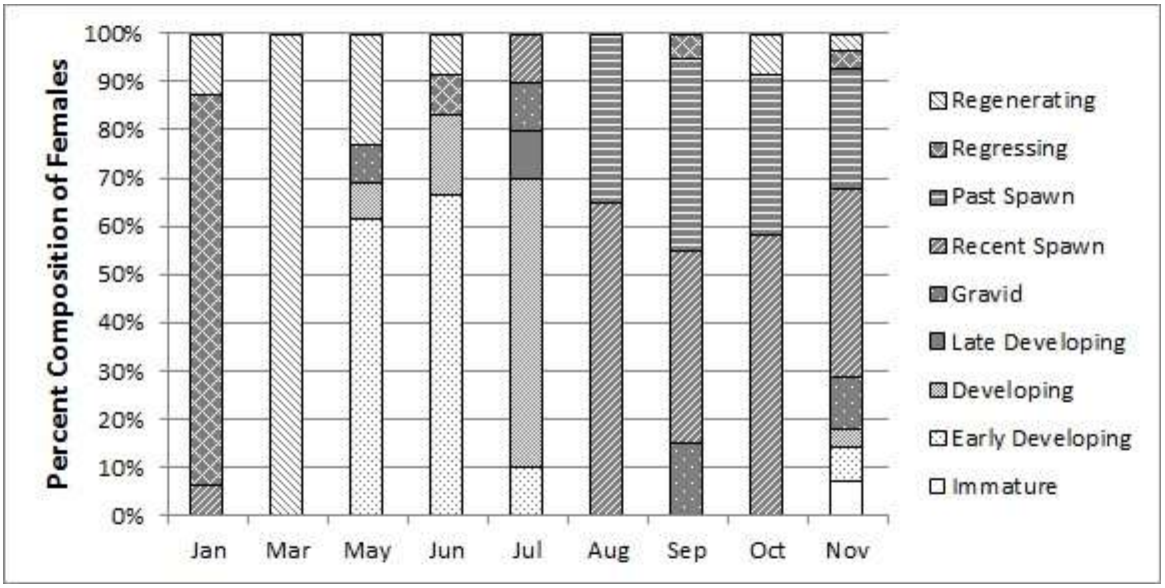



**Figure B3.** Percent composition of female Pacific sanddab (*Citharichthys sordidus*) in each of the histological phases in each of the months for which histological samples were available.

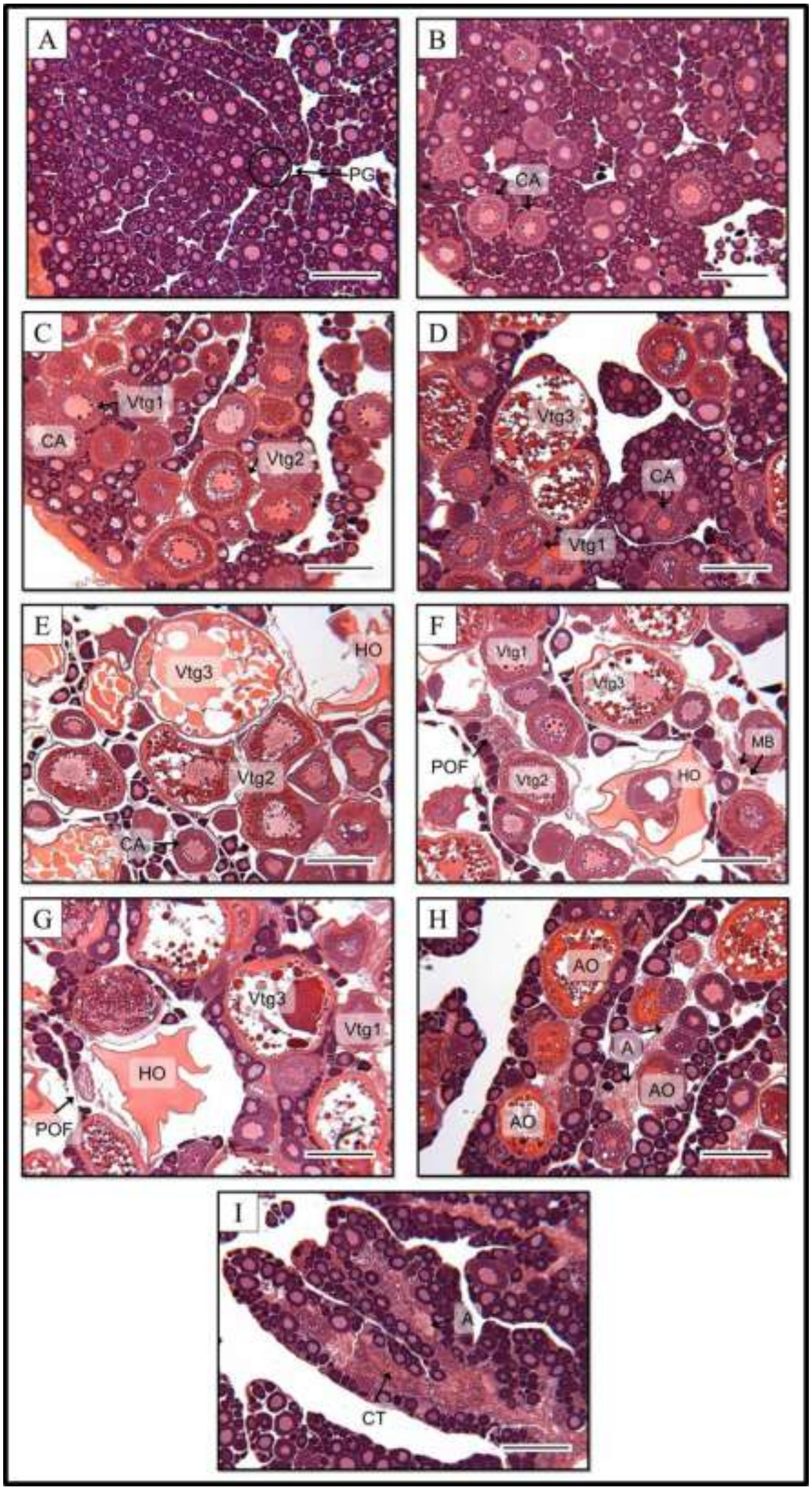

A
PG
B
CA
C
Vtg1
CA
Vtg2
D
Vtg3
CA
Vtg1
E
Vtg3
HO
Vtg2
CA
F
Vtg1
Vtg3
MB
POF
Vtg2
HO
G
Vtg3
Vtg1
HO
POF
H
AO
A
AO
AO
I
A
CT

**Figure B4.** Histological micrographs of the phases of ovarian development in Pacific sanddab (*Citharichthys sordidus*) collected in the Monterey Bay between March 2012 and April 2013. Scale bars=250 µm. Phases were based on descriptions of teleost development in Wallace and Selman (1981) and modified from Lefebvre and Denson (2012) and Brown-Peterson et al. (2011). **(A)** Immature: oogonia and primary growth (PG) are the only oocytes present; no atresia, connective tissue, muscle bundles, or blood vessels present; tissue is highly organized. **(B)** Developing, early developing subphase: early- and mid- cortical alveolar (CA) oocytes present with oogonia and PG; no atresia; tissue is highly organized. **(C)** Developing, mid-maturation subphase: vitellogenic (Vtg) stage 1 and 2 oocytes present with earlier oocyte stages. **(D)** Spawning capable, late developing subphase: early Vtg3 oocytes (nuclear migration and initial yolk coalescence) present with earlier oocyte stages; no evidence of recent spawning activity (postovulatory follicles [POF]). **(E)** Spawning capable, gravid subphase: hydrated oocytes (HO) present with late Vtg3 and earlier oocyte stages; no evidence of recent spawning activity (POF). **(F)** Spawning capable, recent spawn subphase: day0 and day1 postovulatory follicles (<36 hours old are present); muscle bundles (MB), blood vessels, and connective tissue may be present in fish that have spawned previously; the rest of the section resembles the "gravid" subphase. **(G)** Spawning capable, past spawn subphase: day2+ POF present; the rest of the ovary resembles the "gravid" subphase. **(H)** Regressing: Vtg oocytes undergoing alpha atresia (AO); delta and gamma atresia (A) present as well; most advanced "healthy" oocytes are CA stage. **(I)** Regenerating: only oogonia and PG oocytes present; connective tissue (T) and late stage gamma A common in interior of lamellae.

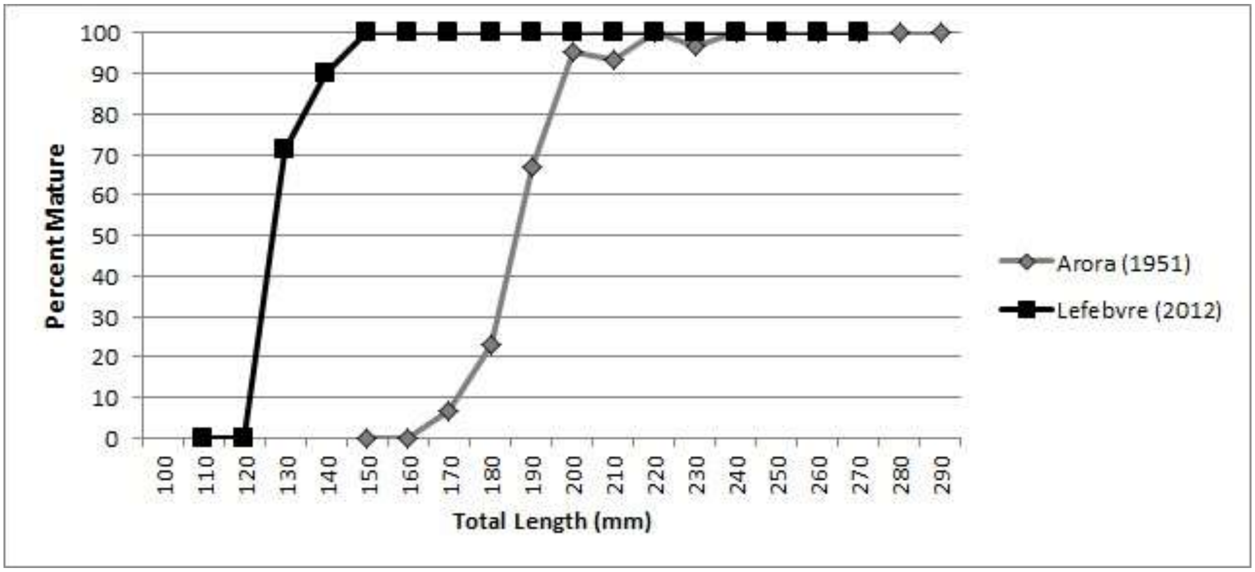
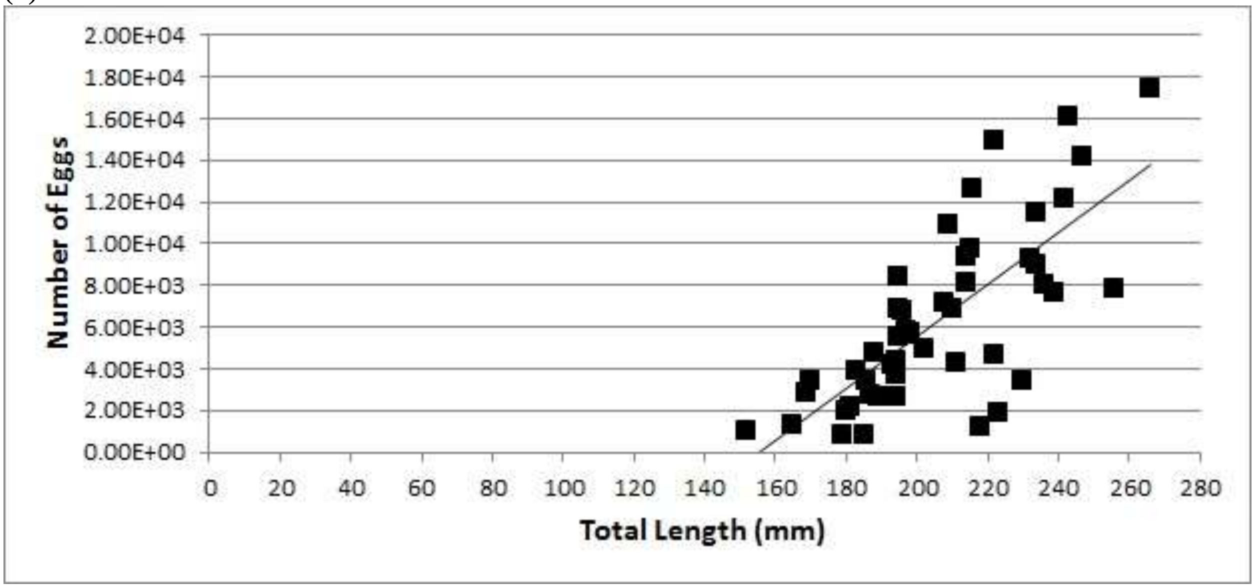



**Figure B5.** The percentage of Pacific sanddab (*Citharichthys sordidus*) females mature at given total lengths. The blue triangles and lines are data from Arora (1951) from fish collected from Pt. Reyes to San Francisco, California in August during the 1930s and 1940s (n=227). The red squares and line are from fish collected in the Monterey Bay between August and November 2012 (n=154).

(**a**)




(**b**)

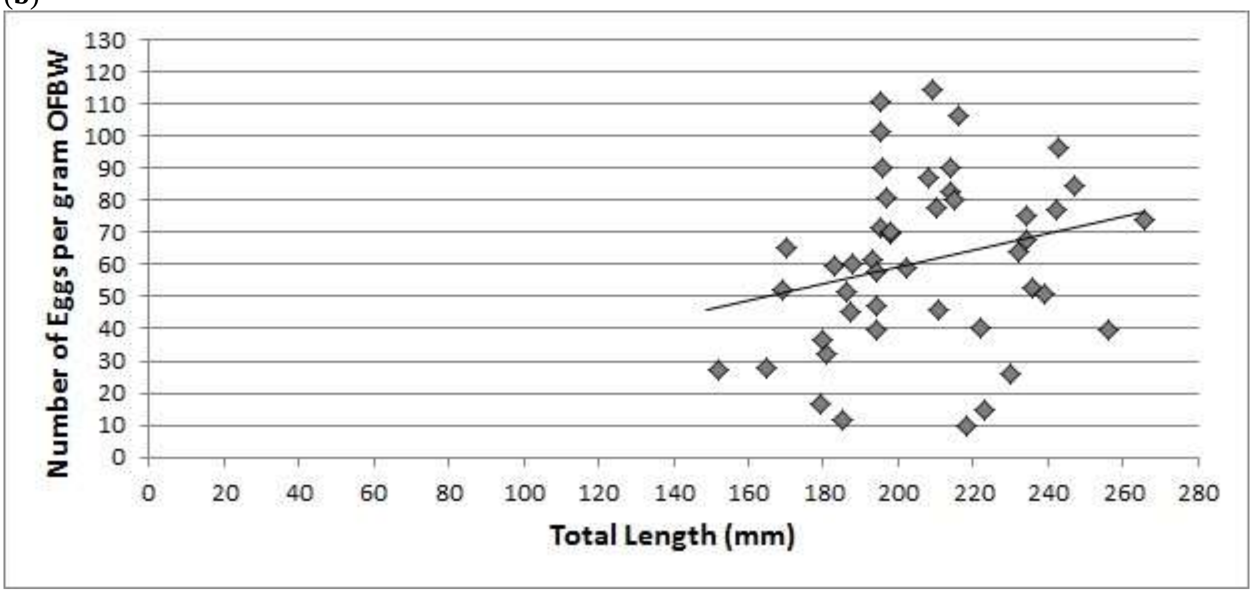



**Figure B6**. Batch fecundities estimated from 50 female Pacific sanddabs (*Citharichthys sordidus*) collected in the Monterey Bay in August and September 2012. **(a)** Absolute batch fecundity increased linearly with fish length ($R^2$=0.55); however, **(b)** Relative batch fecundity showed no significant relationship with length ($R^2$=0.06). OFBW=ovary-free body weight (g).

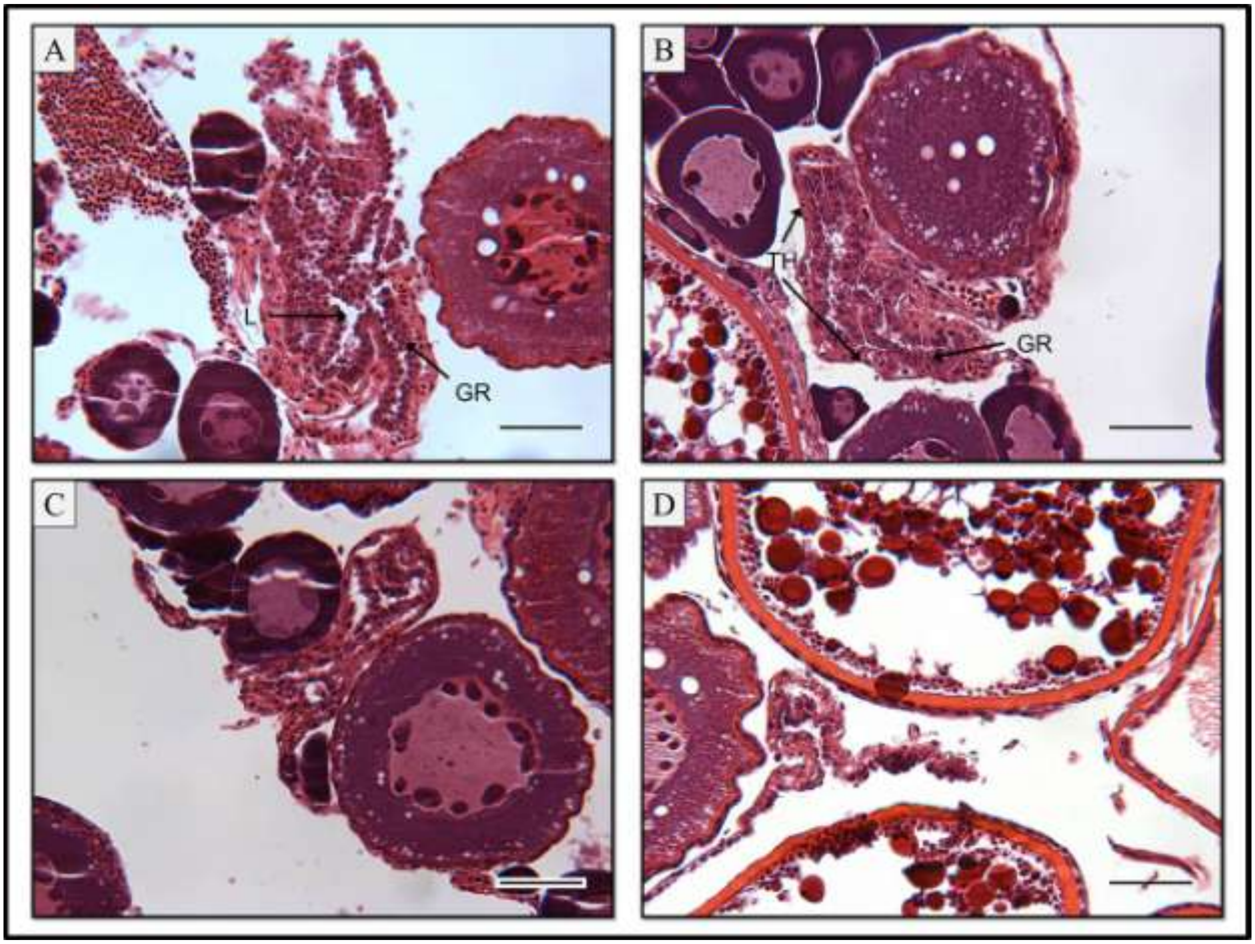



**Figure B7.** Photomicrographs of postovulatory follicles (POFs) from the ovaries of captive Pacific sanddab (*Citharichthys sordidus*) held at 10.6-11.9˚C and sampled successive time intervals post-spawning. TH=thecal cell layer. Scale bars=50 µm. **(A)** Day 0 POF, 0-4 hrs old. Granulosa cells (GR) are cuboidal in shape with prominent nuclei and form a convoluted shape in the lumen (L) of the follicle. **(B)** Day 1 POF, 20-24 hrs old. The POF condenses as the GR layer becomes less convoluted. **(C)** Day 2 POF, 40-48 hrs old. POF is further reduced in size as GR forms a single layer. **(D)** Day 2+ POF, unknown age. Oldest POFs are generally triangular in shape and are recognizable from atretic oocytes when along margin of lamellae.

## Appendix C. Base Model Fits to Length and Age Frequency Data by Year, Fleet and Sex for All Surveys and Fisheries

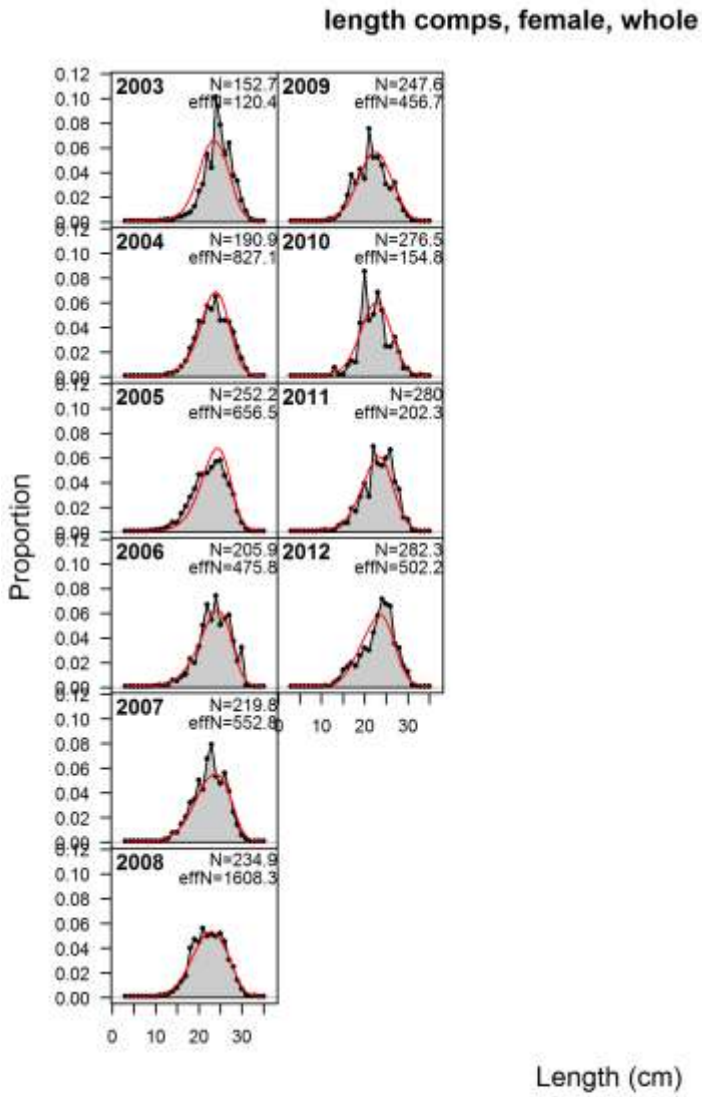



**Figure C.1: Base model fits to length frequency distributions of females from the NWFSC survey from 2003 to 2012.**

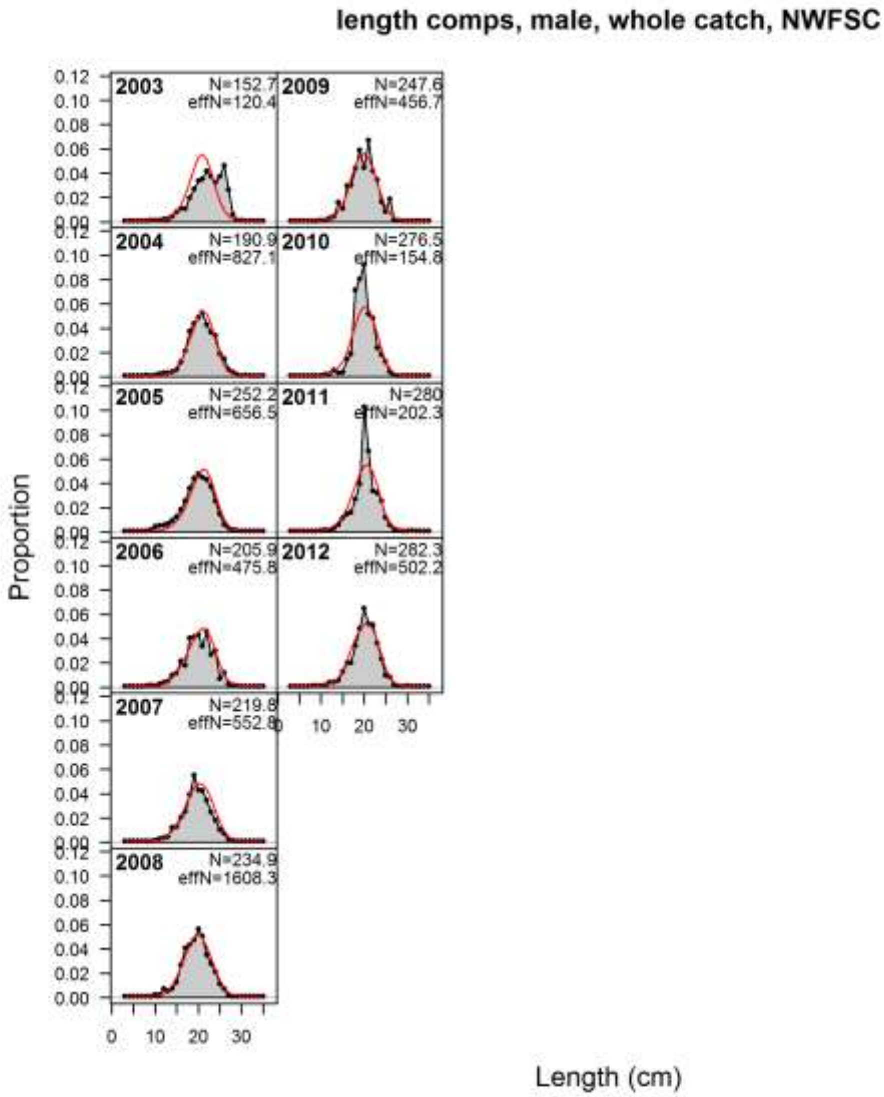



**Figure C.2: Base model fits to length frequency distributions of males from the NWFSC survey from 2003 to 2012.**

length comps, female, whole catch, TriEarlyYr

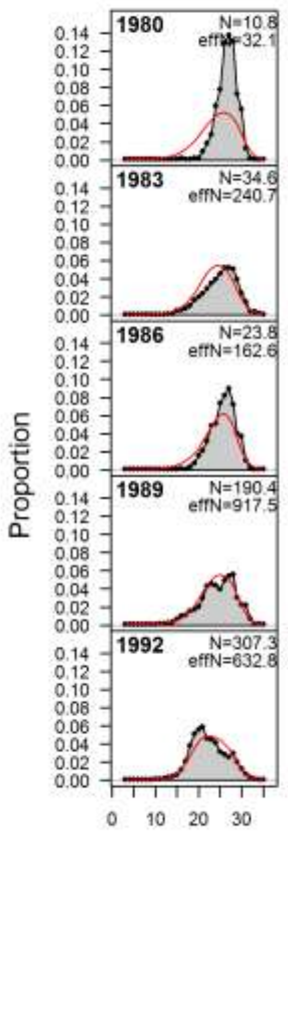



**Figure C.3: Base model fits to length frequency distributions of females from the early year triennial survey from 1980 to 1992.**

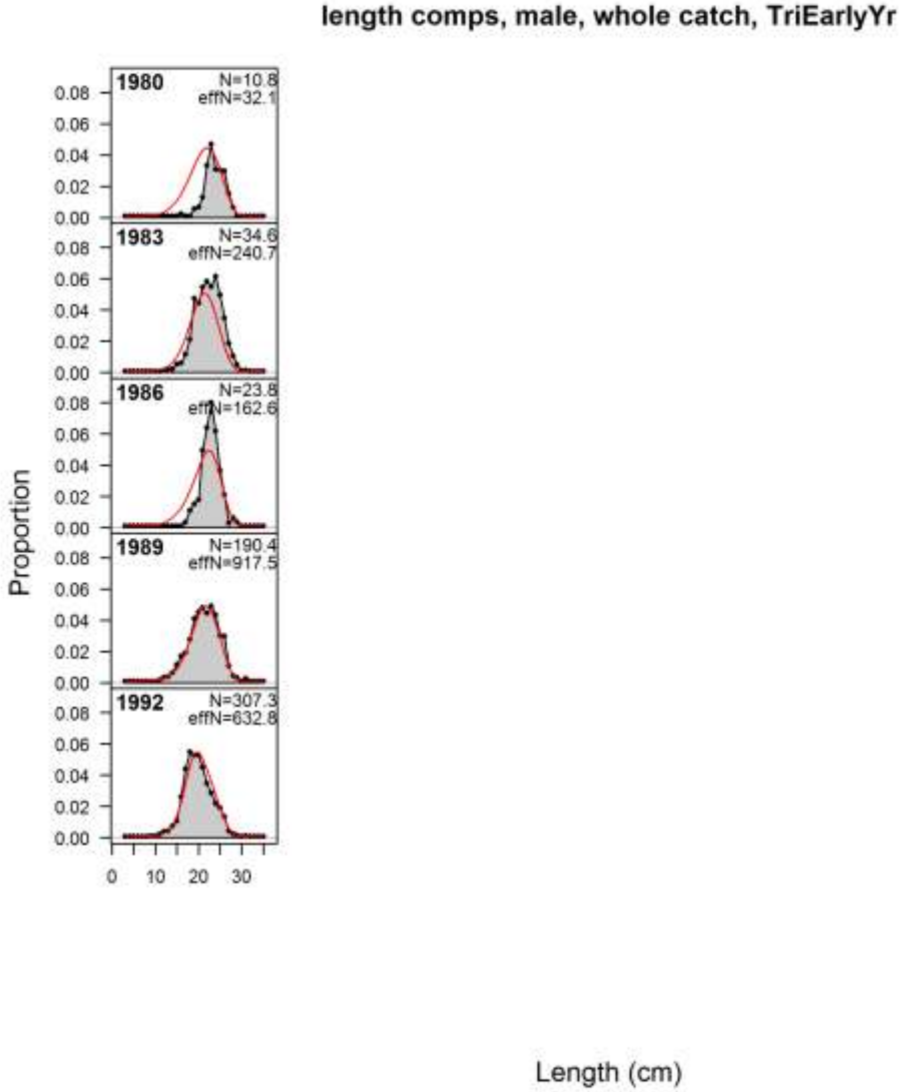



**Figure C.4: Base model fits to length frequency distributions of males from the early year triennial survey from 1980 to 1992.**

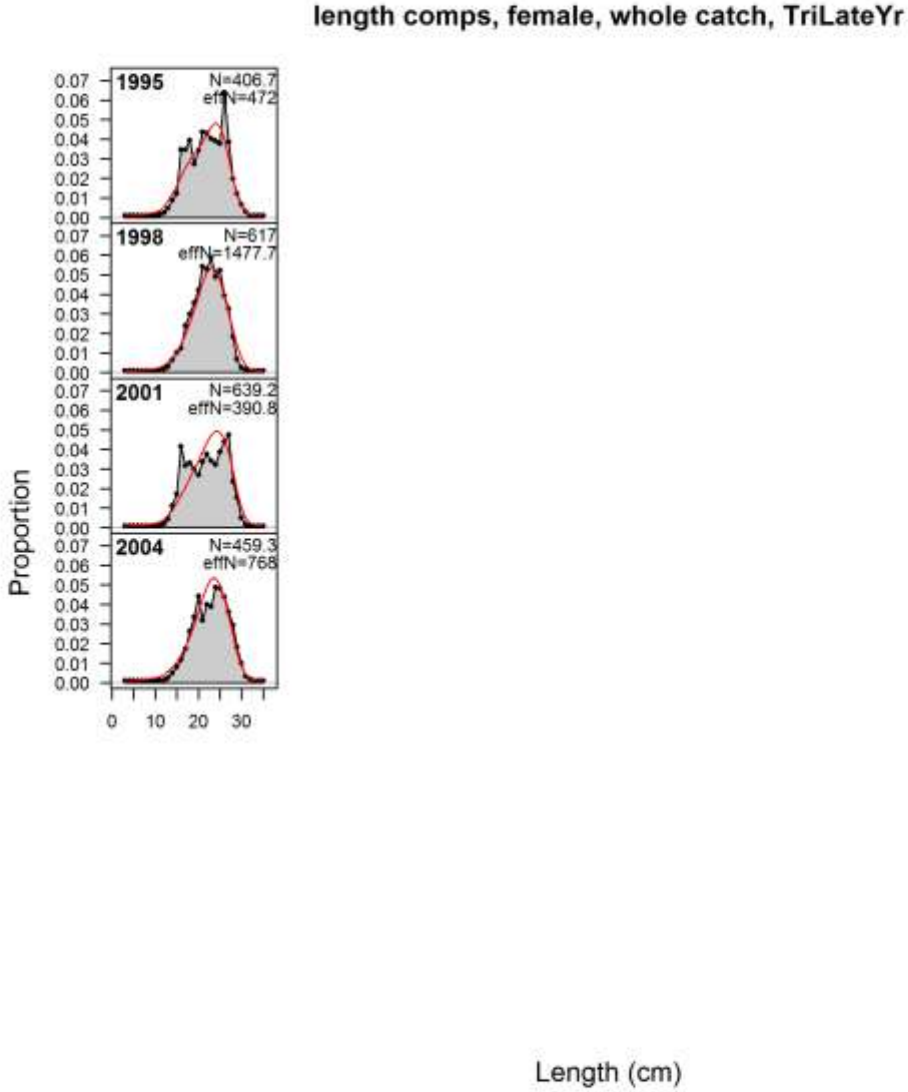



**Figure C.5: Base model fits to length frequency distributions of females from the late year triennial survey from 1980 to 1992.**

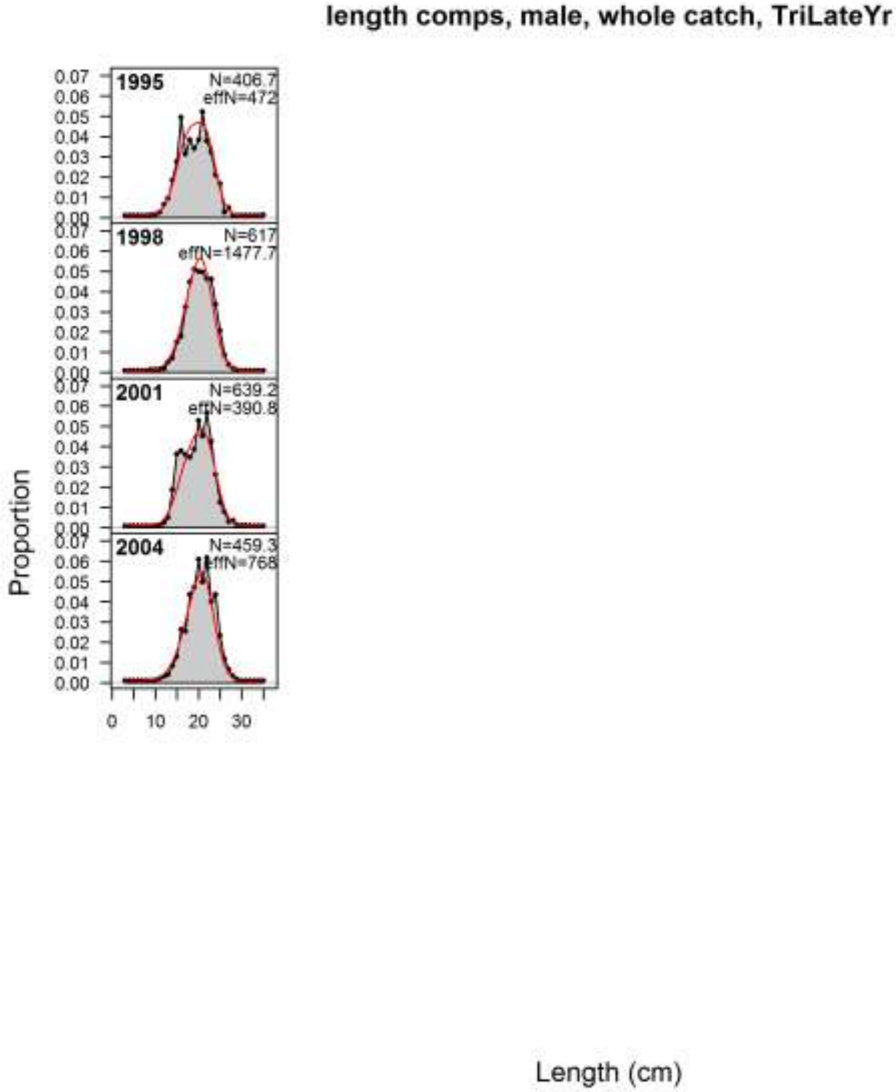



**Figure C.6: Base model fits to length frequency distributions of males from the late year triennial survey from 1980 to 1992.**

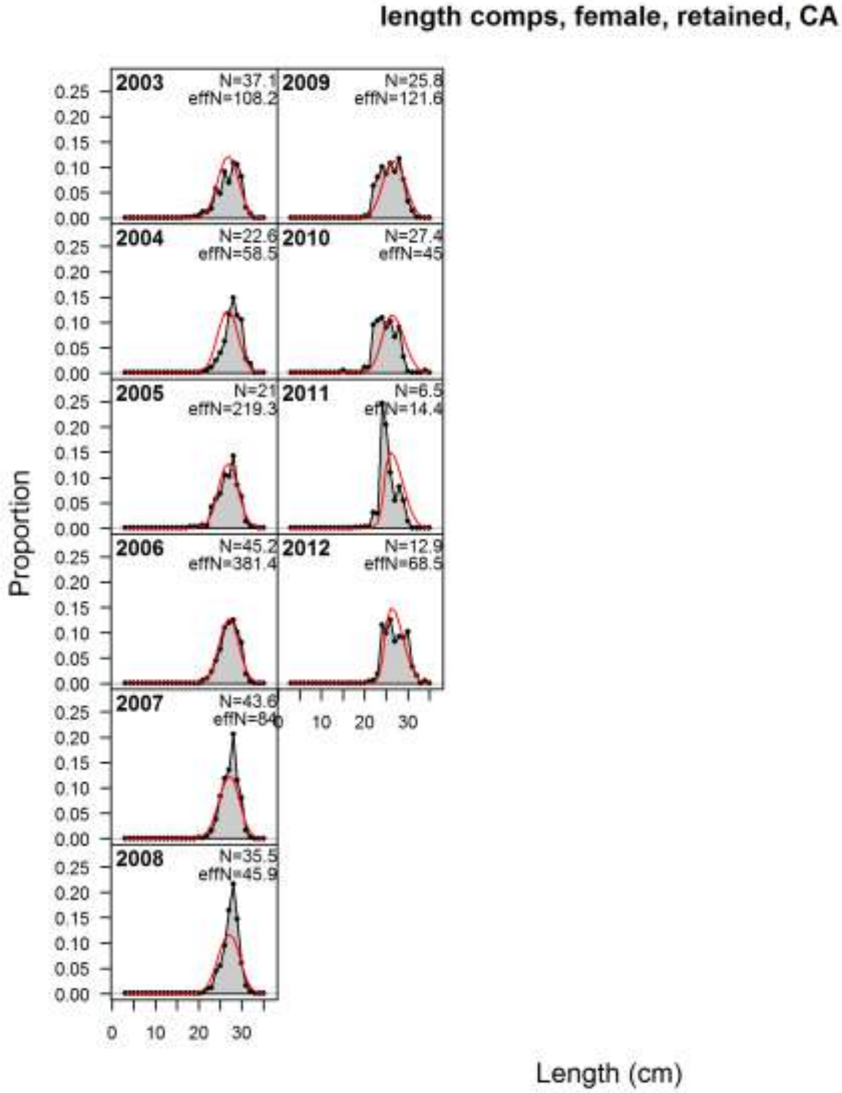



**Figure C.7: Base model fits to length frequency distributions of females for retained catches from the CA fishery from 2003 to 2012.**

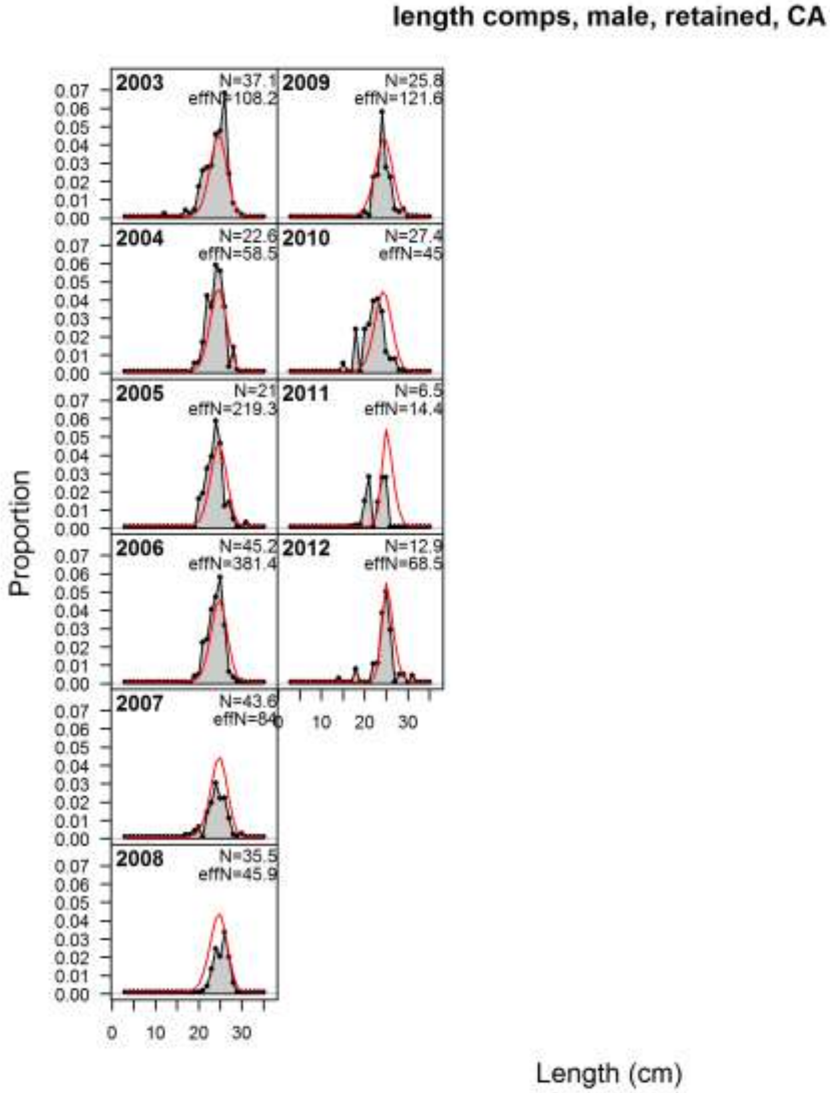



**Figure C.8: Base model fits to length frequency distributions of males for retained catches from the CA fishery from 2003 to 2012.**

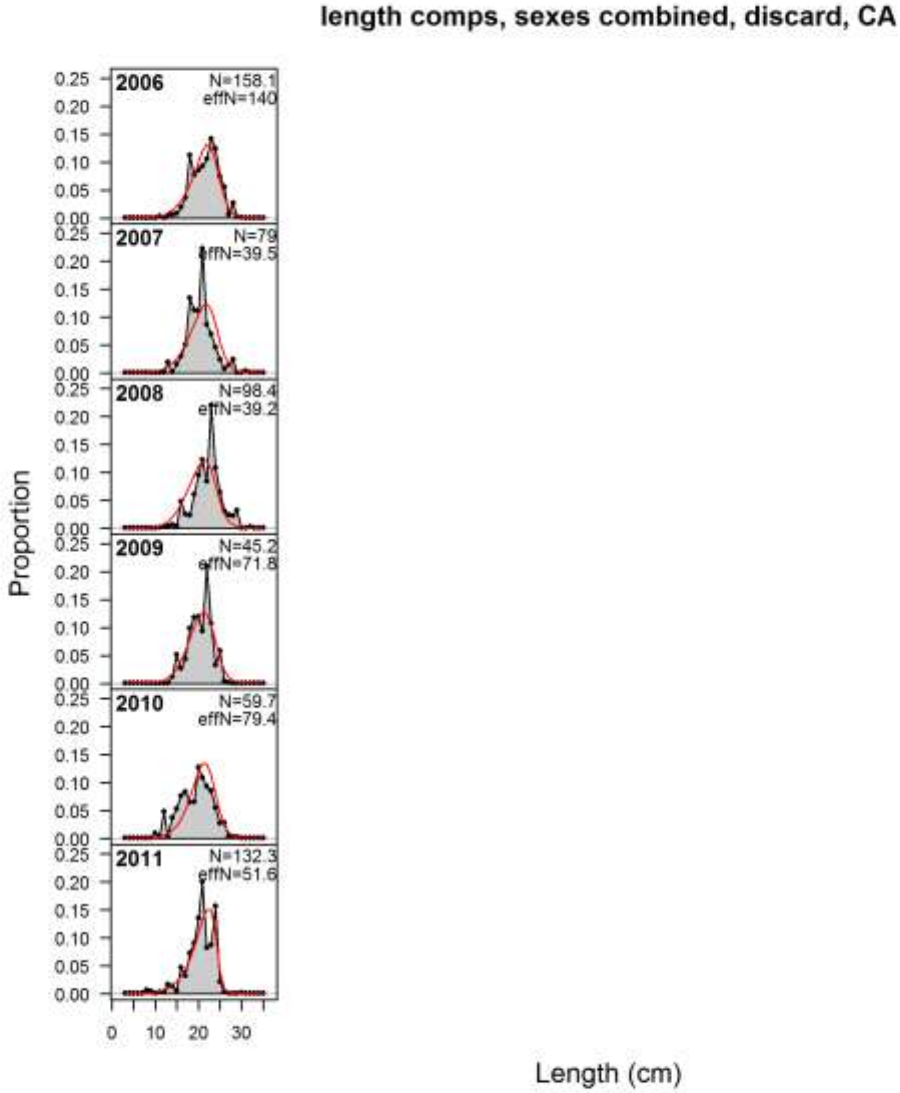



**Figure C.9: Base model fits to length frequency distributions of combined sexes for discarded catches from the CA fishery from 2006 to 2011.**

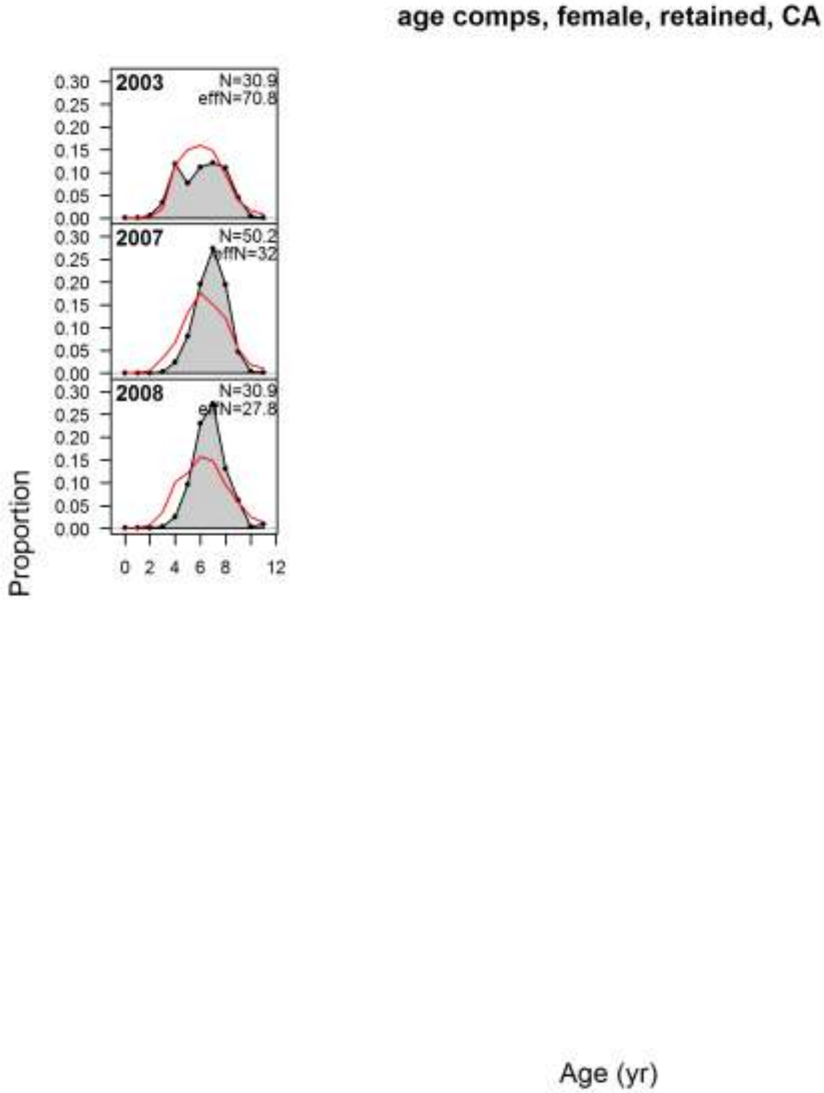



**Figure C.10: Base model fits to age frequency distributions of females for retained catches from the CA fishery from 2003, 2007 and 2008.**

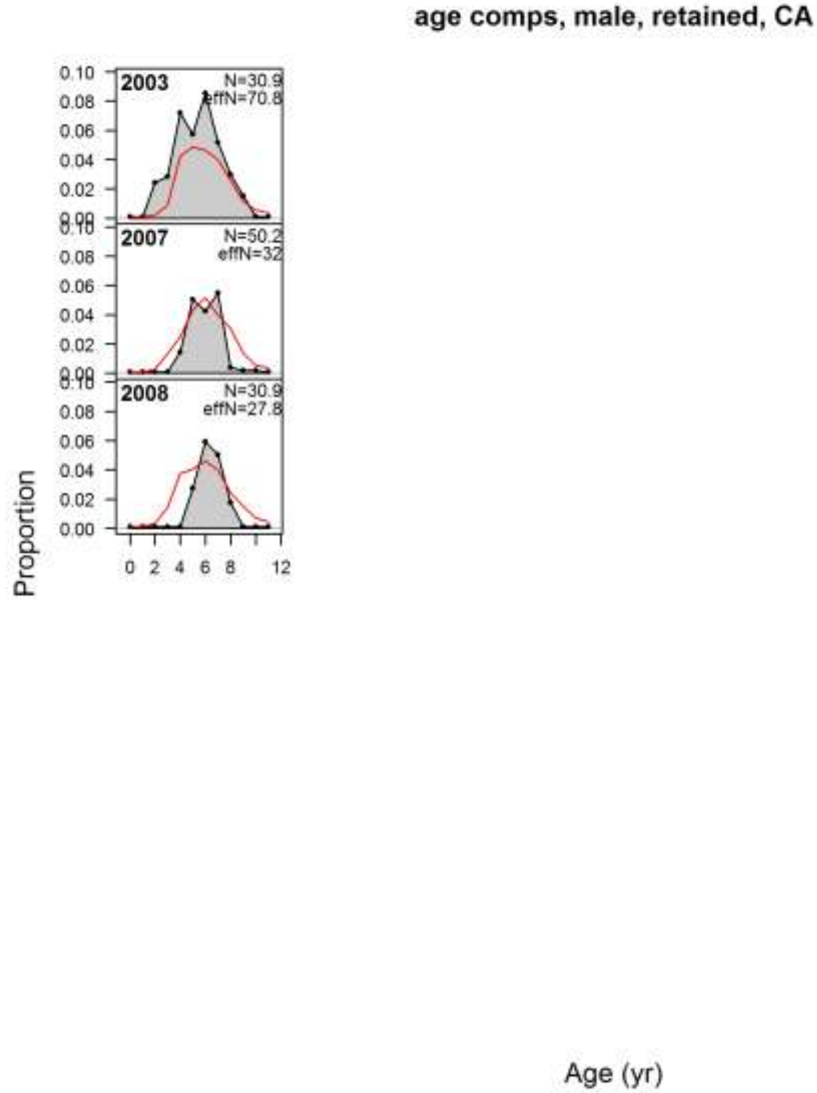



**Figure C.11: Base model fits to age frequency distributions of males for retained catches from the CA fishery from 2003, 2007 and 2008.**

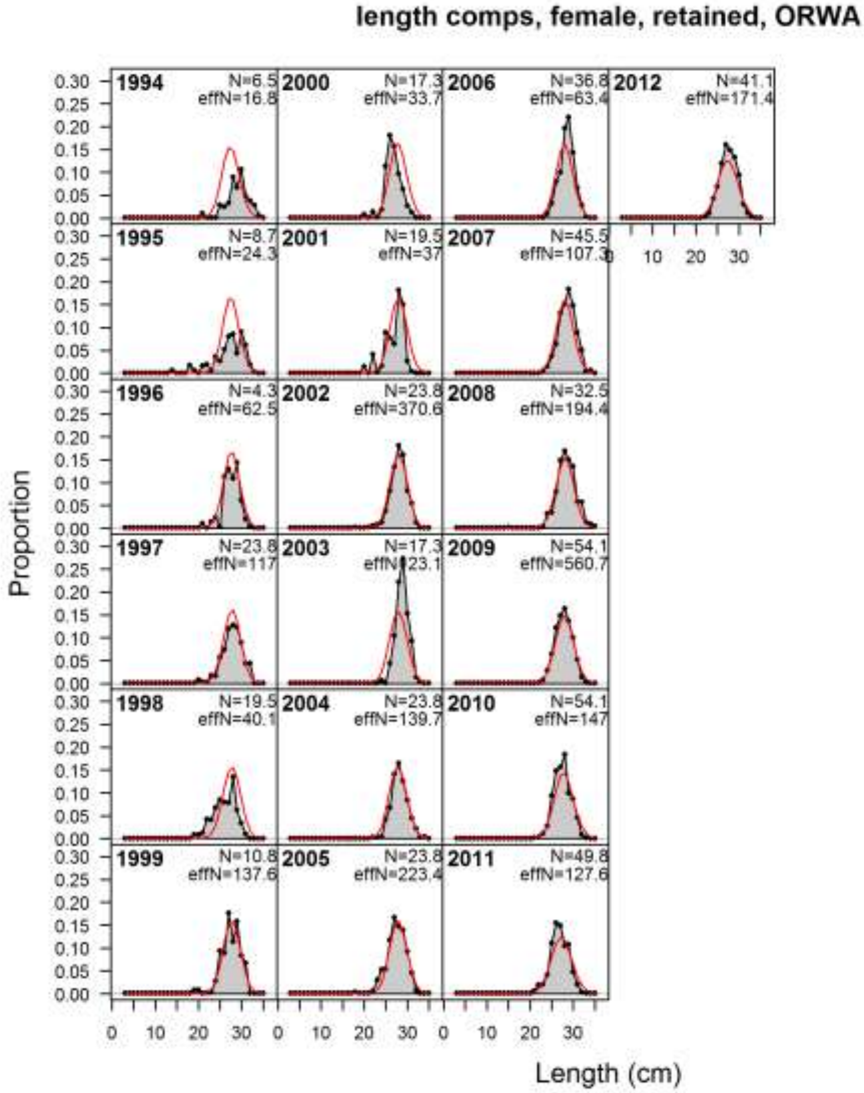



**Figure C.12: Base model fits to length frequency distributions of females for retained catches from the OR/WA fishery from 1990 to 2012.**

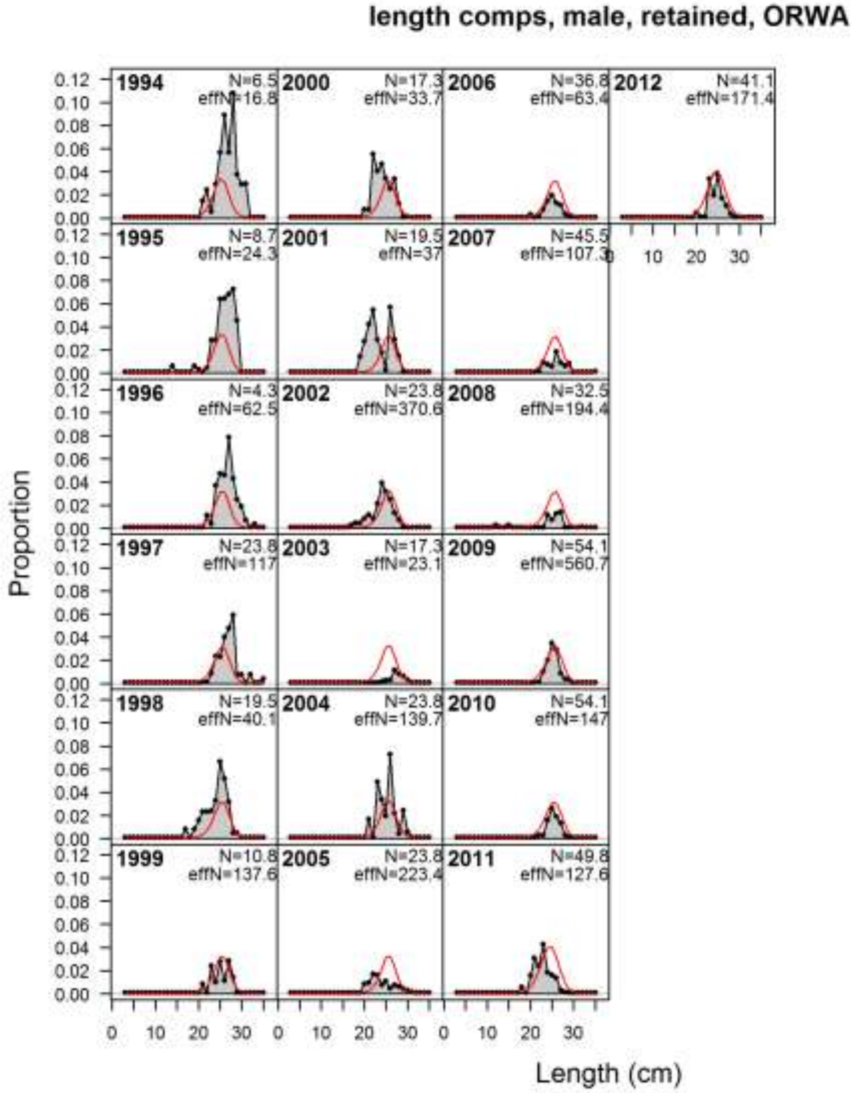



**Figure C.13: Base model fits to length frequency distributions of males for retained catches from the OR/WA fishery from 1990 to 2012.**

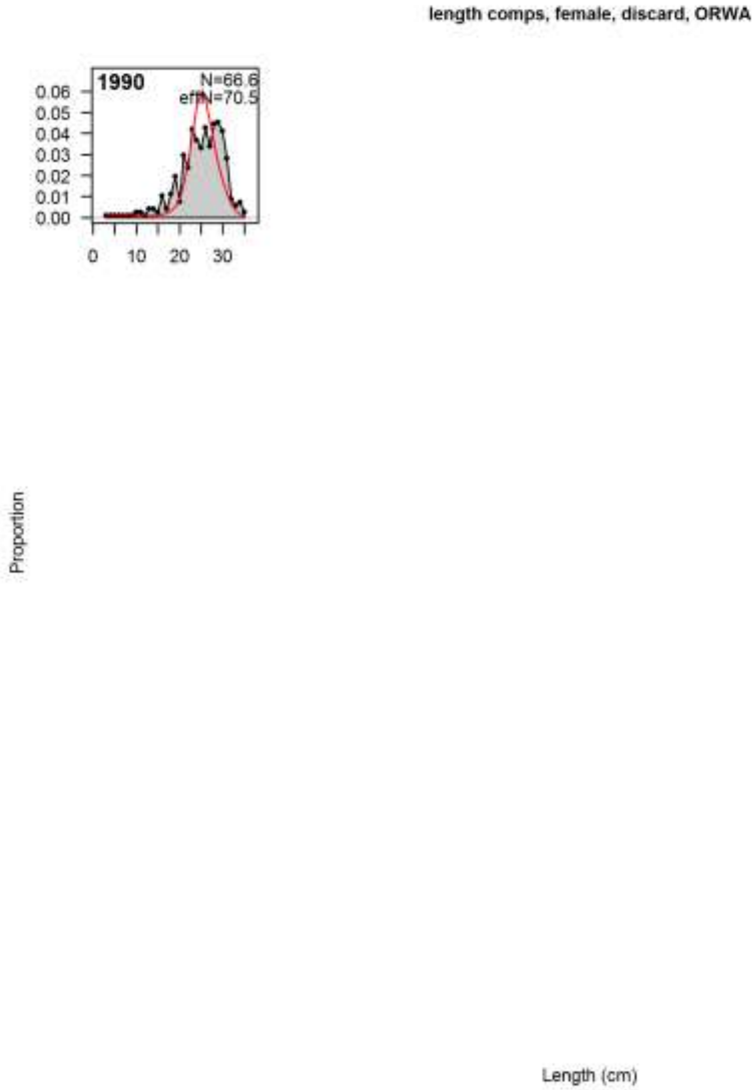



**Figure C.14: Base model fits to length frequency distributions of females for discarded catches from the OR/WA fishery in 1990.**

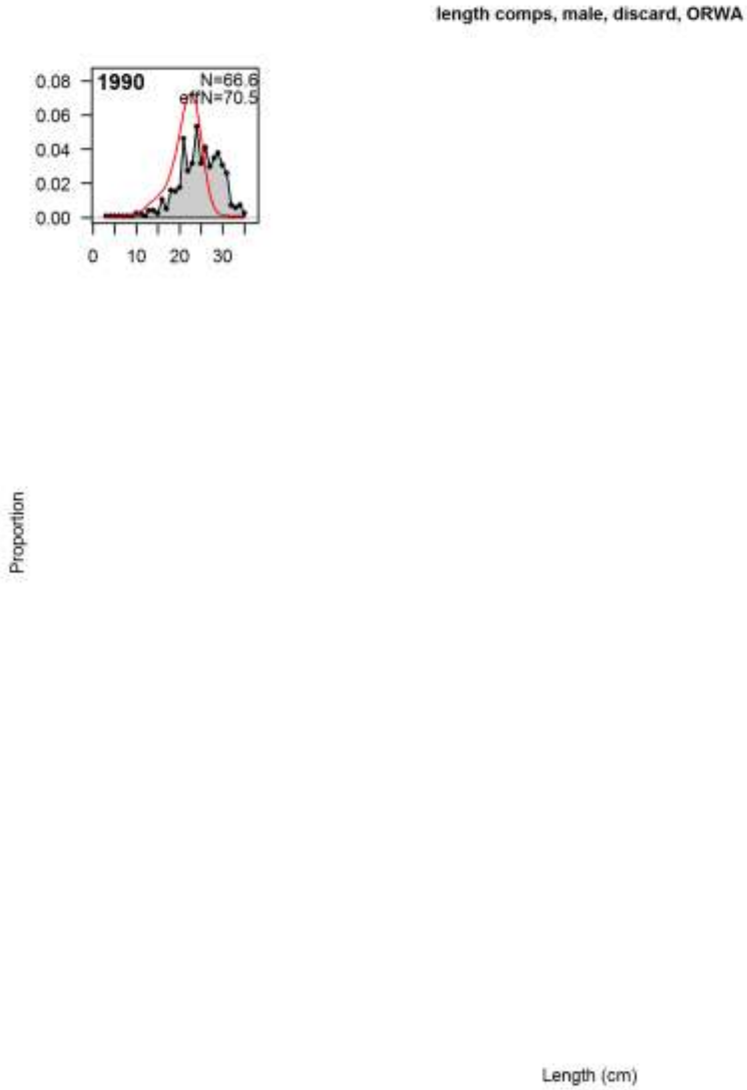



**Figure C.15: Base model fits to length frequency distributions of males for discarded catches from the OR/WA fishery in 1990.**

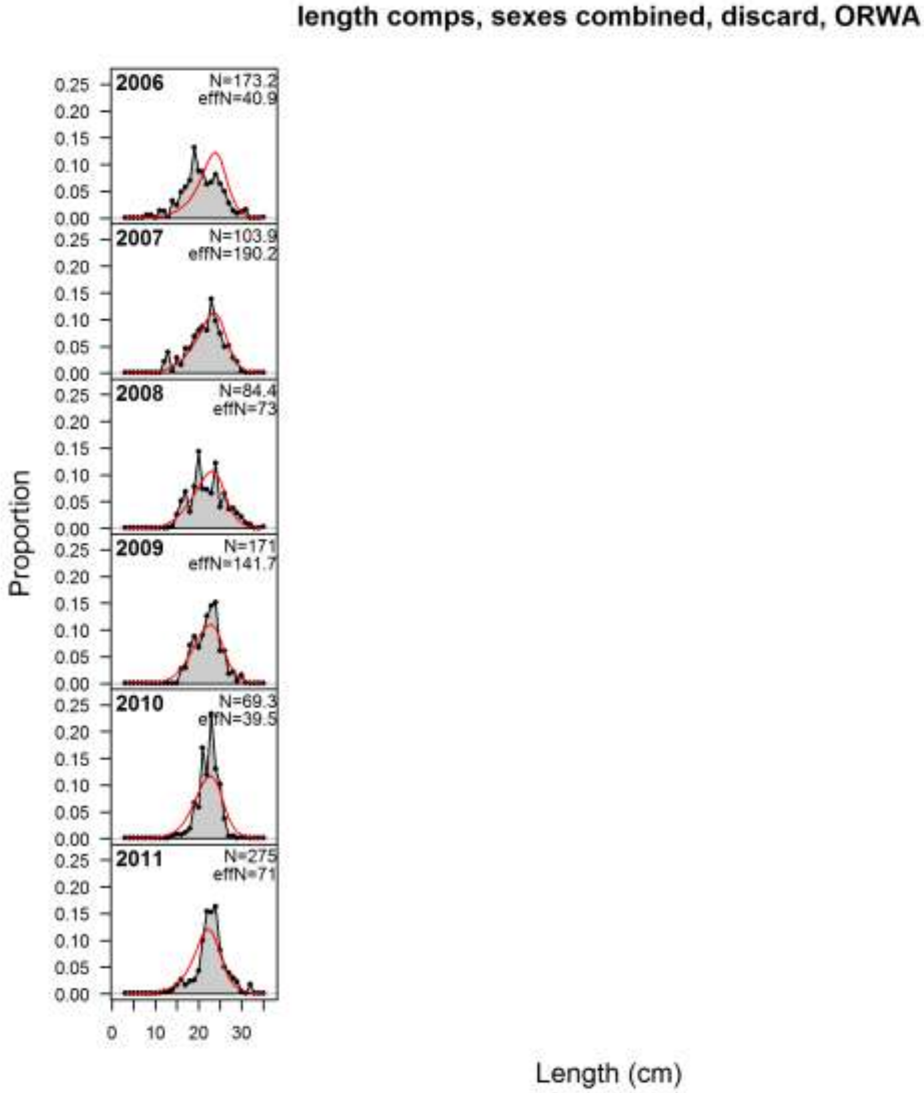



**Figure C.16: Base model fits to length frequency distributions of combined sexes for discarded catches from the OR/WA fishery from 2006 to 2011.**

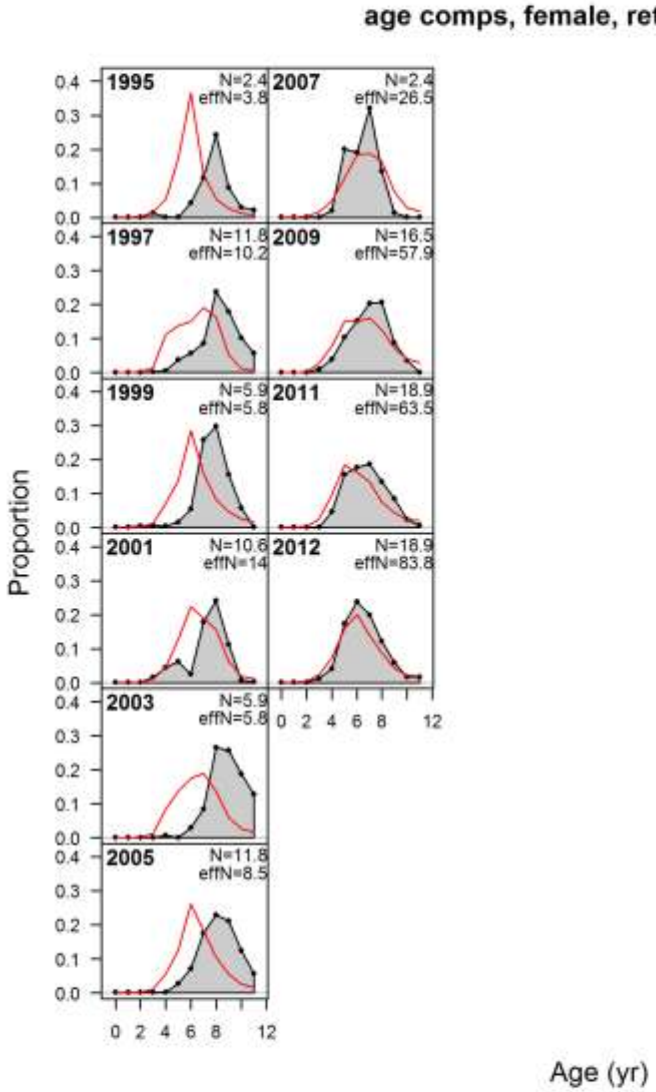



**Figure C.17: Base model fits to age frequency distributions of females for retained catches from the OR/WA fishery from 1995 to 2012.**

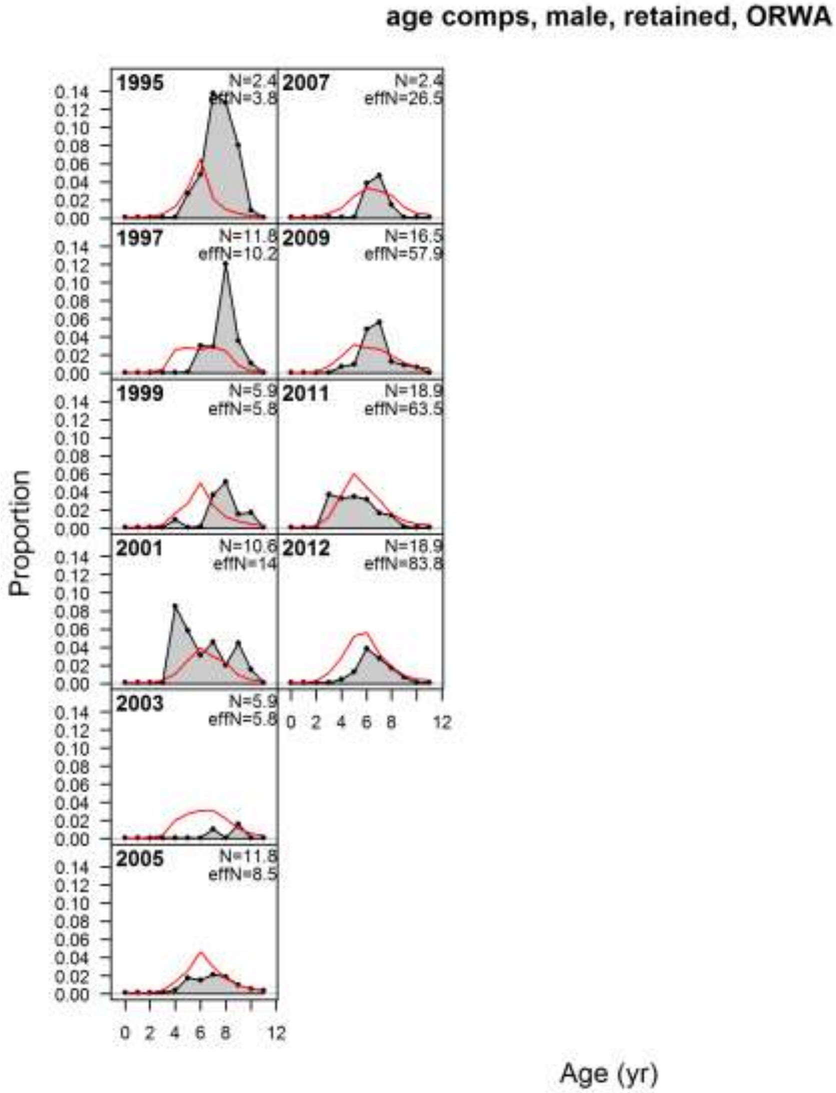



**Figure C.18: Base model fits to age frequency distributions of males for retained catches from the OR/WA fishery from 1995 to 2012.**

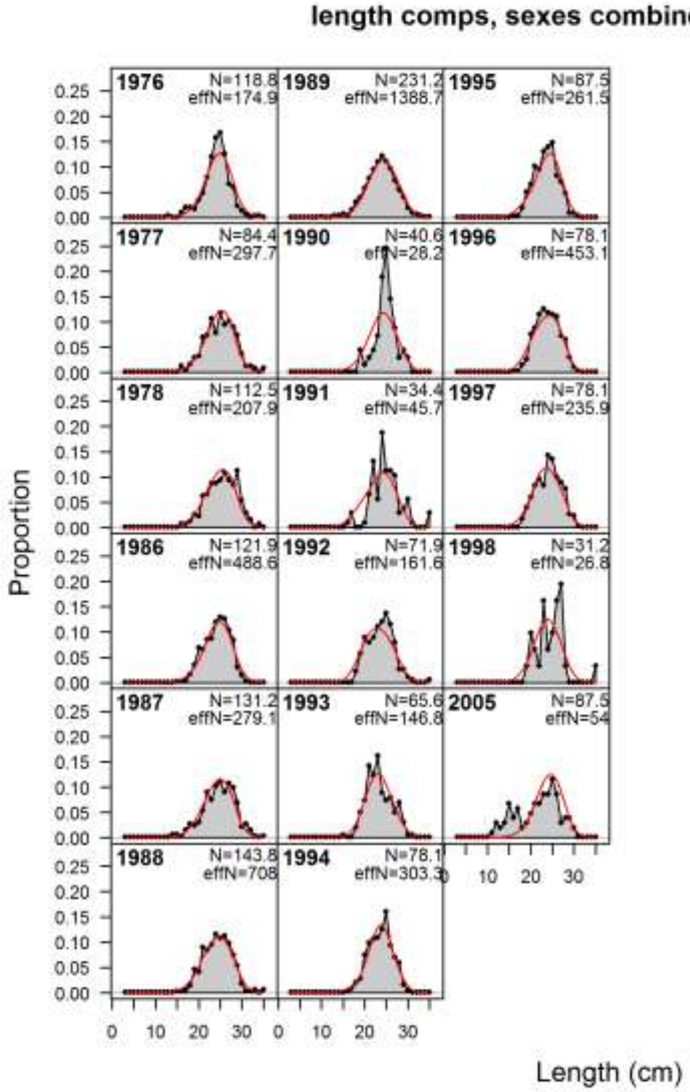



**Figure C.19: Base model fits to length frequency distributions of combined sexes for retained catches from the recreational fishery from 1976 to 2005.**

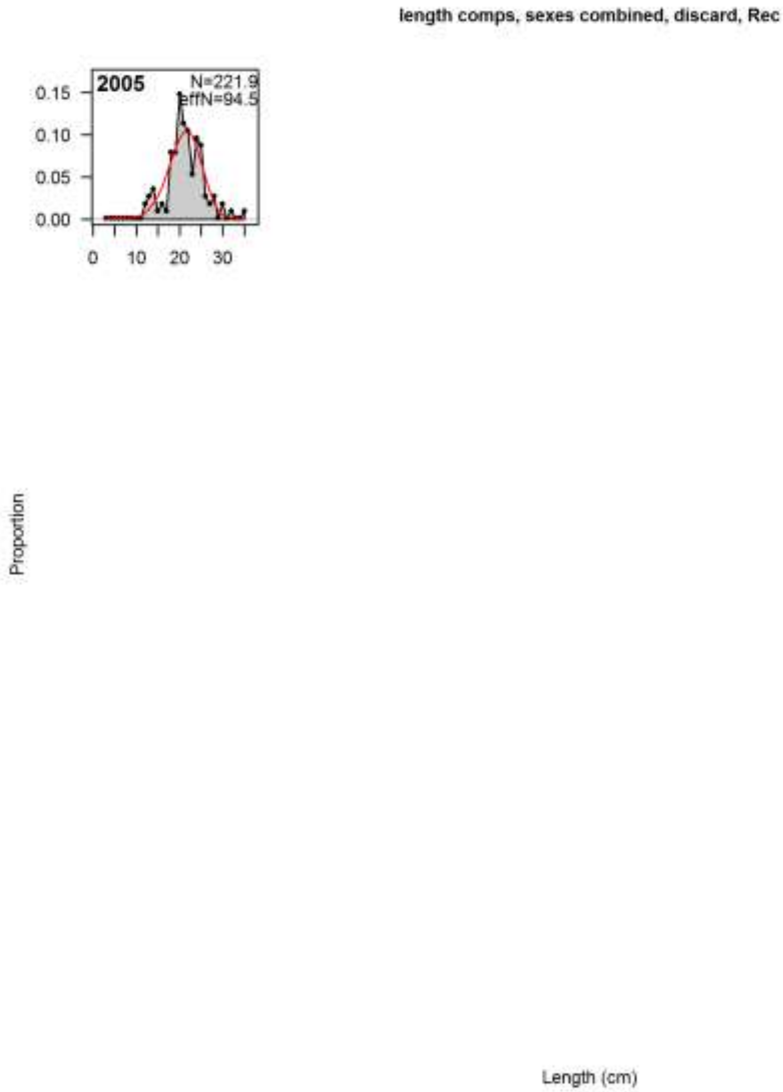



**Figure C.20: Base model fits to length frequency distributions of combined sexes for discarded catches from the recreational fishery in 2005.**

# Appendix D. Input Files of the Base Model to the SS3 Program

## Appendix D.1. Data File (SDB1.dat)

```
#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-
win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

#
# MODEL DIMENSIONS
# ----------------
1888    #_start year
2012    #_end year
1               #_number of seasons per year
12              # vector with N months in each season
1               #_spawning occurs at the beginning of this season
4               #_number of fishing fleets
3               #_number of surveys
1               #_N_areas

# string containing names for all fisheries and
# surveys, delimited by the % character
CA%ORWA%Rec%Mink%NWFSC%TriEarlyYr%TriLateYr
# fraction of season elapsed before CPUE measured or survey conducted
0.50    0.50    0.50    0.50    0.62    0.62    0.50    #_Catch or survey timing_in_season
1   1   1       1   1       1           1
        #_area_assignments_for_each_fishery_and_survey

# Fishery information
1               1   1   1           #_units of catch:  1=bio; 2=num
0.01    0.01    0.01  0.01          #_se of log(catch) only used for init_eq_catch and for
Fmethod 2 and 3; use -1 for discard only fleets

2 #_number of genders; females are gender 1
11 #_accumulator age

#_initial equilibrium catch for each fishery
0.00   0.00   0.00      0.00    #_initial equilibrium catch for each fishery

# Catch outputs from "C:\XiHe1\SDB2013\Landing\SDBLandingNew2.xlsx" (save as .prn to
retain formats)
125             #_N_lines_of_catch_to_read

#CA    ORWA   Rec    Mink   Year   Index
    0.0    0.0    0.0    0.0   1888      1
   59.0    0.0    0.0    0.0   1889      1
  118.1    0.0    0.0    0.0   1890      1
  177.1    0.0    0.0    0.0   1891      1
  236.1    0.0    0.0    0.0   1892      1
```

| | | | | | |
|---|---|---|---|---|---|
| 217.6 | 0.0 | 0.0 | 0.0 | 1893 | 1 |
| 199.1 | 0.0 | 0.0 | 0.0 | 1894 | 1 |
| 180.6 | 0.0 | 0.0 | 0.0 | 1895 | 1 |
| 198.7 | 0.0 | 0.0 | 0.0 | 1896 | 1 |
| 216.7 | 0.0 | 0.0 | 0.0 | 1897 | 1 |
| 234.7 | 0.0 | 0.0 | 0.0 | 1898 | 1 |
| 252.8 | 0.0 | 0.0 | 0.0 | 1899 | 1 |
| 291.5 | 0.0 | 0.0 | 0.0 | 1900 | 1 |
| 330.3 | 0.0 | 0.0 | 0.0 | 1901 | 1 |
| 369.0 | 0.0 | 0.0 | 0.0 | 1902 | 1 |
| 407.8 | 0.0 | 0.0 | 0.0 | 1903 | 1 |
| 446.5 | 0.0 | 0.0 | 0.0 | 1904 | 1 |
| 429.8 | 0.0 | 0.0 | 0.0 | 1905 | 1 |
| 413.1 | 0.0 | 0.0 | 0.0 | 1906 | 1 |
| 396.4 | 0.0 | 0.0 | 0.0 | 1907 | 1 |
| 379.6 | 0.0 | 0.0 | 0.0 | 1908 | 1 |
| 422.1 | 0.0 | 0.0 | 0.0 | 1909 | 1 |
| 464.5 | 0.0 | 0.0 | 0.0 | 1910 | 1 |
| 506.9 | 0.0 | 0.0 | 0.0 | 1911 | 1 |
| 549.3 | 0.0 | 0.0 | 0.0 | 1912 | 1 |
| 591.7 | 0.0 | 0.0 | 0.0 | 1913 | 1 |
| 634.1 | 0.0 | 0.0 | 0.0 | 1914 | 1 |
| 676.6 | 0.0 | 0.0 | 0.0 | 1915 | 1 |
| 1010.9 | 0.0 | 0.0 | 0.0 | 1916 | 1 |
| 1193.8 | 0.0 | 0.0 | 0.0 | 1917 | 1 |
| 794.5 | 0.0 | 0.0 | 0.0 | 1918 | 1 |
| 321.9 | 0.0 | 0.0 | 0.0 | 1919 | 1 |
| 327.4 | 0.0 | 0.0 | 0.0 | 1920 | 1 |
| 355.6 | 0.0 | 0.0 | 0.0 | 1921 | 1 |
| 531.1 | 0.0 | 0.0 | 0.0 | 1922 | 1 |
| 618.7 | 0.0 | 0.0 | 0.0 | 1923 | 1 |
| 771.0 | 0.0 | 0.0 | 0.0 | 1924 | 1 |
| 885.8 | 0.0 | 0.0 | 0.0 | 1925 | 1 |
| 518.9 | 0.0 | 0.0 | 0.0 | 1926 | 1 |
| 404.9 | 0.0 | 0.0 | 0.0 | 1927 | 1 |
| 502.9 | 0.0 | 0.0 | 0.0 | 1928 | 1 |
| 477.1 | 0.0 | 0.0 | 0.0 | 1929 | 1 |
| 279.6 | 0.0 | 0.0 | 0.0 | 1930 | 1 |
| 214.5 | 0.0 | 0.0 | 0.0 | 1931 | 1 |
| 301.5 | 0.5 | 0.0 | 0.0 | 1932 | 1 |
| 247.7 | 0.2 | 0.0 | 0.0 | 1933 | 1 |
| 347.9 | 0.1 | 0.0 | 0.0 | 1934 | 1 |
| 306.4 | 0.2 | 0.0 | 0.0 | 1935 | 1 |
| 282.0 | 0.9 | 0.0 | 0.0 | 1936 | 1 |
| 234.1 | 4.6 | 0.0 | 0.0 | 1937 | 1 |
| 301.2 | 0.1 | 0.0 | 0.0 | 1938 | 1 |
| 368.2 | 14.2 | 0.0 | 0.0 | 1939 | 1 |
| 353.4 | 25.5 | 0.0 | 0.0 | 1940 | 1 |
| 200.5 | 30.5 | 0.0 | 0.0 | 1941 | 1 |
| 160.4 | 78.5 | 0.0 | 5.6 | 1942 | 1 |
| 229.2 | 197.9 | 0.0 | 5.9 | 1943 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 250.1 | 34.3 | 0.0 | 6.3 | 1944 | 1 |
| 268.6 | 15.1 | 0.0 | 5.6 | 1945 | 1 |
| 308.0 | 17.1 | 0.0 | 5.8 | 1946 | 1 |
| 318.2 | 38.1 | 0.0 | 6.5 | 1947 | 1 |
| 365.0 | 61.6 | 0.0 | 10.0 | 1948 | 1 |
| 327.6 | 83.0 | 0.0 | 9.9 | 1949 | 1 |
| 312.9 | 3.9 | 0.0 | 7.3 | 1950 | 1 |
| 246.8 | 5.3 | 0.0 | 8.8 | 1951 | 1 |
| 299.5 | 0.1 | 0.0 | 9.2 | 1952 | 1 |
| 313.2 | 5.5 | 0.0 | 23.1 | 1953 | 1 |
| 341.8 | 7.3 | 0.0 | 30.1 | 1954 | 1 |
| 354.5 | 25.4 | 0.0 | 30.7 | 1955 | 1 |
| 358.0 | 1.3 | 0.0 | 39.8 | 1956 | 1 |
| 313.9 | 0.1 | 0.0 | 57.1 | 1957 | 1 |
| 184.4 | 0.8 | 0.0 | 98.5 | 1958 | 1 |
| 211.7 | 3.2 | 0.0 | 28.0 | 1959 | 1 |
| 158.0 | 8.1 | 0.0 | 37.7 | 1960 | 1 |
| 225.2 | 5.6 | 0.0 | 41.4 | 1961 | 1 |
| 308.4 | 9.5 | 0.0 | 31.7 | 1962 | 1 |
| 252.0 | 3.3 | 0.0 | 30.8 | 1963 | 1 |
| 452.7 | 6.1 | 7.1 | 34.1 | 1964 | 1 |
| 217.3 | 2.4 | 7.4 | 38.8 | 1965 | 1 |
| 326.6 | 9.1 | 15.5 | 27.1 | 1966 | 1 |
| 311.6 | 11.2 | 15.7 | 31.1 | 1967 | 1 |
| 324.1 | 9.4 | 65.9 | 25.8 | 1968 | 1 |
| 315.7 | 22.1 | 73.7 | 24.5 | 1969 | 1 |
| 307.8 | 30.3 | 57.7 | 14.3 | 1970 | 1 |
| 353.9 | 28.9 | 29.1 | 13.0 | 1971 | 1 |
| 417.7 | 55.0 | 28.5 | 5.2 | 1972 | 1 |
| 410.0 | 93.1 | 36.2 | 4.3 | 1973 | 1 |
| 442.4 | 117.8 | 33.4 | 47.5 | 1974 | 1 |
| 460.6 | 175.3 | 19.9 | 63.1 | 1975 | 1 |
| 586.9 | 157.0 | 25.5 | 40.0 | 1976 | 1 |
| 367.2 | 116.9 | 11.0 | 35.1 | 1977 | 1 |
| 337.1 | 116.8 | 2.5 | 0.4 | 1978 | 1 |
| 600.0 | 224.1 | 174.9 | 0.1 | 1979 | 1 |
| 580.8 | 186.1 | 87.6 | 0.8 | 1980 | 1 |
| 427.4 | 162.9 | 216.0 | 0.8 | 1981 | 1 |
| 480.1 | 244.7 | 46.3 | 2.8 | 1982 | 1 |
| 259.1 | 246.8 | 38.5 | 4.9 | 1983 | 1 |
| 251.1 | 280.6 | 40.0 | 0.7 | 1984 | 1 |
| 442.4 | 188.8 | 57.6 | 1.1 | 1985 | 1 |
| 445.6 | 170.2 | 51.4 | 5.6 | 1986 | 1 |
| 533.5 | 237.2 | 12.6 | 0.4 | 1987 | 1 |
| 528.0 | 122.9 | 66.6 | 0.5 | 1988 | 1 |
| 638.7 | 90.8 | 21.1 | 12.1 | 1989 | 1 |
| 653.1 | 227.6 | 33.5 | 0.4 | 1990 | 1 |
| 561.3 | 322.7 | 33.3 | 0.1 | 1991 | 1 |
| 283.3 | 322.4 | 33.3 | 6.3 | 1992 | 1 |
| 352.9 | 288.2 | 49.3 | 0.0 | 1993 | 1 |
| 683.3 | 524.4 | 34.5 | 0.0 | 1994 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 677.5 | 685.5 | 14.3 | 13.2 | 1995 | 1 |
| 789.3 | 105.3 | 50.2 | 0.0 | 1996 | 1 |
| 930.2 | 241.5 | 35.5 | 0.0 | 1997 | 1 |
| 644.3 | 132.5 | 13.3 | 9.0 | 1998 | 1 |
| 930.1 | 273.6 | 20.9 | 0.0 | 1999 | 1 |
| 744.6 | 150.1 | 62.4 | 0.0 | 2000 | 1 |
| 793.1 | 109.9 | 46.9 | 15.0 | 2001 | 1 |
| 387.7 | 362.5 | 153.9 | 0.0 | 2002 | 1 |
| 204.6 | 386.0 | 47.3 | 12.7 | 2003 | 1 |
| 235.4 | 221.2 | 44.6 | 22.1 | 2004 | 1 |
| 207.5 | 139.8 | 45.7 | 5.3 | 2005 | 1 |
| 340.7 | 71.8 | 23.1 | 4.9 | 2006 | 1 |
| 161.8 | 130.4 | 19.7 | 3.3 | 2007 | 1 |
| 73.5 | 123.0 | 27.3 | 5.4 | 2008 | 1 |
| 200.6 | 90.1 | 28.4 | 7.7 | 2009 | 1 |
| 101.5 | 44.8 | 42.7 | 8.9 | 2010 | 1 |
| 45.1 | 101.1 | 81.2 | 8.4 | 2011 | 1 |
| 59.5 | 99.7 | 53.2 | 9.4 | 2012 | 1 |

#_ABUNDANCE INDICES
32 #_number of CPUE observations

#_Units: 0=numbers; 1=biomass; 2=F
#_Errtype: -1=normal; 0=lognormal; >0=T
#_Fleet Units Errtype
1 1 0
2 1 0
3 1 0
4 1 0
5 1 0
6 1 0
7 1 0

# RecFIN CPUE copied from
"C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\EmailData_8_5_2013\Pacific_sanddabFor Model.xlsx"

| #Year | Sea | Flt | Index | CV |
|---|---|---|---|---|
| 1999 | 1 | 3 | 0.1658 | 0.194 |
| 2000 | 1 | 3 | 0.1504 | 0.299 |
| 2001 | 1 | 3 | 0.2214 | 0.444 |
| 2002 | 1 | 3 | 0.1992 | 0.289 |
| 2003 | 1 | 3 | 0.4135 | 0.265 |
| 2004 | 1 | 3 | 0.3477 | 0.230 |
| 2005 | 1 | 3 | 0.0801 | 0.202 |
| 2006 | 1 | 3 | 0.2417 | 0.150 |
| 2007 | 1 | 3 | 0.1421 | 0.162 |
| 2008 | 1 | 3 | 0.1473 | 0.133 |
| 2009 | 1 | 3 | 0.1636 | 0.120 |
| 2010 | 1 | 3 | 0.2693 | 0.121 |
| 2011 | 1 | 3 | 0.2937 | 0.106 |

# NWFSC survey indices
# 3M MCMC outputs
# Copied from
"C:\XiHe1\SDB2013\SurveyData\NWFSC\GLMM3\NWFSCIndies3M_MCMC.csv"

```
2003	1	5	58253.95	0.21019
2004	1	5	49939.52	0.22051
2005	1	5	37508.32	0.18454
2006	1	5	37337.45	0.19642
2007	1	5	25816.00	0.19540
2008	1	5	39337.43	0.19108
2009	1	5	56780.54	0.18919
2010	1	5	65277.99	0.18370
2011	1	5	56330.88	0.18127
2012	1	5	73364.17	0.20418
```

# new data after removal of water hauls: 3M MCMC outputs
# Outputs copied from
"C:\XiHe1\SDB2013\SurveyData\Triennial\TriSurveyCPUEComparisonOneAndTwoTimePeriodsNew1.xlsx"

```
# Year	Sea	Flt	Index	CV
1980	1	6	3372.1	0.42168
1983	1	6	9224.2	0.34384
1986	1	6	10262.6	0.33218
1989	1	6	29373.5	0.35109
1992	1	6	18622.5	0.31633

1995	1	7	45513.1	0.47265
1998	1	7	31151.5	0.65045
2001	1	7	46638.5	0.44623
2004	1	7	65976.1	0.39292
```

#
# IF DISCARD
3	#_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype:  >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for lognormal

```
#Flt	Disc_units	err_type
1	2	-1
2	2	-1
3	2	-1
```

23	#_number of discard observations
# discard rates using total catch as weight

# No discard information before 2002 observer data
# Using average discard rates from 2002 to 2010
# copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"

1986 1 1 0.3256 0.0509 # using average estimate from 2002 to 2010

# Estimates from Jaaon Jannot's data with pooled Pacific sanddab and Unid sanddab
# copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"
#Year Sea Flt Obs StDev
2002 1 1 0.206370.03792
2003 1 1 0.328820.02572
2004 1 1 0.245010.08774
2005 1 1 0.357920.05846
2006 1 1 0.326010.00008
2007 1 1 0.280980.07085
2008 1 1 0.320470.09925
2009 1 1 0.441660.07453
2010 1 1 0.420950.00325
2011 1 1 0.45000 0.05090
2012 1 1 0.45000 0.05090

# Oregon
# From John Wallace's estimates of Pikitch 1985 to 1987 study
# File in
"C:\XiHe1\SDB2013\Discard\PikitchData\JohnWallacePikitchEstimatesNew1\Analysis\dis6methodsNew1-Averaged for model.csv"
1986 1 2 0.5124 0.1116 #Pikitch - John Wallace data

# Estimates from Jaaon Jannot's data with pooled Pacific sanddab and Unid sanddab
# copied from:
"C:\XiHe1\SDB2013\Discard\WCGOP\DataFromJasonJannot_6_5_2013\Analysis1\WCGOP discard summary for model 1.xlsx"
#Year Sea Flt Obs StDev
2002 1 2 0.706790.10712
#2003 1 2 0.878450.06000
2004 1 2 0.626120.15174
2005 1 2 0.587370.11974
2006 1 2 0.466160.10809
2008 1 2 0.485370.09479
2009 1 2 0.578350.07083
2011 1 2 0.383160.0125
2012 1 2 0.383160.0125

# Estiamtes from Meisha Key's data for recreational fisheries
# from
C:\XiHe1\SDB2013\Landing\CACPFVRecData\CPFVDataMeishaKey_7_3_2013\Data\90s_AllDabsDiscardRateEstimate.xlsc
# Pooled all year and use 1993 year
1993 1 3 0.05802 0.025

# Estiamtes from Melissa's data for recreational fisheries

# from
C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\Analysis1\Sanddab_DataRecMelissaMonk_QuickSummary.xlsx
# Pooled all year and use 2005 year
2005 1 3 0.056216 0.025

# If no discard, use the following two lines
#0 #_N_fleets_with_discard
#0 #_number of discard observations

#
#_MEAN BODY WEIGHT
#_----------------
0 #_number of observations
30 #_DF_for_meanbodywt_T-distribution_like
1 # length bin method: 1=use databins; 2=generate from width, min,max below; 3=read nbins, then vector
#
# COMPOSITION CONDITIONERS
# ------------------------
-1 # negative value causes no compression
0.001 #_constant added to proportions at length & age (renormalized to sum to 1 after constant is added)
0 #_combine males into females at or below this bin number
#
#_LENGTH COMPOSITION
#_------------------
#_vector containing lower edge of length bins
33 #_number of length bins
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

78 #_number of lines of length comp observations

# Gender setting: 0=combined femal and male; 1=female only; 2=male only; 3=both genders are used
# if Gender=0, male portions also needed; as for Gender = 1 and 2
# Partition setting: 0=combined; 1=discard; 2=retained

# WCGOP observer discard length comps from Andi
# Sex combined data, Gender = 0
# Outputs from
"C:\XiHe1\SDB2013\Landing\WCGOP\DataFromAndi_4_10_2013\PDAB.Observer.CompsAnalysis1.xlsx"
#Yr SE Flt GD Pt Ns 8 9 10
11 12 13 14 15 16
17 18 19 20 21 22
23 24 25 26 27 28
29 30 31 32 33 34
35 8 9 10 11 12
13 14 15 16 17 18
19 20 21 22 23 24

25 26 27 28 29 30
31 32 33 34 35
2006 1 1 0 1 98 0 0 0 0 0 0.00000.0000 0.0001 0.0027 0.0001
0.0048 0.0054 0.0075 0.0190 0.0373 0.1148 0.0782 0.0875 0.0949 0.1083 0.1453
0.1273 0.0755 0.0562 0.0061 0.0272 0.0013 0.0002 0.0000 0.0001 0.0001 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0001 0.0027 0.0001 0.0048 0.0054 0.0075 0.0190
0.0373 0.1148 0.0782 0.0875 0.0949 0.1083 0.1453 0.1273 0.0755 0.0562 0.0061
0.0272 0.0013 0.0002 0.0000 0.0001 0.0001 0.0000 0.0000
2007 1 1 0 1 49 0 0 0 0 0 0.00000.0000 0.0000 0.0002 0.0000
0.0200 0.0012 0.0152 0.0310 0.0520 0.1385 0.1163 0.1138 0.2295 0.0891 0.0715
0.0473 0.0250 0.0070 0.0143 0.0243 0.0002 0.0001 0.0036 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0002 0.0000 0.0200 0.0012 0.0152 0.0310
0.0520 0.1385 0.1163 0.1138 0.2295 0.0891 0.0715 0.0473 0.0250 0.0070 0.0143
0.0243 0.0002 0.0001 0.0036 0.0000 0.0000 0.0000 0.0000
2008 1 1 0 1 61 0 0 0 0 0 0.00000.0000 0.0001 0.0009 0.0024
0.0030 0.0065 0.0032 0.0491 0.0257 0.0232 0.0614 0.0970 0.1252 0.0864 0.2262
0.1109 0.0657 0.0316 0.0242 0.0223 0.0327 0.0002 0.0000 0.0021 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0001 0.0009 0.0024 0.0030 0.0065 0.0032 0.0491
0.0257 0.0232 0.0614 0.0970 0.1252 0.0864 0.2262 0.1109 0.0657 0.0316 0.0242
0.0223 0.0327 0.0002 0.0000 0.0021 0.0000 0.0000 0.0000
2009 1 1 0 1 28 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000
0.0000 0.0122 0.0528 0.0269 0.0441 0.1015 0.1215 0.1222 0.0962 0.2156 0.1104
0.0333 0.0595 0.0036 0.0004 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0122 0.0528 0.0269
0.0441 0.1015 0.1215 0.1222 0.0962 0.2156 0.1104 0.0333 0.0595 0.0036 0.0004
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2010 1 1 0 1 37 0 0 0 0 0 0.00000.0000 0.0100 0.0035 0.0494
0.0020 0.0379 0.0540 0.0787 0.0857 0.0660 0.0669 0.1309 0.1121 0.0959 0.0874
0.0559 0.0282 0.0287 0.0023 0.0021 0.0024 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0100 0.0035 0.0494 0.0020 0.0379 0.0540 0.0787
0.0857 0.0660 0.0669 0.1309 0.1121 0.0959 0.0874 0.0559 0.0282 0.0287 0.0023
0.0021 0.0024 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 1 0 1 82 0 0 0 0 0 0.00590.0037 0.0001 0.0019 0.0027
0.0158 0.0134 0.0046 0.0476 0.0317 0.0736 0.0912 0.1372 0.2031 0.0837 0.0881
0.1590 0.0213 0.0017 0.0005 0.0003 0.0003 0.0007 0.0003 0.0001 0.0003 0.0003
0.0000 0 0 0 0 0 0.00590.0037 0.0001 0.0019 0.0027 0.0158 0.0134 0.0046 0.0476
0.0317 0.0736 0.0912 0.1372 0.2031 0.0837 0.0881 0.1590 0.0213 0.0017 0.0005
0.0003 0.0003 0.0007 0.0003 0.0001 0.0003 0.0003 0.0000
2006 1 2 0 1 80 0 0 0 0 0 0.00470.0047 0.0001 0.0137 0.0124
0.0022 0.0326 0.0237 0.0490 0.0586 0.0721 0.1357 0.0901 0.0892 0.0648 0.0688
0.0836 0.0654 0.0507 0.0280 0.0139 0.0081 0.0111 0.0155 0.0002 0.0001 0.0000
0.0008 0 0 0 0 0 0.00470.0047 0.0001 0.0137 0.0124 0.0022 0.0326 0.0237 0.0490
0.0586 0.0721 0.1357 0.0901 0.0892 0.0648 0.0688 0.0836 0.0654 0.0507 0.0280
0.0139 0.0081 0.0111 0.0155 0.0002 0.0001 0.0000 0.0008
2007 1 2 0 1 48 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0211
0.0397 0.0028 0.0290 0.0156 0.0466 0.0470 0.0706 0.0816 0.0891 0.0821 0.1429
0.0999 0.0754 0.0507 0.0521 0.0295 0.0213 0.0025 0.0004 0.0001 0.0000 0.0000
0.0000 0 0 0 0 0 0.00000.0000 0.0000 0.0000 0.0211 0.0397 0.0028 0.0290 0.0156
0.0466 0.0470 0.0706 0.0816 0.0891 0.0821 0.1429 0.0999 0.0754 0.0507 0.0521
0.0295 0.0213 0.0025 0.0004 0.0001 0.0000 0.0000 0.0000

```
2008	1	2	0	1	39	0 0 0 0 0 0.00000.0000	0.0004	0.0000	0.0000
	0.0000	0.0031	0.0253	0.0516	0.0705	0.0304	0.0801	0.1473	0.0755	0.0747	0.0665
	0.1251	0.0404	0.0670	0.0366	0.0380	0.0287	0.0210	0.0094	0.0064	0.0000	0.0000
	0.0021	0 0 0 0 0 0.00000.0000	0.0004	0.0000	0.0000	0.0000	0.0031	0.0253	0.0516
	0.0705	0.0304	0.0801	0.1473	0.0755	0.0747	0.0665	0.1251	0.0404	0.0670	0.0366
	0.0380	0.0287	0.0210	0.0094	0.0064	0.0000	0.0000	0.0021
2009	1	2	0	1	79	0 0 0 0 0 0.00000.0000	0.0000	0.0000	0.0000
	0.0000	0.0002	0.0001	0.0268	0.0297	0.0725	0.0898	0.0690	0.0932	0.1285	0.1488
	0.1554	0.0625	0.0623	0.0175	0.0222	0.0043	0.0160	0.0009	0.0002	0.0001	0.0000
	0.0000	0 0 0 0 0 0.00000.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0268
	0.0297	0.0725	0.0898	0.0690	0.0932	0.1285	0.1488	0.1554	0.0625	0.0623	0.0175
	0.0222	0.0043	0.0160	0.0009	0.0002	0.0001	0.0000	0.0000
2010	1	2	0	1	32	0 0 0 0 0 0.00000.0000	0.0000	0.0000	0.0004
	0.0004	0.0032	0.0079	0.0066	0.0113	0.0187	0.0687	0.0594	0.1738	0.1228	0.2402
	0.1336	0.1041	0.0379	0.0039	0.0045	0.0000	0.0013	0.0014	0.0000	0.0000	0.0000
	0.0000	0 0 0 0 0 0.00000.0000	0.0000	0.0000	0.0004	0.0004	0.0032	0.0079	0.0066
	0.0113	0.0187	0.0687	0.0594	0.1738	0.1228	0.2402	0.1336	0.1041	0.0379	0.0039
	0.0045	0.0000	0.0013	0.0014	0.0000	0.0000	0.0000	0.0000
2011	1	2	0	1	127	0 0 0 0 0 0.00000.0000	0.0000	0.0015	0.0037
	0.0031	0.0068	0.0156	0.0267	0.0158	0.0231	0.0257	0.0441	0.1022	0.1581	0.1570
	0.1680	0.0837	0.0509	0.0396	0.0301	0.0222	0.0041	0.0003	0.0171	0.0002	0.0000
	0.0002	0 0 0 0 0 0.00000.0000	0.0000	0.0015	0.0037	0.0031	0.0068	0.0156	0.0267
	0.0158	0.0231	0.0257	0.0441	0.1022	0.1581	0.1570	0.1680	0.0837	0.0509	0.0396
	0.0301	0.0222	0.0041	0.0003	0.0171	0.0002	0.0000	0.0002

# CA and OR trawl length data
# Outputs from directory
"C:\XiHe1\SDB2013\Landing\PacFIN\PacFINCompDataFromDon\PacFINCompDataFromDon_
3_29_2013Set3\Analysis1"
# Length data from "PacFINLengthComp2.csv"
# Sam (NSample) from "PacFINLengthcomp_effN.csv"
# Final outputs to SS3 from "PacFINLengthCompForModelNew1.csv"
#Yr		Sea	Flt	Gen	Pt	Sam		N8.x		N9.x
	N10.x		N11.x		N12.x		N13.x		N14.x		N15.x
	N16.x		N17.x		N18.x		N19.x		N20.x		N21.x
	N22.x		N23.x		N24.x		N25.x		N26.x		N27.x
	N28.x		N29.x		N30.x		N31.x		N32.x		N33.x
	N34.x		N35.x		N8.y		N9.y		N10.y		N11.y
	N12.y		N13.y		N14.y		N15.y		N16.y		N17.y
	N18.y		N19.y		N20.y		N21.y		N22.y		N23.y
	N24.y		N25.y		N26.y		N27.y		N28.y		N29.y
	N30.y		N31.y		N32.y		N33.y		N34.y		N35.y
2003	1	1	3	2	23		0 0 0 0 0 0.000000	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000701	0.001089	0.002236
	0.004790	0.012639	0.012378	0.019722	0.061125
	0.050002	0.096999	0.073807	0.114579	0.111776
	0.086783	0.021653	0.009224	0.000000	0.000000
	0.000000	0 0 0 0 0 0.000000	0.000000	0.000000	0.000000
	0.001649	0.000000	0.000000	0.000000	0.000318
	0.003814	0.001528	0.004082	0.017577	0.026626
```

0.028527 0.029650 0.047690 0.049902 0.071787
0.024918 0.007707 0.003427 0.001292 0.000000
0.000000 0.000000 0.000000 0.000000
2004 1 1 3 2 14 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.002751 0.005809 0.011556 0.025642
0.041643 0.066077 0.122727 0.157848 0.120403
0.111610 0.028954 0.018538 0.000128 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.005010 0.005482 0.017021
0.044243 0.037604 0.062013 0.058582 0.037872
0.002813 0.014021 0.001259 0.000000 0.000387
0.000000 0.000010 0.000000 0.000000
2005 1 1 3 2 13 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.002582 0.002044
0.002650 0.006404 0.006353 0.044233 0.060599
0.072193 0.111641 0.108467 0.150728 0.089827
0.065636 0.013587 0.005781 0.002582 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.016307 0.019533
0.033960 0.040794 0.061656 0.048425 0.012192
0.014361 0.004823 0.000000 0.000000 0.002582
0.000000 0.000060 0.000000 0.000000
2006 1 1 3 2 28 0 0 0 0 0 0.000000 0.000000
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0.000000 0.000000 0.000035 0.000000 0.000000
0.000000 0.006098 0.009749 0.023559 0.047114
0.071302 0.116433 0.127055 0.132729 0.106952
0.085291 0.019739 0.003744 0.000040 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.003388 0.004242 0.022814
0.024946 0.041986 0.049357 0.061011 0.033047
0.005873 0.002680 0.000363 0.000452 0.000000
0.000000 0.000000 0.000000 0.000000
2007 1 1 3 2 27 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.001389 0.000533 0.004811 0.015570 0.039631
0.088485 0.124710 0.143780 0.218938 0.121512
0.085282 0.016356 0.001397 0.000000 0.000000
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0.011114 0.001219 0.000599 0.001893 0.000000
0.000000 0.000000 0.000000 0.000000

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0.000000 0.000000 0.000000 0.000000 0.000000
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0.058262 0.101000 0.174269 0.229607 0.156023
0.063684 0.015921 0.005194 0.000395 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
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0.000000 0.000000 0.000000 0.000000 0.000852
0.003571 0.013564 0.025187 0.020809 0.034826
0.020457 0.005475 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000
2009 1 1 3 2 16 0 0 0 0 0 0.000000 0.000000
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0.000000 0.000000 0.000000 0.000000 0.000000
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0.033933 0.014727 0.000417 0.000374 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.002816 0.000675
0.022821 0.024046 0.060994 0.028522 0.022935
0.004416 0.002693 0.004408 0.000355 0.000177
0.000089 0.000000 0.000000 0.000000
2010 1 1 3 2 17 0 0 0 0 0 0.000000 0.000000
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0.000000 0.000000 0.000000 0.000000
2011 1 1 3 2 4 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000247 0.001219 0.001150
0.002515 0.002590 0.032133 0.029954 0.261509
0.217211 0.116302 0.058103 0.086831 0.057469
0.014367 0.000000 0.000000 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000247 0.000884 0.001206 0.015011 0.029214
0.000000 0.014367 0.028734 0.028734 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000
2012 1 1 3 2 8 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000

| | | | | | |
|---|---|---|---|---|---|
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| | 0.105325 | 0.132436 | 0.087565 | 0.097590 | 0.095541 |
| | 0.107957 | 0.034946 | 0.016375 | 0.000000 | 0.004915 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.002005 | 0.000000 | 0.000000 |
| | 0.000000 | 0.007449 | 0.000000 | 0.000000 | 0.000000 |
| | 0.010553 | 0.010901 | 0.040136 | 0.052767 | 0.030379 |
| | 0.000000 | 0.004218 | 0.004399 | 0.000000 | 0.003815 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 1994 | 1 2 | 3 2 | 3 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.010175 | 0.000000 | 0.000000 | 0.000000 |
| | 0.029666 | 0.025272 | 0.034587 | 0.095043 | 0.069701 |
| | 0.111813 | 0.049350 | 0.038981 | 0.029069 | 0.004921 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.015096 |
| | 0.025008 | 0.004921 | 0.030193 | 0.059262 | 0.093779 |
| | 0.059262 | 0.113936 | 0.039244 | 0.030193 | 0.030526 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 1995 | 1 2 | 3 2 | 4 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.005794 |
| | 0.000000 | 0.000000 | 0.000000 | 0.017381 | 0.005794 |
| | 0.000000 | 0.015611 | 0.019859 | 0.005794 | 0.037241 |
| | 0.027199 | 0.054492 | 0.085491 | 0.090671 | 0.045064 |
| | 0.095178 | 0.065018 | 0.019021 | 0.002478 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.005794 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.005794 | 0.002478 | 0.000000 |
| | 0.004024 | 0.029677 | 0.029453 | 0.067402 | 0.067626 |
| | 0.071649 | 0.076381 | 0.047636 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 1996 | 1 2 | 3 2 | 2 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.011137 | 0.000000 | 0.014376 | 0.024092 |
| | 0.003239 | 0.119667 | 0.137678 | 0.115007 | 0.153079 |
| | 0.063981 | 0.020853 | 0.003239 | 0.000000 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.011137 | 0.003239 | 0.038468 | 0.049605 | 0.048184 |
| | 0.083017 | 0.044945 | 0.025909 | 0.019432 | 0.006477 |
| | 0.000000 | 0.003239 | 0.000000 | 0.000000 | |
| 1997 | 1 2 | 3 2 | 11 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.007945 | 0.001829 | 0.002837 | 0.017276 | 0.015953 |
| | 0.060577 | 0.078276 | 0.126587 | 0.135213 | 0.130432 |

| | | | | | |
|---|---|---|---|---|---|
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| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000457 |
| | 0.000457 | 0.008368 | 0.024316 | 0.023533 | 0.042004 |
| | 0.049990 | 0.062017 | 0.007179 | 0.007488 | 0.000000 |
| | 0.007488 | 0.000000 | 0.000000 | 0.003607 | |
| 1998 | 1 2 | 3 2 | 9 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.007895 |
| | 0.007981 | 0.012406 | 0.044872 | 0.042423 | 0.070830 |
| | 0.089050 | 0.084126 | 0.082699 | 0.142508 | 0.066089 |
| | 0.035896 | 0.009665 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.007861 | 0.000000 | 0.007861 | 0.016020 | 0.024121 |
| | 0.023756 | 0.024567 | 0.034216 | 0.069958 | 0.054032 |
| | 0.032946 | 0.004080 | 0.004080 | 0.000000 | 0.000064 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 1999 | 1 2 | 3 2 | 5 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.008235 |
| | 0.008235 | 0.000000 | 0.001323 | 0.001323 | 0.028014 |
| | 0.098307 | 0.093469 | 0.186975 | 0.120742 | 0.168058 |
| | 0.088973 | 0.070074 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.008235 |
| | 0.000000 | 0.024706 | 0.009559 | 0.028993 | 0.011211 |
| | 0.029414 | 0.014153 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 2000 | 1 2 | 3 2 | 8 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.006899 | 0.000087 | 0.013886 | 0.000578 | 0.018977 |
| | 0.120048 | 0.191432 | 0.166525 | 0.101583 | 0.066502 |
| | 0.027764 | 0.012839 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.006986 | 0.006986 |
| | 0.057845 | 0.042185 | 0.048997 | 0.035674 | 0.026351 |
| | 0.035444 | 0.012269 | 0.000000 | 0.000142 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |
| 2001 | 1 2 | 3 2 | 9 | 0 0 0 0 0 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
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| | 0.093582 | 0.081147 | 0.067482 | 0.192848 | 0.158904 |
| | 0.028108 | 0.003814 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0 0 0 0 0 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

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0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000932 0.002045 0.002622
0.011418 0.007998 0.006135 0.002622 0.000000
0.000000 0.000000 0.000000 0.000000
2004 1 2 3 2 11 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.001872 0.001428 0.003321
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0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.016976
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0.000000 0.000000 0.000000 0.000000
2005 1 2 3 2 11 0 0 0 0 0 0.000000 0.000000
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0.000000 0.000000 0.000000 0.002703 0.000000
0.000000 0.000189 0.005466 0.031505 0.055565
0.056348 0.124088 0.176963 0.156953 0.147040
0.097248 0.047059 0.007056 0.000000 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
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2006 1 2 3 2 17 0 0 0 0 0 0.000000 0.000000
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0.010907 0.002772 0.000377 0.000566 0.000000
0.000000 0.000000 0.000000 0.000000
2007 1 2 3 2 21 0 0 0 0 0 0.000000 0.000000
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0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000060 0.004669 0.014474
0.038479 0.066825 0.139182 0.162253 0.195441
0.156673 0.094168 0.053348 0.004881 0.005275
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000728 0.009122 0.007086 0.005011 0.018969
0.008609 0.005577 0.008502 0.000000 0.000000
0.000000 0.000000 0.000000 0.000668
2008 1 2 3 2 15 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.002197 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000327 0.004593 0.033919
0.035657 0.084958 0.157589 0.179143 0.158224
0.143427 0.062126 0.060719 0.012575 0.009792
0.003965 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.002197 0.000000 0.000000 0.002197 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.011651 0.007277 0.012549
0.014377 0.000000 0.000000 0.000000 0.000000
0.000539 0.000000 0.000000 0.000000
2009 1 2 3 2 25 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000864 0.008205 0.028877
0.068272 0.129624 0.157356 0.173353 0.144434
0.105484 0.054797 0.014297 0.001003 0.000283
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000368 0.010298 0.020586 0.036159 0.030532
0.008497 0.003625 0.003085 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000

2010 1 2 3 2 25 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.001402 0.002321 0.011623 0.029166
0.099786 0.157107 0.165592 0.195601 0.105865
0.091851 0.048002 0.008698 0.000234 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.002209 0.002179 0.016108 0.026836 0.019306
0.013543 0.002388 0.000183 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000
2011 1 2 3 2 23 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.005279 0.019014 0.020531 0.044187
0.117081 0.163652 0.157829 0.109809 0.114325
0.050743 0.020796 0.002399 0.000000 0.000527
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.005121 0.000000 0.015667 0.031692
0.024381 0.044584 0.018900 0.016309 0.013916
0.002331 0.000801 0.000000 0.000126 0.000000
0.000000 0.000000 0.000000 0.000000
2012 1 2 3 2 19 0 0 0 0 0 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000312 0.000000 0.002888 0.010365 0.044695
0.072121 0.126908 0.170412 0.156584 0.139962
0.099788 0.031715 0.011175 0.002468 0.000000
0.000000 0 0 0 0 0 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.003953 0.000447
0.000124 0.035362 0.020008 0.039309 0.017532
0.010449 0.002888 0.000000 0.000536 0.000000
0.000000 0.000000 0.000000 0.000000

# CPFV data from Meisha Key 6_24_2013
# copied from
"C:\XiHe1\SDB2013\Landing\CACPFVRecData\CPFVLengthDataMeishaKey_7_2_2013\Analysis1\DataAllYear1WithOutputs.xlsx"
#Yr Sea Flt Ge Pt Nsm 8 9 10 11 12 13
14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35
8 9 10 11 12 13 14 15 16 17 18
19 20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35
1976 1 3 0 2 38 0 0 0 0 0 0 0 0 0 0
1 0 0 3 6 6 5 11 15 25 38
50 53 40 21 19 7 4 2 0 1 1
0 0 0 0 0 0 0 0 0 0 0 1 0 0 3

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 6 | 5 | 11 | 15 | 25 | 38 | 50 | 53 | 40 | 21 |
| | 19 | 7 | 4 | 2 | 0 | 1 | 1 | 0 | | | |
| 1977 | 1 | 3 | 0 | 2 | 27 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 3 | 1 | 4 | 7 | 8 | 17 | 18 | 26 |
| | 19 | 29 | 23 | 25 | 22 | 18 | 9 | 3 | 3 | 2 | 0 |
| | 2 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | 1 | 4 | 7 | 8 | 17 | 18 | 26 | 19 | 29 | 23 | 25 |
| | 22 | 18 | 9 | 3 | 3 | 2 | 0 | 2 | | | |
| 1978 | 1 | 3 | 0 | 2 | 36 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 2 | 2 | 4 | 8 | 7 | 20 | 21 | 28 |
| | 28 | 30 | 35 | 30 | 27 | 36 | 17 | 9 | 5 | 0 | 2 |
| | 0 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 2 | 4 | 8 | 7 | 20 | 21 | 28 | 28 | 30 | 35 | 30 |
| | 27 | 36 | 17 | 9 | 5 | 0 | 2 | 0 | | | |
| 1986 | 1 | 3 | 0 | 2 | 39 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 2 | 8 | 17 | 34 | 32 | 42 | 43 |
| | 59 | 64 | 62 | 51 | 41 | 15 | 7 | 1 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 2 | 8 | 17 | 34 | 32 | 42 | 43 | 59 | 64 | 62 | 51 |
| | 41 | 15 | 7 | 1 | 0 | 0 | 0 | 0 | | | |
| 1987 | 1 | 3 | 0 | 2 | 42 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 2 | 2 | 1 | 5 | 9 | 8 | 10 | 18 | 30 | 25 |
| | 34 | 37 | 30 | 36 | 33 | 23 | 7 | 9 | 5 | 1 | 0 |
| | 1 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 |
| | 5 | 9 | 8 | 10 | 18 | 30 | 25 | 34 | 37 | 30 | 36 |
| | 33 | 23 | 7 | 9 | 5 | 1 | 0 | 1 | | | |
| 1988 | 1 | 3 | 0 | 2 | 46 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 1 | 2 | 5 | 18 | 16 | 35 | 33 | 37 |
| | 45 | 42 | 44 | 38 | 29 | 21 | 7 | 1 | 1 | 2 | 0 |
| | 2 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 2 | 5 | 18 | 16 | 35 | 33 | 37 | 45 | 42 | 44 | 38 |
| | 29 | 21 | 7 | 1 | 1 | 2 | 0 | 2 | | | |
| 1989 | 1 | 3 | 0 | 2 | 74 | 0 0 0 0 0 0 | | 0 | 1 | 0 | 0 |
| | 4 | 4 | 9 | 6 | 20 | 45 | 58 | 85 | 113 | 139 | 162 |
| | 179 | 163 | 142 | 107 | 80 | 59 | 27 | 12 | 9 | 5 | 2 |
| | 1 | 0 0 0 0 0 0 | | 0 | 1 | 0 | 0 | 4 | 4 | 9 | 6 |
| | 20 | 45 | 58 | 85 | 113 | 139 | 162 | 179 | 163 | 142 | 107 |
| | 80 | 59 | 27 | 12 | 9 | 5 | 2 | 1 | | | |
| 1990 | 1 | 3 | 0 | 2 | 13 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 2 | 3 | 5 |
| | 13 | 17 | 10 | 6 | 2 | 3 | 2 | 0 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 3 | 1 | 2 | 3 | 5 | 13 | 17 | 10 | 6 |
| | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | | | |
| 1991 | 1 | 3 | 0 | 2 | 11 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 1 | 7 | 14 | 6 |
| | 20 | 12 | 12 | 11 | 3 | 4 | 6 | 1 | 0 | 0 | 0 |
| | 3 | 0 0 0 0 0 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 3 | 0 | 0 | 1 | 7 | 14 | 6 | 20 | 12 | 12 | 11 |
| | 3 | 4 | 6 | 1 | 0 | 0 | 0 | 3 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | 1 | 3 | 0 | 2 | 23 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 4 | 11 | 17 | 15 | 17 | 21 |
| | 23 | 26 | 22 | 15 | 5 | 5 | 2 | 1 | 0 | 0 | 0 |
| | 1 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 4 | 11 | 17 | 15 | 17 | 21 | 23 | 26 | 22 | 15 |
| | 5 | 5 | 2 | 1 | 0 | 0 | 0 | 1 | | | |
| 1993 | 1 | 3 | 0 | 2 | 21 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 1 | 0 | 0 | 4 | 10 | 15 | 29 | 25 | 33 |
| | 18 | 15 | 16 | 10 | 14 | 6 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| | 0 | 4 | 10 | 15 | 29 | 25 | 33 | 18 | 15 | 16 | 10 |
| | 14 | 6 | 1 | 1 | 0 | 0 | 0 | 0 | | | |
| 1994 | 1 | 3 | 0 | 2 | 25 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 1 | 2 | 5 | 7 | 19 | 25 | 27 | 28 |
| | 32 | 41 | 24 | 18 | 15 | 4 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| | 2 | 5 | 7 | 19 | 25 | 27 | 28 | 32 | 41 | 24 | 18 |
| | 15 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | | | |
| 1995 | 1 | 3 | 0 | 2 | 28 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 1 | 1 | 6 | 17 | 22 | 34 | 32 | 44 |
| | 47 | 50 | 28 | 24 | 16 | 3 | 3 | 1 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| | 1 | 6 | 17 | 22 | 34 | 32 | 44 | 47 | 50 | 28 | 24 |
| | 16 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | | | |
| 1996 | 1 | 3 | 0 | 2 | 25 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 1 | 1 | 6 | 10 | 30 | 35 | 46 | 50 |
| | 47 | 46 | 44 | 29 | 26 | 12 | 4 | 1 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| | 1 | 6 | 10 | 30 | 35 | 46 | 50 | 47 | 46 | 44 | 29 |
| | 26 | 12 | 4 | 1 | 0 | 0 | 0 | 0 | | | |
| 1997 | 1 | 3 | 0 | 2 | 25 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 18 | 25 | 29 | 25 |
| | 43 | 41 | 30 | 27 | 23 | 8 | 7 | 1 | 0 | 0 | 0 |
| | 0 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 5 | 12 | 18 | 25 | 29 | 25 | 43 | 41 | 30 | 27 |
| | 23 | 8 | 7 | 1 | 0 | 0 | 0 | 0 | | | |
| 1998 | 1 | 3 | 0 | 2 | 10 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 1 | 5 |
| | 2 | 3 | 5 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 0 0 0 0 0 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | 0 | 0 | 1 | 3 | 2 | 1 | 5 | 2 | 3 | 5 | 6 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | | |

# RecFIN data: only one year from Melissa Monk's data
# Data from directory "C:\XiHe1\SDB2013\Landing\RecCatch\MelissaMonkData\Analysis1"
# Length data from file "RecMelissaDataDiscardLength.xlsx"
# Sample size from data sheet "SampleSize" of file "RecMelissaDataDiscardLength.xlsx"

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| #Yr | | Sea | Flt | Gen | Pt | Sam | 8 | 9 | 10 | 11 | 12 |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| | 35 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |

```
        18      19      20      21      22      23      24      25      26      27      28
        29      30      31      32      33      34      35
2005    1       3       0       2       28      0 0 0 0 0 0     0       0       1       3
        2       3       7       4       6       2       3       5       7       7       9
        9       12      9       3       4       4       2       0       0       0       0
        0       0       0       0 0 0 0 0 0     1       3       2       3       7       4
        6       2       3       5       7       7       9       9       12      9       3
        4       4       2       0       0       0       0       0
2005    1       3       0       1       71      0 0 0 0 0 0     0       0       0       2
        3       4       1       2       1       9       9       17      13      12      6
        11      10      3       2       3       0       2       0       1       0       0
        1       0       0       0 0 0 0 0 0     0       2       3       4       1       2
        1       9       9       17      13      12      6       11      10      3       2
        3       0       2       0       1       0       0       1


# NWFSC survey length comps
# use Allan Hicks' expantion program
# program and output dir: "C:\XiHe1\SDB2013\SurveyData\NWFSC\LengthFreqNew2"
# data copied from "NWFSCLengthCompsForModel.xlsx"
#yr            SE      Flt     GD      Pt      Ns      F8              F9              F10
        F11             F12             F13             F14             F15             F16
        F17             F18             F19             F20             F21             F22
        F23             F24             F25             F26             F27             F28
        F29             F30             F31             F32             F33             F34
        F35             M8              M9              M10             M11             M12
        M13             M14             M15             M16             M17             M18
        M19             M20             M21             M22             M23             M24
        M25             M26             M27             M28             M29             M30
        M31             M32             M33             M34             M35
2003    1       5       3       0       132     0 0 0 0 0 0.00000       0.000000.001840.01222
        0.053090.105540.144130.298810.375200.536040.728181.253912.544213.156075.76804
        4.5557010.67838.273735.645896.698913.927873.421391.780530.823120.161830.00422
        0.000000.000000 0 0 0 0 0.00000         0.005780.018550.050530.102220.192430.36289
        0.766811.071071.015271.997792.758193.505753.615014.366083.855443.353563.87896
        4.816362.731270.564210.008760.012600.001700.000000.000000.000000.00000
2004    1       5       3       0       165     0 0 0 0 0 0.00305       0.002940.016600.02600
        0.066520.216000.254480.457280.796821.289462.384203.225174.700824.647636.00390
        5.757826.851224.786174.817114.650673.797592.459831.531160.606840.071890.02698
        0.006370.002280 0 0 0 0 0.07936         0.014780.050970.135930.257060.259460.33642
        0.558101.196512.194703.894774.568135.113825.553184.465183.829683.515761.94149
        1.526190.551250.313870.092780.015610.057570.000000.011160.000000.00000
2005    1       5       3       0       218     0 0 0 0 0 0.00000       0.054650.081350.12514
        0.237790.371370.770460.696411.515622.117712.920443.620614.866074.878115.01043
        5.486335.964436.125664.762104.011263.164921.691580.742150.233280.062760.00617
        0.000000.000000 0 0 0 0 0.01523         0.097470.363020.472480.516330.608440.92735
        1.265971.878512.623883.762694.603174.997834.703484.533363.900662.663561.47995
        0.573590.301600.112210.056640.000000.000000.000000.000000.000000.00000
2006    1       5       3       0       178     0 0 0 0 0 0.00000       0.000000.027300.07732
        0.073650.183990.511080.440250.831491.009272.329742.036253.455245.242557.05928
        5.687707.785195.295825.853266.132933.878302.145463.323990.083700.032330.00000
```

```
	0.000000.000000 0 0 0 0 0.02784	0.058760.035040.184240.325330.414730.95703
	1.154942.215261.825094.220404.309344.502203.500454.777852.791903.098800.63440
	1.173060.166740.078360.041840.000000.000000.000000.000000.000000.00000
2007	1	5	3	0	190	0 0 0 0 0 0.00000	0.000000.000000.02032
	0.158060.272580.732550.749351.473982.110423.316133.608065.287724.463017.10252
	8.342265.604134.980945.880354.313642.523051.413400.535180.196400.005910.00000
	0.000000.000000 0 0 0 0 0.00000	0.007720.072080.186910.323780.400861.20907
	1.253762.105122.590294.045035.808844.501654.433293.588422.581611.845741.00841
	0.688710.194690.049340.008340.006360.000000.000000.000000.000000.00000
2008	1	5	3	0	203	0 0 0 0 0 0.00000	0.000000.000000.06915
	0.125790.241900.443800.740171.307861.730354.147254.919814.705635.876655.22531
	5.331195.213325.442254.711053.148142.534321.415170.681200.174250.040310.04614
	0.000000.000000 0 0 0 0 0.02286	0.000000.128820.150270.677210.492720.68692
	1.255762.757834.220404.530844.961415.917905.299723.658992.890942.150751.08439
	0.693720.115020.012380.000000.018220.000000.000000.000000.000000.00000
2009	1	5	3	0	214	0 0 0 0 0 0.00000	0.000000.001070.01390
	0.166930.194650.518441.094412.203013.960503.196414.436553.647047.928585.48366
	5.477464.778013.148972.777573.304011.860280.910660.475900.071530.007800.00000
	0.000000.000000 0 0 0 0 0.00305	0.000000.039160.050300.213580.382101.60123
	1.101393.045853.086844.593456.186674.632937.038344.345283.572451.645900.80449
	1.891230.092890.015520.000000.000000.000000.000000.000000.000000.00000
2010	1	5	3	0	239	0 0 0 0 0 0.00000	0.000000.000000.00302
	0.075150.709570.152500.174570.918251.304991.176614.564968.989534.800835.30686
	7.217895.705772.551662.542433.329692.025820.684210.634020.061490.000000.09014
	0.000000.000000 0 0 0 0 0.00423	0.000000.011300.100110.149600.478050.27460
	0.305991.447181.915507.531408.466339.753655.472105.085822.470181.837481.25542
	0.362170.058910.000000.000000.000000.000000.000000.000000.000000.00000
2011	1	5	3	0	242	0 0 0 0 0 0.00000	0.000000.032530.09194
	0.051150.142140.456440.701820.728411.920571.692743.003084.137172.968317.28456
	5.831435.645816.317447.006814.261083.616831.191630.989400.191460.059800.00935
	0.000000.000000 0 0 0 0 0.01453	0.012040.044300.110550.113980.234920.55850
	1.144371.506861.623272.778004.1252710.84817.037453.523183.341632.648831.21180
	0.523370.194960.027360.009760.010630.024370.000000.000000.000000.00000
2012	1	5	3	0	244	0 0 0 0 0 0.00105	0.002110.000000.01601
	0.017630.300560.585501.400821.707712.021661.713232.619463.284953.083814.60352
	6.095267.514087.084696.891733.665493.306121.720871.251230.136210.040980.00324
	0.002620.000000 0 0 0 0 0.02317	0.008400.027760.076070.306280.364720.52400
	1.292612.035532.063723.524845.025576.817785.465805.346303.760642.368110.92618
	0.821300.129640.008140.000000.006650.000000.000000.000000.000000.00000

# triennial survey length comps
# use Allan Hicks' expantion program (with "FREQUENCY" variable applied)
# program and output dir: "C:\XiHe1\SDB2013\SurveyData\Triennial\LengthFreqNew1"
# Note: raw data have frequency variable to expand total length measurements
# Outputs are same for analyzing two periods together or separately

#yr		SE	Flt	GD	Pt	Ns	F8		F9		F10
	F11		F12		F13		F14		F15		F16
	F17		F18		F19		F20		F21		F22
	F23		F24		F25		F26		F27		F28
	F29		F30		F31		F32		F33		F34
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | F35 | | F8.1 | F9.1 | F10.1 | F11.1 | F12.1 | F13.1 | F14.1 | F15.1 | F16.1 |
| | F17.1 | F18.1 | F19.1 | F20.1 | F21.1 | F22.1 | F23.1 | F24.1 | F25.1 | F26.1 | F27.1 |
| | F28.1 | F29.1 | F30.1 | F31.1 | F32.1 | F33.1 | F34.1 | F35.1 | | | |
| 1980 | 1 | 6 | 3 | 0 | 5 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 0.1540 | 0.0000 | 0.0000 | 0.1472 | 0.1472 | 0.9242 | 1.8796 | 2.9175 |
| | 6.2674 | 8.2141 | 13.617614.550713.79837.6865 | | | | 5.8748 | 1.3032 | 0.1540 | 0.0000 | 0.0000 |
| | 0.0000 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1472 |
| | 0.0000 | 0.0000 | 0.4793 | 0.5889 | 1.2530 | 3.4558 | 4.8893 | 3.1978 | 3.1476 | 3.0604 | 1.5322 |
| | 0.6121 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1983 | 1 | 6 | 3 | 0 | 16 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0000 |
| | 0.0649 | 0.0543 | 0.4256 | 0.4832 | 0.6724 | 1.0479 | 1.6616 | 2.0633 | 2.4613 | 3.0367 | 3.6682 |
| | 4.0883 | 4.7217 | 5.4304 | 5.4454 | 5.3036 | 4.1017 | 2.4719 | 1.4890 | 0.3879 | 0.2826 | 0.0906 |
| | 0.0000 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0649 | 0.1408 | 0.1324 | 0.4644 | 0.5347 |
| | 1.1542 | 2.1481 | 4.9622 | 4.6160 | 5.7011 | 6.1142 | 5.7638 | 6.4407 | 5.2046 | 3.6145 | 1.8985 |
| | 1.0376 | 0.4297 | 0.0435 | 0.0812 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1986 | 1 | 6 | 3 | 0 | 11 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 0.0911 | 0.0000 | 0.2605 | 0.7310 | 1.6607 | 2.2447 | 3.3250 | 5.1180 |
| | 5.3529 | 7.7411 | 8.6398 | 9.5046 | 7.6200 | 4.2199 | 3.9024 | 1.0567 | 0.1918 | 0.0000 | 0.0000 |
| | 0.0000 | 0 0 0 0 0 0.00000.0000 | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.2605 | 1.0640 | 1.5010 | 1.8179 | 5.1802 | 6.6931 | 8.4135 | 6.4660 | 3.7817 | 2.1499 | 0.1918 |
| | 0.5607 | 0.2594 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1989 | 1 | 6 | 3 | 0 | 88 | 0 0 0 0 0 0.00000.0068 | | | 0.0000 | 0.0438 | 0.0771 |
| | 0.1242 | 0.2442 | 0.5650 | 0.9596 | 1.0786 | 1.5286 | 1.7322 | 2.0817 | 3.0796 | 4.5252 | 4.7717 |
| | 4.5687 | 4.1164 | 5.1725 | 5.6985 | 5.8960 | 3.1704 | 2.3035 | 2.2949 | 0.6462 | 0.0975 | 0.0884 |
| | 0.0000 | 0 0 0 0 0 0.00000.0020 | | | 0.0000 | 0.0790 | 0.2625 | 0.3051 | 0.5495 | 1.1286 | 1.7401 |
| | 1.9520 | 2.8484 | 4.2549 | 4.7112 | 5.0065 | 4.6437 | 5.1160 | 4.5290 | 3.0940 | 3.0725 | 1.0454 |
| | 0.3845 | 0.2094 | 0.0023 | 0.1922 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1992 | 1 | 6 | 3 | 0 | 142 | 0 0 0 0 0 0.00000.0025 | | | 0.0492 | 0.0358 | 0.1166 |
| | 0.2338 | 0.3832 | 0.5727 | 1.1631 | 2.0924 | 3.9804 | 5.3219 | 5.8381 | 6.1370 | 4.8276 | 4.6979 |
| | 4.3003 | 3.2531 | 2.9340 | 2.6019 | 3.0980 | 2.0809 | 1.3034 | 0.6031 | 0.2389 | 0.0546 | 0.0000 |
| | 0.0000 | 0 0 0 0 0 0.00220.0339 | | | 0.0337 | 0.1278 | 0.3133 | 0.3744 | 0.7153 | 1.0244 | 2.6929 |
| | 4.5877 | 5.7323 | 5.5282 | 5.5337 | 4.7185 | 3.6225 | 2.9408 | 2.2184 | 1.9174 | 1.3478 | 0.3591 |
| | 0.1683 | 0.0586 | 0.0046 | 0.0239 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1995 | 1 | 7 | 3 | 0 | 147 | 0 0 0 0 0 0.00000.0000 | | | 0.0191 | 0.0700 | 0.1652 |
| | 0.3879 | 0.8600 | 1.2088 | 3.5988 | 3.5867 | 4.0912 | 2.8104 | 3.5766 | 4.5370 | 4.5036 | 4.1999 |
| | 4.0835 | 3.9361 | 6.7012 | 4.0069 | 2.0106 | 1.2195 | 0.6217 | 0.2259 | 0.0087 | 0.0187 | 0.0073 |
| | 0.0038 | 0 0 0 0 0 0.00000.0206 | | | 0.0618 | 0.1665 | 0.5882 | 0.9103 | 1.8622 | 2.8458 | 5.1871 |
| | 3.2488 | 3.9841 | 3.5193 | 3.9977 | 5.4580 | 3.9407 | 3.3303 | 2.1344 | 1.6796 | 0.1700 | 0.4000 |
| | 0.0076 | 0.0000 | 0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0243 | | | |
| 1998 | 1 | 7 | 3 | 0 | 223 | 0 0 0 0 0 0.00000.0000 | | | 0.0127 | 0.0549 | 0.0761 |
| | 0.2181 | 0.6035 | 0.9799 | 1.2206 | 2.4389 | 3.0883 | 3.7164 | 4.3845 | 5.6669 | 5.5413 | 6.1513 |
| | 5.1088 | 5.4641 | 4.0906 | 3.3753 | 1.8423 | 0.6301 | 0.1879 | 0.0471 | 0.0039 | 0.0000 | 0.0000 |
| | 0.0000 | 0 0 0 0 0 0.00130.0515 | | | 0.0654 | 0.0933 | 0.1233 | 0.4711 | 0.6665 | 1.4970 | 1.8030 |
| | 3.3354 | 4.6779 | 5.3307 | 5.2269 | 5.2053 | 4.8357 | 4.8221 | 3.5022 | 2.1070 | 0.8231 | 0.3165 |
| | 0.0986 | 0.0250 | 0.0110 | 0.0000 | 0.0011 | 0.0000 | 0.0000 | 0.0000 | | | |
| 2001 | 1 | 7 | 3 | 0 | 231 | 0 0 0 0 0 0.00000.0000 | | | 0.0274 | 0.0131 | 0.1022 |
| | 0.3455 | 1.0886 | 1.7243 | 4.3380 | 3.2827 | 3.4400 | 3.1032 | 2.7705 | 3.4884 | 3.9049 | 3.5465 |
| | 3.3260 | 4.0328 | 4.5876 | 4.9510 | 2.4186 | 1.5555 | 0.4354 | 0.0759 | 0.0045 | 0.0022 | 0.0000 |
| | 0.0000 | 0 0 0 0 0 0.00000.0000 | | | 0.0288 | 0.0459 | 0.1542 | 0.4279 | 1.9027 | 3.7758 | 3.9321 |

```
        3.7315  3.5985  4.0247  5.5240  4.7120  5.9467  4.4309  2.7036  1.2394  0.7336  0.2308
        0.2635  0.0197  0.0021  0.0062  0.0005  0.0000  0.0000  0.0000
2004    1       7       3       0       166     0 0 0 0 0 0.00280.0000  0.0000  0.0371  0.0539
        0.1489  0.4361  0.7697  1.1586  1.7452  2.7105  3.4624  4.6078  3.2904  4.1510  4.0376
        5.0830  5.0439  4.5749  3.7485  3.0317  1.8287  0.9540  0.2483  0.1067  0.0133  0.0007
        0.0020  0 0 0 0 0 0.00300.0110  0.0289  0.1098  0.2401  0.3151  0.7732  1.2809  2.6913
        2.6024  4.5516  4.9160  6.3883  5.2082  6.4703  4.1727  4.5444  2.3726  1.1719  0.5722
        0.2455  0.0777  0.0023  0.0000  0.0000  0.0000  0.0000  0.0000

#_Age composition data
12      # number of age bins
0 1 2 3 4 5 6 7 8 9 10 11

2       #_number of unique ageing error matrices to generate
# Vector 1: Set SD to small values to assume no ageing errors
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5
0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

# Vector 2: new ageing error estimates from all ageing error readings (3/21/2013)
0.5775  1.5888  2.5856  3.5679  4.5361  5.4904  6.4308  7.3577  8.2713  9.1716  10.059010.9335
0.2444  0.2444  0.2589  0.2802  0.3114  0.3572  0.4244  0.5231  0.6680  0.8807  1.1928  1.6511

386     #_number of age observations
3       #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
0       #_combine males into females at or below this bin number

# CA trawl fisheries
# Program and output directory: "C:\XiHe1\SDB2013\AgeData\CAFishery\Analysis1"
# Output copied from file "PacFINCAAgeCompForModel.xlsx"
#Yr             Se      Flt     Ge      Pt      AE      LO      HI      Sam     N.0.x
        N.1.x           N.2.x           N.3.x           N.4.x           N.5.x           N.6.x
        N.7.x           N.8.x           N.9.x           N.10.x          N.11.x          N.0.y
        N.1.y           N.2.y           N.3.y           N.4.y           N.5.y           N.6.y
        N.7.y           N.8.y           N.9.y           N.10.y          N.11.y
2003    1       1       3       2       2       -1      -1      8       0.000000
        0.000000        0.004335        0.034406        0.119666        0.076870
        0.112857        0.121735        0.111311        0.045654        0.003356
        0.000000        0.000000        0.000000        0.023702        0.027822
        0.072082        0.057270        0.085785        0.051517        0.029474
        0.014554        0.000000        0.000000
2007    1       1       3       2       2       -1      -1      13      0.000000
        0.000000        0.000000        0.001333        0.023647        0.081477
        0.198816        0.279622        0.197356        0.047363        0.003301
        0.000160        0.000000        0.000000        0.000000        0.000000
        0.013576        0.050458        0.042661        0.055230        0.002949
        0.000941        0.001108        0.000000
2008    1       1       3       2       2       -1      -1      8       0.000000
        0.000000        0.000000        0.002198        0.025421        0.097423
        0.234064        0.279122        0.133398        0.061388        0.003312
        0.009065        0.000000        0.000000        0.000000        0.000000
```

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	0.000000	0.027107	0.059780	0.050639	0.017082
	0.000000	0.000000	0.000000

# OR trawl fisheries
# Program and output directory: "C:\XiHe1\SDB2013\AgeData\ORFishery\Analysis1"
# Output copied from file "PacFINORAgeCompForModel.xlsx"
#Year	Se	Flt	Ge	Pt	AE	LO	HI	Sam	N.0.x	N.1.x
	N.2.x	N.3.x	N.4.x	N.5.x	N.6.x	N.7.x
	N.8.x	N.9.x	N.10.x	N.11.x	N.0.y	N.1.y
	N.2.y	N.3.y	N.4.y	N.5.y	N.6.y	N.7.y
	N.8.y	N.9.y	N.10.y	N.11.y
1995	1	2	3	2	2	-1	-1	2	0.000000
	0.000000	0.000000	0.013385	0.000000	0.000000
	0.043255	0.119480	0.248185	0.089610	0.029870
	0.021627	0.000000	0.000000	0.000000	0.000000
	0.000000	0.026770	0.048397	0.140048	0.129764
	0.081367	0.008243	0.000000
1997	1	2	3	2	2	-1	-1	10	0.000000
	0.000000	0.000000	0.000721	0.004319	0.037217
	0.057620	0.086251	0.241778	0.183529	0.103445
	0.057260	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000213	0.030417	0.028669	0.122784
	0.035505	0.010272	0.000000
1999	1	2	3	2	2	-1	-1	5	0.000000
	0.000000	0.003616	0.005786	0.004339	0.016344
	0.054391	0.262555	0.304870	0.159526	0.058128
	0.000111	0.000000	0.000000	0.000000	0.000000
	0.009001	0.000000	0.000723	0.036950	0.051511
	0.015359	0.016791	0.000000
2001	1	2	3	2	2	-1	-1	9	0.000000
	0.000000	0.000000	0.014865	0.044764	0.062900
	0.025440	0.182349	0.245252	0.114328	0.006565
	0.002049	0.000000	0.000000	0.000000	0.000000
	0.086438	0.058717	0.030876	0.046023	0.020007
	0.044770	0.014658	0.000000
2003	1	2	3	2	2	-1	-1	5	0.000000
	0.000000	0.000000	0.000000	0.005943	0.000000
	0.029586	0.085341	0.270428	0.262572	0.191405
	0.129478	0.000000	0.000000	0.000000	0.000000
	0.000000	0.000000	0.000000	0.009651	0.000000
	0.015594	0.000000	0.000000
2005	1	2	3	2	2	-1	-1	10	0.000000
	0.000000	0.000000	0.000000	0.000192	0.026419
	0.071883	0.178231	0.233017	0.215400	0.126840
	0.056678	0.000000	0.000000	0.000000	0.000835
	0.003613	0.016844	0.014592	0.020853	0.018452
	0.009018	0.004355	0.002778
2007	1	2	3	2	2	-1	-1	2	0.000000
	0.000000	0.000000	0.000000	0.019247	0.205160
	0.194840	0.328174	0.138493	0.014087	0.000000
	0.000000	0.000000	0.000000	0.000000	0.000000
```

```
        0.000000    0.000000    0.038493    0.047420    0.014087
        0.000000    0.000000    0.000000
2009    1   2   3   2   2   -1  -1  14  0.000000
        0.000000    0.000000    0.009765    0.039743    0.105040
        0.154193    0.207033    0.210983    0.088209    0.036001
        0.000342    0.000000    0.000000    0.000000    0.000000
        0.006771    0.009350    0.049034    0.057061    0.011973
        0.008319    0.006184    0.000000
2011    1   2   3   2   2   -1  -1  16  0.000000
        0.000000    0.000000    0.000270    0.046681    0.159013
        0.181223    0.191283    0.136993    0.085737    0.024051
        0.006091    0.000000    0.000000    0.000000    0.037389
        0.033250    0.034790    0.031904    0.016656    0.013900
        0.000770    0.000000    0.000000
2012    1   2   3   2   2   -1  -1  16  0.000000
        0.000000    0.000000    0.012297    0.041732    0.177307
        0.242207    0.203722    0.124450    0.059427    0.017458
        0.016395    0.000000    0.000000    0.000000    0.000199
        0.003888    0.012212    0.038310    0.027616    0.016720
        0.006060    0.000000    0.000000

# NWFSC survey conditiona age-at-length
# Program and output directory: "C:\XiHe1\SDB2013\SurveyData\NWFSC\AgeAtLength1"
# Outputs copied from file: "AgeAtLenForSS3Model.xlsx"
# NOTE: one record with LbinLo = 5 needs to be deleted

#year   Se  Flt gd  prn aE  Lo  Hi  nS  F0  F1  F2
        F3  F4  F5  F6  F7  F8  F9  F10 F11 M0  M1
        M2  M3  M4  M5  M6  M7  M8  M9  M10 M11
2003    1   5   1   0   2   11  11  1   0.0000  100.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        100.0000    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000
2003    1   5   1   0   2   13  13  1   0.0000  100.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        100.0000    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000
2003    1   5   1   0   2   14  14  3   0.0000  0.0000
        100.0000    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000  0.0000  100.0000    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000  0.0000
2003    1   5   1   0   2   15  15  4   0.0000  25.000075.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  25.0000
        75.00000.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
2003    1   5   1   0   2   16  16  13  0.0000  23.076969.2308
        7.6923  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  23.0769
        69.23087.6923  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
2003    1   5   1   0   2   17  17  11  0.0000  9.0909  45.4545
        36.36369.0909  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  9.0909
        45.454536.36369.0909  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
```

2003 1 5 1 0 2 18 18 8 0.0000 0.0000 50.0000
50.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
50.000050.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 19 19 26 0.0000 0.0000 53.8462
34.61547.6923 3.8462 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
53.846234.61547.6923 3.8462 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 20 20 21 0.0000 0.0000 28.5714
38.095228.57144.7619 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
28.571438.095228.57144.7619 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 21 21 24 0.0000 0.0000 16.6667
29.166754.16670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
16.666729.166754.16670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 22 22 34 0.0000 0.0000 2.9412
32.352944.117614.70592.9412 2.9412 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2.9412 32.352944.117614.70592.9412 2.9412 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 23 23 41 0.0000 0.0000 9.7561
21.951248.780517.07320.0000 2.4390 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
9.7561 21.951248.780517.07320.0000 2.4390 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 24 24 51 0.0000 0.0000 1.9608
19.607847.058829.41180.0000 1.9608 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
1.9608 19.607847.058829.41180.0000 1.9608 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 25 25 57 0.0000 0.0000 1.7544
14.035138.596533.33337.0175 5.2632 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
1.7544 14.035138.596533.33337.0175 5.2632 0.0000 0.0000 0.0000 0.0000
2003 1 5 1 0 2 26 26 54 0.0000 0.0000 0.0000
9.2593 27.777829.629614.814812.96301.8519 3.7037 0.0000 0.0000 0.0000 0.0000
0.0000 9.2593 27.777829.629614.814812.96301.8519 3.7037 0.0000 0.0000
2003 1 5 1 0 2 27 27 41 0.0000 0.0000 0.0000
4.8780 9.7561 21.951243.902414.63414.8780 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 4.8780 9.7561 21.951243.902414.63414.8780 0.0000 0.0000 0.0000
2003 1 5 1 0 2 28 28 32 0.0000 0.0000 0.0000
0.0000 15.625015.625012.500031.250015.62506.2500 3.1250 0.0000 0.0000 0.0000
0.0000 0.0000 15.625015.625012.500031.250015.62506.2500 3.1250 0.0000
2003 1 5 1 0 2 29 29 35 0.0000 0.0000 0.0000
0.0000 11.428617.142920.000025.714317.14298.5714 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 11.428617.142920.000025.714317.14298.5714 0.0000 0.0000
2003 1 5 1 0 2 30 30 27 0.0000 0.0000 0.0000
0.0000 0.0000 14.814814.814848.148111.111111.11110.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 14.814814.814848.148111.111111.11110.0000 0.0000
2003 1 5 1 0 2 31 31 12 0.0000 0.0000 0.0000
0.0000 0.0000 8.3333 25.000025.000041.66670.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 8.3333 25.000025.000041.66670.0000 0.0000 0.0000
2003 1 5 1 0 2 32 32 4 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 25.000025.000025.00000.0000 25.00000.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 25.000025.000025.00000.0000 25.00000.0000
2003 1 5 1 0 2 33 33 1 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000
0.0000
2004 1 5 1 0 2 11 11 2 0.0000 0.0000
100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

0.0000 0.0000 100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000
2004 1 5 1 0 2 12 12 3 0.0000 0.0000 66.6667
33.33330.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
66.666733.33330.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 13 13 10 0.0000 10.000040.0000
40.000010.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 10.0000
40.000040.000010.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 14 14 12 0.0000 8.3333 50.0000
41.66670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 8.3333
50.000041.66670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 15 15 11 0.0000 18.181845.4545
36.36360.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 18.1818
45.454536.36360.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 16 16 20 0.0000 15.000035.0000
45.00005.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 15.0000
35.000045.00005.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 17 17 14 0.0000 0.0000 50.0000
28.571421.42860.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2004 1 5 1 0 2 19 19 54 0.0000 0.0000 5.5556
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5.5556 51.851924.074116.66671.8519 0.0000 0.0000 0.0000 0.0000 0.0000
2004 1 5 1 0 2 20 20 80 0.0000 0.0000 6.2500
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2004 1 5 1 0 2 25 25 54 0.0000 0.0000 0.0000
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0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 14.285714.2857
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2005 1 5 1 0 2 13 13 5 0.0000 20.000060.0000
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60.000020.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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80.000020.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2005 1 5 1 0 2 15 15 7 14.28570.0000 42.8571
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42.857142.85710.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2005 1 5 1 0 2 16 16 11 0.0000 9.0909 27.2727
45.454518.18180.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 9.0909
27.272745.454518.18180.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2005 1 5 1 0 2 17 17 26 0.0000 0.0000 23.0769
38.461530.76927.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
23.076938.461530.76927.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 1 | 5 | 1 | 0 | 2 | 18 | 18 | 21 | 0.0000 | 0.0000 | 4.7619 |
| | 42.8571 | 28.5714 | 19.0476 | 4.7619 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 4.7619 | 42.8571 | 28.5714 | 19.0476 | 4.7619 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 19 | 19 | 26 | 0.0000 | 0.0000 | 3.8462 |
| | 42.3077 | 34.6154 | 7.6923 | 11.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 3.8462 | 42.3077 | 34.6154 | 7.6923 | 11.5385 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 20 | 20 | 61 | 0.0000 | 0.0000 | 13.1148 |
| | 26.2295 | 40.9836 | 13.1148 | 6.5574 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 13.1148 | 26.2295 | 40.9836 | 13.1148 | 6.5574 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 21 | 21 | 53 | 0.0000 | 0.0000 | 3.7736 |
| | 26.4151 | 39.6226 | 9.4340 | 20.7547 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 3.7736 | 26.4151 | 39.6226 | 9.4340 | 20.7547 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 22 | 22 | 58 | 0.0000 | 0.0000 | 1.7241 |
| | 17.2414 | 29.3103 | 24.1379 | 20.6897 | 6.8966 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1.7241 | 17.2414 | 29.3103 | 24.1379 | 20.6897 | 6.8966 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 23 | 23 | 54 | 0.0000 | 1.8519 | 1.8519 |
| | 12.9630 | 31.4815 | 25.9259 | 25.9259 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.8519 |
| | 1.8519 | 12.9630 | 31.4815 | 25.9259 | 25.9259 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 24 | 24 | 65 | 0.0000 | 0.0000 | 0.0000 |
| | 12.3077 | 21.5385 | 20.0000 | 29.2308 | 16.9231 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 12.3077 | 21.5385 | 20.0000 | 29.2308 | 16.9231 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 25 | 25 | 71 | 0.0000 | 0.0000 | 1.4085 |
| | 4.2254 | 11.2676 | 36.6197 | 36.6197 | 9.8592 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 1.4085 | 4.2254 | 11.2676 | 36.6197 | 36.6197 | 9.8592 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 26 | 26 | 44 | 0.0000 | 0.0000 | 0.0000 |
| | 4.5455 | 13.6364 | 18.1818 | 38.6364 | 20.4545 | 4.5455 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 4.5455 | 13.6364 | 18.1818 | 38.6364 | 20.4545 | 4.5455 | 0.0000 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 27 | 27 | 39 | 0.0000 | 0.0000 | 0.0000 |
| | 12.8205 | 12.8205 | 15.3846 | 35.8974 | 10.2564 | 5.1282 | 2.5641 | 5.1282 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 12.8205 | 12.8205 | 15.3846 | 35.8974 | 10.2564 | 5.1282 | 2.5641 | 5.1282 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 28 | 28 | 31 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 6.4516 | 38.7097 | 25.8065 | 19.3548 | 6.4516 | 3.2258 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 6.4516 | 38.7097 | 25.8065 | 19.3548 | 6.4516 | 3.2258 | 0.0000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 29 | 29 | 16 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 6.2500 | 18.7500 | 25.0000 | 12.5000 | 12.5000 | 12.5000 | 12.5000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 6.2500 | 18.7500 | 25.0000 | 12.5000 | 12.5000 | 12.5000 | 12.5000 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 30 | 30 | 19 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 42.1053 | 26.3158 | 15.7895 | 0.0000 | 10.5263 | 5.2632 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 42.1053 | 26.3158 | 15.7895 | 0.0000 | 10.5263 | 5.2632 | 0.0000 | |
| 2005 | 1 | 5 | 1 | 0 | 2 | 31 | 31 | 3 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 33.3333 | 0.0000 | 66.6667 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 33.3333 | 0.0000 | 66.6667 | 0.0000 | 0.0000 | 0.0000 | |
| 2006 | 1 | 5 | 1 | 0 | 2 | 11 | 11 | 2 | 0.0000 | 50.0000 | 50.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 50.0000 |
| | 50.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2006 | 1 | 5 | 1 | 0 | 2 | 13 | 13 | 2 | 0.0000 | 0.0000 | 50.0000 |
| | 50.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 50.0000 | 50.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2006 | 1 | 5 | 1 | 0 | 2 | 14 | 14 | 1 | 0.0000 | 0.0000 | |
| | 100.0000 | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

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2006 1 5 1 0 2 15 15 7 0.0000 0.0000 57.1429
42.85710.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
57.142942.85710.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2006 1 5 1 0 2 16 16 4 0.0000 0.0000 50.0000
25.000025.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2006 1 5 1 0 2 17 17 10 0.0000 0.0000 20.0000
50.000010.000020.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2006 1 5 1 0 2 18 18 21 0.0000 0.0000 14.2857
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2006 1 5 1 0 2 20 20 27 0.0000 0.0000 0.0000
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2006 1 5 1 0 2 25 25 48 0.0000 0.0000 0.0000
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7.6923 0.0000 0.0000 7.6923 61.538523.07690.0000 0.0000 0.0000 0.0000 0.0000
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0.0000 0.0000 0.0000 37.500025.000025.000012.50000.0000 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 31 31 5 0.0000 0.0000 0.0000
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2007 1 5 1 0 2 32 32 1 0.0000 0.0000 0.0000
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2010 1 5 1 0 2 16 16 26 0.0000 38.461546.1538
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2011 1 5 1 0 2 22 22 42 0.0000 0.0000 14.2857
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13.333346.666726.66670.0000 6.6667 0.0000 0.0000 0.0000 0.0000 0.0000 6.6667
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2007 1 5 2 0 2 22 22 22 0.0000 0.0000 0.0000
9.0909 22.727331.818222.727313.63640.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 23 23 16 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 24 24 16 0.0000 0.0000 0.0000
6.2500 0.0000 25.000050.00006.2500 0.0000 12.50000.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 25 25 20 0.0000 0.0000 0.0000
5.0000 0.0000 20.000030.000035.000010.00000.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 26 26 4 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 75.00000.0000 25.00000.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 27 27 7 0.0000 0.0000 0.0000
0.0000 0.0000 28.571442.857114.285714.28570.0000 0.0000 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 28 28 1 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 29 29 1 0.0000 0.0000 0.0000
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2007 1 5 2 0 2 30 30 1 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 10 10 1 0.0000 100.0000
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2008 1 5 2 0 2 11 11 3 33.333333.333333.3333
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33.333333.3333
33.33330.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 12 12 3 0.0000 66.666733.3333
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 66.6667
33.33330.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 13 13 2 50.00000.0000 50.0000
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2008 1 5 2 0 2 14 14 4 0.0000 25.000050.0000
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50.000025.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 15 15 9 0.0000 11.111155.5556
22.22220.0000 11.11110.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 11.1111
55.555622.22220.0000 11.11110.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 16 16 13 0.0000 15.384653.8462
23.07690.0000 7.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 15.3846
53.846223.07690.0000 7.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 17 17 17 0.0000 5.8824 47.0588
17.647123.52945.8824 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 5.8824
47.058817.647123.52945.8824 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 18 18 21 0.0000 9.5238 19.0476
47.619014.28579.5238 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 9.5238
19.047647.619014.28579.5238 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 19 19 31 0.0000 0.0000 25.8065
25.806535.483912.90320.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
25.806525.806535.483912.90320.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2008 1 5 2 0 2 20 20 40 0.0000 0.0000 10.0000
25.000027.500025.000012.50000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
10.000025.000027.500025.000012.50000.0000 0.0000 0.0000 0.0000 0.0000

2008 1 5 2 0 2 21 21 29 0.0000 0.0000 3.4483
27.586234.482820.689713.79310.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 22 22 17 0.0000 0.0000 0.0000
23.529423.529423.52945.8824 23.52940.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 23 23 24 0.0000 0.0000 0.0000
12.500012.500029.166741.66674.1667 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 24 24 16 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 25 25 10 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 26 26 6 0.0000 0.0000 0.0000
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2008 1 5 2 0 2 27 27 2 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 11 11 2 50.000050.00000.0000
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2010 1 5 2 0 2 12 12 6 0.0000 100.0000
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2010 1 5 2 0 2 13 13 10 0.0000 100.0000
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2010 1 5 2 0 2 14 14 6 0.0000 100.0000
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2010 1 5 2 0 2 15 15 13 0.0000 30.769261.5385
7.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 30.7692
61.53857.6923 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2010 1 5 2 0 2 16 16 23 0.0000 17.391369.5652
8.6957 0.0000 0.0000 4.3478 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 17.3913
69.56528.6957 0.0000 0.0000 4.3478 0.0000 0.0000 0.0000 0.0000 0.0000
2010 1 5 2 0 2 17 17 22 0.0000 0.0000 54.5455
36.36369.0909 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
54.545536.36369.0909 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2010 1 5 2 0 2 18 18 46 0.0000 2.1739 43.4783
32.608715.21744.3478 0.0000 2.1739 0.0000 0.0000 0.0000 0.0000 0.0000 2.1739
43.478332.608715.21744.3478 0.0000 2.1739 0.0000 0.0000 0.0000 0.0000
2010 1 5 2 0 2 19 19 47 0.0000 2.1277 27.6596
23.404329.787210.63832.1277 2.1277 2.1277 0.0000 0.0000 0.0000 0.0000 2.1277
27.659623.404329.787210.63832.1277 2.1277 2.1277 0.0000 0.0000 0.0000

2010 1 5 2 0 2 20 20 46 0.0000 0.0000 2.1739
23.913045.652213.04356.5217 8.6957 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2.1739 23.913045.652213.04356.5217 8.6957 0.0000 0.0000 0.0000 0.0000
2010 1 5 2 0 2 21 21 42 0.0000 0.0000 4.7619
21.428628.571419.047611.90489.5238 4.7619 0.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 22 22 31 0.0000 0.0000 0.0000
3.2258 19.354822.580632.258119.35483.2258 0.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 23 23 23 0.0000 0.0000 0.0000
0.0000 13.043513.043530.434839.13040.0000 4.3478 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 13.043513.043530.434839.13040.0000 4.3478 0.0000 0.0000
2010 1 5 2 0 2 24 24 21 0.0000 0.0000 0.0000
4.7619 0.0000 28.571423.809523.809514.28574.7619 0.0000 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 25 25 21 0.0000 0.0000 0.0000
0.0000 0.0000 28.571414.285733.333314.28579.5238 0.0000 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 26 26 5 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 27 27 4 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 50.000025.000025.00000.0000 0.0000 0.0000 0.0000 0.0000
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2010 1 5 2 0 2 8 8 1 100.0000 0.0000
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2011 1 5 2 0 2 11 11 4 50.000050.00000.0000
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2011 1 5 2 0 2 12 12 3 33.333366.66670.0000
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2011 1 5 2 0 2 13 13 6 0.0000 100.0000
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2011 1 5 2 0 2 14 14 9 11.111188.88890.0000
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2011 1 5 2 0 2 15 15 4 0.0000 50.000050.0000
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2011 1 5 2 0 2 16 16 10 0.0000 10.000090.0000
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90.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

2011 1 5 2 0 2 17 17 13 0.0000 0.0000 69.2308
30.76920.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
69.230830.76920.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 18 18 22 0.0000 0.0000 45.4545
36.363618.18180.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
45.454536.363618.18180.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 19 19 24 0.0000 0.0000 29.1667
33.333325.000012.50000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
29.166733.333325.000012.50000.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 20 20 31 0.0000 0.0000 12.9032
45.161329.03236.4516 6.4516 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
12.903245.161329.03236.4516 6.4516 0.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 21 21 29 0.0000 0.0000 0.0000
27.586237.931020.689713.79310.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 27.586237.931020.689713.79310.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 22 22 25 0.0000 0.0000 0.0000
16.000032.000032.000012.00008.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 16.000032.000032.000012.00008.0000 0.0000 0.0000 0.0000 0.0000
2011 1 5 2 0 2 23 23 28 0.0000 0.0000 0.0000
3.5714 25.000035.714321.428610.71433.5714 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 24 24 23 0.0000 0.0000 0.0000
0.0000 17.391317.391334.782626.08704.3478 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 25 25 12 0.0000 0.0000 0.0000
0.0000 0.0000 33.333341.666716.66678.3333 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 26 26 7 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 27 27 4 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 25.000075.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 28 28 3 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 33.333366.66670.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 29 29 1 0.0000 0.0000 0.0000
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2011 1 5 2 0 2 31 31 1 0.0000 0.0000 0.0000
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2012 1 5 2 0 2 11 11 1 0.0000 100.0000
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2012 1 5 2 0 2 12 12 1 0.0000 100.0000
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2012 1 5 2 0 2 13 13 2 0.0000 50.000050.0000
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50.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 14 14 6 0.0000 33.333366.6667
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33.3333
66.66670.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 15 15 11 0.0000 0.0000
100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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0.0000 0.0000
2012 1 5 2 0 2 16 16 14 0.0000 0.0000 85.7143
14.28570.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
85.714314.28570.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 17 17 16 0.0000 0.0000 56.2500
31.25006.2500 6.2500 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
56.250031.25006.2500 6.2500 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 18 18 21 0.0000 0.0000 42.8571
42.85719.5238 0.0000 4.7619 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
42.857142.85719.5238 0.0000 4.7619 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 19 19 27 0.0000 0.0000 22.2222
48.148111.111114.81483.7037 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
22.222248.148111.111114.81483.7037 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 20 20 31 0.0000 0.0000 12.9032
41.935519.354825.80650.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
12.903241.935519.354825.80650.0000 0.0000 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 21 21 51 0.0000 0.0000 9.8039
15.686327.451027.451011.76477.8431 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
9.8039 15.686327.451027.451011.76477.8431 0.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 22 22 28 0.0000 0.0000 0.0000
0.0000 35.714335.714317.85717.1429 0.0000 3.5714 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 35.714335.714317.85717.1429 0.0000 3.5714 0.0000 0.0000
2012 1 5 2 0 2 23 23 27 0.0000 0.0000 0.0000
7.4074 11.111129.629629.629618.51850.0000 0.0000 3.7037 0.0000 0.0000 0.0000
0.0000 7.4074 11.111129.629629.629618.51850.0000 0.0000 3.7037 0.0000
2012 1 5 2 0 2 24 24 14 0.0000 0.0000 0.0000
0.0000 7.1429 35.71437.1429 50.00000.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 7.1429 35.71437.1429 50.00000.0000 0.0000 0.0000 0.0000
2012 1 5 2 0 2 25 25 18 0.0000 0.0000 0.0000
0.0000 11.111133.333322.222222.22225.5556 5.5556 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 11.111133.333322.222222.22225.5556 5.5556 0.0000 0.0000
2012 1 5 2 0 2 26 26 4 0.0000 0.0000 0.0000
0.0000 0.0000 50.00000.0000 25.000025.00000.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 50.00000.0000 25.000025.00000.0000 0.0000 0.0000
2012 1 5 2 0 2 28 28 1 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 100.0000 0.0000 0.0000 0.0000 0.0000
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2012 1 5 2 0 2 8 8 1 0.0000 100.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

100.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

#
# MEAN SIZE-AT-AGE
# ----------------
-1 #_number of size-at-age observations; negative value excludes from likelihood
# ENVIRONMENTAL DATA
# ------------------
0 #_number of environmental variables
0 #_number of environmental observations
0 # no wtfreq data
0 # no tag data
0 # no morphcomp data

#
999 #_end of data file

## Appendix D.2. Control File (SDB1.ctl)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1
1 #_N_Growth_Patterns
1 #_N_submorphs
1 #_Nblock_Designs
1 #_blocks_per_pattern
2011 2012 # begin and end years of first blocks

0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate

1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
0 #_Growth_Age-at-L1 (Amin)
11 #_Growth_Age-at-L2 (Amax)
0 #_SD_add_to_LAA (set equal to 0.1 to mimic SS2 v1.xx)
0 #_CV_Growth_Pattern (0: CV=f(LAA) 1: CV=f(A) 2: SD=f(LAA) 3: SD=f(A))

1 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
1 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0 #_hermaphroditism option: 0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
1 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)

# mortality & growth_parms - pop=1 sex=1
# LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn

0.01 2 0.458827 -1.136 3 0.36 1 0 0 0 0 0.5 0 0 # NatM_p_1_Fem_GP_1
2 20 4.23068 4 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amin_Fem_GP_1
10 40 30.3297 29.13 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amax_Fem_GP_1
0.01 0.5 0.169119 0.1645 -1 99 2 0 0 0 0 0.5 0 0 # VonBert_K_Fem_GP_1
0.02 0.35 0.299078 0.21 -1 99 3 0 0 0 0 0.5 0 0 # CV_young_Fem_GP_1
0.02 0.35 0.0415139 0.04 -1 99 3 0 0 0 0 0.5 0 0 # CV_old_Fem_GP_1

0.01 2 0.566423 -0.9848 3 0.3598 1 0 0 0 0 0.5 0 0 # NatM_p_1_Mal_GP_1
2 20 4.65669 4 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amin_Mal_GP_1
10 40 26.4735 27.24 -1 99 2 0 0 0 0 0.5 0 0 # L_at_Amax_Mal_GP_1
0.01 0.5 0.211796 0.1126 -1 99 2 0 0 0 0 0.5 0 0 # VonBert_K_Mal_GP_1
0.02 0.35 0.249627 0.17 -1 99 3 0 0 0 0 0.5 0 0 # CV_young_Mal_GP_1
0.02 0.35 0.0563119 0.05 -1 99 3 0 0 0 0 0.5 0 0 # CV_old_Mal_GP_1

#_wt-len, maturity, and [eggs/kg]=a+b*weight
# Note: in SS3: length in cm and weight in Kg
# LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
-3.00 3.00 0.000005117 0.000005117 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-intercept female
0.00 5.00 3.21400000 3.21400000 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-exponent female
5.00 35.00 12.81910000 12.81910000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (use new data from Lyndsey 5/17/2013 Aug-Nov only)
-9.00 1.00 -5.10500000 -5.10500000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (use new data from Lyndsey 5/17/2013 Aug-Nov only)
# 5.00 35.00 13.58040000 13.58040000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (All data from Lyndsey all months most in Aug-Nov)
# -3.00 3.00 -0.83020000 -0.83020000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (All data from Lyndsey all months most in Aug-Nov)
# 10.00 35.00 19.06242000 7.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Length-inflection (use Arora 1951 data from Aug only)
# -3.00 3.00 -1.89509000 -1.89509000 -1 99 -1 0 0 0 0 0.5 0 0 #_Maturity: Slope; negative value required (use Arora 1951 data from Aug only)
-3.00 3.00 1.00000000 1.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Fecundity: eggs/gm intercept
-3.00 3.00 0.00000000 0.00000000 -1 99 -1 0 0 0 0 0.5 0 0 #_Fecundity: eggs/gm slope
-3.00 3.00 0.000007419 0.000007419 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-intercept male
0.00 5.00 3.08100000 3.08100000 -1 99 -1 0 0 0 0 0.5 0 0 #_wt-len-exponent male

# recruitment apportionment
#
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_growth_pattern
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_area 1
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_recrdistribution_by_season 1
-2 2 1 1 -1 99 -3 0 0 0 0 0.5 0 0 #_cohort_growth_deviation

#
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#

#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K

#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase

#_Spawner-Recruitment
3 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm
#_LO HI INIT PRIOR PR_type SD PHASE
0.1 20 11.24 11.24 -1 99 1 # SR_LN(R0)
0.2 1 0.75 0.8 0 0.09 2 # SR_BH_steep
0 1.5 0.450.45 -1 99 -1 # SR_sigmaR
-5 5 0 0 -1 99 -3 # SR_envlink
-5 5 0 0 -1 99 -4 # SR_R1_offset
0 0.5 0 0 -1 99 -2 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness

1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1976 # first year of main recr_devs; early devs can preceed this era
2011 # last year of main recr_devs; forecast devs start in following year
3 #_recdev phase

1 # (0/1) to read 13 advanced options
-10 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
4 #_recdev_early_phase
0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
1 #_lambda for Fcast_recr_like occurring before endyr+1
#1970.1 #_last_early_yr_nobias_adj_in_MPD
1970.1 #_last_early_yr_nobias_adj_in_MPD
2002.0 #_first_yr_fullbias_adj_in_MPD
2009.7 #_last_yr_fullbias_adj_in_MPD
2012.1 #_first_recent_yr_nobias_adj_in_MPD
0.9080 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
0 #_period of cycles in recruitment (N parms read below)
-3 #min rec_dev
3 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options
#

#Fishing Mortality info

```
0.05	# F ballpark for tuning early phases
1982	# F ballpark year
3		# F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
2.9		# max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# read overall start F value; overall phase; N detailed inputs to read for Fmethod 2
# read N iterations for tuning for Fmethod 3 (recommend 3 to 7)
# if FMethod=2 (instan.), active next line
# 0.1	4	0	# overall start F value; overall phase; N detailed inputs to read

# Number of tuning iterations in hybrid F: 4 or 5 may be good - check how catches data match
estimated catches
# if FMethod=3 (hybrid), active next line: phase for FMothod=3
4		#_Phase for FMethod=3

#_initial_F_parms
#LO HI		INIT	PRIOR PR_type SD	PHASE
 0	0.5 0		0		-1		99	-2		# InitF_1CA
 0	0.5 0		0		-1		99	-2		#
InitF_2ORWA
 0	0.5 0		0		-1		99	-2		# InitF_3Rec
 0	0.5 0		0		-1		99	-2		# InitF_4Mink

# Q_setup details: for columns A, B, C, D
# A = do power: 0=skip, index is proportional to abundance, 1= add an extra parameter for non-
linearity
# B = envir links: 0=skip, 1= add parameter for envior effect on Q
# C = extra SD: 0=skip, 1= add additional parameter for additive constant to input SE (in ln
space)
# D = Q type: <0=mirror lower abs(#) fleet, 0=no par Q is median unbiased, 1=no par Q is mean
unbiased, 2=estimate par for ln(Q)
#		3 = ln(Q) + set of devs about ln(Q) for all years. 4=ln(Q) + set of devs about Q
for indexyr-1

# D definition in SS3 (devtype): <0=mirror, 0=float_nobiasadj, 1=float_biasadj,
2=parm_nobiasadj, 3=parm_w_random_dev, 4=parm_w_randwalk,
5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked

# Q settings
#A B C D -> No Q and with extra SD
 0 0 0 0 # 1 CA
 0 0 0 0 # 2 ORWA
 0 0 1 0 # 3 Rec
 0 0 0 0 # 4 Mink
 0 0 0 0 # 5 NWFSC
 0 0 1 0 # 6 TriEarlyYr
 0 0 1 0 # 7 TriLateYr

#1	#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with
random q; 1=read a parm for each year of index
```

# Parameter settings for extra SD for fishery and/or surveys (if any)
# activate next lines if extra SDs are to be estimated
#LO HI INIT PRIOR PR_Type SD PHASE
0.001 2 0.241555 0.421 -1 99 1 # Q_extraSD_3_Rec
0.001 2 0.432606 0.432 -1 99 2 # Q_extraSD_6_TriEarlyYr
0.001 2 0.0935646 0.093 -1 99 2 # Q_extraSD_7_TriLateYr

#_size_selex_types
# Patter 24 (double normal): 6 parameters:
# P1= PEAK: begging size for the plateau (in cm)
# P2= TOP: width of platuean, as logistice between PEAK and MAXLEN
# P3= ASC_WIDTH: parameter value is ln(width)
# P4= DESC_WDITH: parameter value is in(width)
# P5= INIT: selectivity at first bin, as logistic between 0 and 1
# P6= FINAL: select as last bin, as logistic between 0 and 1
# if P5=-999: ignore the initial selectivity algorithm and simple decay the small fish selectivity according to P3
# if P6=-999: ignore the final selectivity algorithm and simply decay the large fish selectivity according to P4

# Discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead

# Male offset: New gender offset selectivity with 5 parameters:
# Male offset P1: added to the first selectivity parm (peak)
# Male offset P2: added to the third seleectivity parm (width of ascending side); then exp(this sum) per previous transform
# Male offset P3: added to the fourth selectivity parm (width of descending side); then exp(sum) per previous transform
# Male offset P4: added to the sixth selectivity parm (selectivity at final size bin); then 1/(1+exp(-sum)) per previous transform
# Male offset P5: is the apical selectivity for males
# Note: Only P1 and P2 are estimated in most cases

#_Pattern Discard Male Special
24 1 3 0 # 1 CA
24 1 3 0 # 2 ORWA
24 2 0 0 # 3 Rec
5  0 0 1 # 4 Mink
24 0 3 0 # 5 NWFSC
24 0 3 0 # 6 TriEarlyYr
24 0 3 0 # 7 TriLateYr

#_age_selex_types
# Age selectivity = Type 10 (selectivity=0 for age 0 and =1 for all other ages): no parameter needed
# Age selectivity = Type 11 (selectivity=1 for all ages): Additional parameter settings needed (see end of sel para settings)

#_Pattern ___ Male Special

# Type 11
11 0 0 0 # 1 CA
11 0 0 0 # 2 ORWA
11 0 0 0 # 3 Rec
11 0 0 0 # 4 Mink
11 0 0 0 # 5 NWFSC
11 0 0 0 # 6 TriEarlyYr
11 0 0 0 # 7 TriLateYr

#_length_sel
#LO HI INIT PRIOR PR_type SD PHASE enVar use_dev dvMiYrdvMxYr dvStd Block Block_Fxn

10 34.5 34.2554 30 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_1P_1_CA
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_2_CA
-4 12 3.98291 3.42 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_1P_3_CA
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_1P_4_CA
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_1P_5_CA
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_1P_6_CA

3 34.5 24.4278 15 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_1_CA
0.1 10 1.29104 3 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_2_CA
0.001 1 0.985702 1 -1 9 5 0 0 0 0 0.5 1 1 # Retain_1P_3_CA
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_1P_4_CA

-15 15 -2.47815 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_1Male_Peak_CA
-15 15 0.0560898 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_1Male_Ascend_CA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Descend_CA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Final_CA
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_1Male_Scale_CA

10 34.5 34.4975 20 -1 5 5 0 0 0 0 0.5 0 0 # SizeSel_2P_1_ORWA
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_2P_2_ORWA
-8 12 3.67526 3.42 -1 5 5 0 0 0 0 0.5 0 0 # SizeSel_2P_3_ORWA
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_2P_4_ORWA
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_2P_5_ORWA
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_2P_6_ORWA

3 34.5 26.0907 15 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_1_ORWA
0.1 10 1.20642 3 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_2_ORWA
0.001 1 0.886272 1 -1 9 5 0 0 0 0 0.5 1 1 # Retain_2P_3_ORWA
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_2P_4_ORWA

-15 15 -0.0106927 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_2Male_Peak_ORWA
-15 15 0.530417 0 -1 5 5 0 0 0 0 0.5 0 0 # SzSel_2Male_Ascend_ORWA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Descend_ORWA
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Final_ORWA
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_2Male_Scale_ORWA

10 34 29.7404 20 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_3P_1_Rec
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_2_Rec
-4 12 3.68577 3.42 -1 3 5 0 0 0 0 0.5 0 0 # SizeSel_3P_3_Rec
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_3P_4_Rec
-15 8 -999 -7 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_3P_5_Rec
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_3P_6_Rec

3 34 14.0095 15 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_1_Rec
0.1 10 3.289 3 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_2_Rec
0.001 1 0.990329 1 -1 9 5 0 0 0 0 0.5 0 0 # Retain_3P_3_Rec
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # Retain_3P_4_Rec

3 34 3 3 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_1_Rec
1e-005 10 0.001 0.001 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_2_Rec
0.001 1 0.5 0.5 -1 9 -5 0 0 0 0 0.5 0 0 # DiscMort_3P_3_Rec
-10 10 0 0 -1 9 -2 0 0 0 0 0.5 0 0 # DiscMort_3P_4_Rec

-5 34 -1 -1 -1 99 -2 0 0 0 0 0.5 0 0 # SizeSel_4P_1_Mink
-5 34 -1 -1 -1 99 -2 0 0 0 0 0.5 0 0 # SizeSel_4P_2_Mink

10 34 28.4449 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_5P_1_NWFSC
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_2_NWFSC
-4 12 3.78482 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_5P_3_NWFSC
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_5P_4_NWFSC
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_5P_5_NWFSC
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_5P_6_NWFSC
-15 15 -3.76426 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_5Male_Peak_NWFSC
-15 15 -0.481021 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_5Male_Ascend_NWFSC
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Descend_NWFSC
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Final_NWFSC
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_5Male_Scale_NWFSC

10 34 33.9983 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_6P_1_TriEarlyYr
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_2_TriEarlyYr
-4 12 4.31144 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_6P_3_TriEarlyYr
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_6P_4_TriEarlyYr
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_6P_5_TriEarlyYr
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_6P_6_TriEarlyYr
-15 15 -4.80543 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_6Male_Peak_TriEarlyYr
-15 15 -0.411124 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_6Male_Ascend_TriEarlyYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Descend_TriEarlyYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Final_TriEarlyYr
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_6Male_Scale_TriEarlyYr

10 34 30.8193 20 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_7P_1_TriLateYr
-5 3 3 0.7 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_2_TriLateYr
-4 12 4.39848 3.42 -1 5 6 0 0 0 0 0.5 0 0 # SizeSel_7P_3_TriLateYr
-2 6 6 6 -1 5 -3 0 0 0 0 0.5 0 0 # SizeSel_7P_4_TriLateYr
-15 8 -999 -999 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_7P_5_TriLateYr
-5 5 -999 0.15 -1 5 -4 0 0 0 0 0.5 0 0 # SizeSel_7P_6_TriLateYr
-15 15 -6.25803 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_7Male_Peak_TriLateYr

-15 15 -0.811322 0 -1 5 6 0 0 0 0 0.5 0 0 # SzSel_7Male_Ascend_TriLateYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Descend_TriLateYr
-15 15 0 0 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Final_TriLateYr
-15 15 1 1 -1 5 -4 0 0 0 0 0.5 0 0 # SzSel_7Male_Scale_TriLateYr

# Age selectivity = Type 10 (selectivity=0 for age 0 and =1 for all other ages): no parameter needed
# Age selectivity = Type 11 (selectivity=1 for all ages): following lines need to be activated

0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_1P_1_CA
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_1P_2_CA
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_2P_1_ORWA
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_2P_2_ORWA
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_3P_1_Rec
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_3P_2_Rec
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_4P_1_Mink
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_4P_2_Mink
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_5P_1_NWFSC
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_5P_2_NWFSC
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_6P_1_TriEarlyYr
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_6P_2_TriEarlyYr
0 11 0.1 0.1 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_7P_1_TriLateYr
0 11 11 11 -1 99 -2 0 0 0 0 0.5 0 0 # AgeSel_7P_2_TriLateYr

#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
#_Cond 0 #_custom_sel-blk_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no block usage
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
#_Cond 0 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

# Comment out next three lines if no time block
1 #_custom_sel-blk_setup (0/1)

-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage
-5 5 0 0 -1 99 5 #_placeholder when no block usage

2 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

# Tag loss and Tag reporting parameters go next
0 # TG_custom: 0=no read; 1=read if tags exist
# -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0 #_placeholder if no parameters

1 #_Variance_adjustments_to_input_values
#_This part is for iterative reweighting of the input variance factors
#_There are six rows and a value for each fleet_survey on each row
# 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_survey CV, 0 for no efffect
# 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_discard stddev
# 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_mean boday wt stddev
# 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for lencomp effective N (set to 1.0 for no effect)
# 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for agecomp effective N (set to 1.0 for no effect)
# 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for size-at-age effective N (set to 1.0 for no effect)

# re-weight
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_survey CV, 0 for no efffect
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_discard stddev
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_mean boday wt stddev
1.613000 2.165000 3.125000 0.000000 1.157000 2.164000 2.767000 #_Multipier for lencomp effective N (set to 1.0 for no effect)
3.859000 1.181000 1.000000 1.000000 0.180000 1.000000 1.000000 #_Multipier for agecomp effective N (set to 1.0 for no effect)
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_Multipier for size-at-age effective N (set to 1.0 for no effect)

6 #_maxlambdaphase
1 #_sd_offset

8 # number of changes to make to default Lambdas (default value is 1.0)
# lambdas
# Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch; 9=init_equ_catch;
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin; 17=F_ballpark

# Lambdas from comp data from two fisheries (CA and OR/WA) need to be cut (double uses of samples)
# Component 17 was new in new SS3 (used to be turned off automatically, now need to turn off manually) (Hicks' May 25 email)

#like_comp fleet/survey phase value sizefreq_method
4 1 1 0.500 1
4 2 1 0.500 1
5 1 1 0.500 1
5 2 1 0.500 1
17 1 1 0.000 1

17 2 1 0.000 1
17 3 1 0.000 1
17 4 1 0.000 1

0 # (0/1) read specs for more stddev reporting

999

## Appendix D.3. Starter File (starter.ss)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-
win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

SDB1.dat
SDB1.ctl

0 # 0=use init values in control file; 1=use ss2.par
0 # run display detail (0,1,2)
2 # detailed age-structured reports in SS2.rep (0,1,2)
0 # write detailed checkup.sso file (0,1)
1 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all;
3=every_iter,all_parms)
0 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
1 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
1 # Number of bootstrap datafiles to produce
10 # Turn off estimation for parameters entering after this phase
0 # MCMC burn interval
1 # MCMC thin interval
0.00001# jitter initial parm value by this fraction
-1 # begin annual SD report in start year
-2 # end annual SD report in end year (-2=end of annual SD report in last forecast year
0 # N individual STD years (0=none)

#vector of year values

0.001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
0 # min age for calc of summary biomass
1 # Depletion basis: denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
4 # (1-SPR)_reporting: 0=skip; 1=rel(1-SPR); 2=rel(1-SPR_MSY); 3=rel(1-SPR_Btarget);
4=no denominator (report actural 1-SPR values)
1 # F_std reporting: 0=skip; 1=exploit(Bio); 2=exploit(Num); 3=sum(frates)
0 # F_report_basis: 0=raw; 1=rel Fspr; 2=rel Fmsy ; 3=rel Fbtgt

999 # check value for end of file

## Appendix D.4. Forecast File (forecast.ss)

#C 2013_Pacific_Sanddab_Stock_Assessment_Xi_He__NMFS_SWFSC__Santa_Cruz_CA
#SS-V3.24O-opt-win64;_04/10/2013;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_11.1

# Note on Btarget
# Btarget should be 0.25 for flatfish, but setting it to 0.25 causes poor convergence in Fmsy (fish mature at very young)
# Have to fish very hard on the selected fish to get biomass to the target - low targes are not feasible
# Fmsy search fails (QNAN) - getting invalidated variance estimates for other outputs (i.e. most derivated outputs)
# To get around this: set Biomass target to 0.4 or higher, then to manually set ss_output readin values: myreplist$btarg <- 0.25 myreplist$minbthresh <- 0.125

# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=F(SPR); 2=F(MSY);3=F(Btarget); 4=F(endyr); 5=Ave recent F (not implemented); 6= read Fmult (not implemented)
4 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.3 # SPR target (e.g. 0.40), 0.5 for west coast groundfish
0.25 # Biomass target (e.g. 0.40)

#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
0 0 0 0 0 0
2 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below

1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=F(endyr); 5=Ave F (enter yrs); 6=read Fmult
1 # N foreast year
1 # F scaler (only used for Do_Forecast==5)
#_Fcast_years: beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or -integer to be rel. endyr)
0 0 -10 0
1 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0.25 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40)
0.05 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0.75 # Control rule target as fraction of Flimit (e.g. 0.75)
3 #_N forecast loops (1-3) (fixed at 3 for now)
3 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)

2013 #FirstYear for caps and allocations (should be after years with fixed inputs)
0.0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error) (if=0, there will be N_forecase_years less parameters estimated)
0 # Do West Coast gfish rebuilder output (0/1)

-1 # Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
-1 # Rebuilder: year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F: 1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2 # basis for fcast catch tuning and for fcast catch caps and allocation (2=deadbio; 3=retainbio; 5=deadnum; 6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F: rows are seasons, columns are fleets
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet
-1 -1 -1 -1
# max totalcatch by area (-1 to have no max); must enter value for each fleet
-1
# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
0 0 0 0
#_Conditional on >1 allocation group
# allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
3 # basis for input Fcast catch: 2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
# Input fixed catch values
#Year Seas Fleet Catch(or_F)

999 # verify end of input

Agenda Item G.3.a
Attachment 12
September 2013

# Pacific Sanddab

## Stock Assessment Review (STAR) Panel Report

NOAA Fisheries, Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, California, 95060

**August 5-9, 2013**

### STAR Panel Members

Tom Jagielo, Scientific and Statistical Committee, (Panel Chair)
Kevin Piner, NMFS Southwest Fisheries Science Center (SWFSC)
Beatriz Roel, Center of Independent Experts
Yan Jiao, Center of Independent Experts

### Pacific Fishery Management Council (PFMC) Advisors

Bob Leos, California Department of Fish and Wildlife, GMT
Gerry Richter, Point Conception Groundfishermen's Association, GAP
John DeVore, Pacific Fishery Management Council (PFMC)

### Stock Assessment Team (STAT)

Xi He, NMFS Southwest Fisheries Science Center
John C. Field, NMFS Southwest Fisheries Science Center
Lyndsey Lefebvre, NMFS Southwest Fisheries Science Center
Meisha Key, California Department of Fish and Wildlife, SSC

## Overview

The Pacific Sanddab STAR Panel (Panel) met in Santa Cruz, California during 5-9 August 2013 to review a draft stock assessment of Pacific sanddab (*Citharichthys sordidus*) off the U.S. west coast, prepared by the Pacific sanddab stock assessment team (STAT). Tom Jagielo (Panel Chair) welcomed participants, reviewed the Pacific Fishery Management Council's (PFMC) *Terms of Reference for the Groundfish Stock Assessment and Review Process*, and discussed logistics for the Panel meeting. Dr. Beatriz Roel agreed to serve as rapporteur.

The draft assessment document and extensive background material (previous assessments, previous STAR Panel reports, etc.) were provided (via the PFMC FTP site) to the Panel two weeks in advance of the Panel meeting. The FTP site was also used for common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Dr. Xi He led the presentation of the draft assessment document, and together with Dr. John Field presented subsequent analyses carried out during the week.

This is the first stock assessment for Pacific sanddab. The assessment was conducted using Stock Synthesis (SS, version 3.24O, April 2013) (Methot and Wetzel 2013). The assessment assumes a single stock and four fisheries: 1) two commercial trawl fisheries, 2) one recreational fishery, and 3) one trawl fishery for mink food. Survey and index data included: 1) the Northwest Fisheries Science Center (NWFSC) triennial bottom trawl survey (split in two periods), 2) the NWFSC bottom trawl survey, and 3) a California Commercial Passenger Fishing Vessel (CA CPFV) fishery catch-per-unit-effort (CPUE) index. Multiple model runs were conducted and reviewed to examine model assumptions and structure, and to identify uncertainties in the assessment.

This first assessment of Pacific sanddab represents an extensive modeling effort; however, it did not result in a quantitative estimate of depletion as a measure of stock status. During the STAR Panel meeting, it was not possible to reconcile the extremely high discrepancy between swept area and model-based biomass estimates. Thus, the STAT team and STAR Panel could not be confident in model estimates of biomass. It is noteworthy, however, that all model scenarios presented indicated a healthy stock status. Further, if the survey estimates of biomass and historical catches are correct, the stock is lightly exploited.

The Panel commends the STAT team for their presentations, willingness to respond to the Panel's requests for additional analyses, and their dedication in finding possible solutions to difficult assessment problems. The SWFSC and PFMC staffs are thanked for arranging the meeting facilities, hotel accommodations, and the FTP site containing the background materials.

## Discussion and Additional Analyses Requested by the STAR Panel

**Request 1:** Compare growth differences between Arora (1951) and Lefebvre (2013) or simply compare mean length-at-age.

Rationale: Noteworthy differences in size-at-maturity were reported in the two studies.  The STAR panel wanted to examine the possibility that size-at-age may also have changed with time.

Response: A definitive comparison could not be carried out since the ageing methodology is not comparable: Arora (1951) used scale widths to age sanddab while Lefebvre (2013) used otoliths. Thus, the mean size-at-age data may not be directly comparable.  There is no strong evidence of a dramatic difference in growth between the two studies with the exception of ages 1 and 2. However, the smaller length-at-age in ages 1 and 2 may be explained by differences in timing of sampling.

**Request 2**: Run a new base model with: 1) the new recreational CPUE index, 2) the revised mink food fishery catches, 3) a retention time block at 2011, 4) empirical discard estimates for recent years, and 4) the 2003 OR/WA discard rate estimate removed.  All additional exploratory analyses should use this base model.

Rationale: These data changes are technical fixes to the model and, in the case of the 2003 discard rate estimate, provide a better fit to the discard estimates.  Approximately 100% of the 2011-2012 trawl fishery was observed; therefore, model-estimated discard rates should not apply.

Response: the new candidate base model was modified as requested. A change regarding the use of empirical discard estimates was implemented for both 2011 and 2012; however, it was necessary to base the discard rate for 2012 on 2011discard rates.

**Request 3**: Conduct a sensitivity run for the pre-1930s CA catch history by doubling and halving the CA trawl catches prior to 1930.

Rationale: Explore model sensitivity to uncertain historical catches.

Response: The STAT team presented results for doubling and halving the pre-1930s CA catch. For the double catch runs, the results indicated higher R0 and M values compared to the base model; further, the SSB trajectory was scaled up and depletion increased.  Reducing the catch by half did not make much of a difference. Apparently, the model needs to increase the biomass substantially to be able to accommodate the composition data.

**Request 4**: Clarify that the mesh size study data used in the model (Wallace et. al. 1996) were filtered adequately to inform fishery discard rates and catch composition.

Rationale: Justify whether these data are appropriate to be used in the assessment.

Response: the STAT team clarified that no discard rate data from the mesh size study were used. The STAT team revised the base model by dropping two rows of composition data for 1990 (OR and WA). The STAR Panel supported this change in the base model. Dropping the data resulted in 1) substantial changes in $R_0$ (which increased from 11.4 to 12.28) and 2) larger uncertainties in biomass estimates. The STAT team indicated they will further investigate the effects of these changes.

**Request 5**: Justify why only triennial survey index data were removed in the sensitivity run, but not the length composition data. Explore removing the length composition data as well. Additionally, provide a sensitivity run removing the early triennial survey index and composition data.

Rationale: To explore the overall influence of the triennial survey.

Response: Justification was presented for retaining the triennial survey composition data in the base model. The STAT team indicated that the composition data are less influenced by sampling designs, gear, etc. while it provides important information to the model. Further, that they are the only sex specific length composition for years prior to 1995. Results were presented for Run 5a where both the index and the composition data for the early period were removed. This resulted in a somewhat higher SSB with much larger uncertainty. For Run 5b, where both series were removed (early and late), the results showed similar trends to the base model although the uncertainty was reduced. It appears that there is an interaction between the two sets of triennial survey data which was not explained at this point.

**Request 6**: Test the influence of the fishery age composition and survey conditional age-at-length data by 1) removing the age composition data, 2) fixing growth parameters from the base model and removing conditional age-at-length data, and 3) fixing growth parameters from the base model and removing all of these data, to explore reasons for the variable scale of the SSB.

Rationale: Examine the influence of the age composition data on the estimated SSB.

Response: The STAT team provided the results from three runs that illustrated the impact of the age composition data on the results. Removing the conditional age-at-length data makes a big difference to the population scale; however, removing the marginals does not.

**Request 7**: Profile on $\ln(R_0)$ with each likelihood component (by fleet, survey, and data component).

Rationale: To understand which components are most influential on the estimated scale of SSB.

Response: This request was deferred until an acceptable base model is developed.

**Request 8**: Simple production model to test R0 scale.

Rationale: to explore the impact of age and length composition data on the model scaling.

Response: An age structured production model (where recruitment is deterministic) resulted in a small scaling change, and a change in the timing of the decline in recent years. Depletion increased compared to the base model.

**Request 9:** Using the new base model (incorporating the provisions from Requests 2 and 4, and using the 2011 trawl discard rates for 2012 for both CA and OR/WA fleets), provide a run exploring a Lorenzen M or some other modeling structure to allow higher Ms for younger fish. Show the total likelihood, including the number of estimated parameters.

Rationale: This is consistent with the NMFS Natural Mortality workshop recommendations and allows exploration of how this modeling treatment affects the scale of the population.

Response: The survey catchabilities for the Wednesday base were provided for reference, The values of Q were: 1) NWFSC 19.4, and 2) Triennial 4.8 (early); 13.6 (late). A set of runs were carried out assuming a Lorenzen M reference age from 1 to 5 (R1 to R5). The results indicated that SSB and R0 increased as reference age increased, as expected. This exercise did not resolve the discrepancy between the NWFSC trawl survey and the model estimated biomass estimates of population scale.

**Request 10**: Provide a sensitivity analysis that allow dome-shaped selectivity for all surveys except for one fishery (which selects for the largest fish), which should remain asymptotic. M should be fixed according to the new base model. Provide fits to the composition data aggregated across all years. Show the total likelihood, including the number of estimated parameters.

Rationale: This analysis may provide a better understanding of the role of asymptotic selectivity on biomass scaling.

Response: The following runs were carried out:
Run10: dome-shaped allowed for all fleets and surveys except for the CA fleet.
Run10a: dome-shaped allowed for all surveys, all fisheries asymptotic
Run10b: dome-shaped allowed for all surveys and fleets.
The results indicated that Runs 10 and 10a had similar SSB trajectories. Run 10b resulted in much higher biomass. Examination of the resulting selectivity curves suggested that the there is little information in the data indicating a dome shape selectivity. Selectivity in this case was functionally asymptotic; R0 went up but this is likely to be because of M being high (0.7). The STAR panel noted that trying to concurrently estimate all dome shape selectivities and M resulted in parameter confounding.

**Request 11**: If requests 9 and/or 10 do not result in significant changes to model results, provide these runs with removal of conditional age-at-length (fix growth parameters according to the new base model).

Rationale: This will provide better insight into the parameters affecting biomass scale.

Response: the STAT provided the results from 3 model runs; the resulting catchabilities for the NWFSC and triennial (early and late) surveys are provided under Q as follows:
Run11a (Run9-R1, Lorenzen M, R1): Q=12,2, 4.5, 9.5; ln(R0)=15.0,
Run11b (Run10: dome shape selectivity except for CA) Q=5.21, 2.58, 4.58
Run11c (WedBase): Q = 4.2, 1.9, 3.7, M = 0.70, 0.81; ln(R0) = 15.21; h= 0.8.

Run 11c made a noteworthy difference to the SSB (scaling it up substantially), while run 11b resulted in an intermediate result between 11a and 11c. The STAR Panel concluded that the conditional age-at-length information appears to have a disproportionate effect on the population scale in the model.

**Description of Base Model and Alternative Models Used to Bracket Uncertainty**

The final base model: 1) included the new recreational CPUE index, 2) used the revised mink food fishery catches, 3) put a retention time block at 2011, 4) assumed the discard rate in 2012 was equal to the discard rate in 2011, 5) removed the 2003 OR/WA discard rate estimate, and 6) removed the Wallace (1996) mesh size study length composition data.

The model assumed the stock was in an unfished condition in 1888 and subject to exploitation by the four fisheries modeled in the assessment. Two sexes were used in the model given evidence of sexually dimorphic growth. The assessment also assumes sex-specific natural mortality and a sex-specific length-weight relationship. Natural mortality was assumed to be constant for all ages for each sex. Key assumptions in the base model included the following: 1) the Beverton-Holt stock-recruit function; 2) asymptotic, sex-specific, time-invariant selectivity functions for all fleets and surveys; and 3) time-invariant catchability coefficients (Qs) for all surveys. The assessment assumed that reported catches, by all commercial and recreational fleets, were accurate, especially in recent years, and that historical catches of Pacific sanddabs might not be well recorded.

The likelihood components included in the assessment model are: catches, discards, indices, length and age compositions, recruitment deviations, parameter priors, and parameter soft bounds.

Changes were made to the input data during the STAR panel, including the following:

- the revised mink food fishery catches,
- a 2011-2012 discard rate based on empirical discard estimates for 2011 (imposed by putting a retention time block in 2011);
- removal of the 2003 OR/WA discard rate estimate; and
- removal of the length composition data from the Wallace (1996) mesh size study.

The final base model estimated a very low stock biomass compared to the estimates from the trawl surveys. The difference between model and trawl survey estimates of biomass (almost an order of magnitude) triggered further investigation. Subsequent analyses (e.g., sensitivity analyses and likelihood profiles over recruitment at virgin biomass, $R_0$) were directed at identifying factors that could be influential in scaling this parameter.

Alternatives explored include:

1. structuring the triennial survey as one continuous survey;
2. selectivity functions allowed to be dome-shaped;
3. an alternative model that changed the start year of the model to 1970;
4. re-parameterizations that incorporated Lorenzen M;

5. removing various compositional data and conditional ages; and
6. models with an emphasis placed on the trawl surveys and an informative prior on survey Q.

**Comments on the Technical Merits of the Assessment**

The STAR panel lauded the STAT for a detailed analysis of input data and model performance. As the first stock assessment for this species, the selection and analyses of the input data were thorough and appropriate. The fit to the primary abundance index was good and fits to the compositional data were generally reasonable. The use of the conditional age-at-length data resulted in reasonable estimates of growth.

**Areas of Disagreement**

There were no areas of disagreement between the STAT and members of the STAR panel.

**Unsolved Problems and Major Uncertainties**

The major uncertainty in this assessment is the basic scale of the population; a critical uncertainty that was not resolved during the STAR panel meeting. Swept area biomass estimates (from fishery-independent sources) resulted in four to twenty two times the model estimates of biomass. Numerous sensitivity analyses were provided by the STAT team in an attempt to explain this discrepancy. The STAT team and STAR panel discussed potential mechanisms; however, a definitive reason was not found in the time allotted.

Concerns were expressed about the uncertain historical trawl catch data in the early 1900s. There is uncertainty associated with the assumed discard rate and size compositions used to construct historical removals.

There is great uncertainty whether this stock is subject to time-varying life history parameters. For example, evidence was presented indicating a 6 cm shift in the size at 50% maturity between the 1950s (Arora 1951) and the recent period (Lefebvre 2013). The model assumed the results from the Lefebvre (2013) study for the entire time series.

The STAT team underscored the point that a strong correlation existed between model parameters. The current model estimates steepness (h), natural mortality (M), virgin equilibrium recruitment ($R_0$), and growth. While steepness and natural mortality were estimated with informed priors, the STAR panel suggested that a more parsimonious parameterization might be advisable, given the confounding nature of these parameters.

**Concerns Raised by the GMT and GAP Advisors During the Meeting**

There were no concerns raised by the GMT and GAP advisors during the meeting.

**Prioritized Research Recommendations**

1. Exploration of the biomass estimates derived from trawl surveys, especially the NWFSC shelf/slope survey to address the discrepancy between survey- and model-based estimates of biomass.
2. Evaluate historical reconstructions of landings and discards.
3. Explore the possibility of time-varying life history parameters (e.g., regime shifts that potentially affect maturity, M, and growth).
4. Further explore the influence of the individual data sources on model results.
5. Explore ways to index the abundance of sanddabs in nearshore areas (i.e., waters shallower than 55 m) where the trawl surveys were not conducted.
6. Explore potential stock structure of this population, including the population in waters off Mexico and Canada.

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Agenda Item G.3.b
Supplemental GAP Report
September 2013

# GROUNDFISH ADVISORY SUBPANEL REPORT ON APPROVE STOCK ASSESSMENTS

The Groundfish Advisory Subpanel (GAP) reviewed the latest stock assessments for aurora rockfish, rougheye/blackspotted rockfish, shortspine and longspine thornyhead, cowcod and Pacific sanddabs. The GAP also reviewed the stock assessment review (STAR) Panel reports documenting the review of these assessments. The GAP offers the following comments and recommendations.

The GAP supports the Scientific and Statistical Committee (SSC) recommendations to adopt the first full assessments for aurora rockfish and rougheye/blackspotted rockfish. Since these are the first assessments of these species, the GAP also supports the SSC recommendation that the next assessments be full assessments due to the fact that there will likely be more compositional data available for those reviews.

The GAP also supports the SSC endorsements of the shortspine thornyhead, longspine thornyhead, and cowcod assessments. We agree that the next assessment for cowcod should be a full assessment as there will be a new remotely operated vehicle (ROV) survey of cowcod habitat in the Southern California Bight available for that next review. The GAP wholeheartedly agrees with the SSC suggestion that extractive surveys within the Cowcod Conservation Areas (CCAs) be evaluated given the need for a better abundance index.

The GAP supports the use of these new assessments to inform management in 2015 and beyond.

The Pacific sanddab assessment was recommended by the STAR Panel and the SSC for determining stock status. It will not be used for management purposes though the GAP notes that all indications are that the stock is healthy and is lightly exploited.

Lastly, the GAP discussed the June Council motion that requested the three data-moderate nearshore species assessed this spring (brown, copper and China rockfish) be moved to the mop-up panel for further review to consider area stratification north and south of 42° N. latitude. The GAP supports the SSC recommendation to only move China rockfish to that panel for further review as the data, in particular catch per unit of effort (CPUE) data for brown rockfish and copper rockfish is sparse north of 42° N. latitude. It is the GAP's understanding that the revised assessment of China rockfish will result in three new assessments which will include the populations north of 40° 10' N. latitude, north of 42° N. latitude and south of 42° N. latitude. The SSC will review the results of these assessments and provide its recommendations at the November Council meeting.

PFMC
09/14/13

THE GROUNDFISH MANAGEMENT TEAM REPORT ON STOCK ASSESSMENTS FOR 2015-2016 GROUNDFISH FISHERIES

The Groundfish Management Team (GMT) discussed the stock assessments conducted for aurora rockfish, rougheye rockfish, shortspine thornyhead, longspine thornyhead, cowcod, and Pacific sanddab for the 2015-2016 harvest specifications and management measures cycle. No unresolved concerns were noted by GMT advisors to the STAR Panel reviews.

After a joint discussion between the GMT and the Scientific and Statistical Committee (SSC) regarding the motion made by the Council in June 2013 to evaluate alternative stratification of brown, copper, and China rockfish assessments, the GMT provides the following for consideration.

The SSC approved the china, brown, and copper rockfish stock assessments for use in management in 2015-2016 at the June Council meeting (June 2013, Agenda Item F.5.b Supplemental SSC Report). The SSC proposed an analysis to provide an indication of the effect of re-stratifying the catch in the China rockfish assessment, which the GMT supports. Some on the team emphasize that the same general issues are at play with China rockfish— an index of abundance that covers only part of the area and potential differences in fishing intensity between areas— also apply to some degree for brown rockfish and copper rockfish. A key difference is that no new indices of brown and copper rockfish abundance are available in the near term to look at a different stratification. The GMT may discuss the related issue of apportioning OFLs and ABCs between north and south stock complexes in later agenda items.

The GMT supports the SSC recommendation that the China, brown, and copper rockfish assessments be approved for use in management in 2015-2016. The GMT continues to agree that stocks determined to be in the precautionary zone should be prioritized for full assessment in future cycles as outlined in Agenda Item H.2.b, Supplemental NWFSC Powerpoint, March 2013. A full assessment of China rockfish for off-year science research may provide an opportunity to further examine restratification of the assessment or the development of additional indices of abundance.

In the future more advance review of data at the summer 2014 GMT meeting could be conducted after adoption of stocks for future assessment in April 2014. Off-year science research regarding variation in depletion and removals along the coast that should be accounted for in stock assessment may facilitate future data-moderate assessments by informing appropriate stratification encompassing management units. For the purposes of expediency, assumptions are made regarding stratification of assessment and such analyses would save time by identifying structure in advance. In addition, examination of management measures between states through time may also inform whether differential management may reinforce the need to stratify the assessment. Further off-year science research on methods to apportion catch across management boundaries may help address concerns expressed by some on the GMT regarding how the OFL is split when a species is rarely encountered across the boundary as is the case for brown and copper rockfishes. Taking on fewer data-moderate assessments or dedicating more personnel to allow analysis of more stocks may be advisable to allow greater resources for examining alternative models. The GMT would appreciate continued opportunities to participate in the review of data used in data-moderate and full assessments, especially those for vulnerable species such as China and copper rockfishes.

PFMC
09/14/13

# SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON APPROVE STOCK ASSESSMENTS

The Scientific and Statistical Committee (SSC) reviewed the six assessments which were reviewed at Stock Assessment Review (STAR) panels this summer, along with reports from those STAR panels. In addition, the SSC discussed the Council's request for further work on the China, brown and copper rockfish data-moderate assessments.

## Aurora Rockfish

The first full assessment of aurora rockfish was conducted in 2013. The assessment estimates that the spawning stock biomass of aurora rockfish at the start of 2013 was 1673 metric tons and was depleted to 64% of its unfished level. There is little chance that the stock's spawning biomass has ever been below the Council's target level (40% of unfished). Natural mortality was used as the axis of uncertainty to bracket the states of nature in the decision table.

The SSC notes that the assessment results were very sensitive to the assumed value of natural mortality, and unresolved areas of uncertainty included: 1) an unusual pattern in the estimated recruitment deviations, and 2) unexpectedly strong dome-shaped survey selectivity, while fishery selectivity was asymptotic.

The SSC endorses the use of the 2013 aurora rockfish assessment as the best scientific information available for status determination and management in the Council process. The SSC recommends that aurora rockfish should be treated as a category 1 stock because the assessment is based on a fully developed age-structured model. The SSC recommends using the sigma value of 0.39 for aurora rockfish, and that the next stock assessment should be a full stock assessment to more fully explore model structure and data issues (e.g., the likely availability of more age composition data).

## Rougheye and Blackspotted Rockfish

Rougheye rockfish and blackspotted rockfish are two closely related species of slope rockfish, which have only recently been recognized as separate species. The assessment treats them as a single complex of species (hereafter referred to as rougheye rockfish) because most data sets available for stock assessment do not distinguish between them. This is the first full assessment of rougheye rockfish. Overfishing limit (OFL) estimates for rougheye rockfish were previously obtained using catch-only methods (depletion based stock reduction analysis (DB-SRA)).

Assessment results indicate that the west coast stock is currently at 47 percent of the unexploited level, and therefore remains above the $B_{MSY}$ proxy of $B_{40\%}$. Harvest rates of rougheye rockfish have been close to or above the $F_{MSY}$ proxy of $F_{50\%}$ for rockfish since the mid-1980s, including four of the last 10 years, suggesting that harvest of rougheye rockfish needs to be more closely monitored in the future.

Major uncertainties in the rougheye rockfish assessment include possible differences in the life histories and abundance trends of two species in the complex, uncertainty in natural mortality, and sensitivity in model results to alternative methods of weighting composition data. Natural mortality was used to bracket uncertainty in the states of nature in the decision table. The SSC notes that a small error was found in the decision table and that the corrected version will be included in the final document.

The SSC endorses the use of the 2013 rougheye rockfish assessment as the best scientific information available for status determination and management in the Council process. The SSC recommends that rougheye rockfish be treated as a category 1 stock because the assessment is based on a fully developed age-structured model. The SSC recommends that the next assessment be a full assessment, with the expectation that progress can be made in addressing major assessment uncertainties, such as determining the biology and distribution of rougheye rockfish and blackspotted rockfish individually, and increasing the amount of age data available for the assessment.

**Shortspine Thornyhead**

The previous full assessment of shortspine thornyhead was conducted in 2005. The 2005 assessment estimated the stock to be above the management threshold of $B_{40\%}$ and that overfishing had never occurred. The new assessment estimates the stock depletion ($B_{2013}/B_0$) to be 74% with overfishing never having occurred. The equilibrium recruitment parameter ($R_0$) was used to bracket uncertainty in the states of nature.

The SSC notes that 1) important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are highly uncertain, 2) the surveys did not cover the entire depth distributions of the species, 3) key parameters (e.g., M and h) are fixed, and 4) models are sensitive to small changes in assumptions.

The SSC endorses the use of 2013 shortspine thornyhead assessment as the best scientific information available for status determination and management in the Council process. The SSC recommends that shortspine thornyhead be treated as a category 2 stock because of the lack of age data and inability to discern year class strength. The SSC recommends exploring data-moderate approaches before scheduling the next assessment.

**Longspine Thornyhead**

The previous full assessment of longspine thornyhead was conducted in 2005. The 2005 assessment estimated the stock to be above the management threshold of $B_{40\%}$ and that overfishing had never occurred. The new assessment estimates the stock depletion ($B_{2013}/B_0$) to be 75% with overfishing never having occurred. The equilibrium recruitment parameter ($R_0$) was used to bracket uncertainty in the states of nature.

The SSC notes that 1) important fishery data (historical catches and discards) and key population vital rates (maturity, age and growth) are highly uncertain, 2) the surveys did not cover the entire depth distributions of the species, 3) key parameters (e.g., M and h) are fixed, and 4) models are sensitive to small changes in assumptions.

The SSC endorses the use of 2013 longspine thornyhead assessment as the best scientific information available for status determination and management in the Council process. The SSC recommends that longspine thornyhead be treated as a category 2 stock because of the lack of age data and inability to discern year class strength. The SSC recommends exploring data-moderate approaches before scheduling the next assessment.

**Cowcod**

Full assessments of cowcod south of Point Conception were conducted during 1999, 2005, and 2007, with the latter two assessments based on the Stock Synthesis framework. The 2009 assessment was an update to the 2007 assessment, which included revised historical recreational catch data for California, along with updated indexes. The 2013 full assessment for cowcod was based on Extended Depletion-Based Stock Reduction Analysis (XDB-SRA), unlike the earlier assessments. The 2007 and 2009 assessments used Stock Synthesis but did not include age and length data, so were similar to an XDB-SRA assessment. The 2013 assessment included data from five indices, but excluded the commercial passenger fishing vessel (CPFV) index which had been used in previous assessments. This index had suggested a more depleted stock and was excluded because of difficulties identifying effort directed towards cowcod.

The stock is estimated to be 34 percent of its unfished level at the start of 2013. However, the estimate of depletion is highly uncertain (95% credibility interval from 15 to 66 percent of the unfished level). All of the indices used in the assessment are sources of considerable uncertainty, particularly due to the spatial distribution of survey effort, the age classes sampled, and/or the high unexplained variance between the model predictions and the data. However, all indices are showing qualitatively similar increasing trends. The lack of survey information from the core area in which cowcod are located remains a key source of uncertainty.

The SSC endorses the use of the 2013 cowcod assessment as the best scientific information available for status determination and management in the Council process. The SSC recommends that cowcod be treated as a category 2 stock because the assessment is based on a data-moderate method of stock assessment. A rebuilding analysis needs to be conducted for this stock, which will be reviewed by the SSC Groundfish Subcommittee before the November Council meeting. The SSC recommends that the next assessment of cowcod be a full assessment, and ideally that the stock be assessed once an index of abundance from the remotely operated vehicle (ROV) survey of cowcod habitat in the Southern California Bight becomes available and has been reviewed. Finally, the SSC recommends that the decision not to conduct extractive surveys in the Cowcod Conservation Areas (CCAs) should be re-evaluated given the need for reliable indices of abundance for cowcod. The hook and line survey, in particular, could be conducted within the CCAs with minimal mortality impacts through the use of descending devices.

**Pacific Sanddab**

The first full assessment for Pacific sanddabs was conducted in 2013. Management advice for Pacific sanddabs has previously been based on application of DB-SRA.

The base model from the 2013 stock assessment predicts that the spawning biomass was 96 percent of the unfished level at the start of 2013, well above the target biomass for flatfish stocks of 25 percent. However, there are major inconsistencies between the estimates of biomass from the triennial and NWFSC surveys and the estimates of biomass from the assessment, with the assessment inferring that catchability for the surveys is substantially larger than 1 (>19 for the NWFSC survey), which the Stock Assessment Team (STAT) and STAR panel agreed was implausible.

The SSC recommends that this assessment not be used for deciding harvest specifications. However, the information included in the assessment document is sufficient to conclude that the stock is well above the $B_{MSY}$ proxy of 25 percent of the unfished level. Pacific sanddab should remain as a category 3 stock and the OFL be based on DB-SRA. The SSC notes that Pacific sanddab should not be a high priority for a future full assessment given the magnitude of the catch relative to survey estimates of abundance. Pacific sanddab could be considered for data-moderate assessment the next time it is assessed.

**Reconsideration of data-moderate assessments for nearshore rockfish species**

The SSC met with the Groundfish Management Team (GMT) to discuss the Council's request that the data-moderate assessments for three nearshore species be re-considered at a mop-up STAR Panel meeting prior to the November Council meeting (Council's June Decision Summary Document). Specifically the Council requested consideration of area stratification north and south of 42º N latitude for the data-moderate stock assessments for brown rockfish, copper rockfish, and China rockfish. Dr. E.J. Dick (SWFSC, Data-Moderate STAT member) and John DeVore were available to answer questions and contribute to the discussions.

**Brown rockfish**

The SSC notes that the data-moderate STAR Panel explored XDB-SRA assessment models for brown rockfish in the southern and central regions (split at Point Conception) but reverted to a combined region model because conflicting trends in the catch per unit effort (CPUE) indices produced implausible results. No model was attempted for the portion of the population north of Cape Mendocino (40º10' N latitude) because no CPUE index could be derived. Only about 1% of the coastwide landings of brown rockfish are taken north of Cape Mendocino. It is not feasible to conduct an XDB-SRA assessment for brown rockfish north of 42º N latitude.

**Copper rockfish**

The lack of survey or CPUE data for copper rockfish also restricts the ability to apply data-moderate assessment methods for copper rockfish north of 42º N latitude. The region north of Cape Mendocino accounts for only about 4% of the landings of copper rockfish. It is not feasible to conduct an XDB-SRA assessment for copper rockfish north of 42º N latitude.

**China rockfish**

China rockfish is the only of these three nearshore species for which an appreciable proportion of the landed catch is taken north of 42º N latitude. Further, a CPUE abundance index was developed for the XDB-SRA assessment for the portion of the population north of Cape Mendocino at 40º10' N latitude. However, developing a CPUE index that corresponds only to the region north of 42º N latitude is not feasible to accomplish in the near-term. The SSC recommends 1) that an XDB-SRA assessment for the portion of the population north of 42º N latitude be conducted using the existing northern CPUE abundance index, applied to catch data series restricted to north of 42º N latitude and 2) that a separate XDB-SRA assessment for the portion of the population south of 42º N latitude be conducted using the existing southern CPUE abundance index, applied to catch data series restricted to south of 42º N latitude. The SSC's expectation is that the net result of these new assessments will be to move some of the biomass from the northern portion to the southern portion of the population.

The SSC notes that results from a set of assessments structured with a north-south boundary at 42º N latitude will require further analysis to develop OFL values corresponding to the management boundary at 40º10' N latitude.

Update of Oregon recreational catch data

The recreational catch data series used in the assessments reviewed by the Data-Moderate STAR Panel were taken directly from the Recreational Fisheries Information Network (RecFIN) database. The Oregon data in RecFIN prior to 1993 were based on catch rates (fish per angler day) obtained from angler interviews conducted by the Marine Recreational Fisheries Statistics Survey (MRFSS) and then expanded by MRFSS estimates of angler-days derived from telephone interviews. The Oregon Recreational Boat Survey (ORBS) provides more accurate estimates of recreational landings of groundfish species. The SSC recommends that the additional XDB-SRA analyses of the China rockfish (described above) be conducted using the historic (pre-1993) estimates of China rockfish landings from the ORBS program rather than the MRFSS estimates. Also, the current XDB-SRA assessment for China rockfish North of Cape Mendocino should be redone using the revised Oregon landings data.

The SSC anticipates that revisions to the Oregon catch series for copper and brown rockfish will be so small as to have inconsequential effects on the existing XDB-SRA coastwide assessment for brown rockfish and the existing XDB-SRA assessment for copper rockfish north of Point Conception. The SSC will confirm this at its November meeting.

Summary

The process for revising the data-moderate assessment for China rockfish will result in three new assessments: 1) for the population north of 40º10' N latitude; 2) for the population north of 42º N latitude; and 3) for the population south of 42º N latitude, the first two of which will be affected by the revised Oregon catch data series. The existing assessment for the population south of 40º10' N latitude is unaffected by the revised Oregon catch data (and does not involve a boundary change). The SSC will review the results of these assessments and provide recommendations to the Council regarding China rockfish at the November meeting.

Agenda Item G.4
Situation Summary
September 2013

# SCIENCE IMPROVEMENTS FOR THE NEXT GROUNDFISH MANAGEMENT CYCLE

This year is considered the "on-year" for intensive science activities as new groundfish stock assessments and rebuilding analyses are formally approved for fishery management decision-making for groundfish fisheries in 2015 and beyond. While it is not entirely accurate to characterize the biennial management cycle in terms of an "on-year" and "off-year" for science, it is correct to distinguish the year in which stock assessments are conducted (the "on year") and the year other science activities are planned to prepare for the following assessment cycle and to resolve scientific issues that play a significant role in groundfish decision-making.

There are many activities that should be considered for "off-year" science improvements. Some of these activities may be planned and sponsored by the National Marine Fisheries Service (NMFS) fisheries science centers; some activities may be planned and sponsored by the Council or the Council's Scientific and Statistical Committee; and some activities have been recommended by Stock Assessment Review Panels this year (Agenda Item G.4.a, Attachment 1).

The Council should consider the proposals and advice of the NMFS fisheries science centers, Council advisory bodies, other agencies, and the general public regarding off-year science improvements, and plan and prioritize science activities for 2014.

## Council Action:

**1. Prioritize and Plan Science Activities for 2014.**

Reference Materials:

1. Agenda Item G.4.a, Attachment 1: STAR Panel Recommendations for Off-year Science Improvements.

Agenda Order:

a. Agenda Item Overview — John DeVore
b. Northwest Fisheries Science Center Report — Michelle McClure
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Prioritize and Plan for 2014 Science Improvements

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# STAR PANEL RECOMMENDATIONS FOR OFF-YEAR SCIENCE IMPROVEMENTS

General recommendations from recent (i.e., 2009, 2011, and 2013) stock assessment review (STAR) panels

- Apply other assessment methodologies, potentially including catch curves, surplus production models, stock reduction analysis, etc., to evaluate whether the information obtained on stock status, vital rates, and productivity are consistent with the assessment model.

- Conduct a formal review of all historical catch reconstructions and, if possible, stratify by month and area. The Scientific and Statistical Committee (SSC) recommended this be done after the Washington historical catch reconstruction effort is completed. The mixing of U.S. and Canadian catches is of particular concern for the Washington fleet. The accuracy and wide availability of consistent basic information is essential to the development of Pacific coast assessments. In addition to the raw data, the reliability and availability of more spatially dis-aggregated forms of the data should be investigated to determine if they could be used to develop more spatially or temporally explicit models without sacrificing accuracy.

- Discard estimates from the West Coast Groundfish Observer Program (WCGOP) should be presented, reviewed (similar to catch reconstructions), and be made available to the assessment process.

- Develop guidelines for use of the Lorenzen model for age-dependent natural mortality. The 2011 STAR panel investigated the use of age-dependent natural mortality (M) in both the Dover sole and sablefish assessments. In each case one of the reasons for exploring different mortality schedules was the potential imbalance between the genders in the age- and length composition information, either in the sex ratio at older ages (Dover sole) or in the ratio of young to old fish (Sablefish). The use of the Lorenzen M model, which is based on a decline in M with age by the inverse of the growth rate, implies a link with size-based predation. However, with likely wider use of this model feature there should be development of some guidance on the appropriateness of the implementation in other stock assessments.

- Conduct new studies of maturity by length and age based on more comprehensive coastwide and depth-based sampling and using histological techniques for determining maturity stage. Given that there is uncertainty regarding the temporal stability of maturity schedules, there should be periodic monitoring to explore for changes in maturity.

- Modify the Stock Synthesis (SS) code to allow changes to the plus-group age. The STAR panel found it very helpful to be able to modify the plus-group in the age-composition data to investigate the influence of old versus young age composition data. This feature could also be used to explore the influence of ageing errors. The current version of SS requires restructuring of the input data if the plus-group is changed.

- Explore broader area assessments into Mexico and Canada for transboundary stocks.

- Exploring relative or absolute abundance of groundfish species in the Cowcod Conservation Areas (CCAs) is a key research priority. Submersible or other non-invasive survey methods could potentially provide additional information on habitat and abundance for these species. Also, it is important to develop alternative methods to monitor length and age compositions of fish inside the CCAs.

- A Management Strategy Evaluation (MSE) approach is needed to evaluate the 40-10 harvest control rule when applied to a stock with dramatically episodic recruitment, such as the Pacific hake stock. An MSE is also recommended to examine the likely performance of new flatfish control rules.

- SS3 implements new options for bias adjustment of stock recruit relationships that have been used with little or no peer review. Simulation testing is needed to confirm that bias adjustment is justified in all cases. Guidelines should be developed on how to configure bias adjustment settings to reflect the biological characteristics of the stock and the available assessment information.

- Develop methods to incorporate uncertainty in natural mortality and/or steepness in model configurations in which these parameters are fixed. The delta method for propagating uncertainty (McCall in prep.) is a promising approach that warrants further evaluation.

- Recommendations for a trawl survey workshop: Explore a Generalized Linear Mixed Method (GLMM) approach with a calendar date covariate to estimate catch per unit of effort (CPUE) indices for the entire triennial survey time series. A species assemblage meta-analysis approach could be used to develop priors for the ratios of catchability ($q$) among the early triennial, the late triennial, and the Northwest Fisheries Science Center (NWFSC) surveys. Consistent residual patterns in NWFSC surveys for a number of assessments suggests there may be some unknown factor affecting survey catchability, or that some factor is affecting the productivity of multiple stocks in the same way.

  From the 2013 data-moderate STAR panel: consider including a vessel factor (as a random effect) when developing indices for the triennial survey. Splitting the triennial survey into early and last periods became established practice without looking at the issue comprehensively or considering the loss of information from breaking a time series. A comprehensive evaluation of the issues and trade-offs is still needed. Consider developing generalized linear mixed model (GLMM) models in which latitude and depth are treated as continuous covariates rather than as factors.

  From the 2013 darkblotched/petrale STAR panel: Revisit the approach used to select among error models and whether to include extreme catch event (ECE) components when conducting the GLMM analyses. For survey GLMM analyses, the stock assessment teams (STATs) need to report a standard summary of the raw data and fitting of the model including both results and diagnostics. Additional research should attempt to identify (and perhaps simulation test) a method for model selection including the error distribution, the treatment of random vs. fixed effects, and the inclusion of ECE mixture distributions that can be reliably applied across all species.

From the 2013 aurora/rougheye STAR panel: A workshop should be held to evaluate methods for constructing survey GLMM estimates. Topics that should be explored include: (a) the effect of treating vessels as random, when in fact the vessels hardly vary from one year to the next; (b) possible aliasing of the index values with the Vessel x Year interactions; and (c) the using information from the GLMM for combining length composition data collected by different vessels. One goal for the workshop should be to provide adequate documentation of the GLMM methods that will be used to produce survey biomass indices for future assessments.

- Explore the relationship between ageing precision, recruitment variability, and bias adjustment (and effects on depletion estimates) using simulation methods, and develop recommended procedures for appropriate methods to follow.

- Investigate alternative methods of re-weighting the data series in SS.

  From the 2013 aurora/rougheye STAR panel: A workshop should be held to evaluate methods (a) for the iterative reweighting of composition data (e.g., current approach based on SS3 calculation of effective sample size (effN) (versus the Francis approach) and (b) formulae for developing initial weightings (the initial input N values).

- More work is needed to better understand the performance of maximum likelihood and Bayesian estimators of stock size and trends when large numbers of poorly-informed recruitment deviations are estimated. Although it is logically appealing to include such uncertainty, even when there are little coherent data informing cohort strengths, technical and computational issues need to be solved before this approach can be implemented in situations such as yelloweye rockfish.

- Accessing and processing recreational intercept data from Recreational Fishery Information Network (RecFIN) and the three states is much too cumbersome for the Stock Assessment Teams (STATs). A single database that holds all the raw recreational data in a consistent format would greatly expedite processing and interpretation of the data, and would reduce the potential for introduction of errors.

- The 2013 data-moderate STAR panel strongly emphasizes the value of conducting a data workshop during which catches, indices, biology, and other data inputs are reviewed.

- The historical commercial passenger fishing vessel (CPFV) drift-specific data should be keypunched, which should allow the algorithm for developing CPFV-based data indices to be improved.

- Habitat maps should be developed so that structural rather than true zeros (e.g., absence of fish) are designated using data which are independent from the data used to determine the indices.

- Where possible, historical otolith samples aged using a combination of surface and break-and-burn methods should be re-aged using the break-and-burn method. Early surface read otoliths should also be re-aged using the break and burn method. Historical otoliths aged with a standard method will allow the further evaluation of the potential impacts of consistent under-aging using surface read methods, changes in selectivity during early periods without any composition information, and potential changes in growth.

- The effect of the implementation of the individual fishing quota catch shares program in 2011 on fleet behavior, including impacts on discards, fishery selectivity, and fishing locations, would benefit from further study.

- The extent of spatial and temporal variability on productivity processes such as growth, recruitment, and maturity is currently unknown and would benefit from further research.

- Investigate methods to include uncertainty in historical catches in the modeling.

- Maturity schedules are often largely determined by size and not age. An additional option is needed in SS to allow the modeling of maturity-at-length with an asymptote <1.0 to reflect atresia or skip-spawning.

- Age-at-maturity and other life history parameters are inherently uncertain for cowcod (and other species) and require further investigation. Future assessments should consider incorporating the uncertainty associated with age at 50 percent maturity.

- Priors to be used in extended depletion-based stock reduction analysis (XDB-SRA) models based on rockfish should be developed.

- Explore ways to index the abundance of sanddabs (and other nearshore species) in nearshore areas (i.e., waters shallower than 55 m) where the trawl surveys are not conducted.

<u>Recommendations for future data-moderate assessments</u>

- Nine stocks proved to be too many assessments to review at this STAR Panel. Reviewing a smaller number of assessments (4-8) may be a more feasible goal for STAR Panel review, depending on the level of pre-STAR panel review of data inputs. If area-specific models are considered in addition to coast-wide models, additional time or fewer stocks should be scheduled. However, the first time that any assessment method or stock assessment is reviewed is always the most challenging, and future STAR Panels may find that the review goes much smoother.

- The STAR Panel recommends that data-moderate assessments continue to be reviewed at full STAR panels for at least the next assessment cycle. As methods become standardized and the review process becomes more routine, it should be anticipated that the review process can be streamlined somewhat.

- Objective criteria should be developed to specify minimum standards for model outputs to be considered “acceptable” and “preferred” and included in the Terms of Reference for stock assessments. Such criteria might include minimum goodness-of-fit criteria and acceptable limits on posterior distributions.

- While the STAR Panel made some progress in comparing XDB-SRA and extended simple stock synthesis (exSSS), our strategy of attempting to isolate the sources of difference between the two models ultimately proved unsuccessful, and resulted in complex requests to the STAT that were difficult to accomplish in the available time. The STAR Panel suggests that some of the model comparison work is more appropriate outside the STAR panel review process, particularly as it involves fundamental differences in how stock productivity is modeled.

- A standardized set of sensitivity runs, diagnostic plots, and performance statistics, such as runs tests on the residuals, should be developed to rapidly evaluate the performance of data-moderate assessments. Some pre-STAR panel planning involving the STAT and SSC to develop an analysis “package” could be helpful.

- As with any assessment and review process, there is a trade-off between the number of data-moderate assessments and quality of the assessment and review. This trade-off should be taken into account when planning for future STAR panel reviews of data-moderate assessments.

- The MSE should be further explored to evaluate the performance of exSSS and XDB-SRA. Other potential topics include error in the catch time series, uninformative indices of abundance, and time-varying productivity. The MSE could also be used to test whether more constrained models, such as fixing steepness or $B_{MSY}/B_0$, result in improved model performance.

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Agenda Item G.4.b
Supplemental NWFSC PowerPoint
September 2013

Science, Service, Stewardship

# Research Priorities

Michelle McClure, FRAM Division
Northwest Fisheries Science Center

September 13, 2013

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# FRAM Assessment-related “Off-year” Research Priorities

- Inputs to Assessment Models
- Modeling Improvements
- Management and Agency Priorities

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# Data Inputs to Assessment Models

**1,2,5. Length- and age-composition data:**

- Improve methods for calculating/using catch proportions-at-length/age

> Promote use of standardized, more-accurate methods

**3. Survey GLMM code:**

- Improve the calculation of survey indices and associated uncertainty

> Create more accurate indices and characterizations of uncertainty

**4. Catch uncertainty and historical reconstructions:**

- Advance historical reconstructions for all FMP species
- Improve ways of modeling historical catch uncertainty

> Reduce ad hoc decisions about historical catches

> Better understand possible implications of catch uncertainty

**6. Ageing error and bias: determination and modeling:**

- Improve methods for determining/specifying ageing error and bias outside and within stock assessment models.

> Improve recruitment estimation

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# Biological Inputs to Assessment Models

**9. Treatment of stock-recruitment steepness**

- Review meta-analytical and other approaches for determining stock-recruit steepness (h).
  > Reduce uncertainty in stock assessment outcomes due to unknown steepness

**10. Maturity: Incorporating error and uncertainty**

- Develop methods for estimating and incorporating uncertainty and inter-annual variability in maturity and fecundity-at-age in stock assessments
  > Improve understanding of historical changes in spawning output
  > Model historical and future changes in spawning output more realistically

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# Modeling Improvements

## 7. Refining data-limited assessments:

- Improve the inputs and assumptions for Tier-2 and Tier-3 stock assessments
- Improve estimation of uncertainty in data-moderate assessments

> Increase precision of Tier-2/3 assessments

> Better understand relationships between data-limited and benchmark results

## 8. Rebuilding improvements and projections:

- Increase the range of rebuilding model options

> Increased range of rebuilding options

> Improved understanding of rebuilding-alternative trade-offs

## 13. Recruitment: Autocorrelation and climate considerations:

- Improve ability to model inter-annual and climate-related recruitment patterns

> Improve model estimates, through accounting for such correlations

> Improve forecasts, through better understanding of the recruitment processes

## 14. Develop penalties for changes in time varying parameters:

- Investigate methods to estimate inter-annual variability in time-varying parameters (e.g., growth and selectivity)

> Improve the specification of time-varying parameters in models

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# Management and Agency Priorities

## 11. Stock assessment prioritization:

- Evaluate FMP species using general approach proposed by the NMFS Stock Assessment Prioritization Working Group
- > More systematic inventory of factors relevant to prioritizing 2015 stock assessments

## 12. Programmatic reviews: Assessment & peer-review:

- Prepare and present materials for independent review of PFMC groundfish assessment and review processes
- > Agency-required review that may identify ways to improve

## 15. Update IEA groundfish status indicators:

- Update groundfish indicators using most recent assessment results
- > Up-to-date IEA indicators for use by Council

# CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE REPORT ON SCIENCE IMPROVEMENTS FOR THE NEXT GROUNDFISH MANAGEMENT CYCLE

The California Department of Fish and Wildlife (CDFW) offers the following comments for Council consideration on prioritizing science activities for 2014.

## Research in the Cowcod Conservation Areas (CCA)

As part of the 2012 off-year science improvements, the Council recommended prioritizing exploring the relative or absolute abundance of groundfish in the CCAs. Such non-invasive survey methods could greatly enhance the amount of data informing stock assessments and provide information on habitat and species abundance. This type of research is also extremely valuable because it can accomplish what trawl surveys cannot or are unsuitable for because of the inaccessibility inside the CCAs or adjacent areas. Given the importance of these data for stock assessments, CDFW supports prioritization of this item as an off-year science activity for 2014.

## Data-moderate Stock Assessments

In 2013, the Council employed a new approach for stock assessments using data moderate methods. The results were intended to provide an understanding of the stock status, provide estimates to inform harvest limits, and help managers prioritize whether a more data intensive (i.e., full assessment) was necessary. As with any new method, issues came up during the STAR Panel and all of the stocks could not be reviewed (or compared) as thoroughly as intended.

Trying to balance the increasing demand to complete (or update) a greater number assessments with limited staff resources is a challenge. Data moderate assessments will likely be a useful tool to help achieve these goals. As such, CDFW supports the STAR Panel's recommendations for improvements to data moderate assessments for inclusion as part of the off-year science activities. These improvements will help refine the data moderate stock assessment review process and Council decision making.

## Apportionment North and South of 40°10' N latitude.

During planning for the 2012 off-year science activities, the Groundfish Management Team (GMT) recommended the Council prioritize development of alternative apportionment methods north and south of 40°10' N latitude (Agenda Item G.10.c, Supplemental GMT Report, September 2011). Although the original impetus for this request arose from the apportionment used in the data poor assessment methods, it is also applicable to data moderate assessments. Given the importance of apportionments and the resulting implications when setting harvest limits, CDFW_recommends that the Council include development of alternative methods to apportion catch north and south of 40°10' N latitude as an off-year science activity for 2014.

## West Coast Groundfish Observer Program (WCGOP) Discard Estimates

During planning for 2012 off-year science activities, the Science and Statistical Committee considered the review of WCGOP methods to estimate discard rates to be a high priority issue (Agenda Item G.10.c, Supplemental SSC Report, September 2011). In addition to stock assessments, WCGOP discard estimates also form the foundation for the nearshore bycatch projection model. This bycatch model is used by the GMT to project target and overfished species impacts under various depths and harvest levels. These results are then used by the Council to inform their decision making on nearshore fishery management. Given the importance of WCGOP data, CDFW supports efforts to review the methodology to ensure adequacy for both stock assessments and commercial modeling.

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Agenda Item G.4.c
Supplemental GAP Report
September 2013

GROUNDFISH ADVISORY SUBPANEL REPORT ON
SCIENCE IMPROVEMENTS FOR THE NEXT GROUNDFISH MANAGEMENT CYCLE

The Groundfish Advisory Subpanel (GAP) received a presentation from Dr. Michelle McClure on science improvements for the next groundfish management cycle. The GAP also reviewed the STAR Panels' recommendations under this agenda item.

Generally, the GAP understands the Council has to prioritize science needs and improvements, taking into consideration the recommendations by the STAR Panels, science centers and Scientific and Statistical Subcommittee, but request the Council concentrate on changes and suggestions that have the most benefit to the industry.

Thus, our recommendation in September 2011 (Agenda Item G.10.b, Supplemental GAP Report) still stands. Briefly, we requested four workshops: 1) A workshop on transboundary stocks; 2) one on the $B_0$ harvest management framework; 3) one to review historical catch reconstructions; and 4) one to develop techniques (non-extractive) to survey Cowcod Conservation Areas. That statement is attached for your review.

We understand there are budgetary concerns at all levels of government (including Canada, in the case of transboundary stocks), but fiscal concerns also affect every harvester, processor and community when it comes to operating small businesses. The GAP supports these improvements and believes they will be the most productive at making the industry and management process more efficient.

It is also the GAP's understanding that a workshop will be held to review stock assessments and the stock assessment process. We request industry members also be included in this workshop, as we reiterate the collective knowledge of the fishing industry will certainly aid conveners and participants of these workshops.

PFMC
09/13/13

Agenda Item G.10.b
Supplemental GAP Report
September 2011

# GROUNDFISH ADVISORY SUBPANEL REPORT ON SCIENCE IMPROVEMENTS FOR THE NEXT GROUNDFISH MANAGEMENT CYCLE

The Groundfish Advisory Subpanel (GAP) received a presentation from Mr. John DeVore on science improvements for the next groundfish management cycle. The GAP also reviewed the Scientific and Statistical Committee's statement under this agenda item. The GAP recommends the following activities in priority order to improve the science informing groundfish management.

1. Workshop on Transboundary Stocks

The distribution of many west coast groundfish stocks extends beyond the borders of the west coast exclusive economic zone (EEZ), yet assessments for these stocks are limited geographically to the EEZ. Results of west coast assessments of transboundary stocks are likely compromised by not incorporating data collected comprehensively from surveys and fisheries throughout the range of these stocks. Important stocks such as sablefish, Pacific ocean perch, spiny dogfish, canary rockfish, and yelloweye rockfish are transboundary stocks and their dynamics are likely not as well understood as they could be if assessments were more geographically comprehensive. A workshop to evaluate these effects and consider new assessment protocols to address these limitations may improve assessments of transboundary stocks. The GAP notes this issue is perennially raised by the stock assessment review (STAR) panels that evaluate assessments of transboundary stocks.

2. Workshop on the $B_0$ Harvest Management Framework

The current biomass-based harvest management framework relies on estimates of initial, unexploited spawning stock biomass ($B_0$) to determine the status of stocks. Stock status, or relative depletion, is defined as the ratio of estimated current spawning stock biomass to estimated $B_0$. However, estimation of $B_0$ is extremely uncertain and such estimates tend to change dramatically from assessment to assessment as assumptions regarding historical catch and stock productivity change. This leads to fishery instability and lack of confidence in assessment results. The GAP notes that other regions do not use such a harvest management framework and assessments and management actions tend to be much more stable and much less contentious. For instance, assessments of North Pacific groundfish do not include poorly estimated historical catches prior to the mid-1970s because there is no need to estimate $B_0$. These assessments tend to produce more consistent and plausible results, largely because they are based less on assumptions and more on empirical data. The Council sponsored a groundfish harvest policy evaluation workshop in December 2006, which began to explore the limitations of our current framework. Many of the shortcomings of our $B_0$ framework were evaluated and it was concluded there may be better ways to manage many of our stocks. Workshop participants also supported another workshop to continue this evaluation. The GAP strongly recommends this second workshop be scheduled next year to evaluate an alternative framework for assessing groundfish stocks and managing west coast groundfish fisheries.

3. Workshop to Review Historical Catch Reconstructions

One of the consistent recommendations from the 2011 STAR panels was to convene a workshop to review historical catch reconstructions of west coast groundfish. To date, historical catch reconstructions have been done for California and Oregon fisheries. While there was a peer review of the California catch reconstruction effort, further refinements of methods to reconstruct historical California catches have been subsequently identified in STAR panels and no such peer review of the Oregon catch reconstruction effort has been done. The GAP understands that there are plans to reconstruct historical Washington catch reconstructions as well. Given the sensitivity of assessment results (especially estimates of $B_0$) to assumptions regarding historical catches, a formal workshop to review methods to reconstruct historical catches should be done. The GAP strongly recommends the participation of fishermen in any workshop designed to review catch reconstructions since their knowledge will certainly be helpful in interpreting historical catch data.

4. Workshop to Develop Techniques to Survey the Cowcod Conservation Areas

One notable limitation in stock assessments of many groundfish species that occur in the Southern California Bight is the lack of fishery-independent survey data from the Cowcod Conservation Areas (CCAs). This is a critical uncertainty in recent assessments of bocaccio, blackgill rockfish, greenspotted rockfish, and, of course, cowcod. No surveys, including the Northwest Fisheries Science Center shelf/slope trawl survey are allowed to survey the CCAs. However, development of an effective non-extractive survey technique is critically needed to better understand the distribution and relative abundance of species that reside in the CCAs. The GAP therefore recommends development of techniques to survey the CCAs and other areas that cannot be effectively accessed by our current groundfish surveys.

The GAP would also like to participate in the other workshops recommended for next year since these activities will likely affect future assessments and management actions. The collective knowledge of fishermen will certainly aid participants in each of these workshops.

PFMC
09/18/11

# GROUNDFISH MANAGEMENT TEAM REPORT ON SCIENCE IMPROVEMENTS FOR NEXT GROUNDFISH MANAGEMENT CYCLE

The Groundfish Management Team (GMT) reviewed the materials under this agenda item and had a discussion with Dr. Michelle McClure of the National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC). The GMT thanks Dr. McClure for her time and patience in working around the GMT's schedule. Overall, the GMT recognizes that the efforts of the NMFS Science Centers provide the fundamental science used for conservation and management policies.

Additionally, the GMT has the following items that we would like to have considered for the "off-year" science improvements. Choosing off-year science improvements involves prioritizing staff and other resources and consideration of how well certain questions can be addressed with the existing data and methods. Given time and other constraints, we were not able to get into specifics about how issues would be best addressed or to consider matters of timing. Mainly we attempt to flag issues the team sees as important. The following are in no particular order of priority.

*Spatial analysis of exploitation, fishing effort, and trends in abundance*

An analysis of catch per unit effort and removals by port, county, or district or other appropriate stratification using the methods similar to Cope and Punt (2009) should be conducted to identify regions with differential depletion (e.g. for rockfish species) that should be considered in stock assessments similar to explorations of population structure. Such analyses may be conducted across a number of species belonging to various groundfish complexes to examine patterns of differential depletion as a result of exploitation by differing sectors. The analysis would likely be focused on species that are sedentary (and possibly those that co-occur) and the results compared to test for the presence of regional trends in abundance. Such analysis would support the requirement in the Stock Assessment Terms of Reference to include, "Species/area, including an evaluation of any potential biological basis for regional management." Differential exploitation may provide a justification for regional management beyond a strictly biological or stock structure basis. Any additional research that would aid the process of determining stratification used in assessments or allocations across management boundaries would be welcomed by the GMT.

*Transboundary Stocks*

In their report under this agenda item, the Groundfish Advisory Subpanel (GAP) is reiterating a recommendation for attention to the transboundary stock issue. We agree that it is a very key issue for many groundfish stocks. It comes up frequently in our discussions. For instance, at this meeting, it has been mentioned in the context of at least three other agenda items. For example, in consideration of the "in the fishery" classification and stock complex evaluation, and just on the northern border, at this meeting alone we have discussed questions about the management of dusky rockfish, Pacific cod, walleye pollock, shortraker rockfish, tiger rockfish, and more. Similar issues are present on the southern border with Mexico as well. We understand there is concern that not much can be done on the research/science or stock assessment side of things without international cooperation. Not weighing in on that question, we emphasis that there are scientific questions about the stock unit of conservation. The questions related to this may be similar to the discussion above on spatial analysis and regional variations in abundance and depletion history. If not an off-year activity, some discussion about the scientific realities of managing these stocks and how it fits within the Magnuson-Stevens Act National Standard 3 and other requirements could be beneficial.

*Data-Moderate Stock Assessments*

The recent data-moderate sock assessments for nearshore species were largely dependent on data from the party and charter fleet. Data for this sector are sparse in some parts of the coast. In addition, some species are predominantly distributed in shallower depths than party and charter vessels typically fish, but where private and rental vessels regularly access. Such data is available for a long time series and provide a substantial number of angler interviews. Thus the data from the private recreational fishery may provide valuable data to inform indices of abundance for future assessments. The GMT would like to see an evaluation of methods to derive catch per unit effort indices from the private and rental boat mode of the recreational fishery for use in future data-rich and data-moderate stock assessments of nearshore and/or shelf species.

*Catch Reconstructions and Discards*

The GMT supports the continuation of the historic catch reconstruction process, including holding an independent review of the work completed to date. This may be supplemented by a workshop on modeling discards for periods prior to the West Coast Groundfish Observer Program (WCGOP). The WCGOP data have enabled stock assessments to represent discarded catch in a more complex and accurate way for recent years. However, the accurate representation of discards during earlier periods has been more difficult. Just as the catch reconstructions have brought more consistency to treatment of landed catch, further research on methods for modeling discards could increase consistency among assessments and may reveal better ways to account for the full history of changes in fishing practices.

*$B_0$ Workshop*

We understand that the SSC will recommend this workshop. We support the idea as well. As we understand it, the focus would involve a look at the Council's harvest policies and potentially inform several outstanding questions (e.g. the appropriateness of the fishery management plan's (FMP's) $B_{msy}$ and $F_{msy}$ proxies). Also, like we mention in Agenda Item H.1, such analysis will help explore considerations of additional flexibility and conservation objectives that are being discussed nationally (e.g. pretty good yield and the mixed stock exception). We understand the Management Strategy Evaluation (MSE) being prepared for Amendment 24 could be adapted for this analysis to explore some of these questions.

*Ecosystem-related Analysis*

We continue to support exploration of the connections between the ecosystem analyses (e.g. integrated ecosystem assessments) and related activities and the groundfish analyses, for example, the Tier 1 environmental impact statement (EIS) and the analysis that will follow it, stock assessments, and more. Connecting our understanding of ecosystem impacts with cumulative impacts of management, stock status, etc. will provide greater context for the effect of various Council actions and policies on the marine environment. The Council has already requested that time be spent on certain activities and we point out that the Science Centers and the Scientific and Statistical Committee (SSC) will likely be allocating time this year and next to these effort.

*Ongoing Socioeconomic Discussion with the SSC - Possible Workshop and SSC recommendations*

We support a joint GMT and SSC workshop to continue identifying and discussing groundfish-related socioeconomic needs and priorities. Though we appreciate the model reviews that the SSC's Economics and Groundfish Subcommittees have engaged in so far, the recommended priorities that the SSC identified and the socioeconomic-related priorities of the team may differ. We would like an opportunity to discuss these differences with the SSC and a workshop would be helpful for clarifying the GMT's socioeconomic needs and concerns relative to the SSC's recommendations.

Regarding the SSC's recommendations identified in their report (Agenda Item F.7.b, Supplemental SSC Report, June 2013), the GMT provided a complete list of items that we are addressing during this 2015-16 biennial process, and will begin to address after this process is complete. This list can be found in Agenda Item G.7.b, Supplemental GMT Report, September 2013. The GMT would like further discussion with the SSC on some of these items and will work with Council staff to facilitate these discussions.

PFMC
09/14/13

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON SCIENCE IMPROVEMENTS FOR THE NEXT GROUNDFISH MANAGEMENT CYCLE

The Scientific and Statistical Committee (SSC) reviewed possible topics for off-year science workshops related to improving groundfish stock assessments for the 2017-18 management cycle based on recommendations from recent Stock Assessment Review (STAR) panels (Agenda Item G.4a, Attachment 1). Dr. Owen Hamel gave a presentation on assessment-related "off-year" research priorities for the FRAM division at the NWFSC. The NWFSC priorities are grouped into a) inputs to assessment models, b) model improvements and c) management and agency priorities. Many of these activities are best regarded as research projects for individual scientists or small teams, and would not necessarily be appropriate for Council-sponsored workshops. There may be a need for the SSC to review refinements to existing methods or data inputs prior to their use for stock assessment, and this should be possible during regular SSC meetings, or during 1-day meetings of the SSC Groundfish Subcommittee scheduled before or after meetings of the full SSC.

The SSC identified four priority topics for off-year science workshops. Two of these workshops were also recommended in 2011, but could not be completed for various reasons. The SSC continues to regard them as priority topics.

**Workshops related to stock assessments (in priority order):**

1. **Workshop to review historical landings time series (recommended in 2011)**. A major effort to reconstruct historical landings was initiated in 2008 in response to the Council's call to compile the best estimates of catch history early in the development of Pacific Coast groundfish fisheries. Currently, this effort has produced published estimates for California fisheries, and more recently, estimates for Oregon fisheries. Data bases have been developed for raw landings and historical species composition data for Washington, but the analysis has not yet been done. An off-year science workshop would review reconstructions of all landings comprehensively, ideally when the Washington estimates are available. This review would need to be structured differently than the other proposed workshops, since the most expertise is to be found among current and former employees of state agencies and experienced fishermen and processors. Estimation of the extent of uncertainty of the historical catch estimates due, for example, to uncertainty in estimates of landings species compositions, would also be a priority for this workshop.

2. **Workshop on methods of data reweighting.** Most West Coast assessments use effective sample size to weight the composition data by fleet. During the aurora and rougheye rockfish STAR panel, CIE reviewer Dr. Chris Francis provided compelling evidence that this standard approach resulted in implausible residual patterns. An alternative approach proposed by Dr. Francis for the most part eliminated these "bad" residual patterns. However, it remains to be determined whether this approach is the "best" general approach for deriving reweighting factors. The issue, while technical in nature, has important consequences, since it is not unusual for assessment results to be

fairly sensitive to the weights given to composition data. The SSC recommends that a scientific workshop be sponsored to review the state of the art for reweighting stock assessment data, with the aim of preparing a guide to good practices for future assessments. This workshop would also benefit CPS stock assessments.

3. **Workshop on the shape of the stock productivity curve.** Recent data-moderate assessment approaches such as Extended Depletion-Based Stock Reduction Analysis (XDB-SRA) are designed to have greater flexibility in how productivity changes with stock size. In contrast, nearly all full assessments of West Coast groundfish use the two-parameter Beverton-Holt stock recruit relationship, which imposes strong constraints on the shape of the stock productivity curve. While the approach used in XDB-SRA has conceptual appeal, it is not clear whether such flexibility is appropriate given what is known about the growth and mortality of West Coast groundfish. The two approaches represent a fundamental difference in how stock productivity is modeled, and there are important implications to biomass and fishing mortality reference points used in Council's harvest control rules. The SSC recommends that a scientific workshop be sponsored that would evaluate the suitability of these alternative ways of modelling stock productivity in data-moderate and full assessments.

4. **Workshop on estimation of $B_{MSY}$ proxies (recommended in 2011).** The Council's harvest control rules depend on estimates of stock size relative to a $B_{MSY}$ proxy, with a default $B_{MSY}$ proxy defined as some fraction of unfished stock size, $B_0$. Changes in stock assessment methods or data inputs can lead to large changes in estimated $B_0$ and in some cases to marked changes in depletion levels, overfishing limits, acceptable biological catches, or rebuilding times. This workshop would review alternative control rules (e.g., control rules based on "Dynamic $B_0$" or on direct estimates of $B_{\mathrm{MSY}}$) and compare their performance with current approaches using management strategy evaluation (MSE). The workshop would build on the last $B_0$ workshop, but would be more focused on the performance of control rules. It would also include review of stock status for a range of stocks when stock status determinations are based on "Dynamic $B_0$." The evaluation of control rules could be based on the MSE currently being developed to evaluate rebuilding revision rules.

Successful workshops require dedicated research, careful organization before the workshop, and post-meeting development of scientific reports, all of which come at a cost of time and resources. The Council should be cognizant of the trade-off between the number of workshops that are held and amount of progress that can be made on other projects with the potential to improve data inputs and stock assessments.

With the adoption of the Council's Fishery Ecosystem Plan, the SSC anticipates a greater workload next year reviewing ecosystem-related documents, including annual reports of ecosystem status and technical documents to support the Council's ecosystem initiatives. Depending on the nature of the document and its intended use by the Council, these reviews could range from short, focused reviews (1 or 2-day) by SSC Ecosystem Subcommittee, to more extensive reviews similar to the methodology review process used for CPS and Groundfish. For example, the Ecosystem Workgroup is proposing a science workshop to evaluate information on the food habits of Council-managed species with the goal of refining criteria for identifying forage fish species. This workshop would benefit from SSC Ecosystem Subcommittee participation as reviewers of the scientific information developed for the workshop.

Agenda Item G.5
Situation Summary
September 2013

CONSIDERATION OF INSEASON ADJUSTMENTS

Management measures for groundfish are set by the Council with the general understanding that these measures will likely need to be adjusted within the biennium to attain, but not exceed, the annual catch limits (ACL). This agenda item will consider inseason adjustments to ongoing 2013 fisheries. Potential actions include adjustments to the Rockfish Conservation Area (RCA) boundaries and modifications to commercial and recreational fishery catch limits; however, at this meeting, trawl RCA adjustments will be considered under Agenda Item G.6. Adjustments are, in part, based on recent landings and the latest information from the West Coast Groundfish Observer Program.

In March, the Council recommended issuing the maximum eligible (up to 10 percent) surplus carryover quota pounds (QP) for all non-whiting species in the shorebased individual fishing quota fishery (IFQ). The National Marine Fisheries Service (NMFS) issued carryover for all non-whiting IFQ species except lingcod and petrale sole (see Agenda Item F.9.b, NMFS Letter 1, June 2013). NMFS requested guidance from the Council on how to issue surplus carryover for lingcod because the QP management unit was previously coastwide but is now divided north and south of 40°10' N. latitude. The Council recommended an approach for issuing lingcod surplus carryover (see Agenda Item F.9.b, NMFS Report, June 2013), which was implemented by NMFS on July 9 (http://tinyurl.com/k373exp). Surplus carryover for petrale sole was not issued because NMFS determined there was a high risk of exceeding the 2013 petrale sole ACL. The Council recommended the Groundfish Management Team (GMT) re-analyze the risk of exceeding the petrale sole ACL for the September Council meeting when more information regarding the progress of the 2013 fishery is available. The GMT is expected to provide such analysis in a supplemental report.

**Council Action:**

1. **Consider information on the status of 2013 fisheries and adopt inseason adjustments, as necessary.**
2. **Consider the latest catch estimates for petrale sole relative to the potential issuance of surplus carryover.**

Reference Materials:

1. Agenda Item G.5.c, Public Comment.

Agenda Order:

a. Agenda Item Overview — Kelly Ames
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt Inseason Adjustments to 2013 Groundfish Fisheries, Including Petrale Sole Carryover

PFMC
08/22/13

# GROUNDFISH ADVISORY SUBPANEL REPORT ON CONSIDERATION OF INSEASON ADJUSTMENTS

The Groundfish Advisory Subpanel (GAP) met with the Groundfish Management Team (GMT) to discuss progress of this year's fishery and possible inseason adjustments. The GMT discussion was led by Mr. Dan Erickson. The GAP offers the following recommendations and comments on proposed inseason adjustments to ongoing groundfish fisheries.

Limited Entry Fixed Gear Sablefish Fishery North of 36° N. Latitude

Current trip limit (1,110 weekly/3,300 bimonthly)

Industry has requested an increase in trip limits for sablefish for the balance of the year (Period 6). The GMT analyzed 3 alternatives for the Council to consider. The GAP supports **GMT Alternative 2, (1 landing per week of up to 1,850 lb., not to exceed 5,500 lb. per 2 months)** The model suggests a sufficient buffer (est. 91 percent take) but still allows for a small opportunity to make a few extra dollars in what has been a very difficult market this year.

Open Access Fixed Gear Sablefish Fishery North of 36° N. Latitude

Current trip limit (300 daily/800 weekly/1,600 bimonthly)

Open Access representatives on the GAP have requested exploring the possibility of an increase in trip limits for sablefish for the remainder of the year (period 6). Open access fishermen are currently working with a very narrow profit margin due to high fuel prices, poor sablefish prices and low trip limits. The GAP supports **GMT Alternative 2, (300 lb. per day, or 1 landing per week of up to 1,200 lb., not to exceed 2,400 lb. per 2 months).** The GAP believes sablefish effort may actually be lower than the model predicts due to the District 10 Dungeness crab opener November 15. Those that choose to fish sablefish will appreciate the extra fish.

Limited Entry Fixed Gear Sablefish Fishery South of 36° N. Latitude

**No action.**

Open Access Fixed Gear Sablefish Fishery South of 36° N. Latitude

Current trip limit (300 daily/1,460 weekly/2,920 bimonthly)

Conception area Open Access sablefish catch is running well below its harvest guideline due in part to a very difficult market in the southern California region. Those that are able to find a buyer will appreciate the extra opportunity. The GAP supports **GMT Alternative 2, (380 lb. per day, or 1 landing per week of up to 1,800 lb., not to exceed 3,800 lb. per 2 months).**

Limited Entry/Open Access Fixed Gear Deeper Nearshore Rockfish South of 40° 10' N. Latitude

Current trip limit (900 lb. per 2 month period)

The Port San Luis Commercial Fishermen's Association requested an increase in the trip limits for deeper nearshore rockfish for the balance of the year (Period 6). The GMT analyzed this request and has noted that there would be a minimal increase in the bycatch of Canary rockfish (.1 MT?). The updated scorecard shows total projected impacts to Canary rockfish remain well below the ACL (84.3%). The GAP therefore recommends increasing the deeper nearshore rockfish trip limits from the current 900 lb. per 2 month period up to **1,000 lb. per 2 month period (Period 6).**

Petrale Surplus Carry-Over in the Limited Entry Trawl Individual Fishing Quota (IFQ) Fishery

The GAP believes that the 10% Petrale Sole surplus carryover should be implemented. Based on informed discussion from participants (harvesters and processors) there is confidence that the allocation will not be exceeded in 2013. The GAP believes in principle that the carryover of surplus fish should always occur when allocations will not be exceeded. The ability to carry fish over also allows fishermen the ability to relax their harvesting effort and not feel that they have to fish right up to their allocation which can result in deficits that need to be covered.

Recreational Groundfish Fishery South of 34° 27' N. Latitude

The GAP recreational representative for the Southern California charter boat fleet wishes to inform the Council that they will be pursuing an inseason request to open the shelf rockfish fishery during the currently closed months of January and February of 2014. This request will be coming forward at the November Council meeting in Costa Mesa. The GAP supports consideration of this request.

Summary of GAP Recommendations

1) Limited Entry Fixed Gear Sablefish Fishery North of 36° N. Latitude.

**GMT Alternative 2, (1 landing per week of up to 1,850 lb., not to exceed 5,500 lb. per 2 months)**

2) Open Access Fixed Gear Sablefish Fishery North of 36° N. Latitude.

**GMT Alternative 2, (300 lb. per day or 1 landing per week of up to 1,200 lb., not to exceed 2,400 lb. per 2 months)**

3) Limited Entry Fixed Gear Sablefish Fishery South of 36° N. Latitude.

**No Action**

4) Open Access Fixed Gear Sablefish Fishery South of 36° N. Latitude.

**GMT Alternative 2, (380 lb. per day, or 1 landing per week of up to 1,800 lb., not to exceed 3,800 lb. per 2 months)**

5) Limited Entry/Open Access Fixed Gear Deeper Nearshore Rockfish South of 40° 10 N. Latitude.

**Increase to 1,000 lb. per 2 month period (period 6)**

6) Recreational groundfish South of 34° 27' N. Latitude

   An inseason request to open the shelf rockfish fishery during the months of January and February 2014 (To be presented in November).

PFMC
09/13/13

# THE GROUNDFISH MANAGEMENT TEAM REPORT ON CONSIDERATION OF INSEASON ADJUSTMENTS

**Action items:**

- Proposed trip limit increases for the limited entry and open access fixed-gear sablefish DTL sectors.
- Request to increase the shallow nearshore and deeper nearshore rockfish bimonthly trip limits to 1,000 pounds per vessel south of 40°10' N latitude for Period 6 of 2013.
- Evaluation of the potential issuance of 2012 petrale sole surplus carryover into the 2013 shorebased IFQ fishery.

**Informational items:**

- Research
- IFQ snapshot
- Scorecard update

The Groundfish Management Team (GMT) considered the most recent information on the status of ongoing fisheries, research, and requests from industry and provides the following recommendations for 2013 inseason adjustments.

The GMT also received guidance from the National Marine Fisheries Service (NMFS) Northwest Region (NWR) regarding timing of implementation of inseason recommendations from this meeting. NMFS anticipates implementing routine inseason adjustments to fishery management measures by November 1, 2013.

# 1. ACTION ITEMS

## 1.1. Fixed Gear Sablefish, Daily-Trip-Limit (DTL) Fisheries

This section discusses 2013 inseason considerations for the four fixed gear daily trip limit (DTL) fisheries, including both limited entry (LE) and open access (OA), north and south of 36° N. latitude. Hereafter, they will be referred to as follows: LE North, LE South, OA North, and OA South.

### 1.1.1. Current status and No Action Alternative

Current projections under the No Action alternative for the sablefish DTL fisheries are shown in Figure 1 and Table 1. The current 2013 projection for the LE North fishery, assuming a continued linear decline in ex-vessel price throughout the remainder of 2013 (from $2.15/lb. in Period 4, to an ultimate low of $1.83/lb. in Period 6), is 82 percent of the landing target (165 mt vs. 197 mt target, Table 1). Ex-vessel price is one predictor in the current model. Ex-vessel prices in this sector have been in steady decline throughout 2013, as well as during most of 2012. The current No Action projection for OA North is 83 percent of the landing target (239 mt vs. 291 mt target, Table 1).

The LE South fishery is projected to take 96 percent of its landing target under No Action (427 mt vs. 446 mt), while the OA South is currently predicted to take 51 percent of its landing target (186 mt vs. 362 mt). The Council has recently managed the two southern DTL fisheries under a sharing that was weighted to the LE sector. Taken together, the current projected attainment of the two southern DTL fisheries is 613 mt of 808 mt, or 76 percent of the sum of landing targets.

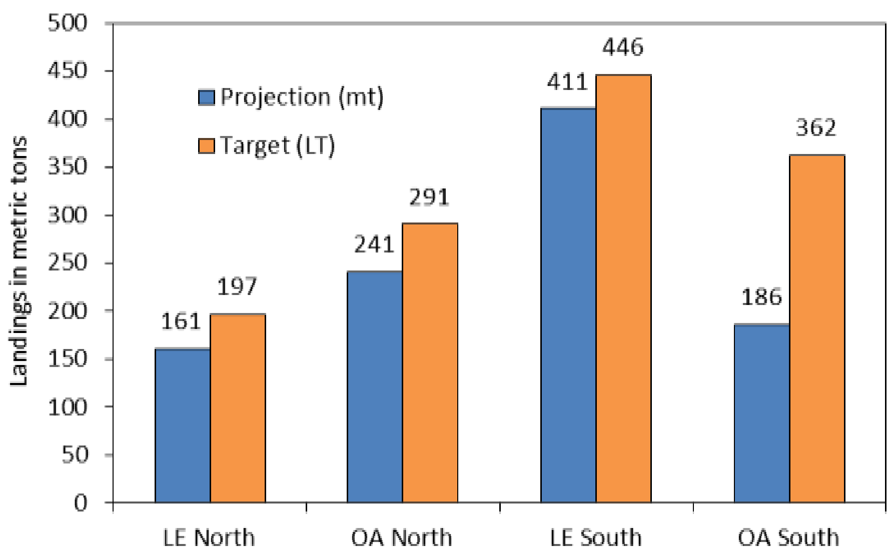


**Figure 1. Current landings projections and landing targets for the fixed gear, DTL sablefish fisheries under No Action in 2013.**

**Table 1. Current annual landings projections, corresponding attainment, targets and landing limits for the fixed gear sablefish, DTL fisheries under No Action, in Period 6 of 2013.**

| Metric | LE North | OA North | LE South | OA South | South sum |
|---|---|---|---|---|---|
| Projection (mt) | 161 | 241 | 427 | 186 | 613 |
| Target (LT) | 197 | 291 | 446 | 362 | 808 |
| Difference | 36 | 50 | 19 | 176 | 195 |
| Projected attainment | 82% | 83% | 96% | 51% | 76% |
| Bimonthly TL | 3,300 | 1,600 | - | 2,920 | - |
| Weekly TL | 1,110 | 800 | 1,880 | 1,460 | - |
| Daily TL | - | 300 | - | 300 | - |

1.1.2. Alternative trip limits

The GMT developed three potential action alternatives for the LE North, OA North, and OA South fisheries, for Council consideration (Table 2), which consist of landing limit increases.

For both the LE North and the OA North sectors, Alternative 1 results in a projected attainment of 89 percent of the landing targets (197 and 291 mt, respectively), whereas Alternative 2 (the slightly more liberal alternative) would result in harvest of 91 percent of the respective targets for both sectors. Alternative 3 (the most liberal alternative) is expected to result in 95 percent attainment of the respective targets for both sectors.

For the OA South fishery, Alternative 1 has a corresponding projected attainment of 64 percent of the landing target (362 mt), whereas Alternative 2 (more liberal) is estimated to result in 72 percent attainment of the target. Alternative 3 is projected to result in an annual attainment of 77 of the target.

The weekly limit in Alternative 3 for the OA South fishery was set to 1,880 pounds, in order to not exceed the weekly limit in the LE South fishery, and refrain from encouraging an effort shift between the two sectors. No alternatives are presented for the LE South fishery (other than No Action), since projected attainment for this fishery under No Action is already 96 percent of the target.

**Table 2. Alternative landing limits (in pounds), for the limited entry and open access sectors of the sablefish non-trawl fixed-gear fisheries north and south of 36° N. latitude in Period 6 (November and December) of 2013. There are no alternatives presented for the LE South fishery, since projected attainment for this fishery under No Action is already 96 percent.**

| Limits & Attainment | LE North | OA North | OA South | South Sum |
|---|---|---|---|---|
| **No Action** | | | | |
| Bimonthly | 3,330 | 1,600 | 2,920 | - |
| Weekly | 1,110 | 800 | 1,460 | - |
| Daily | - | 300 | 300 | - |
| **Alternative 1** | | | | |
| Bimonthly | 5,000 | 2,100 | 3,500 | - |
| Weekly | 1,710 | 1,050 | 1,750 | - |
| Daily | - | 300 | 350 | - |
| Projected attainment | 89% | 89% | 64% | 82% |
| **Alternative 2** | | | | |
| Bimonthly | 5,500 | 2,400 | 3,800 | - |
| Weekly | 1,850 | 1,200 | 1,800 | - |
| Daily | - | 300 | 380 | - |
| Projected attainment | 91% | 91% | 72% | 85% |
| **Alternative 3** | | | | |
| Bimonthly | 6300 | 2600 | 4,000 | - |
| Weekly | 2,100 | 1,300 | 1,880 | - |
| Daily | - | 325 | 400 | - |
| Projected attainment | 95% | 95% | 77% | 87% |

### 1.1.3. Uncertainty in ex-vessel price and forecasted landings in the LE North fishery

We addressed uncertainty in ex-vessel prices for the LE North fishery through the remainder of the year, by producing forecasts for each alternative under three different price assumptions, including a) continued linear decline (at 2013 rate), b) flat (price remains at Period 4 average level for the remainder of the year), and c) reversal (linear trend reverses to a linear increase at the opposite slope as 2013 price decline). Ex-vessel sablefish price is one predictor in this model. Our assumption was that the fishery would experience a continued decline in ex-vessel prices for the remainder of the year, and this is reflected in the alternatives in Table 2. Under an assumption of price reversal, the highest projected annual landings were over the landing target (under Alternative 3 and a price reversal; projected attainment = 104 percent). A matrix of different projected annual harvest amounts in the LE North fishery, according to price and alternative is expressed in Figure 2 and Table 3.

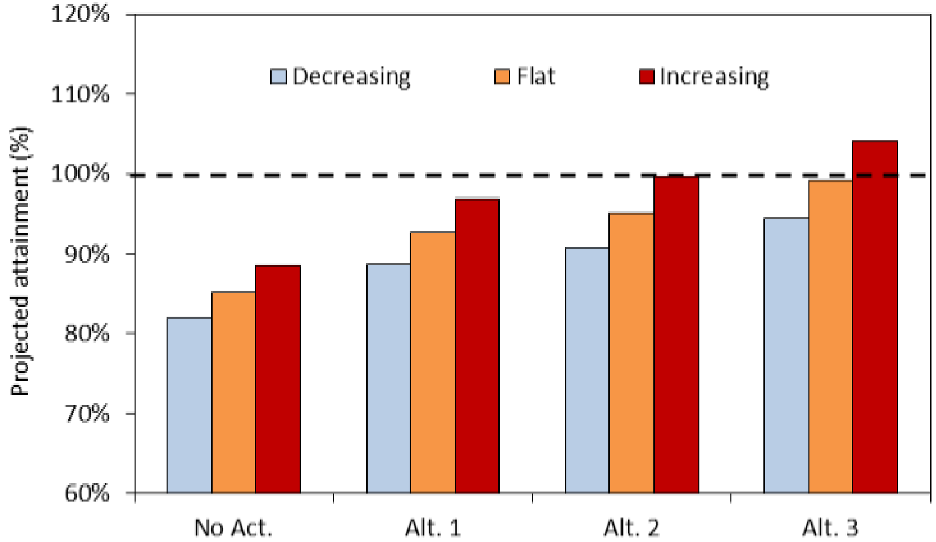


**Figure 2. Projected annual attainment rates for the LE North daily trip limit fishery in 2013, under the range of alternatives, with corresponding assumptions about sablefish ex-vessel prices for the remainder of 2013.**

**Table 3. Matrix of projected annual harvest amounts (landings, mt) and accompanying attainment rates for the LE North daily trip limit fishery in 2013, under the range of alternatives, with corresponding assumptions about sablefish ex-vessel prices for the remainder of 2013.**

| Price assumption | | No Action | Alt. 1 | Alt. 2 | Alt. 3 |
|---|---|---|---|---|---|
| Decreasing | Projection | 161 | 175 | 179 | 186 |
| | Attainment | 82% | 89% | 91% | 95% |
| Flat | Projection | 168 | 183 | 187 | 195 |
| | Attainment | 85% | 93% | 95% | 99% |
| Increasing | Projection | 174 | 191 | 196 | 205 |
| | Attainment | 89% | 97% | 100% | 104% |

1.2. Shallow and Deeper Nearshore Rockfish Trip Limits South of 40°10' N Latitude

The GMT received a request to increase the trip limits for the shallow and deeper nearshore rockfish complexes for the area south of 40°10' N. latitude (Agenda Item G.5.c Public Comment). The industry requested trip limits increases only for Period 6 in 2013 and are outlined in Table 4. The GMT notes that changes to a trip limit for period 6 in 2013 will remain in place for period 6 in 2014 (unless subsequently modified by the Council). The request for the shallow nearshore rockfish complex, however, is a moot point since the trip limit amount requested is already in place (NMFS Public Notice NMFS-SEA-13-16). Therefore, analysis was completed for just the deeper nearshore rockfish complex. State fish ticket data (September 3, 2013) indicate that landings for 2013 are on par with those from 2010 through 2012, where catch was well below the annual catch limits (ACL).

**Table 4. Limited entry and open access shallow and deeper nearshore rockfish complex bi-monthly trip limits (current and proposed, in pounds) for the area south of 40°10' N. latitude.**

| | | Nov/Dec |
|---|---|---|
| Shallow Nearshore Rockfish | Current | 1,000 / 2 mo. |
| | Proposed | 1,000 / 2 mo. |
| Deeper Nearshore Rockfish | Current | 900 / 2 mo. |
| | Proposed | 1,000 / 2 mo. |

The proposed trip limit is expected to keep target species well within harvest specifications. This trip limit increase of 100 pounds would increase the mortality impacts of canary by 0.1 mt with no appreciable increase for yelloweye rockfish estimated in the nearshore bycatch model (Table 5).

**Table 5. Scorecard changes as a result of implementing the proposed nearshore rockfish trip limits (in mt).**

| Species | Nearshore Scorecard Share | Model Estimates with Updated Observer Data a/ | Industry Proposal Estimates |
|---|---|---|---|
| Canary | 6.2 | 7.2 | 7.3 |
| Yelloweye | 1.2 | 1.1 | 1.1 |

a/ The nearshore model was updated with the latest WCGOP data at the March 2013 meeting.

The proposed trip limit option (and catch estimates) assume similar fleet behavior under the slightly higher trip limit. Analysis of the most recent landings data for this fishery indicates that less than 10 percent of the participants in the area south of 40°10' N latitude take greater than 50 percent of their potential maximum allowable take. If fleet behavior changes such that the landings of deeper nearshore rockfish exceed those currently accounted for within the nearshore model, as a result of this proposed change, there could be an increase in overfished species impacts. Current projections for overfished species can be found in Attachment 1.

1.3. Petrale sole surplus carryover from 2012 to 2013

At the June 2013 PFMC meeting, the GMT was tasked by the PFMC with evaluating the issuance of 2012 petrale sole surplus carryover into the 2013 shorebased individual fishing quota (IFQ) fishery for Council reconsideration in September (June 2013 PFMC Meeting Decision Summary Document, http://www.pcouncil.org/wp-content/uploads/0613decisions.pdf).

The GMT previously discussed the issue of carryover in June 2012 (Agenda Item D.8.b, Supplemental GMT Report), September 2012 (Agenda Item H.5.b., Supplemental GMT Report), and March 2013 (Agenda Item H.3.b. Supplemental GMT Report). Those discussions included basis for allowing eligible surplus carryover for sablefish from 2011 to 2012 (September 2012 statement), discussions regarding long-term solutions to carryover provisions (September and June 2012 statements) meaning (or penalty) of exceeding ACLs relative to exceeding overfishing levels (OFLs; June statement), and finally, issuance of surplus carryover pounds for sablefish and petrale sole from 2012 to 2013.

In this section, the GMT reviews updated catch projections for petrale sole, current catch data and other relevant information. Catch data from the IFQ vessel account database were queried on August 13, 2013, and the GMT scorecard for overfished species was updated for September. The GMT was also provided guidance and information from the NMFS, Northwest Region (NWR) regarding surplus carryover quota pounds (QP) from the 2012 fishery. The data provided by NWR are final. Updated 2013 annual catch projections reflect these data.

The NMFS made a decision in May, not to issue 2012 surplus carryover for petrale sole in 2013. The rationale for that decision is detailed in the May 6 letter to the PFMC (http://www.pcouncil.org/wp-content/uploads/F9b_NMFS_LTR1_JUN2013BB.pdf). The NMFS letter to the Council highlights the following points relevant to their decision.

1) Petrale sole is an overfished species. The new 2013 assessment is now complete, and the stock status did not change.
2) The IFQ program caught more than the allocation last year. In the 2011-12 surplus carryover decision, the NMFS established a policy in May of 2012 to not issue surplus carryover when 100 percent or more of the preceding year's allocation was caught (The percent attainment for the trawl sector in 2012 was 100.3 percent).
3) There is a potentially high risk of exceeding the petrale sole ACL in 2013.

### 1.3.1. Updated catch projection for petrale sole during 2013

The current projection calls for continued high attainment of the petrale sole trawl allocation and ACL in 2013. Catch of petrale during 2013 is currently proceeding very similarly to previous years (next section), upon which the current projection was based. Overall attainment of the petrale sole allocation in the 2012 season of the IFQ program is shown in Table 6, and on the IFQ Program public website (https://www.webapps.nwfsc.noaa.gov/ifq/).

The GMT's best estimate is that if surplus carryover pounds were issued for petrale sole from 2012 to 2013, this would lead to a projected 97.5 percent attainment of the 2013 ACL (2,526 mt/2,592 mt, Table 1). Without surplus carryover of petrale sole, the projected attainment of the petrale sole ACL is then 96.7 percent (2,507 mt/2,592 mt). Table 6 and Table 7 show the components of the calculation. If 15 mt of surplus carryover were issued, that projection changes to 97.3 percent of the ACL; if 10 mt were issued, the projection changes to 97.1 percent.

Overall attainment of the total available petrale sole pounds in the 2012 season of the IFQ program, and currently for 2013 is shown in Table 6, and on the IFQ Program public website (https://www.webapps.nwfsc.noaa.gov/ifq/). The current ACL attainment estimate differs from the GMT's previous projection of petrale attainment of the 2013 ACL, (which rounded to 99 percent) by approximately one percent only because the method of calculation is slightly different. The current projection reflects attainment of total available pounds in the IFQ fishery, rather than the previous method, which treated 2012 trawl allocation plus a remainder for additional pounds caught, such as surplus carryover pounds separately. The current method is the most appropriate since carryover pounds must be debited first for each account as fish are caught.

Petrale sole is currently an overfished species managed under a rebuilding plan. Catch of petrale sole is trawl-dominant, with 94 percent of the catch estimated to have come from the IFQ fishery in 2012. Since such a high proportion of the total catch comes from the commercial trawl sector, large unexpected amounts of catch are unlikely to appear from many other sectors during a given season; only the tribal fishery, with a set-aside of 220 mt in 2013, appears capable of adding any substantial uncertainty in catch, above the commercial trawl sector.

The IFQ fishery is seeing a large increase in targeting opportunity for this valuable species in 2013, since the petrale sole ACL more than doubled from 2012 to 2013 (from 1,160 mt in 2012, to 2,592 mt in 2013), and the amount of surplus carryover (20 mt) from 2012, relative to the 2013 ACL is small (0.7 percent).

It should be noted that changes to rockfish conservation area (RCA) boundaries are unlikely to be effective at curtailing petrale sole catch in the IFQ fishery, as an inseason accountability measure. Petrale sole's highest density is reported to be 160 to 250 fathoms, and adults migrate seasonally between deep winter spawning areas to shallower spring feeding grounds (Status of the Pacific Coast Groundfish Fishery, Vol. 1, 2008, PFMC, http://www.pcouncil.org/wp-content/uploads/SAFE_2008_March.pdf). Modified RCA boundaries exist to allow or deny access to those shallow spring feeding grounds. However, by the time managers could become aware that a conservation concern due to high catch has developed, the opportunity to use RCA boundaries will have already passed, and petrale sole will have left their spring feeding grounds, and returned to deeper waters. On average, half of the annual petrale sole catch each year has occurred during four winter months in the IFQ program (November through February), and 28 percent of the annual catch happens in November and December alone (2011-2012, Figure 2.b.). Moving the seaward RCA to outside the area of highest density (deeper than 250 fm), although potentially somewhat effective, would be a severe accountability measure, which would make fishing very difficult for many target species. Taken together, this means that RCAs are not an effective tool to mitigate catch of petrale sole (late in the year), given the likely timing of need for implementation of an accountability measure to stay within the petrale sole ACL.

The GMT reminds the Council that current regulations provide the option of issuing up to 10 percent of the eligible surplus carryover. I.e., the Council may elect to reduce the eligible carryover percentage if necessary.

**Table 6. Projected all-sector catch and attainment of 2013 ACL in metric tons (mt), considering potential issuance of surplus carryover (with carryover) in the Shorebased IFQ Program, from 2012 to 2013. Final values are rounded to the nearest metric ton for presentation in the table. Sector catch projections are from projection model output, catch of set-asides is assumed 100 percent attainment, in agreement with the GMT overfished species scorecard for September 2013.**

| Species | Petrale Sole |
|---|---|
| Projected percent of 2013 ACL | 97.47% |
| 2013 OFL (mt) | 2,711 |
| 2013 ACL (mt) | 2,592 |
| Sum of projected 2013 impacts (all sectors) | 2,526 |
| Projected 2013 IFQ fishery catch ([2012 % attainment from Table 7 * 2013 total available]; converted to mt) | 2,284 |
| At-sea whiting | 5.0 |
| Non-trawl | 2.2 |
| Recreational | 1.0 |
| Set-aside incidental OA | 2.4 |
| Set-aside EFP | 0.0 |
| Set-aside research | 11.6 |
| Set-aside tribal | 220.0 |

**Table 7. Projected catch and attainment within only the Shorebased IFQ Program (mt), considering attainment of total available quota pounds in 2012 (surplus and allocated pounds). Surplus carryover pounds are debited first, and thus should be considered together with allocated pounds when examining attainment and projecting catch for 2013. Final values are rounded to the nearest metric ton for presentation in the table.**

| IFQ species | Petrale Sole |
|---|---|
| 2012 allocation | 1,055 |
| 2012 final total catch | 1,058 |
| 2011 eligible surplus carryover into 2012 | 28 |
| 2012 total available w/ surplus carryover | 1,083 |
| 2012 attainment of total available | 97.70% |
| 2012 attainment of allocation only | 100.31% |
| 2013 allocation | 2,318 |
| 2012 eligible surplus carryover into 2013 | 20 |
| 2013 total available w/ surplus carryover | 2,338 |
| 2013 projected catch | 2,284 |
| 2013 projected attainment (of total available) | 97.70% |

### 1.3.2. Current petrale sole catch summary

Currently, petrale sole catch is progressing along a historically familiar trajectory, according to expectations based on the previous two years, and projections made in May. Catch of this species is highly trawl-dominant; for example, 94 percent of catch was from the IFQ program in 2012. The remaining six percent was caught by tribal fisheries, and less than one percent of the total catch consisted of incidental catch from other fisheries. The tribal fishery is estimated to have caught the entire tribal set-aside in 2012 (69 mt caught, of 65 mt set-aside listed in 2012 regulations), and is expected to catch the entire set-aside again this year (220 mt set-aside for 2013).

A check of monthly attainment and current annual attainment on August 13 revealed that annual attainment (Figure 3, panel a) as of July 31 was at the average of 2012 and 2013, at 48.1 percent (residual of -0.4 percent from average). Attainment on August 13 was 50.1 percent. Figure 3, panel a. shows monthly cumulative attainment of petrale sole advancing toward the annual allocation at a very similar rate (approximately at the mean) as the past two years (Figure 3, panel b), suggesting that 2013 annual catch will likely be very similar to projections (very close to attaining the full trawl allocation, and thus, close to attaining the ACL). Figure 3, panel c. shows monthly cumulative catch, which is progressing at a much faster rate than 2011 or 2012, due to the increased ACL which accompanies rebuilding of the stock. Figure 3, panel d. shows monthly catch in pounds.

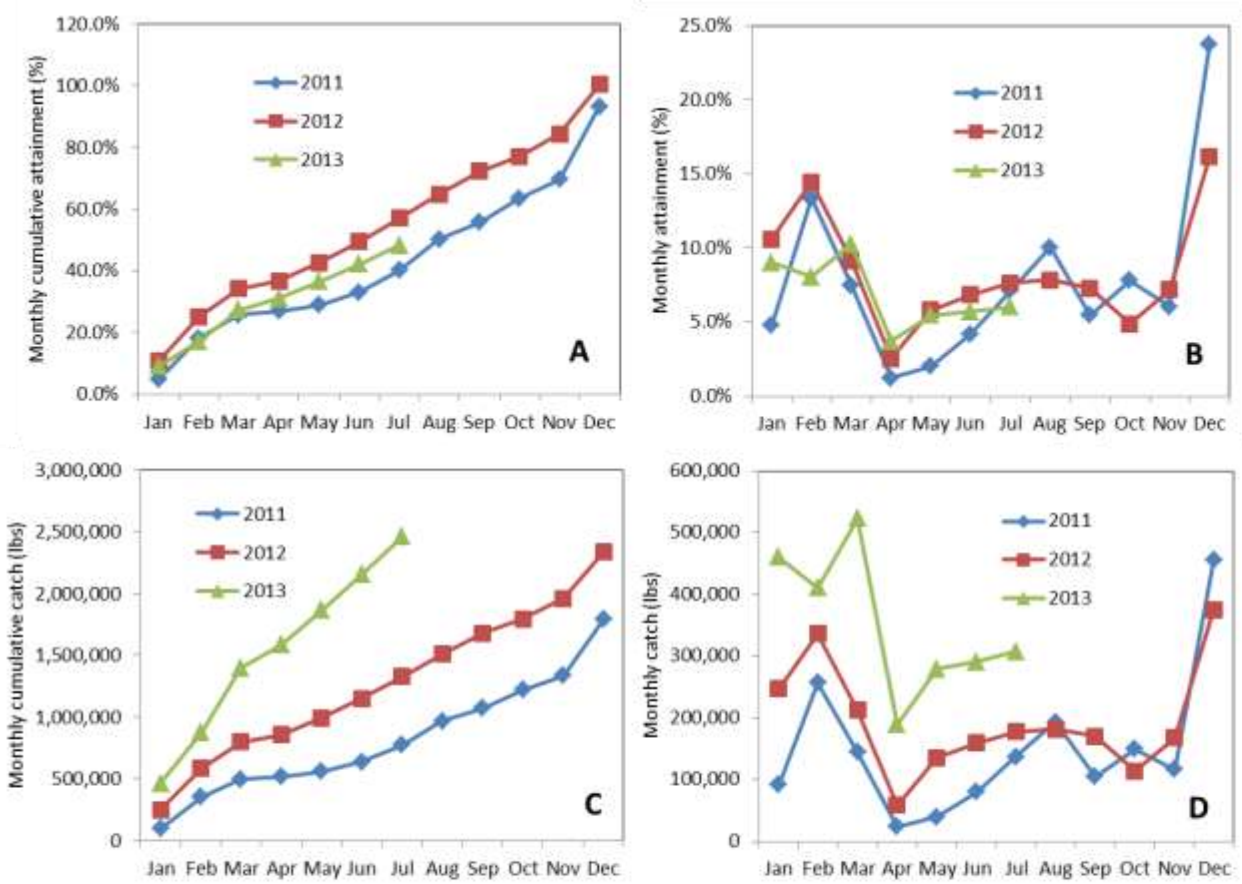


**Figure 3. Petrale sole total catch in the IFQ program, viewed as (a) monthly cumulative attainment of the annual allocation, (b) monthly attainment of the annual allocation, (c) monthly cumulative total catch, and (d) monthly catch (d). Catch is shown in pounds round weight. Panel a. shows monthly cumulative attainment of petrale sole advancing toward the annual allocation at a very similar (nearly average) rate as the past two years, suggesting that catch will likely be similar to May projections (very close to the trawl allocation, and thus, the ACL). Panel d. indicates that December is normally the month with the highest catch of any throughout the year, and highlights ineffectiveness of most reasonable accountability measures to prevent catch from exceeding the ACL.**

**The GMT recommends:**

1. **Consider the three alternatives brought forward by the GMT (Table 2 and Table 3), which show potential trip limit increases to the LE North, OA North and OA South, fixed-gear sablefish DTL fisheries, according to the Council's risk tolerance. If adopted, regulations should go into effect for the Period 6 (November and December).**

2. **Consider increasing the deeper nearshore rockfish trip limits south of 40°10' N latitude, from "900 lb./2 months" to "1,000 lb./2 months". If adopted, regulations should go into effect for Period 6 (November and December).**

3. **Consider the potential issuance of surplus carryover of petrale sole including progress of the IFQ fishery to date.**

## 2. INFORMATIONAL ITEMS

### 2.1. Research

The International Pacific Halibut Commission (IPHC) concluded their 2013 stock assessment survey, including new stations off of northern California and research stations in Washington. The total catch of yelloweye rockfish from all stations was 0.4 mt. In the overfished species scorecard (Attachment 1) the set-aside for the IPHC survey was 1.1 mt. The GMT has not received updates on any other research activities. Based on this information the projected impact to yelloweye rockfish for research has been decreased by 0.7 mt (from 3.3 mt to 2.6 mt) in the scorecard.

The GMT will adjust the scorecard at the November meeting if there are any further updates on research.

### 2.2. IFQ Fishery Catch Summary

The following (Table 8) is a "snapshot" of catch in the shorebased IFQ fishery for the period of January 1 through September 6, 2013. Total catch by IFQ catch category are available from http://www.webapp.nwfsc.noaa.gov/ifq/.

### 2.3 Scorecard Update (overfished species)

The current scorecard (Attachment 1) reflects updates to research for yelloweye rockfish and an error correction in the Incidental Open Access set-aside projected impacts for darkblotched rockfish. Both items decreased the projected impacts from what was in previous scorecards. Additionally, it was noticed that the canary rockfish projected impacts for the at-sea trawl sector had not been updated from 2012. The projected impacts should have been equal to the allocation. This correction does not affect the projected impacts for all trawl sector combined nor the overall total.

**Table 8**. **2012 IFQ quota species harvest as of September 6, 2013. These data were generated from the NOAA West Coast Groundfish IFQ Application.**

| Quota Year: 2013 | | | | |
|---|---|---|---|---|
| | Sector | Catch to | % Catch | Quota Pounds |
| IFQ Species | Quota Pounds | Date | to Date | Remaining |
| Arrowtooth flounder | 8,479,264 | 4,147,748 | 48.9% | 4,331,516 |
| Bocaccio rockfish south of 40°10' N. lat. | 165,126 | 21,649 | 13.1% | 143,477 |
| Canary rockfish | 87,964 | 13,646 | 15.5% | 74,318 |
| Chilipepper rockfish south of 40°10' N. lat. | 2,423,983 | 640,958 | 26.4% | 1,783,025 |
| Cowcod south of 40°10' N. lat. | 2,205 | 280 | 12.7% | 1,925 |
| Darkblotched rockfish | 587,976 | 140,325 | 23.9% | 447,651 |
| Dover sole | 49,018,682 | 12,850,022 | 26.2% | 36,168,660 |
| English sole | 14,032,486 | 301,727 | 2.2% | 13,730,759 |
| Lingcod north of 40°10' N. lat. | 2,695,305 | 564,176 | 20.9% | 2,131,129 |
| Lingcod south of 40°10' N. lat. | 1,089,993 | 26,601 | 2.4% | 1,063,392 |
| Longspine thornyheads north of 34°27' N. lat. | 4,100,267 | 1,719,805 | 41.9% | 2,380,462 |
| Minor shelf rockfish north of 40°10' N. lat. | 1,119,948 | 48,019 | 4.3% | 1,071,929 |
| Minor shelf rockfish south of 40°10' N. lat. | 178,574 | 22,391 | 12.5% | 156,183 |
| Minor slope rockfish north of 40°10' N. lat. | 1,712,835 | 296,820 | 17.3% | 1,416,015 |
| Minor slope rockfish south of 40°10' N. lat. | 829,181 | 168,463 | 20.3% | 660,718 |
| Other flatfish | 9,236,501 | 1,223,750 | 13.2% | 8,012,751 |
| Pacific cod | 2,480,830 | 241,974 | 9.8% | 2,238,856 |
| Pacific halibut (IBQ) north of 40°10' N. lat. | 236,660 | 52,495 | 22.2% | 184,165 |
| Pacific ocean perch north of 40°10' N. lat. | 241,241 | 56,336 | 23.4% | 184,905 |
| Pacific whiting | 188,929,545 | 131,433,859 | 69.6% | 57,495,686 |
| Petrale sole | 5,110,315 | 2,810,764 | 55.0% | 2,299,551 |
| Sablefish north of 36° N. lat. | 4,030,050 | 2,442,438 | 60.6% | 1,587,612 |
| Sablefish south of 36° N. lat. | 1,327,800 | 58,825 | 4.4% | 1,268,975 |
| Shortspine thornyheads north of 34°27' N. lat. | 3,054,183 | 1,223,757 | 40.1% | 1,830,426 |
| Shortspine thornyheads south of 34°27' N. lat. | 110,231 | 5,007 | 4.5% | 105,224 |
| Splitnose rockfish south of 40°10' N. lat. | 3,346,838 | 55,769 | 1.7% | 3,291,069 |
| Starry flounder | 1,656,774 | 5,364 | 0.3% | 1,651,410 |
| Widow rockfish | 2,191,016 | 298,745 | 13.6% | 1,892,271 |
| Yelloweye rockfish | 2,205 | 85 | 3.9% | 2,120 |
| Yellowtail rockfish north of 40°10' N. lat. | 5,809,905 | 637,978 | 11.0% | 5,171,927 |

Attachment 1. Scorecard for September 2013. Allocations[a] and projected mortality impacts (mt) of overfished groundfish species for 2013.

| Fishery | Bocaccio b/ | | Canary | | Cowcod b/ | | Dkbl | | Petrale | | POP | | Yelloweye | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Date*: 13 September 2013** | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts | Allocation a/ | Projected Impacts |
| **Off the Top Deductions** | 8.4 | 8.4 | 17.5 | 18.1 | 0.1 | 0.1 | 20.8 | 17.7 | 234.0 | 234.0 | 16.5 | 20.6 | 5.8 | 5.1 |
| EFPc/ | 6.0 | 6.0 | 1.5 | 1.5 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Research d/ | 1.7 | 1.7 | 4.5 | 4.5 | 0.1 | 0.1 | 2.1 | 2.1 | 11.6 | 11.6 | 5.2 | 5.2 | 3.3 | 2.6 |
| Incidental OA e/ | 0.7 | 0.7 | 2.0 | 2.0 | -- | -- | 18.4 | 15.0 | 2.4 | 2.4 | 0.4 | 0.6 | 0.2 | 0.2 |
| Tribal f/ | | | 9.5 | 10.1 | | | 0.1 | 0.4 | 220.0 | 220.0 | 10.9 | 14.8 | 2.3 | 2.3 |
| **Trawl Allocations** | 74.9 | 74.9 | 52.5 | 52.5 | 1.0 | 1.0 | 281.4 | 281.4 | 2,323.0 | 2,323.0 | 126.8 | 126.8 | 1.0 | 1.0 |
| **---SB Trawl** | 74.9 | 74.9 | 26.2 | 26.2 | 1.0 | 1.0 | 266.7 | 266.7 | 2,318.0 | 2,318.0 | 109.4 | 109.4 | 0.6 | 0.6 |
| **---At-Sea Trawl** | | | 8.6 | 8.6 | | | 14.7 | 14.7 | 5.0 | 5.0 | 17.4 | 17.4 | | |
| **a) At-sea whiting MS** | | | 3.6 | 3.6 | | | 6.1 | 6.1 | | | 7.2 | 7.2 | | |
| **b) At-sea whiting CP** | | | 5.0 | 5.0 | | | 8.6 | 8.6 | | | 10.2 | 10.2 | | |
| **Non-Trawl Allocation** | 236.7 | 125.5 | 46.0 | 27.2 | 1.9 | 0.8 | 14.8 | 3.5 | 35.0 | 2.2 | 6.7 | 0.2 | 11.2 | 10.4 |
| Non-Nearshore | 72.3 | | 3.5 | | | | | | | | | | 1.1 | |
| LE FG | | | | 0.9 | | | | 2.8 | | | | 0.2 | | 0.4 |
| OA FG | | | | 0.1 | | | | 0.5 | | | | 0.0 | | 0.1 |
| Directed OA: Nearshore | 0.9 | 0.5 | 6.2 | 7.2 | | 0.0 | | 0.2 | | | | | 1.2 | 1.1 |
| Recreational Groundfish | | | | | | | | | | | | | | |
| WA | | | 3.1 | 0.9 | | | | -- | | -- | | -- | 2.9 | 2.9 |
| OR | | | 10.8 | 4.7 | | | | -- | | -- | | -- | 2.6 | 2.5 |
| CA | 163.5 | 125.0 | 22.4 | 13.4 | | 0.8 | | -- | | -- | | -- | 3.4 | 3.4 |
| **TOTAL** | 320.0 | 208.8 | 116.0 | 97.8 | 3.0 | 1.9 | 317.0 | 302.6 | 2,592.0 | 2,559.2 | 150.0 | 147.6 | 18.0 | 16.5 |
| **2013 Harvest Specification** | 320 | 320 | 116 | 116 | 3.0 | 3.0 | 317 | 317 | 2,592 | 2,592 | 150 | 150 | 18 | 18 |
| **Difference** | 0.0 | 111.2 | 0.0 | 18.2 | 0.0 | 1.1 | 0.0 | 14.4 | 0.0 | 32.8 | 0.0 | 2.4 | 0.0 | 1.5 |
| **Percent of ACL** | 100.0% | 65.3% | 100.0% | 84.3% | 100.0% | 64.7% | 100.0% | 95.5% | 100.0% | 98.7% | 100.0% | 98.4% | 100.0% | 91.8% |

| Key | | |
|---|---|---|
| | (grey) | = not applicable |
| | -- | = trace, less than 0.1mt |
| | (black) | = Fixed Values |
| | (light blue) | = off the top deductions |

a/ Formal allocations are represented in the black shaded cells and are specified in regulation in Tables 1b and 1e. The other values in the allocation columns are 1) off the top deductions, 2) set asides from the trawl allocation (at-sea petrale only) 3) ad-hoc allocations recommended in the 2013-14 EIS process, 4) HG for the recreational fisheries for canary and YE.

b/ South of 40°10' N. lat.

c/ EFPs are amounts set aside to accommodate anticipated applications. Values in this table represent the estimates from the 13-14 biennial cycle, which are currently specified in regulation.

d/ Includes NMFS trawl shelf-slope surveys, the IPHC halibut survey, and expected impacts from SRPs and LOAs.

e/ The GMT's best estimate of impacts as analyzed in the 2013-2014 Environmental Impact Statement (Appendix B), which are currently specified in regulation.

f/ Tribal values in the allocation column represent the the values in regulation. Projected impacts are the tribes best estimate of catch.

# GROUNDFISH MANAGEMENT TEAM INFORMATIONAL REPORT ON THE SELECTED SPECIES SCORECARD

At the June 2012 meeting, the Council requested the Groundfish Management Team (GMT) provide landings information by sector for aurora, rougheye, shortraker, China, copper, and quillback rockfish under the inseason agenda item (see Council meeting minutes at http://tinyurl.com/ldaaoqo). The purpose of presenting these data is to gain a better understanding of how catch accrues by sector throughout the year for these species. This information is not intended to inform inseason action. Per the Council request, the GMT prepared a landings report (Table 1, Table 2, and Table 3) of these selected species.

Originally, landings information was to be summarized from existing automated database reports. However, the GMT went a step further, and together with Pacific States Marine Fisheries Commission (PSMFC), Pacific Fisheries Management Council (PFMC) and National Marine Fisheries Service (NMFS) staff, developed a database reporting tool housed within PacFIN, which updates regularly to inform this data request. The current report includes discard estimates from the current year in the at-sea sectors (via NORPAC), recreational fisheries (via RecFIN), and annual discard estimates from the most recent year available (West Coast Groundfish Observer Program, 2011) in the shorebased sectors. Annual shoreside discard estimates from 2011 are intended to serve as a proxy, since current discard estimates are not available for these species and sectors.

Three tables are presented; Table 1 summarizes catch by species and management area, while Table 2 summarizes catch by species and sector, only for the area north of 40°10' N. latitude, and Table 3 does the same for the area south of 40°10' N. latitude. Footnotes in Table 1 include the anticipated 2015 OFLs to inform how current catches relate to potential future harvest specifications (i.e., 2015). Landings data were better than 90 percent complete through May in Washington and California, and through July in Oregon, at the time of this query, September 11, 2013. Component overfishing levels (OFLs) were taken from the 2013-14 Biennial Harvest Specifications Final Environmental Impact Statement. The estimates given here may not match exactly with every sector estimate obtained separately from independent databases, due to reporting lag and data capture date.

Rougheye rockfish is the only species appears to be harvested at or above the component OFL. The 2013 landings are at 99.5 percent of the component OFL, and if 2013 at-sea discard and the proxy estimate of 2013 annual shoreside discard are included, that figure would be 153 percent of the 2013 component OFL. It is important to note that since OFLs are set for stock complexes, rather than for individual stocks within a complex, the Scientific and Statistical Committee recommends against using OFL contribution values to evaluate whether overfishing is occurring for component stocks (see http://tinyurl.com/kz7p639). Such explorations inform the performance of the stock complex.

**Table 1.** Catch estimates of selected species, identified in the June 2012 PFMC meeting, including landings for shoreside and at-sea sectors for 2013, at-sea sector discard for 2013, and shoreside discard from 2011 (proxy for 2013 annual shoreside discard), aggregated by species, complex and management area. For informational purposes; not intended for inseason Council action.

| SPECIES | COMPLEX | MGMT AREA | 2013 RETAINED (mt) | 2013 DISCARD (mt) | 2011 WCGOP ANNUAL DISCARD (mt) | SUM ALL | 2013 COMP. OFL (mt) | % OF OFL |
|---|---|---|---|---|---|---|---|---|
| AURORA ROCKFISH a/ | MINOR SLOPE | N. 40°10' | 8.10 | 0.00 | 2.08 | 10.19 | 15.4 | 66% |
| | | S. 40°10' | 2.40 | | 1.10 | 3.50 | 26.1 | 13% |
| CHINA ROCKFISH | MINOR NS | N. 40°10' | 7.48 | 0.34 | 0.11 | 7.94 | 9.8 | 81% |
| | | S. 40°10' | 3.94 | 0.08 | 1.12 | 5.13 | 16.6 | 31% |
| COPPER ROCKFISH | MINOR NS | N. 40°10' | 4.70 | 0.07 | 0.05 | 4.82 | 26.0 | 19% |
| | | S. 40°10' | 42.59 | 1.69 | 0.12 | 44.40 | 141.5 | 31% |
| QUILLBACK ROCKFISH | MINOR NS | N. 40°10' | 5.99 | 0.25 | 0.05 | 6.29 | 7.4 | 85% |
| | | S. 40°10' | 0.39 | 0.00 | 0.00 | 0.39 | 5.4 | 7% |
| ROUGHEYE ROCKFISH b/ | MINOR SLOPE | N. 40°10' | 70.87 | 1.87 | 35.97 | 108.71 | 71.1 | 153% |
| | | S. 40°10' | 0.00 | | 0.08 | 0.08 | 0.4 | 20% |
| SHORTRAKER ROCKFISH | MINOR SLOPE | N. 40°10' | 11.93 | | 0.34 | 12.27 | 18.7 | 66% |
| | | S. 40°10' | | | | 0.00 | 0.1 | 0% |
| SHORTRAKER/ROUGHEYE | MINOR SLOPE | N. 40°10' | | | 0.38 | 0.38 | NA | - |

a/ Aurora rockfish projected 2015 OFLs are 17.4 mt north of 40° 10' and 74.3 mt south of 40° 10'; percentage of 2015 OFLs are 57 percent and 5 percent, respectively

b/ Rougheye rockfish projected 2015 OFLs are 201.9 mt north of 40° 10' and 4.1 mt south of 40° 10'; percentage of 2015 OFLs are 35 percent and 2 percent respectively

**Table 2**. Catch estimates of selected species, in the management area ***North of 40°10' N. latitude only***, identified in the June 2012 PFMC meeting, including landings for shoreside and at-sea sectors for 2013, at-sea sector discard for 2013, and shoreside discard from 2011 (proxy for 2013 annual shoreside discard), aggregated by species, management area, and sector. For informational purposes; not intended for inseason Council action.

| SPECIES | FINAL SECTOR NAME | 2013 RETAINED (mt) | 2013 DISCARD (mt) | 2011 WCGOP ANNUAL DISCARD (mt) | SUM ALL | % OF FISHERY |
|---|---|---|---|---|---|---|
| AURORA ROCKFISH | AT-SEA HAKE CP | 0.00 | 0.00 | 0.04 | 0.04 | 0.4% |
| | AT-SEA HAKE MS | 0.00 | 0.00 | | 0.00 | 0.0% |
| | IFQ FIXED GEAR | 0.01 | | 0.00 | 0.01 | 0.1% |
| | IFQ TRAWL GEAR | 7.92 | | 1.90 | 9.82 | 96.4% |
| | INCIDENTAL/MISCELLANEOUS | 0.13 | | 0.12 | 0.25 | 2.4% |
| | NONNEARSHORE FIXED GEAR | 0.01 | | 0.02 | 0.03 | 0.3% |
| | SHORESIDE HAKE | 0.03 | | 0.00 | 0.03 | 0.3% |
| | TREATY | | | 0.00 | 0.00 | 0.0% |
| CHINA ROCKFISH | CA RECREATIONAL | 0.30 | 0.04 | | 0.34 | 4.2% |
| | INCIDENTAL/MISCELLANEOUS | 0.00 | | | 0.00 | 0.0% |
| | NEARSHORE FIXED GEAR | 3.01 | | 0.11 | 3.12 | 39.3% |
| | OR RECREATIONAL | 2.13 | 0.04 | | 2.17 | 27.3% |
| | WA RECREATIONAL | 2.05 | 0.26 | | 2.31 | 29.1% |
| COPPER ROCKFISH | CA RECREATIONAL | 0.40 | 0.01 | | 0.41 | 8.5% |
| | INCIDENTAL/MISCELLANEOUS | 0.01 | | | 0.01 | 0.1% |
| | NEARSHORE FIXED GEAR | 0.63 | | 0.05 | 0.68 | 14.1% |
| | OR RECREATIONAL | 2.82 | 0.00 | | 2.82 | 58.6% |
| | WA RECREATIONAL | 0.84 | 0.06 | | 0.90 | 18.7% |
| QUILLBACK ROCKFISH | CA RECREATIONAL | 0.70 | 0.00 | | 0.70 | 11.2% |
| | IFQ TRAWL GEAR | 0.04 | | 0.03 | 0.06 | 1.0% |
| | INCIDENTAL/MISCELLANEOUS | 0.01 | | | 0.01 | 0.1% |
| | NEARSHORE FIXED GEAR | 0.96 | | 0.02 | 0.99 | 15.7% |
| | OR RECREATIONAL | 3.50 | 0.10 | | 3.61 | 57.4% |
| | WA RECREATIONAL | 0.78 | 0.14 | | 0.92 | 14.7% |

| | | | | | | |
|---|---|---|---|---|---|---|
| ROUGHEYE ROCKFISH | AT-SEA HAKE CP | 2.98 | 1.51 | 26.81 | 31.31 | 28.8% |
| | AT-SEA HAKE MS | 0.61 | 0.35 | | 0.96 | 0.9% |
| | IFQ FIXED GEAR | 0.14 | | 8.04 | 8.18 | 7.5% |
| | IFQ TRAWL GEAR | 46.29 | | 0.04 | 46.33 | 42.6% |
| | INCIDENTAL/MISCELLANEOUS | 0.81 | | 0.01 | 0.82 | 0.8% |
| | NEARSHORE FIXED GEAR | | | 0.00 | 0.00 | 0.0% |
| | NONNEARSHORE FIXED GEAR | 13.76 | | 0.99 | 14.74 | 13.6% |
| | SHORESIDE HAKE | 0.04 | | 0.00 | 0.04 | 0.0% |
| | TREATY | 6.24 | | 0.08 | 6.32 | 5.8% |
| SHORTRAKER ROCKFISH | AT-SEA HAKE CP | | | 0.03 | 0.03 | 0.3% |
| | IFQ FIXED GEAR | | | 0.21 | 0.21 | 1.7% |
| | IFQ TRAWL GEAR | 10.80 | | 0.03 | 10.83 | 88.2% |
| | INCIDENTAL/MISCELLANEOUS | 0.20 | | 0.00 | 0.20 | 1.6% |
| | NONNEARSHORE FIXED GEAR | 0.46 | | 0.07 | 0.53 | 4.3% |
| | SHORESIDE HAKE | 0.06 | | 0.00 | 0.06 | 0.5% |
| | TREATY | 0.42 | | 0.00 | 0.42 | 3.4% |
| SHORTRAKER/ROUGHEYE ROCKFISH | AT-SEA HAKE CP | | | 0.01 | 0.01 | NA |
| | IFQ FIXED GEAR | | | 0.22 | 0.22 | NA |
| | IFQ TRAWL GEAR | | | 0.00 | 0.00 | NA |
| | NONNEARSHORE FIXED GEAR | | | 0.15 | 0.15 | NA |

**Table 3.** Catch estimates of selected species, in the management area ***South of 40°10' N. latitude only***, identified in the June 2012 PFMC meeting, including landings for shoreside and at-sea sectors for 2013, at-sea sector discard for 2013, and shoreside discard from 2011 (proxy for 2013 annual shoreside discard), aggregated by species, management area, and sector. For informational purposes; not intended for inseason Council action.

| SPECIES | FINAL SECTOR NAME | 2013 RETAINED (mt) | 2013 DISCARD (mt) | 2011 WCGOP ANNUAL DISCARD (mt) | SUM ALL | % OF FISHERY |
|---|---|---|---|---|---|---|
| AURORA ROCKFISH | IFQ FIXED GEAR | 0.01 | | 0.00 | 0.02 | 0.4% |
| | IFQ TRAWL GEAR | 2.34 | | 0.75 | 3.09 | 88.2% |
| | NONNEARSHORE FIXED GEAR | 0.05 | | 0.35 | 0.40 | 11.3% |
| CHINA ROCKFISH | CA RECREATIONAL | 3.62 | 0.08 | | 3.70 | 72.1% |
| | INCIDENTAL/MISCELLANEOUS | 0.02 | | 0.00 | 0.02 | 0.4% |
| | NEARSHORE FIXED GEAR | 0.30 | | 1.12 | 1.41 | 27.5% |
| COPPER ROCKFISH | CA RECREATIONAL | 40.65 | 1.69 | | 42.34 | 95.4% |
| | INCIDENTAL/MISCELLANEOUS | 0.48 | | 0.00 | 0.48 | 1.1% |
| | NEARSHORE FIXED GEAR | 1.47 | | 0.12 | 1.58 | 3.6% |
| QUILLBACK ROCKFISH | CA RECREATIONAL | 0.37 | 0.00 | | 0.37 | 95.2% |
| | NEARSHORE FIXED GEAR | 0.02 | | 0.00 | 0.02 | 4.8% |
| ROUGHEYE ROCKFISH | IFQ TRAWL GEAR | 0.00 | | 0.00 | 0.00 | 1.4% |
| | NONNEARSHORE FIXED GEAR | | | 0.08 | 0.08 | 98.6% |

Agenda Item G.5.c
Public Comment
September 2013

Chuck Tracy - NOAA Affiliate <chuck.tracy@noaa.gov>

# Fwd: September, 2013 PFMC Meeting Groundfish Inseason Agenda Item G.5

1 message

**PFMC Comments - NOAA Service Account** <pfmc.comments@noaa.gov> Mon, Aug 19, 2013 at 10:51 AM
To: Chuck Tracy - NOAA Affiliate <chuck.tracy@noaa.gov>, Kelly Ames - NOAA Affiliate <kelly.ames@noaa.gov>
Cc: John DeVore - NOAA Affiliate <john.devore@noaa.gov>

---------- Forwarded message ----------
From: **Bill James** <Halibutbill@live.com>
Date: Sat, Aug 17, 2013 at 10:34 PM
Subject: September, 2013 PFMC Meeting Groundfish Inseason Agenda Item G.5
To: "pfmc." <pfmc.comments@noaa.gov>
Cc: Bill James <Halibutbill@live.com>

Madame Chair members of the Council: My name is Bill James. I am a California Commercial Nearshore Fishermen representing myself and I am also speaking as the fisheries consultant for the Port San Luis Commercial Fishermen's Association in Central California.

We request a increase in the bi-monthly trip limit for period six (NOV-DEC) for 1). Shallow Nearshore Rockfish Species and 2) Deeper Nearshore Rockfish Species to 1000 lbs. per the two months south of 40:10.

Again this year the landings of Nearshore Species is far below the ACL for the year. This time of the year (nov-dec)our market is open and can readily accept our increased catch.

Please increase 1). the Shallow Nearshore Rockfish Species south of 40:10 to 1000 pounds per 2 months and also 2). increase the Deeper Nearshore Rockfish Species south of 40:10 to 1000 pounds per two months for period six (nov-dec).

I wish to thank the Council for allowing me to submit this request. Sincerely, Bill James

--
Thank you for your comments to the Pacific Fishery Management Council. Your comments have been received and will be forwarded to the appropriate staff member for processing.

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220
Phone: 503-820-2280
Toll Free: 1-866-806-7204
Fax: 503-820-2299
Twitter: http://Twitter.com/PacificCouncil

# CONSIDERATION OF TRAWL ROCKFISH CONSERVATION AREA (RCA) BOUNDARY MODIFICATIONS

Rockfish conservation areas (RCA) are closed to commercial gear types targeting groundfish in order to protect a complex of species, such as overfished species. RCA boundaries are defined by latitude and longitude points, and are intended to approximate depth contours. Although both the eastern and western trawl and non-trawl RCA boundaries have changed over time, the area between 100 and 150 fathoms (fm) has remained closed to bottom trawl and non-trawl gears targeting groundfish since January 2003. Other fishing gears and activities, including mid-water trawl, recreational fishing, non-groundfish fishing (e.g., pink shrimp trawl, salmon troll, etc.), and scientific research are permissible in the RCA. Adjustments to the RCA boundaries are considered routine actions, which can be modified through a single Council meeting and implemented through a single *Federal Register* notice, when appropriate.

At their March 2013 meeting, the Council considered the performance of the shorebased individual fishing quota (IFQ) fishery in 2011 and 2012, progress to date in 2013, as well as additional pre-IFQ bycatch rate data, and recommended the shoreward boundary of the trawl RCA be moved from 75 to 100 fm from the area 40°10’ to 48°10’ N. latitude in Period 2. The RCA modification was intended to provide greater access to target species while allowing the individual accountability afforded by the rationalized fishery to minimize bycatch of overfished species.

At the April 2013 Council meeting and in a subsequent letter, National Marine Fisheries Service (NMFS) announced that the RCA modifications could not be implemented under the inseason procedures and that such adjustments should allow for public input through a notice and comment rulemaking (Agenda Item F.9.b, NMFS Letter 2, June 2013). The Council recommended the following adjustments for implementation through a notice and comment rulemaking: between 40°10' and 48°10' N. latitude, implement a 100 fm shoreward boundary and 150 fm seaward boundary beginning in Period 6 in 2013 through 2014. Routine adjustments of the RCA would still be available to address emerging concerns, if necessary. At its June 2013 meeting, the Council was notified that NMFS was preparing an additional analysis of the proposed action in the form of an Environmental Assessment (EA).

Under this agenda item, the Council should consider the impact analysis contained in the draft EA (Agenda Item G.6.b, Draft EA). Alternative 1 describes the Council-recommended RCA structure as described above from the April meeting. Alternative 2 is the same as Alternative 1, except that in the area from the 40°10’ N. latitude to 45°46’ N. latitude, the seaward RCA boundary would be 200 fm modified year-round. The additional alternative was added by NMFS because that area may have had a greater opportunity to recover from bottom trawl gear impacts. In the event the Council decides to recommend an alternate RCA configuration in light of the new analysis, recommendations can be made at this time.

**Council Action:**

1. **Consider analysis in the draft EA and recommend a trawl RCA structure for the 2013-2104 fisheries.**

Reference Materials:

1. Agenda Item G.6.b, Draft EA: Trawl Rockfish Conservation Area Boundary Modifications.

Agenda Order:

a. Agenda Item Overview — Kelly Ames
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Consider Recommendations for Trawl RCA Boundary Modifications for 2013-2014 Groundfish Fisheries

PFMC
08/22/13

# Trawl Rockfish Conservation Area (RCA) Boundary Modifications

## *Draft* Environmental Assessment

September 2013

National Marine Fisheries Service
Sustainable Fisheries Division
Northwest Region

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# CHAPTER 1 INTRODUCTION

## 1.1 How This Document is Organized

This document proposes alternatives (Chapter 2), describes the current physical, biological, and socio-economic environments relevant to the action (Chapter 3), and analyzes the alternatives for trawl rockfish conservation area (RCA) boundary configurations (Chapter 4). The analyses in Chapter 4 compare the action alternatives to the No Action Alternative and provide an assessment of the potential impacts relative to specified ecological, biological, and socio-economic resources.

## 1.2 Purpose and Need

The purpose of the action is to increase access to target stocks through liberalizations of the trawl RCA boundaries from 40°10’ to 48° 10’ N. latitude while allowing the individual accountability of the shorebased trawl Individual Fishing Quota (IFQ) program to minimize bycatch and incidental catch of overfished species. The action is needed to enable participants the ability to more fully and efficiently utilize their quota pounds while still meeting the Council’s and Agency’s goal for sustainability of the Pacific Coast groundfish fishery.

## 1.3 Background

An RCA is an area closed to fishing by particular gear types, bounded by lines specifically defined by latitude and longitude coordinates established at 50 CFR 660.391–394. Although the boundary lines defined by the latitude and longitude coordinates are typically generalized approximations of depth, the RCAs are not actually defined by depth contours, and the boundary lines that define the RCA may close areas that are deeper or shallower than the actual depth contours. Vessels that are subject to the RCA restrictions may not fish in the RCA, or operate in the RCA for any purpose other than transiting. The coordinates establishing a specific boundary line, such as the 100 fathom (fm) line, can be used to define RCAs for different gear types.

There are numerous commercial gears used in the Pacific coast groundfish fishery, among which are groundfish trawl gears. There are two primary types of groundfish trawl: bottom trawl and midwater trawl. Bottom trawl gear is divided into large footrope and small footrope gear (including selective flatfish gear). The action being considered here would affect where vessels fishing with groundfish bottom trawl gear can fish. Trawl RCA boundaries have been routinely adjusted over various depths since their inception. Once RCA boundary lines are established in regulation through latitude and longitude coordinates and are available for use, there are two primary ways in which RCAs can change through time. The first is modification of latitude and longitude coordinate points to better approximate a particular depth contour while allowing access to target stocks, or to correct inaccurate coordinates. The second is changing already approved waypoints to alter seaward and shoreward boundary lines that are used to define the RCA (e.g., an RCA originally bounded by the lines approximating the 75 fm and 150 fm depth contours may be changed to be bounded from the shoreline to 250 fm). The action alternatives under consideration, described in Chapter 2, are this second type of change.

### *1.3.1* History of the Trawl RCAs North of 40°10' N. Latitude

Depth-based management measures, particularly the setting of large areas closed to bottom trawling, were first implemented in 2002 to reduce catch of darkblotched rockfish. Darkblotched rockfish was declared overfished in 2000 and management measures at the time were proving inadequate to keep catch within the species' optimum yield (OY). Through the use of depth-based closures, the Council and NMFS sought to allow some fishing for healthy stocks while still protecting darkblotched rockfish.

After reviewing the darkblotched rockfish depth distribution and the depth distribution of healthy co-occurring stocks, in 2002, the Council recommended prohibiting bottom trawling between lines approximating the 100 fm and 250 fm depth contours north of 40°10' N. latitude. To allow vessels to fish for nearshore flatfish and deepwater species occurring outside of the primary darkblotched rockfish depth range, flatfish trawling shoreward of the 100 fm line was still allowed, as was bottom trawling seaward of the 250 fm line. (67 FR 57973, September 13, 2002). The only depth-based management measure in the groundfish fishery that was in use prior to that action was a 20 fm contour off California south of 40°10' N. lat., used to control fishing inside and outside of that contour by commercial and recreational hook-and-line fisheries.[1]

Subsequently, when designing 2003 management measures, the Council recommended and NMFS implemented trawl RCAs that would provide protection for several overfished species including darkblotched rockfish, canary, lingcod, widow rockfish, yelloweye rockfish, and Pacific ocean perch. For the 2003 limited entry bottom trawl fisheries north of 40°10' N. lat., the Council recommended a closed area between lines approximating

[1] For the month of September, all groundfish bottom trawling shoreward of the 100 fm line was prohibited. Other closures, such as the cowcod conservation areas, were established earlier (e.g., 2001).

the 100‑250 fm depths, with the shoreward boundary line moving to a 75 fm line for the months of July-August. In the months of January–February and November–December, the offshore closed area boundary was revised to allow some bottom trawling in areas where petrale sole tends to aggregate. These revisions, often referred to as "petrale cutouts" are still in use when the trawl RCA boundary is established using the "modified" boundary lines as described in regulation. For example, the modified 200 fm line would include petrale cutouts, the 200 fm line would not.

While the majority of U.S. protected areas were established to conserve biodiversity or ecosystem structure (NOAA 2008), the management goal of the RCA was to aid in rebuilding overfished rockfish species (*Keller et al., in prep., 2013*).

Beginning in 2007, the structure of the RCA became highly complex, due to efforts by management to allow as much access to target species as possible, while avoiding discrete areas with high bycatch rates of rebuilding species (*Agenda Item E.5.b, Supplemental GMT Report, March 2007*); much of this management effort was focused on controlling catch of darkblotched rockfish and canary rockfish; breaking up the RCA into numerous discreet blocks to encourage more seaward effort in areas of lower risk of extreme catch events for darkblotched rockfish, to take some fishing pressure off of the shoreward areas, and balance against bycatch of canary rockfish on the shelf.

### 1.4 Scoping

At the Council's March 7–11, 2013 meeting in Tacoma, Washington, the Groundfish Advisory Sub-panel (GAP ) requested a liberalization of the shoreward trawl RCA from 75 fm to 100 fm, between 40° 10' N. latitude and 48° N. latitude, for the latter part of Period two (March-April). The GAP stated that the boundary change could increase access to target species such as yellowtail rockfish, Pacific cod, lingcod, and Dover sole (*Agenda Item H.3.b, Supplemental GAP Report*). The Groundfish Management Team (GMT) analyzed current and historical catch data to assess the potential for increased catch of overfished species resulting from the proposal (*Agenda Item H.3.b, Supplemental GMT Report*). After consideration, the Council adopted the recommendation to move the shoreward trawl rockfish conservation area boundary from 75 to 100 fm between 40°10' and 48°10' N. latitude for Period two.

Due to questions about the adequacy of the timing of the Federal Register notice announcing the March 2013 meeting, the Council's recommendations from March were considered "Preliminary Selections" to be formalized under a specific agenda item at the April 6–11, 2013 Council meeting in Portland, Oregon. At the April meeting, the Council reaffirmed its recommendation from the March meeting. In addition, Mr. Frank Lockhart (Assistant Regional Administrator for Sustainable Fisheries, NMFS Northwest Region) met with the GAP to discuss NMFS' intention to make any liberalizations being considered for 2013-2014 trawl RCA boundaries through full notice and comment rulemaking. The setting of depth-based management measures, such as changes to RCA boundaries, is designated as a routine management measure under the Groundfish FMP. As a routine measure, the Council can make recommendations for changes at a single Council meeting, which typically occurs under the groundfish inseason agenda items. Under the typical inseason process, NMFS usually asserts it has good cause to waive the Administrative Procedure Act requirements for notice and comment rulemaking because allowing for the time necessary for notice and comment would be impracticable and contrary to the public interest. However, under the specific circumstances, it did not seem that the benefits of the Council's March recommendation, as reconfirmed at the April meeting, outweighed the public's interest in having the opportunity to provide comment. (*PFMC, June, Agenda Item F.9.b, NMFS Letter 2*).

Based on NMFS' belief that that it was in the broader public interest to allow for notice and comment rulemaking during the consideration of RCA liberalizations for 2013-2014, at its April meeting the Council also considered shoreward and seaward trawl RCA boundary modifications beyond its March recommendation. Specifically, the GAP recommended making changes to the trawl RCA boundaries north of 40° 10' N. lat. to 48° 10' N. lat. through the remainder of 2014 beginning in period six of 2013 such that a 100 fm shoreward boundary and 150 fm seaward boundary would be in place year round north of 40° 10' N. lat. to 48° 10' N. lat. The GAP noted the recent low attainments of some economically important species and that liberalizing the RCA lines would allow trawlers to take advantage of opportunities to maximize the potential of their business plans, while allowing the IFQ system to minimize risks to stocks of concern. (*Agenda Item D.8.b Supplemental GAP Report*.) After consideration, the Council adopted the GAP's recommendation.

Additionally, at the Council's June 18-25, 2013 meeting in Garden Grove, California, NMFS staff notified GMT and GAP members that there was an area in the 2013-2014 recommendation that would open fishing grounds that may have had some opportunity to recover from impacts caused by bottom trawl gear. The Council was also made aware of NMFS' intention to prepare an environmental assessment (EA). The Council requested to have opportunity to evaluate the draft EA on the proposed action and either reaffirm its April recommendation, or revise their recommendation during the public comment period for the proposed action.

Additionally, an environmental organization provided public comment on the inseason agenda item (*PFMC, June 2013, agenda item F.9*). That testimony mentioned concerns about opening areas that may have recovered from bottom trawling impacts prior to completion of the groundfish Essential Fish Habitat (EFH) review. The group also stated that habitat value and the risks of a bycatch "disaster tow" should be the focus of analysis with respect to RCA boundary modifications.

Last, representatives from industry commented that they were in support of the proposed action at the March, April, and June Council meetings.

# CHAPTER 2 DESCRIPTION OF ALTERNATIVES



## 2.1 Alternatives

This EA considers three alternatives: (1) a no-action alternative (status-quo); (2) the action alternative as recommended by the Council at the April 2013 meeting; and, (3) an action alternative that would keep the area that may have had a greater opportunity to recover from bottom trawl gear (150 fm- modified 200 fm, 40° 10' to 45° 46' N. lat.) closed to groundfish bottom trawling for 2013-2014. Under all of the alternatives, only changes to RCA boundaries are considered. All other existing closed areas (including EFH conservation areas) would be maintained, as would all existing gear requirements.

### *2.1.1* No-Action Alternative

Under the no-action alternative, trawl RCAs stay as they are currently and are described in Table 2-1, below.

Table 2-1: Current (No-Action) trawl RCA boundaries (fathom) for the area between 48°10' N. lat. and 40°10' N. lat. Grey filled cells indicate the boundaries and seasons which would be changed under the action alternative(s). "m" indicates a boundary line that is modified to keep open areas seaward of the RCA for fishing winter aggregations of petrale sole.

| Area | Boundary | Jan-Feb | Mar-Apr | May-Jun | Jul-Aug | Sep-Oct | Nov-Dec |
|---|---|---|---|---|---|---|---|
| 48°10' - 45°46' | shoreward | 75 | 75 | 100 | | | 75 |
| | seaward | [m]200 | 150 | 150 | | | 150 |
| 45°46' - 40°10' | shoreward | 75 | 75 | 100 | | | 75 |
| | seaward | [m]200 | 200 | 200 | | | [m]200 |

### *2.1.2* Alternative 1, 100 fm Shoreward Boundary, 150 fm Seaward Boundary.

Under alternative 1, trawl RCAs would be modified as recommended by the Council at its April 2013 meeting.

The end result under alternative 1 would be a trawl RCA structure south of 48° 10' N. latitude that prohibits bottom trawling between the 100 fm and 150 fm RCA boundary lines. Specifically, the proposed action would change the trawl RCA boundaries as follows: (1) from a shoreward boundary line between 40° 10' N. latitude and 48° 10' N. latitude approximating 75 fm to a line approximating100 fm during periods 1, 2, and 6; (2) from a seaward boundary line between 40° 10' N. latitude and 45° 46' N. latitude approximating 200 fm to a line approximating 150 fm, during periods 1-6 (note that the modified 200 fm line is currently in place in periods 1 and 6), and; (3) from a seaward boundary line between 45° 46' N. latitude and 48° 10' N. latitude approximating the modified 200 fm to a line approximating 150 fm, during period 1. Table 2-2 below depicts the trawl RCA boundaries under alternative 1.

Table 2-2: Alternative 1 trawl RCA boundaries (fathom) for the area between 40°10' N. lat. and 48°10' N. latitude. Note: no-action trawl RCA boundaries prior to November 1, 2013 will be as demonstrated in the No-Action alternative for 2013.

| Area | Boundary | Jan-Feb | Mar-Apr | May-Jun | Jul-Aug | Sep-Oct | Nov-Dec |
|---|---|---|---|---|---|---|---|
| 48°10' - 40°10' | shoreward | 100 | | | | | |
| | seaward | 150 | | | | | |



### *2.1.3* Alternative 2, Maintaining an RCA closure from 40°10' N. latitude to 45°46' N. latitude, 150 fm to modified 200 fm.

Under alternative 2, all of the trawl RCA boundary modifications under alternative 1 would be implemented with the exception of the changes to the seaward boundary from 200 fm to 150 fm, 40° 10' N. lat to 45° 46' N. lat. Instead, the seaward boundary in this area would be changed to the modified 200 fm line year-round. The end result under alternative 2 would be a trawl RCA structure south of 48° 10' N. lat. that: (1) prohibits bottom trawling between the 100 fm and 150 fm RCA boundary lines from 45° 46' N. latitude to 48° 10' N. latitude; and (2), prohibits bottom trawling from 100 fm to the modified 200 fm line from 40° 10' N. latitude to 45° 46' N. latitude. Specifically, the proposed action would change the trawl RCA boundaries as follows: (1) from a shoreward boundary line between 40° 10' N. lat. and 48° 10' N. lat. approximating 75 fm to a line approximating100 fm during periods 1, 2, and 6; (2) from a seaward boundary line between 45° 46' N. latitude and 48° 10' N. latitude approximating the modified 200 fm to a line approximating 150 fm, during period 1.; (3) from a seaward 200 fm boundary in periods 2-5 to a modified 200 fm boundary in periods 2-5. The table below depicts the trawl RCA boundaries under alternative 2

Table 2-3: Alternative 2 trawl RCA boundaries (fathom) for the area between 40°10' N. lat. and 48°10’ N. latitude. Note: no-action trawl RCA boundaries prior to November 1, 2013 are as demonstrated in the no-action alternative for 2013. “m” indicates a boundary line that is modified to keep open areas seaward of the RCA for fishing winter aggregations of petrale sole.

| Area | Boundary | Jan-Feb | Mar-Apr | May-Jun | Jul-Aug | Sep-Oct | Nov-Dec |
|---|---|---|---|---|---|---|---|
| 48°10' - 45°46' | shoreward | 100 | | | | | |
| | seaward | 150 | | | | | |
| 45°46' - 40°10' | shoreward | 100 | | | | | |
| | seaward | m200 | | | | | |

## 2.2 Alternatives considered but rejected from analysis

At the Council’s March 7-11, 2013 meeting, the Council considered an industry request for changes to the trawl RCA boundaries forwarded by the GAP and analyzed by the GMT (see Scoping1.4). After consideration, the Council adopted the recommendation to move the shoreward trawl rockfish conservation area boundary from 75 to 100 fm between 40°10' and 48°10' N. latitude for Period two (March-April). Because the March recommendation, which was reconfirmed at the Council’s April meeting, was considered a preliminary selection and would have only made boundary changes for the last two weeks of Period 2, the alternative was rejected. Making changes only for two weeks within a single period is not considered further in this EA under either Alternatives 1 or 2 because the short-term change would not fully meet the need to provide increased access to underutilized target species.

Neither the Council nor the GAP recommended changes to RCA boundaries south of 40° 10' N. latitude because the trawl RCA south of 40°10' N. lat. was already based on a 100 fm shoreward boundary and a 150 fm seaward boundary, and thus was not restricting access to target stocks in the same manner as the trawl RCA between 40° 10' N. latitude and 48° 10' N. latitude. Additional changes to trawl RCA boundaries could be considered in the future under a different action. Changes to RCA boundaries north of 48°10' N. lat. were not recommended due to concerns with high bycatch rates of yelloweye and canary rockfish.

NMFS also considered but rejected an alternative that would have made the shoreward boundary change from 75 to 100 fm and the seaward boundary change from north of 45° 46’ N. lat. to 48° 10’ N. lat. from the modified 200 fm line to the 150 fm line, but maintained the no-action seaward boundaries from 40° 10’ N. lat. to 45° 46’ N. lat. This alternative was rejected from detailed analysis because the modified 200 fm line was already in place between 40° 10’ N. lat. and 45° 46’ N. lat. and being trawled in periods 1 and 6. Accordingly, an alternative that established a year-round modified 200 fm boundary in this area was more consistent with the purpose and need and is considered in Alternative 2.

Total elimination of the trawl RCA between 40°10' N. lat. and 48°10' N. lat. was not recommended for detailed analysis because gathering additional information about the shorebased IFQ fishery's performance in areas with potentially greater impacts to overfished species was warranted. Additional changes to trawl RCA boundaries could be considered in the future under a different action.

# CHAPTER 3 STATUS OF THE AFFECTED ENVIRONMENT

## 3.1 Physical Environment

A divergence in prevailing wind patterns causes the west wind drift (North Pacific Current) to split into two broad coastal currents when it reaches the North American Continent near Vancouver, B.C.: the California Current to the south and the Alaska Current to the north. As there are really several dominant currents in the California Current region, all of which vary in geographical location, intensity, and direction with the seasons, this region is often referred to as the California Current System.

## 3.2 West Coast Marine Ecosystem

Along the U.S. west coast within the California Current system, spatial patterns of biological distribution (biogeography) have been observed to be influenced by various factors including depth, ocean conditions, and latitude. Cape Mendocino (Mendocino Escapement) is one of the most noteworthy influences to the latitudinal distribution of rockfish species diversity in the PFMC area. Most stock assessments for groundfish tend to be either coastwide assessments, or are relative to the stocks north or south of Cape Mendocino (occasionally Cape Blanco).

The California Current Ecosystem (CCE) is loosely defined as encompassing most of the U.S. and Canada west coasts, from the northern end of Vancouver Island, British Columbia, to Point Conception, California. The trophic interactions in the CCE are extremely complex, with large fluctuations over years and decades.

To some degree, food webs are structured around coastal pelagic species (CPS) that exhibit boom-bust cycles over decadal time scales in response to low frequency climate variability, although this is a broad generalization of the trophic dynamics. Similarly, the top trophic levels of such ecosystems are often dominated by highly migratory species such as salmon, albacore tuna, sooty shearwaters, fur seals, and baleen whales, whose dynamics may be partially or wholly driven by processes in entirely different ecosystems, even different hemispheres.

### 3.3 Essential Fish Habitat

EFH is defined by the Magnuson-Stevens Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16 U.S.C. 1802(10)).

### *3.3.1* Non-Groundfish Species

EFH has been designated for non-groundfish species, such as salmon, coastal pelagic species, and highly migratory species. For salmonids, EFH in the action area is limited to pelagic habitats. For coastal pelagic and highly migratory species EFH is limited to pelagic (e.g. in the water column) or oceanographic (e.g. temperature) habitats.

### *3.3.2* Pacific Coast Groundfish

Groundfish EFH has been deemed through the PFMC process to include 1) all ocean and estuarine waters and substrates in depths less than or equal to 3,500 m, to the upriver extent of saltwater intrusion, which is defined based on ocean salt content during low runoff periods, and 2) areas associated with seamounts in depths greater than 3,500 m. The groundfish EFH designation describes 59.2 percent of the EEZ, which equates to 48,719,109 ha (142,042 square miles) in addition to state waters such as bays and estuaries (Figure 3-1) (EFH EIS, NMFS 2005).

NMFS prepared an EIS evaluating programmatic measures designed to identify and describe west coast groundfish EFH (figure 3-1 below, NMFS 2005), and minimize potential fishing impacts on west coast groundfish EFH. The Council took final action amending the groundfish FMP to incorporate new EFH provisions in November 2005. NMFS partially approved the amendment in March 2006. Implementing regulations became effective in June 2006.

In addition to identifying EFH and describing HAPCs, the Council also adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH. Principal among these are closed areas to protect sensitive habitats. There are three types of closed areas: bottom trawl closed areas, bottom contact closed areas, and a bottom trawl footprint closure. The bottom trawl closed areas are closed to all types of bottom trawl fishing gear. The bottom trawl footprint closure closes areas in the EEZ between 1,280 m (700 fm) and 3,500 m (1,094 fm), which is the outer extent of groundfish EFH. The bottom contact closed areas are closed to all types of bottom contact gear intended to make contact with the bottom during fishing operations, which includes fixed gear such as longline and pots. A more complete description of groundfish and associated EFH is contained in the groundfish FMP

Bottom trawl gear is documented often in scientific literature as having a higher impact to ocean habitat than other gear types, largely due to the unique impacts of bottom trawl gear to bottom substrate caused primarily from the trawl doors. Trawl doors can penetrate the substrate, and footropes and sweep gear may flatten and disturb biogenic mound, biogenic depression microhabitats, and micro-topographic structures (De Marignac et al., 2008). Fish utilize these micro-habitats for protection from predation and as refugia from currents (De Marignac et al., 2008).

Bottom trawling is anticipated to cause greater impact to mixed and hard substrates, as these habitats have been observed to have the vast majority of sensitive biota such as coral and sponges. Although fishermen may try to avoid these substrate types to reduce gear damage, incidental encounters with these substrates may result in some increased impacts to sensitive biota.

Small footrope gear (less than 8" in diameter) requirements were implemented to reduce impact and incentive for trawling activities in mixed (boulder) and hard substrates, and are currently required in regulation when fishing shoreward of 100 fm. In comparing differences in bottom trawl fishing patterns since before and after small footrope gear requirements were put in place, "Spatial shifts in fishing effort away from rock habitat were strikingly evident (intensity decreases were 69 - 93.7%) for all reference sites after the 2000 footrope restriction (*Bellman et al, 2005*)." Maximum trawl footrope diameter restrictions were implemented in 2000 to help control rockfish catch in hard substrate areas; reductions in rockfish catch limits prior to 2000 had already reduced trawl activity within these areas. Because these two measures were implemented together, it has confounded the effects of reduced trip limits and footrope diameter restrictions (*Hannah, 2008*). However, regarding soft substrate, small footrope gear may have a larger impact on mud substrate than sand, as small footropes may dig into the more consolidated mud causing greater disruption and longer recovery from impacts.

The impacts of specific fisheries can vary widely on the characteristics of the gear and fleet (*Kaplan et al., 2012*). It is typically assumed that trawl-induced changes have detrimental effects on production of desired species, however heavily trawled systems remain very productive (Hilborn, 2007). Recent analysis by NWFSC staff investigating long-term abundance of rockfish and demersal groundfish in the survey area has been conducted. The authors point out that there is "clear evidence that CPUE was higher in the closed area of the RCA for multiple fish species including rockfishes and other commercially targeted and non-target species, even though we were unsure if the differences were related to the original siting of the RCA in high density rockfish habitat (*Keller et al., in prep., 2013*)." It is difficult to determine if the differences observed in catch among areas existed before the closure or are a result of the ongoing protection from commercial bottom trawling afforded to closed and periodically closed areas (*Keller et al., in prep., 2013*). The consistently and significantly greater catch taken in the closed area of the trawl RCA after accounting for covariates suggests that the closure provided some degree of protection for demersal fish species within its borders (*Keller et al., in prep., 2013*)."

This analysis highlights a few key points in the Final EFH Synthesis Report to PFMC, April 2013 (*incorporated by reference*).

- The majority of bottom trawling effort occurred over soft seafloor habitats on the shelf and upper slope before EFH conservation areas were enacted, but shifted to the upper slope post-2006.
- The majority of observed fixed gear effort occurred over soft seafloor habitat.
- Midwater trawling ranges from 8-31% annually over EFH conservation areas where bottom trawling is prohibited.
- Bottom trawl effort did not appear to occur where bottom contact gear was prohibited either before or after the EFH conservation areas were established. A low level of bottom trawl fishing in these areas is likely attributable to having only start and end points of trawl sets.
- In areas were only fixed gear is allowed, effort has ranged annually from 4 – 18% of the

total fixed gear effort.

- 5% of observed fixed gear fishing effort on both the shelf and upper slope occurred over hard habitat. The highest effort relative to hard habitat occurred over the central shelf (23.7%).

Existing EFH conservation areas, other Federal closed areas, and the various state Marine Protected Areas will not be affected by this proposed action (Figure 3-2, below).

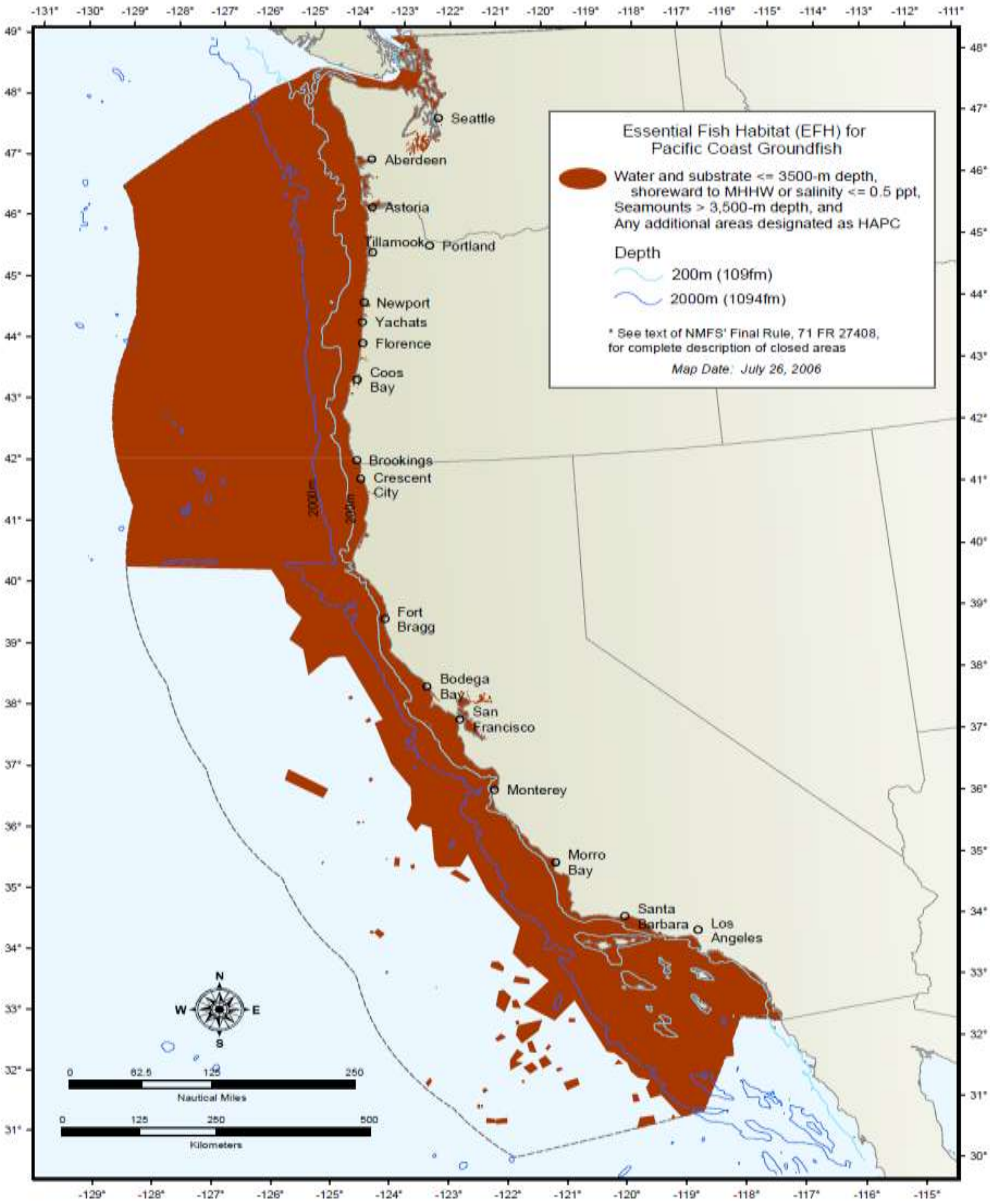



Figure 3-1: Map of EFH boundaries (AM 19 EFH EIS, 2005, NMFS 2005)

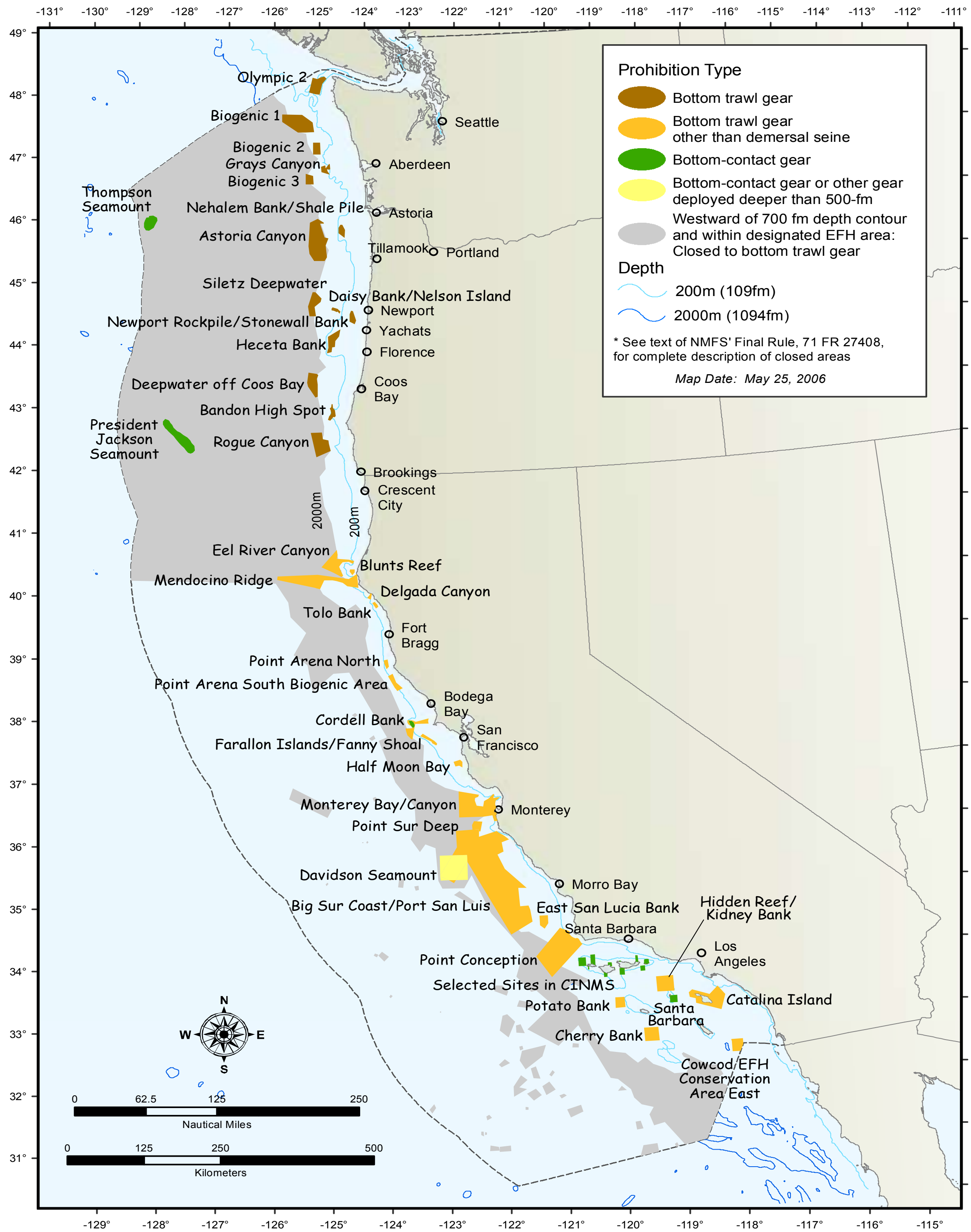



Figure 3-2: Map of EFH area closures to protect Pacific Coast groundfish habitat (AM 19 EFH EIS, 2005, NMFS 2005).

### 3.3.3 Benthic Habitat Substrates and Recovery

Considering that the trawl RCAs were established to reduce catch of overfished species, this EA describes the overfished groundfish species most likely to be affected by the proposed action in section 3.4.2 and analyzes the potential for increased catch of overfished species in Chapter 4, section 4.4.2. However, this EA also addresses the primary offshore benthic habitat types contained within the trawl RCA areas that would be opened to groundfish bottom trawling under the action alternatives, taking into account their rates of recovery from historic and current impacts.

Offshore habitat recovery from the effects of trawl fishing varies by habitat type (2005 EFH EIS). Offshore biogenic mixed and hard habitats generally have longer recovery times from trawl gear impact compared to offshore unconsolidated habitats such as soft substrate (2005 EFH EIS). Offshore mixed and hard bottom habitats may take up to 2.8 years to recover from pre-fishing conditions for non-structure forming benthic habitats (Table 3-1, below). This estimation does not take into account more defined habitat categories, such as slope sponge, which may take up to 10.5 years to recover (2005 EFH EIS, table 3-1), nor coral species, some of which are known to live beyond 100 years or more. Regeneration rates for corals following disturbance are also not fully understood in the scientific literature.

Table 3-1: Recovery time (years) for four major gear and three bottom types adapted from PFMC 2004 (EFH EIS) & PFMC 2013 (EFH habitat synthesis report, April 2013).

| Part B Recovery Times | Bottom Trawl | Midwater Trawl | Fixed Gear Distance | Fixed Gear Point |
|---|---|---|---|---|
| | | | | |
| Hard shelf | 2.8 | na | 0.1 | 0.1 |
| Hard upper slope | 2.8 | na | 0.3 | 0.1 |
| Hard lower slope | 2.8 | na | 0.3 | 0.1 |
| | | | | |
| Mixed shelf | 2.8 | na | 0.4 | 0.1 |
| Mixed upper slope | 2.8 | na | 0.4 | 0.1 |
| Mixed lower slope | 2.8 | na | 0.4 | 0.1 |
| | | | | |
| Soft shelf | 0.4 | na | 0.4 | 0.1 |
| Soft upper slope | 1 | na | 0.4 | 0.1 |
| Soft lower slope | 1 | na | 0.4 | 0.1 |

Table 3-1 (above) demonstrates the estimated recovery time (years) for four major gear and three bottom types (*PFMC 2005 Amendment 19, EFH EIS, PFMC 2013 EFH habitat synthesis report, April 2013*). It is important to note that recovery times for bottom trawl habitat in soft substrates are estimated to be substantially less than hard or mixed/medium substrates, ranging from 0.4 to 1 year, whereas impacts on hard and medium substrates are approximately 2.8 years. However, some large coral and sponge species, particularly larger species over 30 cm in height are known to tangle, damage, or experience mortality when pulled from substrate during entanglements from various fishery gear types (fixed gear longline or pot, groundfish and non-groundfish), or when bottom trawl gear (groundfish and shrimp) encounters medium and hard substrate (Brancato et al, 2007, NMFS). Recovery time for some hard corals could be on the order of 100 years (EFH 5-year review, Apendix J, September 2012).

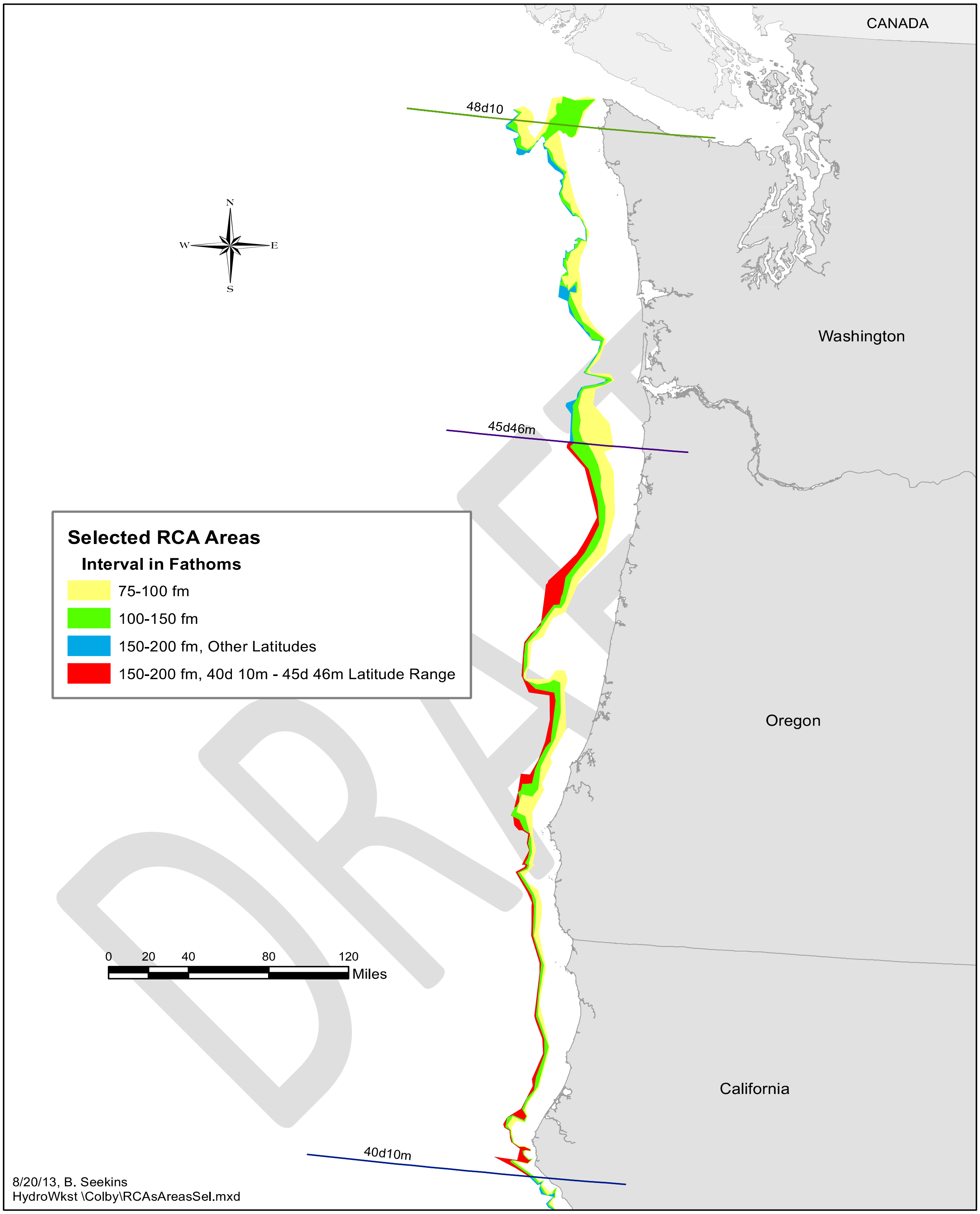



Figure 3-3: Proposed action area with selected RCA areas, interval by fm, emphasis added for 40° 10' N. latitude, 45° 43' N. latitude, and 48° 10' N. latitude. Interval by fm is represented in yellow (75-100 fm), green (100-150 fm), blue (North of 45° 46' N. lat. to 48° 10' N. lat., 150-200 fm), and red (North of 40° 10' N. lat. to 45° 46' N. lat., 150-200 fm). Modified petrale cutouts are not displayed. Any discrepancies between the CSV coordinate files illustrated here and the coordinates published in the *Federal Register* will be resolved in favor of the *Federal Register*.

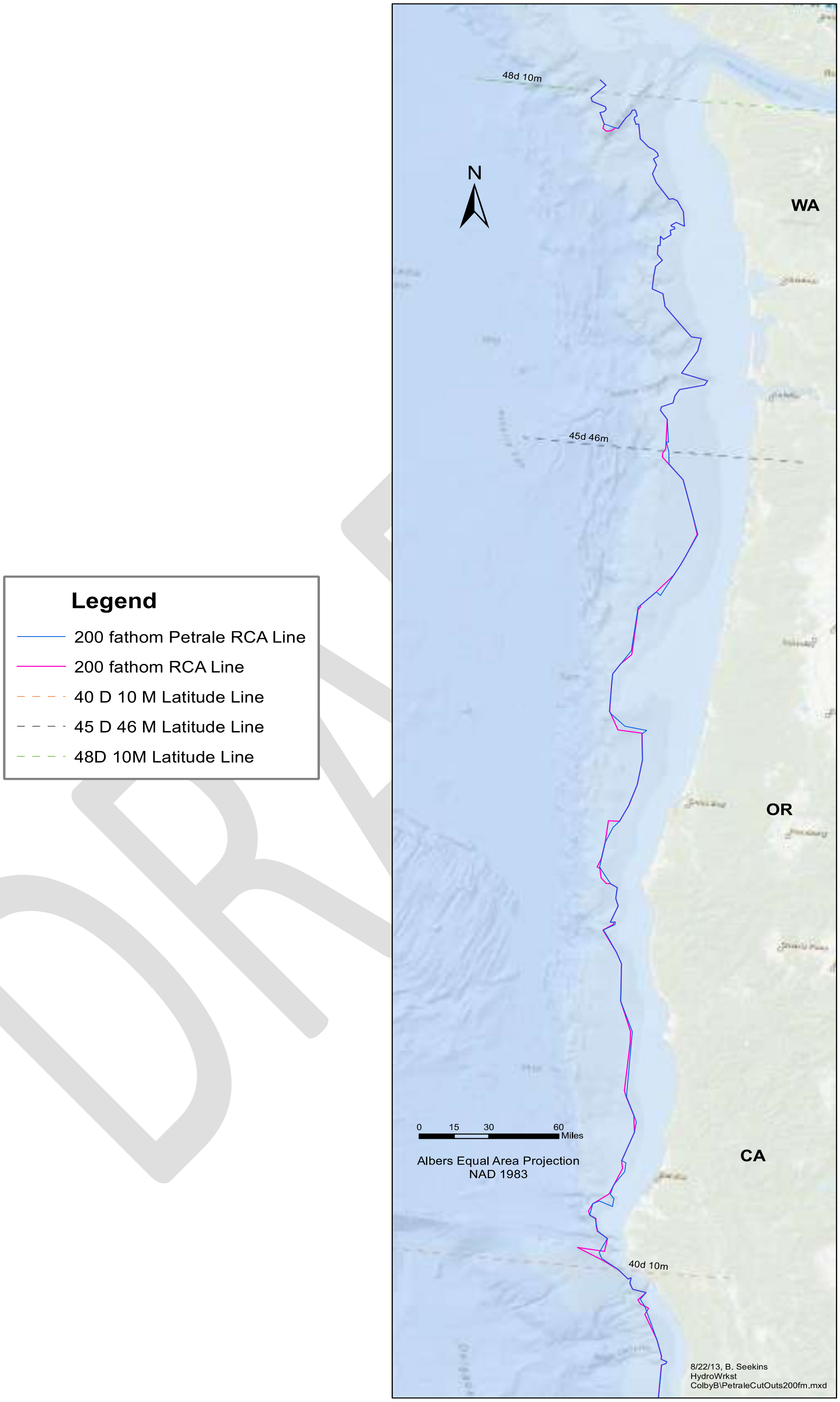



Figure 3-4: Proposed action area with selected RCA areas, 200 fm estimated waypoint line and modified "petrale cutouts", North of 40° 10' N. lat. to 48° 10' N. lat., 150-200 fm). Any discrepancies between the CSV coordinate files illustrated here and the coordinates published in the *Federal Register* will be resolved in favor of the *Federal Register*.

### 3.3.3.1 Description of Substrate Types in the Action Area

Bottom topography varieties may best be summarized among the following substrate types, which may occur in nearshore, shelf, or slope benthic environments:

1. Soft substrate: unconsolidated sediment, mud, silt, sand.
2. Medium/mixed substrate: low-relief, cobble and boulder.
3. Hard substrate: steep ridge, rocky reef.

Some species of groundfish (and non-groundfish) may utilize varying substrate types at different stages in their life history. For example, rockfish were usually quiescent beside or within erect structures, but over flat seafloor they were swimming or moved passively with the current (Du Preez & Tunnicliffe, 2011). Previously published studies agree that most rockfish have higher abundances in areas that are difficult to trawl and that most flatfish have higher abundances in areas that are easier to trawl (*Zimmerman, 2003*). Trawl marks on the California seafloor are commonly oriented parallel to bathymetric contours (Bellman et al, 2005).

*Soft substrate*

Soft substrate may be the least susceptible to habitat impact by various groundfish gear types, including bottom trawl. Although some degradation of invertebrate communities resulting from bottom trawling has been described in various scientific literature publications and EFH publications, impacts are considered to be less than when gear interacts with hard or medium substrates. Shoreward of the trawl RCA, bottom trawl fishing vessels may target species such as aggregations of lingcod, yellowtail rockfish, pacific sanddabs, and other groundfish species that prefer soft sandy substrate or shallow mud, or are able to be intercepted while transiting through soft substrates between mixed and hard substrate regions. Rockfish recruitment to soft benthic habitats has been documented (*Johnson et al., 2001*). Seaward of the RCA, fishing vessels can target what is often referred to as the “Deepwater Dover sole assemblage,” or Dover, Shortspine thornyhead, and Sablefish (DTS) complex. Some species may migrate spatially among depth zones depending on temporal season or interannual changes, but fish assemblages on deeper mud-dominated bottoms appeared to be relatively constant among years **(**B.N. Tissot et al., 2007). “Deep mud slope” is the primary habitat fished by commercial bottom trawlers outside the Heceta bank region (*Tissot et al, 2007*).

*Mixed substrate*

Mixed substrate may be second most susceptible to habitat impact (and hence, longer times for recovery from impacts). Although vertical relief may be less common in mixed substrates, boulders/cobble, boulder/sand substrate may serve as intermittent refuge for groundfish from predators, between potential feeding or localized seasonal depth migrations for overfished rockfish, or other more prominent latitudinal migratory groundfish. Epibenthic sponges or corals greater than 30 cm may have additional habitat benefit when connected to boulders or mixed substrate. In general, bottom trawl fishermen try to avoid mixed or hard substrate areas as trawling in those areas can cause damage to their nets and rigging. Mid-depth boulder-cobbles (55 fm to 82 fm) had the second lowest density of fish and the lowest species richness (about 43 fish species) compared to the other major habitats, and is of sufficiently low relief to be fished by commercial bottom trawlers (*Tissot et al, 2007*).

*Hard substrate*

Hard substrate is one of least common substrates within the proposed action area, but these substrates are also among the most important to rockfish. Off the West Coast of northern British Columbia it was locally observed that 95% of the rockfish occurred on 27% of the seafloor surveyed (*Du Preez & Tunnicliffe, 2011*). Other observations documented that "most of the hard substrate (bedrock and boulders) had attached benthic invertebrates, and at two of the sand transects, there were significant numbers of seawhips and hydroids present (*Rooper et al., 2010*)." GIS analysis of 5,039 bottom trawl events from U.S. West Coast bottom trawl surveys (1977-1998) estimated that the survey area was about 77% trawlable, but five of the 30 strata were less than 50% trawlable, while untrawlable areas by definition cannot be towed (*Zimmerman, 2013*). Jagielo et al (2003) found higher rockfish (*Sebastes*) abundances on untrawlable (rocky) sites off Washington State (*Zimmerman, 2003*). In general, bottom trawl fishermen try to avoid hard substrate areas as trawling in those areas can cause damage to their nets and rigging. In some ROV observations, "the shallow rock-ridge and large-boulder habitat was clearly untrawlable, and thus represented a natural refuge from the bottom-trawl fishery (*Tissot et al, 2007*)." From submersible observations made off southern B.C., Richards (1986) found that yelloweye rockfish abundance increased with habitat complexity, whereas greenstriped rockfish abundance did not (*Zimmerman, 2003*).

#### 3.3.3.2 Proportion of Substrate Types in the Action Area

Data supporting substrate assumptions in this assessment are from Oregon State University (titled "NOAA EFH Synthesis Benthic Substrate"), which were put together as part of the Groundfish EFH review process. The data is a compilation of many data sources, but is characterized by the hardness. Percentages of substrate within the different depth zones throughout this assessment *do not* subtract EFH conservation areas within RCA depth zones, nor do they subtract area opened under the modified 200 fm line (petrale cutout areas). Therefore, actual square mileage estimates within depth zones that would be opened under the proposed action are less than that described below to some extent. However, most EFH conservation areas are outside of the RCAs.

*75-100 fathom RCA Depth Zone*

Figure 3-5and Table 3-2 (below) demonstrate the amount of: (1) estimated soft seabed (90 percent, 1,882 square miles); (2) estimated mixed seabed (3 percent, 63 square miles); and, (3) estimated hard seabed (7 percent, 144 square miles) within the 75-100 fathom RCA depth zone.

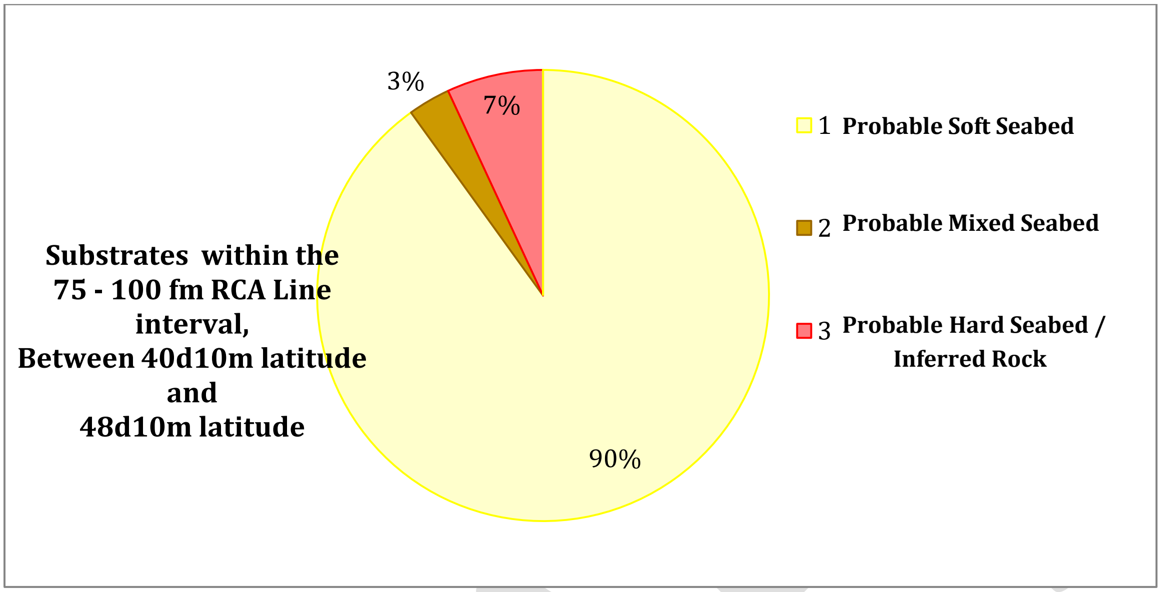



Figure 3-5: Substrates within the 75-100 fathom line interval, between 40° 10' N. latitude and 48° 10' N. latitude, and estimated substrate (seabed) types soft, mixed, and hard.

Table 3-2: Comparison of probable substrate type by 75-100 fathom range, square miles, and percent substrate type between 40° 10' N. latitude and 48° 10' N. latitude, including probable substrate (seabed) types soft, mixed, and hard.

| Substrate Type | Fathom Range | Sq Miles | % Substrate |
|---|---|---|---|
| Probable Soft Seabed | 75-100fm | 1882.00 | 90.06 |
| Probable Mixed Seabed | 75-100fm | 63.40 | 3.03 |
| Probable Hard Seabed / Inferred Rock | 75-100fm | 144.39 | 6.91 |

*100-150 fathom RCA Depth Zone*

Figure 3-6 and Table 3-3 demonstrate the amount of: (1) estimated soft seabed (94 percent, 1,289 square miles); (2) estimated mixed seabed (3 percent, 47 square miles); and, (3) estimated hard seabed (3 percent, 38 square miles) within the 100-150 fathom RCA depth zone between 40° 10' N. latitude and 48° 10' N. latitude. The proposed action does not include any groundfish bottom trawling within the 100-150 fathom RCA depth zone between 40° 10' N. latitude and 48° 10' N. latitude. However, fixed gear fisheries, midwater trawling, pink shrimp fisheries, and other non-groundfish fisheries may be conducted in this depth zone under existing regulations.

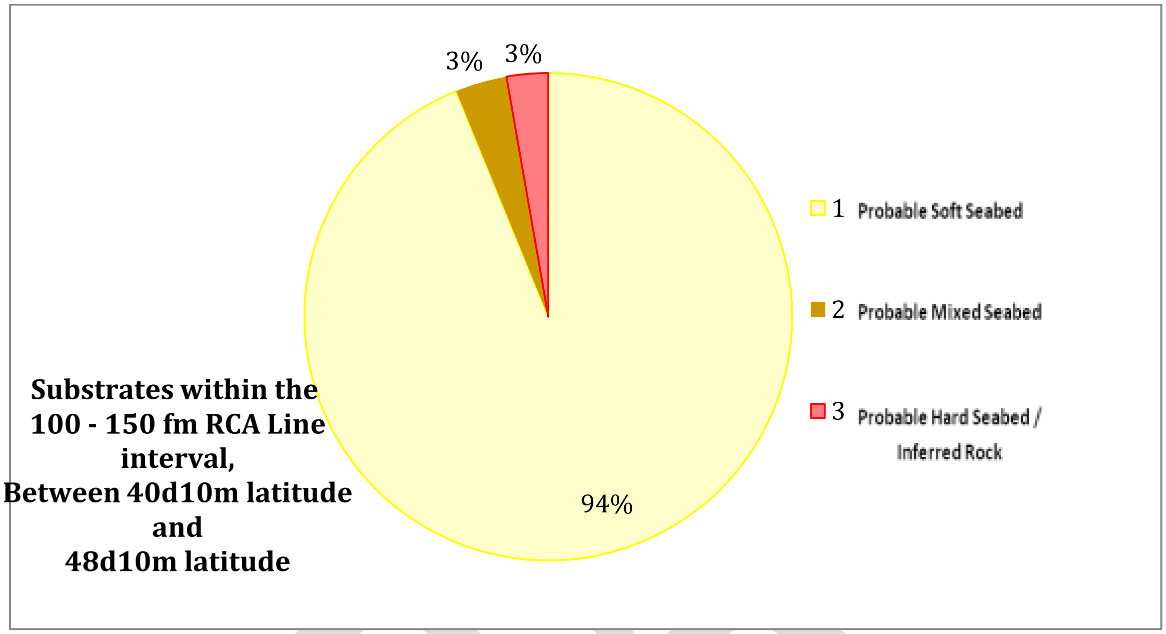



Figure 3-6: Substrates within the 100-150 fathom line interval, between 40° 10' N. latitude and 48° 10' N. latitude, and estimated substrate (seabed) types soft, mixed, and hard.

Table 3-3: Comparison of probable substrate type by100-150 fathom range, square miles, and percent substrate type between 40° 10' N. latitude and 48° 10' N. latitude, including probable substrate (seabed) types soft, mixed, and hard.

| Substrate Type | Fathom Range | Sq Miles | % Substrate |
|---|---|---|---|
| Probable SoftSeabed | 100 - 150 fm | 1289 | 93.83 |
| Probable Mixed Seabed | 100 - 150 fm | 47 | 3.42 |
| Probable Hard Seabed / Inferred Rock | 100 - 150 fm | 37.82 | 2.75 |

*150-200 fathom RCA Depth Zone*

Figure 3-7 and Table 3-4 (below) demonstrate the amount of: (1) estimated soft seabed (93 percent, 885 square miles); (2) estimated mixed seabed (4 percent, 36 square miles); and, (3) estimated hard seabed (3 percent, 32 square miles) within the 150-200 fathom RCA depth zone between 40° 10’ N. latitude and 48 10’ N. latitude.

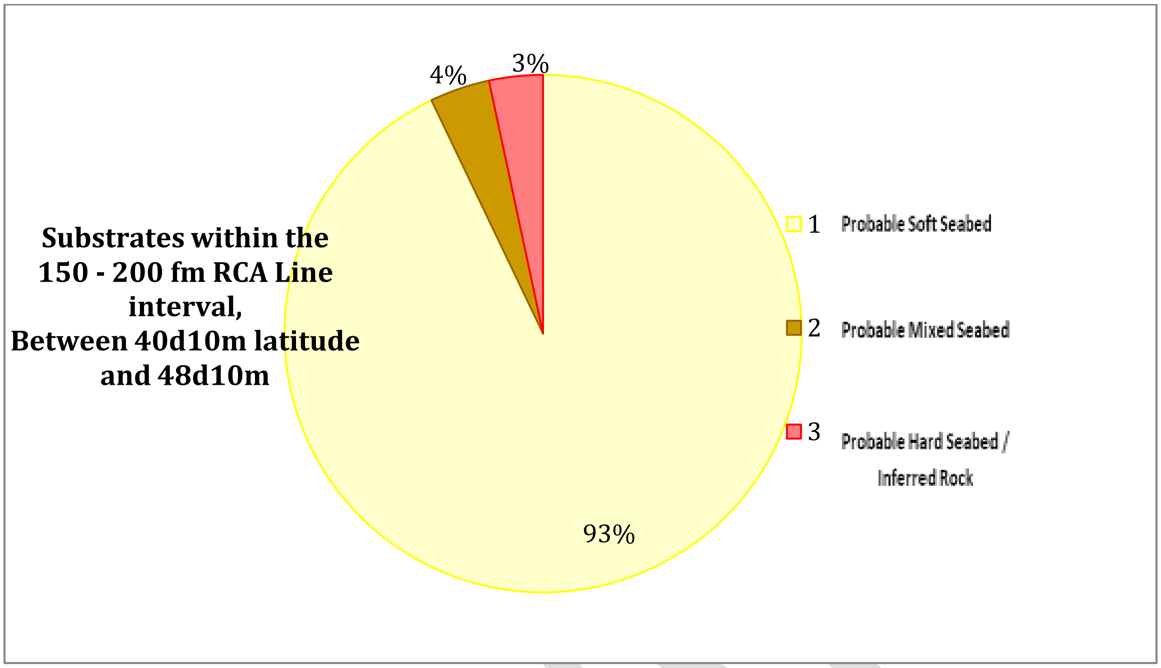



Figure 3-7: Substrates within the 150-200 fathom line interval, between 40° 10’ N. latitude and 48° 10’ N. latitude, and estimated substrate (seabed) types soft, mixed, and hard.

Table 3-4: Comparison of probable substrate type by 150-200 fathom range, square miles, and percent substrate type between 40° 10’ N. latitude and 48° 10’ N. latitude, including probable substrate (seabed) types soft, mixed, and hard.

| Substrate Type | Fathom Range | Sq Miles | % Substrate |
|---|---|---|---|
| Probable Soft Seabed | 150 - 200 fm | 885 | 92.89 |
| Probable Mixed Seabed | 150 - 200 fm | 35.69 | 3.75 |
| Probably Hard Seabed / Inferred Rock | 150 - 200 fm | 32 | 3.36 |

The seaward area from 40° 10’ N. latitude to 45° 46’ N. latitude, 150-200 fm (Figure 3-8, below) within the proposed action area is comprised primarily of soft substrate (greater than 90 percent), which recovers from bottom trawl gear in a shorter amount of time compared to other substrate types (Table 3-1, above).

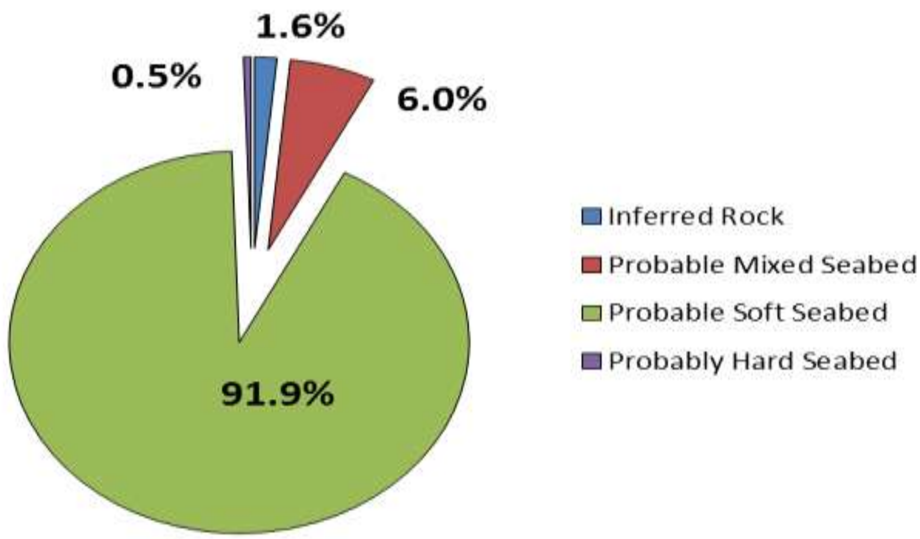



Figure 3-8: Proportional distribution of different substrate types in the area between the 150 and 200 fathom RCA boundaries, between 40° 10’ N. lat. and 45° 46’ N. lat.

The seaward area from 45°46’ N. lat. to 48°10’ N. lat. 150-200 fm (Figure 3-9, below) within the proposed action area is also comprised primarily of soft substrate (greater than 95 percent), which recovers from bottom trawl gear in a shorter amount of time compared to other substrate types (Table 3-1, above).

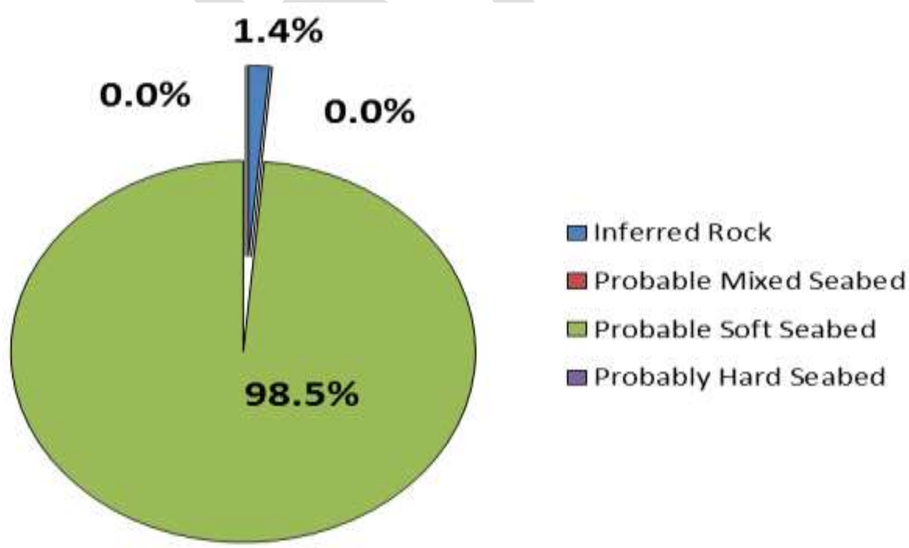



Figure 3-9: Proportional distribution of different substrate types in the area between the 150 and 200 fathom RCA boundaries, between 45°46’ N. lat. and 48°10’ N. lat.

### *3.3.4* Current Habitat as Affected by Fishing Gear

The impacts of specific fisheries can vary widely depending on the characteristics of the gear and fleet (*Kaplan et al., 2012*). The effects of fishing on EFH are described in detail in the Amendment 19 EFH EIS and subsequent documents generated by the ongoing EFH review. Generally, on the West Coast, benthic habitats are most disturbed by bottom trawl gear (e.g., groundfish and pink shrimp), and to a lesser extent, fixed gear. Some of the areas containing substrate types described above by proportion estimated in each RCA depth interval were closed to specific gear types through Amendment 19. See Figure 3-10 and Figure 3-11, below. For a complete depiction of all EFH closures established through Amendment 19 see Figure 3-2, above.

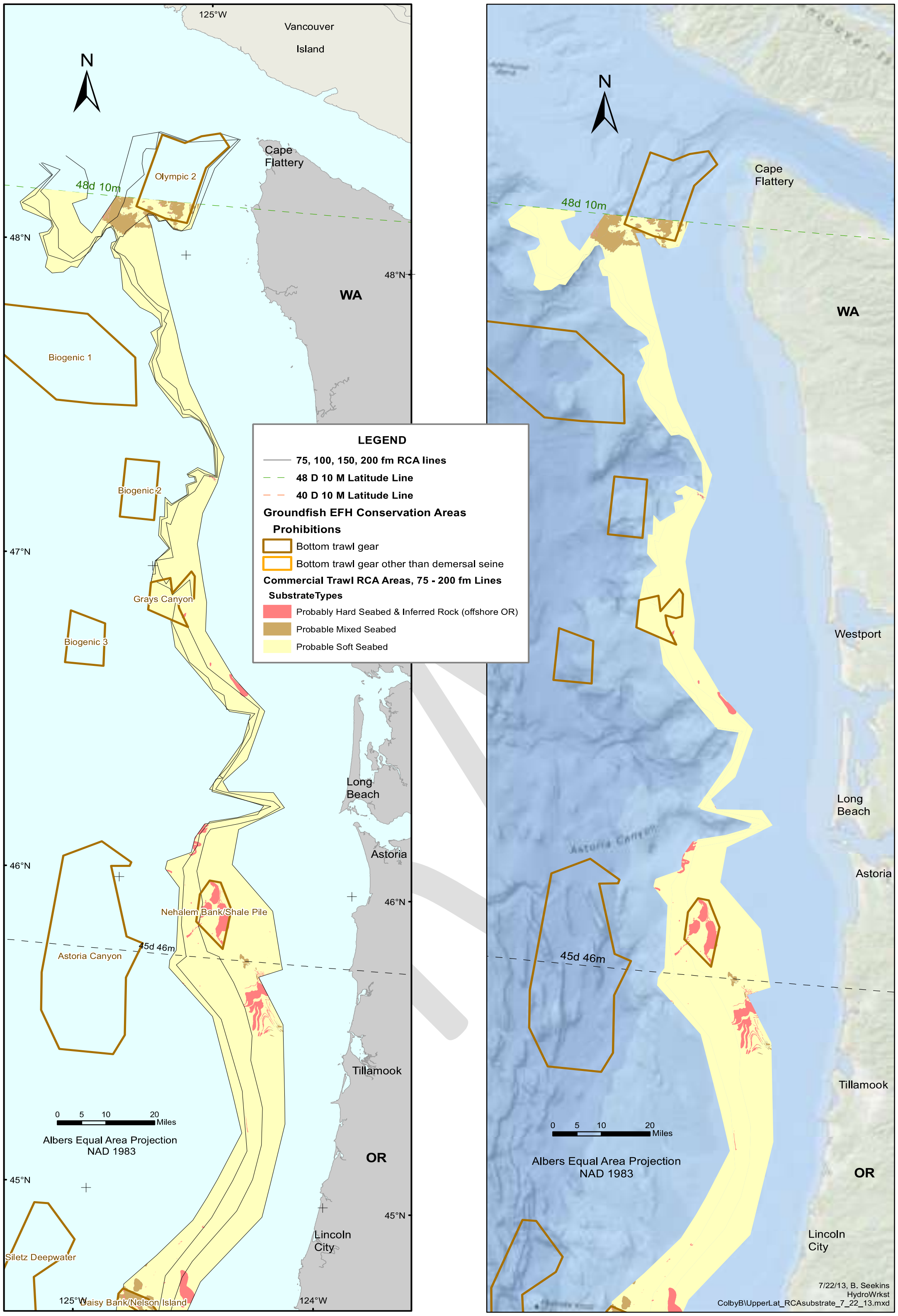



Figure 3-10. Proposed action area with selected RCA areas, interval by fm, 45° 46' N. latitude to 48° 10' N. latitude. Interval by fathom areas is represented in 75, 100, 150 and 200 fathom lines.

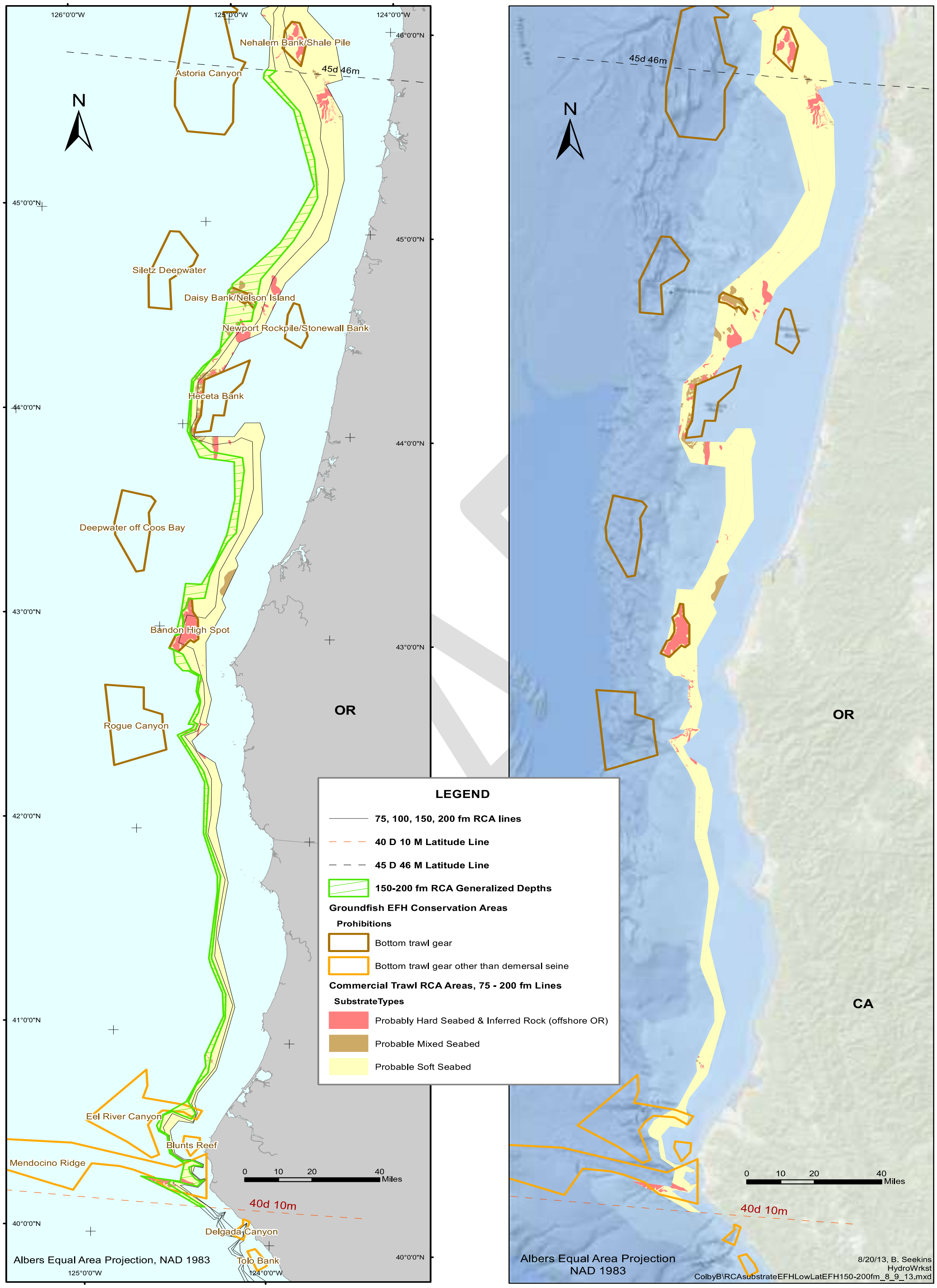



Figure 3-11: Proposed action area with selected RCA areas, interval by fm, 40° 10’ N. latitude to 45° 43’ N. latitude. Interval by fathom areas is represented in 75, 100, 150 and 200 fathom lines. 150-200 fm RCA Generalized depth zone (green polygon border) represents the seaward area in Alternative 2 that would remain closed to bottom trawling, unlike in Alternative 1.

#### 3.3.4.1 Current Habitat as Affected by Groundfish Bottom Trawl Gear

Bottom trawling involves the towing of a funnel shaped net or nets behind a fishing vessel, which use “doors” to spread the mouth of the net. The trawl gear varies depending on the species sought and the size and horsepower of the boats used to fish the gear on the bottom. The mouth of trawl nets is spread horizontally in the water column by the use of two doors located one on each side of the net, forward and outward of the net. The doors, generally made of metal, are pushed apart and down by hydrodynamic forces and by their own weight, and some increase their spread by bottom friction. Fishermen choose trawl doors based on the horsepower of their vessel. Of the major components, trawl doors affect the smallest area of seabed, though trawl door marks are the most recognizable and frequently observed effect of trawls on the seabed. The trawl net is wide at the mouth tapering to an intermediate piece attached to the codend, the bag that collects the fish. The mesh sizes for the net and cod-end are regulated to allow undersized species to escape during fishing. The bottom contact rate in Midwater trawl fisheries for Pacific Whiting or pelagic rockfish is already understood to be very low (8 percent or less) in the whiting fishery and lower still in the pelagic rockfish fishery (7 percent or less), therefore midwater trawl gear habitat impacts are anticipated to be less than that by bottom trawl vessels.

The top of the mouth of the net is called the headrope (headline or floatline). The headrope usually overhangs the footrope to ensure that fish disturbed by the groundrope do not escape upwards, but selective flatfish nets have a cutrope to allow overfished rockfish an opportunity to escape, while flatfish will continue to be herded into the net. Only selective flatfish trawl gear (which utilizes small footropes) is required shoreward of the 100 fathom RCA line, and large footrope gear seaward of the 100 fathom line (although in practice seaward of the western trawl RCA boundaries) may not exceed 19 inches in diameter. The footrope or groundrope is directly attached to the lower leading edge of the mouth of the net. The footrope may be weighted with chain or may be rope-wrapped cable when used on a soft bottom. The footrope may contain boulders, rubber disks, or rubber rollers (also called bobbins) attached to the footrope under the center and wing sections of the net, to allow the net to ride over obstacles.

Two or more riblines are used on bottom trawl nets and midwater trawl nets. The riblines go fore and aft in the net to provide strength to the net. Bottom fish trawl nets are attached by sets of bridles (upper and lower bridles) to the doors, or may be attached to mud gear which in turn is attached to the doors. Bridles are made of wire rope (also called cable). They function to hold the net open as it is towed and help herd fish into the path of the trawl net. The bridles are cables that connect the trawl doors to the trawl net. The bottom bridle may be in contact with the seabed for a part of their distance.

The intermediate of the net is the section where the net begins to funnel into the cod-end. The intermediate section of the net is often where bycatch reduction devices (BRDs), special net webbing for halibut and salmon, or flexible plastic rockfish excluders are integrated. The cod end is the last section of the net, which contains the nets’ contents. As the net is retrieved back to the fishing vessel rear deck by two powerful winches on each side of the starboard and port sides of the vessel, a large steel hoist extending across and above the back deck is firmly affixed to the back of the vessel. This allows the intermediate section of the net to be hoisted above the vessel, ultimately resulting in the cod end of the net being brought aboard, and its contents being dumped on deck.

RCA configurations have dictated where groundfish bottom trawl gear could be fished north of 40° 10’ N. latitude since 2002 (Table 3-5). Total estimated trawl effort from 2002 to 2009 was 436,899 tow-hours across the four trawl fisheries evaluated (*Guy et al., 2013*). Pink shrimp and groundfish trawling accounted for most of the west coast trawl effort (54% and 25% of hours) (*Guy et al., 2013*). As shown in Table 3-5, below, some areas that would be open under the alternatives have been opened to trawling intermittently throughout the year in the recent past. However, the area that would remain closed under Alternative 2, 150 to modified 200 fm from 40° 10' N. latitude to 45° 46' N. latitude has not been opened to bottom trawling since October 2004, with the exception of a small area that was opened for four summer months in 2007 (45° 03' N. latitude to 45° 46' N. latitude).

Table 3-5: Yellow shading indicates area not trawled since October 1, 2004 (North of 40° 10' N. latitude), with extra emphasis provided in red shading to highlight the brief incursion from 250 fm to 150 fm as far south as 45° 03' N. latitude between April 1, 2007 to August 1, 2007.

| Year | Area (North of 40°10') | Jan | Feb | Mar | April | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | North of 40°10' | N/A, PFMC (Council) introduced Cowcod Conservation Areas south of 40°10' | | | | | | | | | | | |
| 2002 | North of 40°10' | N/A, PFMC (Council) retained Cowcod Conservation Areas south of 40°10' | | | | | | | | Shore-250 | 100-250 | 100-250 | 100-250 |
| 2003 | North of 40°10' | 100-m250 | | 100-250 | | 50-200 | | 75-200 | | 50-200 | | 0-m200 | |
| 2004 | North of 40°10' | 75-m200 | | 60-200 | | 60-150 | | 75-150 | | | 0-250 | | |
| 2005 | North of 40°10' | 75-m200 | | 100-200 | | | | | | | 0-250 | | |
| 2006 | North of 40°10' | 75-m200 | | 75-200 | | | | 100-250 | | 75-250 | | 75-m250 | |
| | North of 48°10' | 75 - m250 | | 75 - 250 | 0 - 150 | | | | | 0 - 200 | 75 - 200 | 75 - m200 | |
| | 48°10' - 46°38' | | | | 75 - 150 | | | | | 75 - 200 | | | |
| | 46°38' - 46°16' | | | | 60 -150 | | | | | 60 -200 | | | |
| | 46°16' - 45°03' | | | | 75 - 150 | | | | 75 - 200 | | | | |
| | 45°03' - 43°20' | 75 - m250 | | 75 - 250 | 75 - 200 | | | | | | | 75 - m200 | |
| | 43°20' - 42°40' | | | | 0 - 200 | | | | | | 75 - 200 | | |
| 2007 | 42°40' -40°10' | | | | 75 - 200 | | | | | | | | |
| | North of 48°10' | 0 - m200 | | 0 - 200 | | 0 - 150 | | | | | | 0 - m200 | |
| | 48 10 - 46 38.17 | 75 - m200 | | 60 - 200 | | 60 - 150 | | | | | 75 - 150 | 75 - m200 | |
| | 46 38.17 - 46 16 | | | 60 - 200 | | | | 60 - 150 | | | | | |
| | 46 16 - 45 46 | | | 75 - 200 | | 75 - 150 | | | | 75 - 200 | | | |
| | 45 46 - 43 20.83 | 75 - m200 | | 75 - 200 | | | | | | | | 75 - m200 | |
| | 43 20.83 - 42 40.50 | 0 - m200 | | 0 - 200 | | | | | | | | 0 - m200 | |
| 2008 | 42 40.5 - 40 10 | 75 - m200 | | 75 - 200 | | 60 - 200 | | | | | 75 - 200 | 75 - m200 | |
| | North of 48°10' | 0 - m200 | | | 0 - 200 | 0 - 150 | | | | 0 - 200 | | 0 - m200 | |
| | 48°10' - 45°46' | 75 - m200 | | | 75 - 200 | 75 - 150 | | 100 - 150 | | 75 - 200 | | 75 - m200 | |
| 2009 | 45°46' - 40°10' | 75 - m200 | | | 75 - 200 | 75 - 200 | | 100 - 200 | | 75 - 200 | | 75 - m200 | |
| | North of 48°10' | 0 - m200 | | 0 - 200 | | 0 - 150 | | | | 0 - 200 | | 0 - m200 | 0 - 250 |
| | 48°10' - 45°46' | 75 - m200 | | 75 - 200 | | 75 - 150 | | 100 - 150 | | 75 - 200 | | 75 - m200 | 75 - 250 |
| 2010 | 45°46' - 40°10' | 75 - m200 | | 75 - 200 | | 75 - 200 | | 100 - 200 | | 75 - 200 | | 75 - m200 | 75 - 250 |
| | North of 48°10' | 0 - m200 | | 0 - 200 | | 0 - 150 | | | | 0 - 200 | | 0 - m200 | |
| | 48°10' - 45°46' | 75 - m200 | | 75 - 200 | | 75 - 150 | | 100 - 150 | | 75 - 150 | | | |
| 2011 | 45°46' - 40°10' | 75 - m200 | | 75 - 200 | | 75 - 200 | | 100 - 200 | | 75 - 200 | | 75 - m200 | |
| | North of 48°10' | 0 - m200 | | 0 - 200 | | 0 - 150 | | | | 0 - 200 | | 0 - m200 | |
| | 48°10' - 45°46' | 75 - m200 | | 75 - 150 | | 100 - 150 | | | | | | 75 - 150 | |
| 2012 | 45°46' - 40°10' | 75 - m200 | | 75 - 200 | | 100 - 200 | | | | | | 75 - m200 | |

Based on the table above (Table 3-5), the recovery index (Table 3-1), and various fishery impacts on the distribution of substrate types within the RCA depth line intervals (75-100 fm, 150 to 200 fm), only benthic habitat between 40° 10' N. latitude to 45° 46' N. latitude (150 to modified 200 fm) may have recovered from groundfish bottom trawl gear, assuming areas that are opened to trawling are in fact being extensively trawled.

**75-100 fm, 40° 10' N. latitude to 48° 10' N. latitude:** Within this depth interval (75-100 fm), the substrate types are approximately 90 percent soft, 10 percent mixed and hard substrates. Based on the EFH synthesis report habitat recovery table described above (table 3-2), it would take an estimated 2.8 years for the hard and mixed substrate areas to recover if closed to all bottom trawling activity. However, it would take one year for the soft areas to recover, which comprise 90 percent of the area in the 75-100 fathom range. Under the no-action RCA configuration, the area between 40° 10' N. latitude and 48° 10' N. latitude from 75-100 fm is currently open to bottom trawling in periods 3, 4, and 5 (May through October). Accordingly, if it is assumed that bottom trawling occurs in these areas when open, then there has not been sufficient time for recovery to occur in the areas that have been impacted. Observed groundfish bottom trawl effort distribution by trawl hours, depth and latitude are described in figures 3-8, below. The observed groundfish bottom trawl effort between 75 and 100 fm, particularly above 43° N. latitude, indicates this area is heavily utilized. The area between 40° 10' N. latitude and 43° N. latitude, 75 fm to 100 fm is less frequently trawled by groundfish bottom trawl gear, while other bottom trawl gear such as pink shrimp bottom trawl gear (described below) frequently occurs south of 43° N. latitude in this depth range.

**150-200 fm, 45° 46' N. latitude to 48° 10' N. latitude:** Within this depth interval (150 to 200 fm, 45° 46' N. latitude to 48° 10' N. latitude), the substrate types are approximately 98.5 percent soft, and 1.4 percent mixed and hard substrates. Based on the EFH synthesis report habitat recovery table described above (Table 3-1), it would take an estimated 2.8 years for the hard and mixed substrate areas to recover if closed to all bottom trawling activity. However, it would take one year for the soft areas to recover, which comprise 98.5 percent of the area in the 150 to 200 fathom range, 45° 46' N. latitude to 48° 10' N. latitude. Under the no-action RCA configuration, the area between 45° 46' N. latitude to 48° 10' N. latitude from 150 to 200 fm is currently open to bottom trawling in periods 2-6 (March through December 31). Accordingly, if it is assumed that bottom trawling occurs in these areas when open, then there has not been sufficient time for recovery to occur in the areas that have been impacted. The observed effort from 2005 to 2011 demonstrates that open groundfish bottom trawl habitat between 150 and 200 fm (Figure 3-12 and Table 3-6, below), above 45° 46' N. latitude is currently utilized.

**150 to 200 fm, 40° 10' N. latitude to 45° 46' N. latitude:** For the area that has been closed since 2004 (within 150- modified 200 fm, 40° 10' N. latitude to 45° 46' N. latitude), having been largely closed for almost 9 years, it appears that even the habitat types (Table 3-1) with potentially longer recovery (e.g., slope sponge maximum estimated recovery time of 10.5 years) would have had some opportunity to recover. There was a small area between 45° 03' N. latitude to 45° 46' N. latitude that was opened to groundfish bottom trawling April 1, 2007 to August 1, 2007 (Table 3-5, above). However, it has been approximately six years since that narrow area has been opened, longer than the estimated bottom trawl recovery times of 2.8 years. Therefore, throughout this environmental assessment, the two areas (40° 10' N. latitude to 45° 03' N. latitude and 40° 10' N. latitude to 45° 46' N. latitude) will be referred to as one area that has had a chance to recover from bottom trawl gear from 40° 10' N. latitude to 45° 46' N. latitude, 150 to modified 200 fm. The observed effort from 2005 to 2011 demonstrates that benthic habitat between 150 and modified 200 fm (described in Figure 3-12, below), 40° 10' N. latitude to 45° 46' N. latitude, is not generally utilized due to the RCA closure. Some effort that may be showing up in this latitudinal depth zone may be a result of differences in way points in the federal register and the actual depth contours, or allowed modified petrale cut-outs, which enable fishermen to access limited areas of soft substrate to access target species. In this latitudinal range, effort is heavier outside of 200 fm (Figure 3-12 and Table 3-6, below).

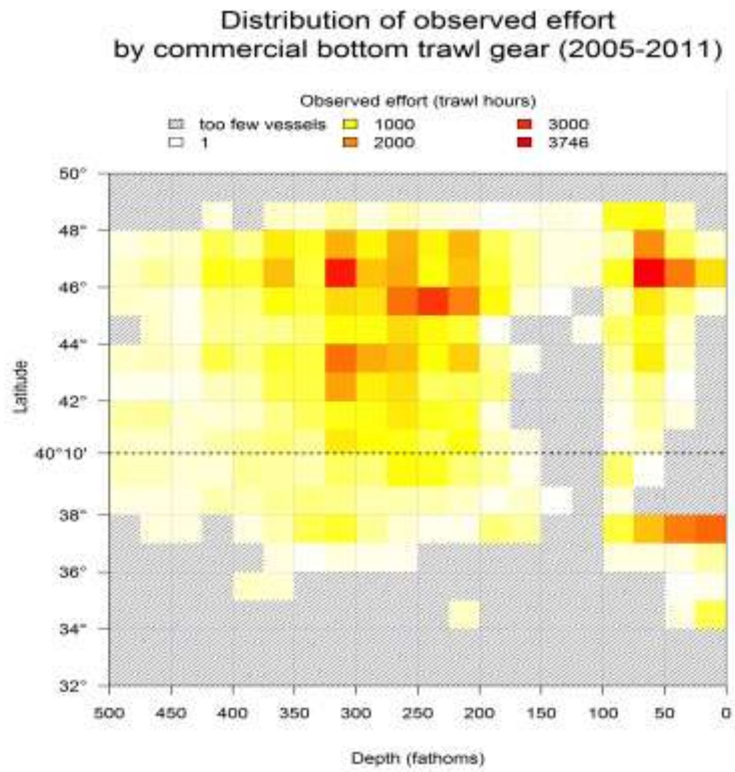



Figure 3-12: WCGOP distribution data of bottom trawl observed trips from 2005-2011, by latitude, longitude, and effort hours under tow.

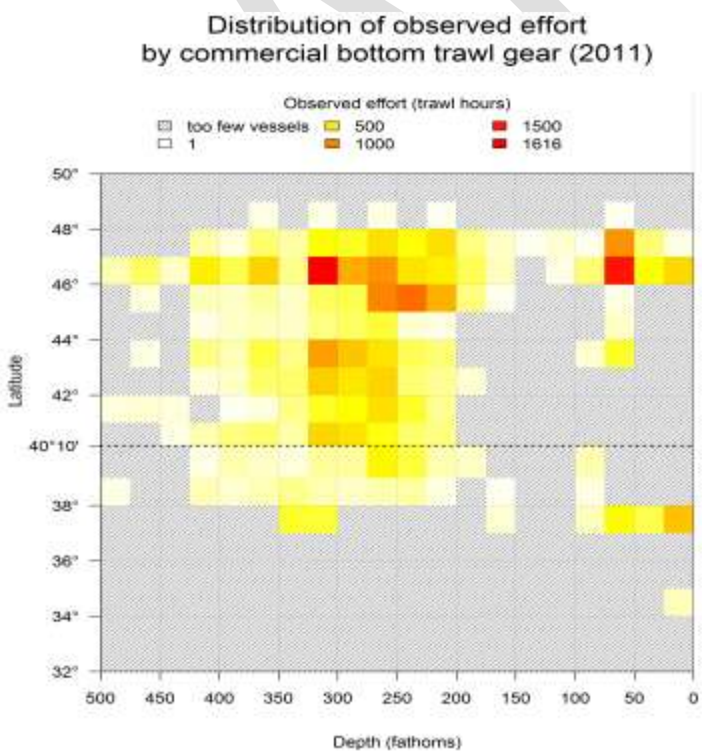



Figure 3-13: WCGOP distribution data of bottom trawl observed trips during 2011, by latitude, longitude, and effort hours under tow.

Inferences from observer data may have certain limitations, such as the possibility that an observer effect may be occurring when an observer is present onboard the vessel. Therefore, vessel practices on unobserved trips may be different to some extent, and subsequently, assumptions on spatial effort may be limited. However, since the inception of the trawl rationalization program in 2011, with the 100 percent monitoring requirement, observer effects are not a concern. Table 3-6 (below) demonstrates the observer coverage rates from 2002 to 2010, north of 40° 10' N. latitude, which ranged from 13 to 24 percent. Cells showing tiny amounts of effort (Figure 3-13, above) in the trawl RCA could have a variety of explanations. It could be errors in the database, unintentional incursions, or the fact that the RCA boundary is like a big polygon, such that there could be locations near the boundary where a recorded actual average depth could vary from waypoints defined in regulation, which are designed to simplify compliance and enforcement.

Table 3-6: Non-whiting Observer Coverage Rates, 2002-2010 (pre-IFQ). Total trips, tows, vessels and groundfish landings observed in the limited entry groundfish bottom trawl fishery, 2002-2010. Coverage rates are computed as the observed proportion of total FMP groundfish landings (excluding Pacific hake), summarized from fish ticket landing receipts. Source: NWFSC

http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/bottom_trawl.cfm#coverage

| | Observed | | | | Fleet Total | Coverage Rate |
|---|---|---|---|---|---|---|
| Management Area / Year | # of trips | # of tows | # of vessels | Groundfish landings (mt) | Groundfish landings (mt) | % landings observed |
| North of 40° 10' N Lat | | | | | | |
| 2002 | 432 | 2567 | 93 | 1940.2 | 15369.9 | 13% |
| 2003 | 316 | 1791 | 95 | 2076.3 | 14185.9 | 15% |
| 2004 | 444 | 2697 | 75 | 3302.0 | 13971.0 | 24% |
| 2005 | 396 | 2881 | 83 | 3573.8 | 16216.5 | 22% |
| 2006 | 365 | 2506 | 70 | 2979.9 | 15378.4 | 19% |
| 2007 | 283 | 2054 | 73 | 2890.4 | 17893.7 | 16% |
| 2008 | 356 | 2727 | 83 | 4426.2 | 21257.7 | 21% |
| 2009 | 484 | 3814 | 85 | 5425.7 | 23373.1 | 23% |
| 2010 | 287 | 2257 | 72 | 3739.8 | 19825.4 | 19% |

### 3.3.4.2 Current Habitat as Affected by Groundfish Fixed Gear

Bottom longline gear fits into two categories: gear that targets fish living directly on the bottom (halibut, cabezon, lingcod etc.) and gear that targets fish living very near the bottom (sablefish, rockfish etc.). Marking buoys, buoy lines and anchors are the same for both types of bottom longline. Additionally hook spacing and size, gangion size and length can also be the same. The difference in longlines for fish living directly on the bottom as opposed to fish living near the bottom comes between gangions and the groundline and in the composition of the groundline itself.

The longline is marked on both ends with a cane flagpole with a radar reflector and a flotation buoy. Below the buoys the buoy line (30-50 fm longer than the water depth) travels from the surface down to the anchor on the bottom. Groundline is used between the anchors, and gangions are snapped or tied to the groundline with the baited hooks at the opposite end. Weights of one to five pounds are sometimes attached to the groudline either to speed sinking rate through upper waters that might house non-desired species, or when fishing uneven bottom contours. A series of weights are used along the groundline to sink the groundline to the bottom. The floats have enough buoyancy to lift the groundline, hooks and gangions, but not enough to hold up the weights. The principal components of the longline that can produce effects on the seabed are the anchors or weights, the hooks and the mainline. If the hauling vessel is not above the part of the line that is being lifted, the line, hooks and anchors can be pulled across the seabed before ascending. If the hooks and line snare exposed organisms they can be injured or detached.

Pots are baited boxes set on the ocean floor to catch various fish and shellfish. They can be circular, rectangular or conical in shape. All pots contain entry ports and escape ports that allow undersized species to escape. The pots used for the sablefish pot fishery are highly selective for sablefish and are fished off a long-line in series (a set of pots) at various depths. They are generally fished in waters up to 600 fm, though sometimes as deep as 760-800 fm. Up to 50 pots are attached to each groundline line. The groundline is usually 3⁄4 inch polypropylene (ranging from 5/8" to 1 1/8"). Pots are spaced every 15 to 40 fm along the line, with 20 fm being average. An anchor weighs each end of the line. Pots are set and retrieved using line haulers and/or drums.

Whereas bottom trawl fishing vessels will typically try to avoid areas of hard and mixed boulder substrates, fixed gear is very effective at accessing these areas. Limited evidence suggests that longline gear may entangle and pull large sponge and coral from boulder or rocky substrate, and that target species are abundant in these areas. Fixed gear impacts on soft substrate are expected to be minimal. The sablefish longline and near-shore rockfish longline fisheries together set an estimated 86.2 million hooks from 2002 to 2009 (*Guy et al., 2013*). The sablefish longline fishery set the majority of hooks (77%), most in the shelf-break domain (92%) (*Guy et al., 2013*). Table 3-7, below depicts the non-trawl (i.e., fixed gear) RCA configurations overtime.

Table 3-7: Fixed gear RCA depth boundaries by year and month, 2002-2013, including inseason changes. Emphasis in yellow shading represents historical fixed gear RCAs in the trawl RCA proposed action area (fm).

<table>
<tr><th>Year</th><th>Location</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="6">2013</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>43 00 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>42 00 - 43 00</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>40 10 - 42 00</td><td colspan="12">20 fm depth contour - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 fm - 150 fm line</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm line (also applies around islands)</td></tr>
<tr><td rowspan="6">2012</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>43 00 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>42 00 - 43 00</td><td colspan="12">20 - 100 fm</td></tr>
<tr><td>40 10 - 42 00</td><td colspan="12">20 fm depth contour - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 fm - 150 fm line</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm line (also applies around islands)</td></tr>
<tr><td rowspan="7">2011</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>45 03 83 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>43 00 - 45 03 83</td><td colspan="12">30 - 125 fm (125 line reduced to 100 fm during directed halibut days)</td></tr>
<tr><td>42 00 - 43 00</td><td colspan="12">20 - 100 fm</td></tr>
<tr><td>40 10 - 42 00</td><td colspan="12">20 fm depth contour - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 fm - 150 fm line</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm line</td></tr>
<tr><td rowspan="7">2010</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>45 03 83 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>43 00 - 45 03 83</td><td colspan="12">30 - 125 fm (125 line reduced to 100 fm during directed halibut days)</td></tr>
<tr><td>42 00 - 43 00</td><td colspan="12">20 - 100 fm</td></tr>
<tr><td>40 10 - 42 00</td><td colspan="12">20 fm depth contour - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 fm - 150 fm line</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm line</td></tr>
<tr><td rowspan="7">2009</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>45 03 83 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>43 00 - 45 03 83</td><td colspan="12">30 - 125 fm (125 line reduced to 100 fm during directed halibut days)</td></tr>
<tr><td>42 00 - 43 00</td><td colspan="12">20 - 100 fm</td></tr>
<tr><td>40 10 - 42 00</td><td colspan="12">20 fm depth contour - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2008</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2007</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="12">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2006</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="4">30 - 150 fm</td><td colspan="4">20 - 150 fm</td><td colspan="4">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2005</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="4">30 - 150 fm</td><td colspan="4">20 - 150 fm</td><td colspan="4">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2004</td><td>North 46 16</td><td colspan="12">shore - 100 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="12">30 - 100 fm</td></tr>
<tr><td>34 27 - 40 10 (+ islands)</td><td colspan="4">30 - 150 fm</td><td colspan="4">20 - 150 fm</td><td colspan="4">30 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)</td><td colspan="12">60 fm - 150 fm</td></tr>
<tr><td rowspan="4">2003</td><td>North 46 16</td><td colspan="10">shore - 100 fm</td><td colspan="2">shore - 200 fm</td></tr>
<tr><td>40 10 - 46 16</td><td colspan="10">27 - 100 fm</td><td colspan="2" rowspan="3">shore - 150 fm</td></tr>
<tr><td>34 27 - 40 10</td><td colspan="10">20 - 150 fm</td></tr>
<tr><td>South 34 27 (+ islands)20</td><td colspan="8">20 - 150 fm</td><td colspan="2">30 - 150 fm</td></tr>
<tr><td>2002</td><td>South 40 10</td><td colspan="6"></td><td colspan="6">CLOSED > 20fm (exceptions: sablefish, S Thorny and slope RF)</td></tr>
</table>

**<u>75-100 fm, 40° 10' N. latitude to 48° 10' N. latitude:</u>** Due to the fixed gear RCAs, (Table 3-7, *above*), there is no substantial fixed gear effort shoreward of the 100 fathom depth contour in this depth zone (Figure 3-14, below). Within this depth interval (75-100 fm), the substrate types are approximately 90 percent soft, 7 percent mixed, and 3 percent hard substrate. Based on the EFH synthesis report habitat recovery table described above (Table 3-1), it would take an estimated 0.1

year for hard substrate areas, and 0.4 year for the mixed and soft substrate areas impacted by fixed gear to recover if closed to all fixed gear activity.

**150-200 fm, 45° 46’ N. latitude to 48° 10’ N. latitude:** There is substantial fixed gear effort seaward of the 100 fathom depth contour in this area (Figure 3-14, below). Within this depth interval (150-200 fm), the substrate types are approximately 98.5 percent soft, 1.4 percent mixed, and a negligible amount of hard/rock substrate (figures 3-6, 3-6 and table 3-4). Based on the EFH synthesis report habitat recovery table described above (Table 3-1), it would take an estimated 0.1year for hard substrate areas, and 0.4 year for the mixed and soft substrate areas impacted by fixed gear to recover if closed to all fixed gear activity.

**150 to 200 fm, 40° 10’ N. latitude to 45° 46’ N. latitude:** Due to the fixed gear RCAs, (Table 3-7, *above*), there is substantial fixed gear shoreward of the 100 fm depth contour in this area (Figure 3-14, below). Within this depth interval (150-200 fm), the substrate types are approximately 91.9 percent soft, 6 percent mixed, and 2 percent hard/rock substrate (Figure 3-7, Table 3-7, and Table 3-4). Based on the EFH synthesis report habitat recovery table described above (Table 3-1), it would take an estimated 0.1 year for hard substrate areas, and 0.4 year for the mixed and soft substrate areas impacted by fixed gear to recover if closed to all fixed gear activity. However, disruption to biogenic habitat such as coral or sponges where fixed gears are able to access untrawlable hard or mixed areas may take longer to recover.

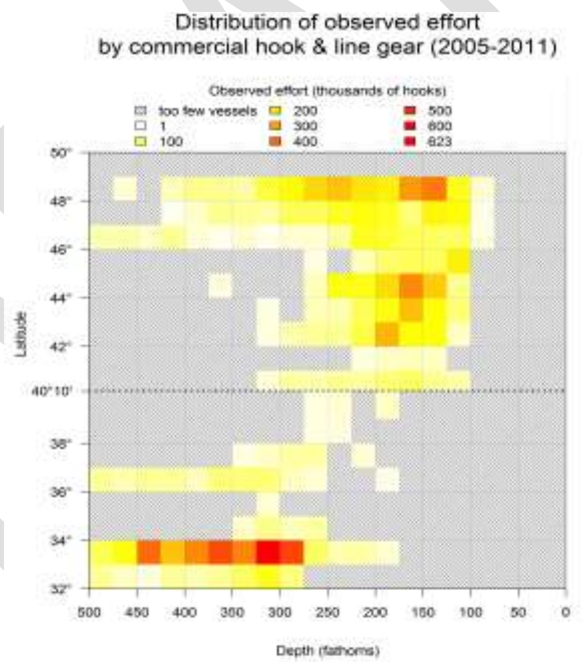



Figure 3-14: Observed 2005-2011 longline fixed-gear effort by depth (fm) and latitude. Heat cell units in thousands of hooks observed.

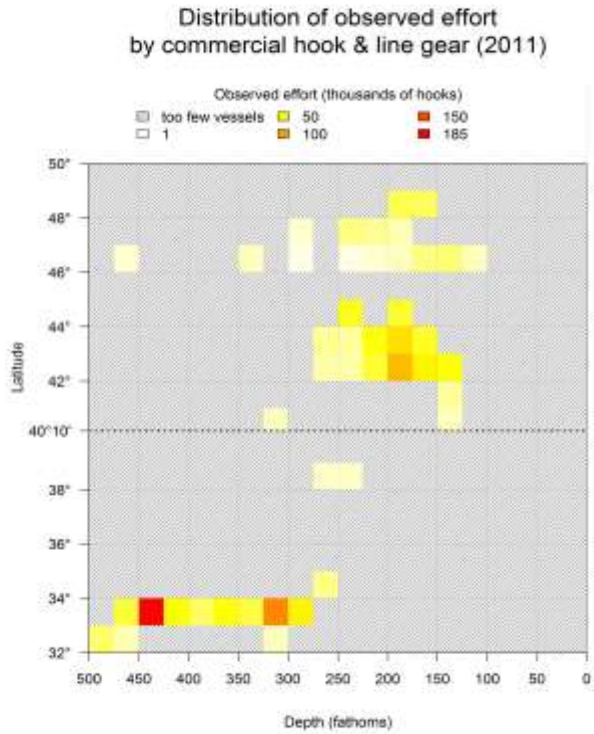



Figure 3-15: Observed 2011 longline fixed-gear effort by depth (fm) and latitude. Heat cell units in thousands of hooks observed.

Figure 3-12 and Figure 3-13 (above) may help to provide a rough contextual sense of longline fixed gear effort within the trawl RCA depth/latitude range (heat cell units are described as number of observed hooks set), particularly that within the "core" trawl RCA (100-150 fm) and seaward of the trawl 150 fm RCA boundary from 2005 to 2011.

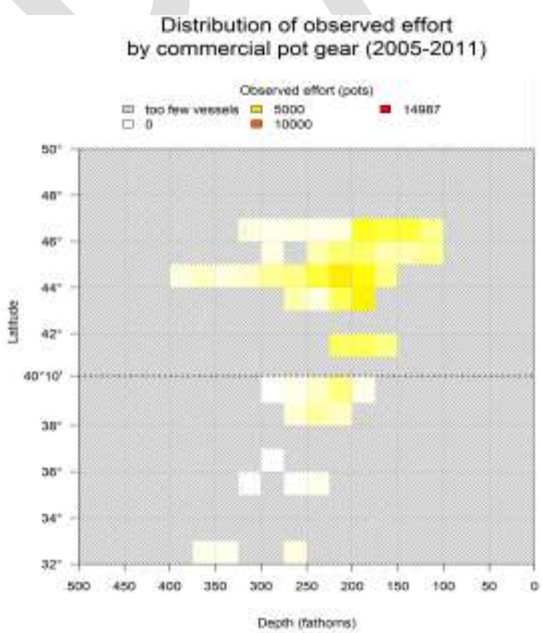



Figure 3-16: Observed 2005-2011 groundfish pot fixed-gear effort by depth (fm) and latitude. Heat cell units in numbers of pots observed.

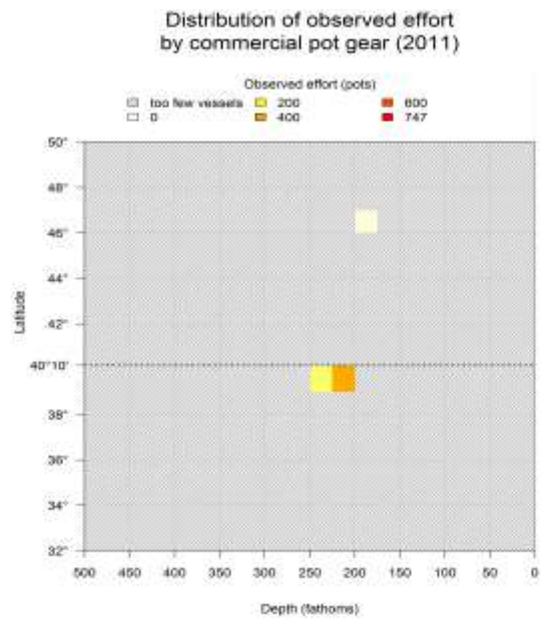



Figure 3-17: Observed 2011 groundfish pot fixed-gear effort by depth (fm) and latitude. Heat cell units in numbers of pots observed.

Figure 3-14 and Figure 3-15 demonstrate that a substantial amount of fixed gear effort occurs within and seaward of the trawl RCA, some of which may be on mixed or hard substrate areas that are untrawlable. Pot fixed gear effort is consistently in more narrow, upper slope depths, 150-250 fm (Figure 3-16, Figure 3-16 above). This fishing behavior is likely due to sablefish abundance.

#### 3.3.4.3 Current Habitat as Affected by Pink Shrimp Bottom Trawl Gear

The pink shrimp trawl fishery includes vessels using non-groundfish trawl gear (previously called "exempted" trawl gear), which is gear other than the Pacific Coast groundfish trawl gear that is authorized for use with a valid groundfish limited entry permit endorsed for trawl gear. Non-groundfish trawl gear includes trawl gear used to fish for pink shrimp, ridgeback prawn, California halibut south of Pt. Arena, and sea cucumbers south of Pt. Arena.

The pink shrimp trawl fishery commonly uses a four seam net in a box trawl design. A single rigged shrimp vessel may use the same doors that are used by groundfish trawl vessels, while a double rigged shrimp vessel uses doors that are typically much larger than those used by groundfish trawlers. Of the major components, trawl doors affect the smallest area of seabed, though trawl door marks are the most recognizable and frequently observed effect of trawls on the seabed. The footropes used in pink shrimp trawling are not protected with any rollers or bobbins or other gear and are generally rigged to run about 12-18 inches off the bottom (31-46 cm). That is, the footrope of shrimp nets is not designed to contact the bottom. A groundline with disks or bobbins that are two to five inches (5 cm-13 cm) in size may be suspended below the footrope by ladder chains that drag along the bottom, which helps to prevent the footrope from digging into the bottom. The bridles are cables that connect the trawl doors to the trawl net. The bottom bridle may be in contact with the seabed for a part of their distance. Additional detail about the various gears used off the Pacific Coast can be found in chapter 3 of the EFH EIS.

Pink shrimp bottom trawling is allowed, and occurs, within the groundfish trawl RCA. Bycatch Reduction Devices (BRDs) have been required since 2001, and have greatly reduced finfish catch (including overfished species)(Figure 3-18, below). Pink shrimp bottom trawl fisheries are now well documented as having negligible overfished rockfish species bycatch. BRDs are effective at nearly eliminating rockfish bycatch into the cod-end (Figure 3-18).

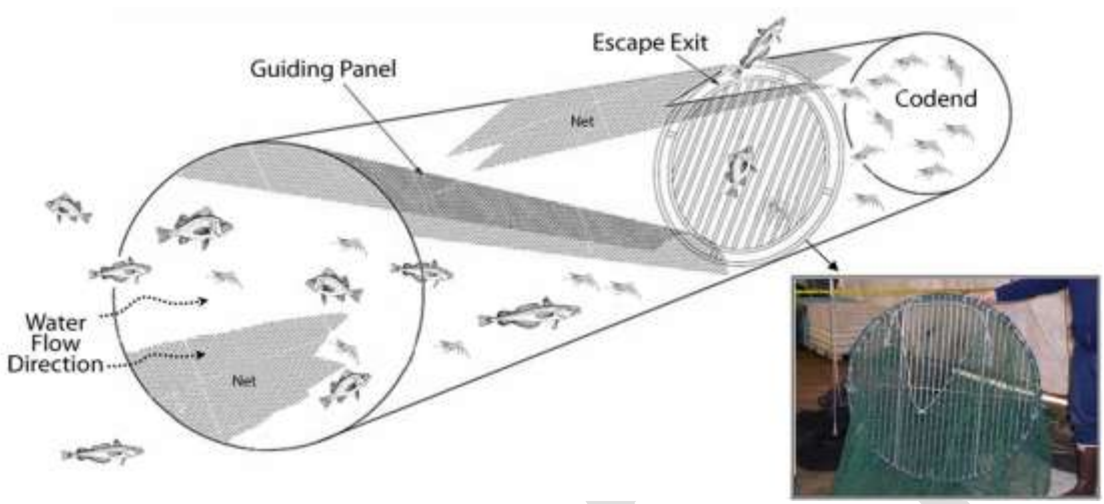



Figure 3-18: Diagram of a finfish excluder used in pink shrimp bottom trawl nets. Source: Frimodig et al., 2009, NMFS 2009.

Recent annual pink shrimp bottom trawl effort by depth suggests that hauls outside150 fm are not documented (Table 3-8). Additional WCGOP data from NWFSC staff suggests that the majority of observed effort occurs between 50 to 110 fm (Figure 12). Oregon State logbook data, figure 3-13 (below) suggests that there are a fair number of logged sets within depths between 60 to 120 fm, ranging from approximately 40 to 150 fm. Washington logbook data may suggest similar trends (Table 3-8). VMS data of all trips may help determine if that there is any sampling bias or observer effect in fishing locations, and to better determine the spatial extent of shrimp trawling impacts on benthic habitat.

Table 3-8: History of pink shrimp trawl effort from state logbook records in max depth (fm) and total number of recorded hauls. CDFW has not been able to do much with their shrimp and prawn logs in recent years due to a lack of data entry personnel (*Peter Kalvass, CDFW, Personal Communication*).

**RECENT PINK SHRIMP TRAWL EFFORT (depth)**

| State | Year | max depth (fm) | hauls |
|---|---|---|---|
| Washington | 2012 | 142 | 3,531 |
| | 2011 | 105 | 2,495 |
| | 2010 | N/A | N/A |
| Oregon | 2012 | 148 | 9,657 |
| | 2011 | 117 | 9,736 |
| | 2010 | 122 | 8,220 |
| California | N/A | N/A | N/A |

**<u>75-100 fm, 40° 10' N. latitude to 48° 10' N. latitude:</u>** Available observer data (Table 3-8, Figure 3-19, Figure 3-20) suggest that there is a high degree of pink shrimp trawl effort in the 75 to 100 fathom depth zones, and therefore, impacts by pink shrimp bottom trawl gear are expected. Within this depth interval (75-100 fm), the substrate types are approximately 90 percent soft, 10 percent mixed and hard substrates. Based on the EFH synthesis report habitat recovery table described above (Table 3-1), it would take an estimated 2.8 years for the hard and mixed substrate areas to recover, and one year for soft habitat to recover if closed to all groundfish bottom trawling activity. However, estimates of recovery may be different between pink shrimp trawl gear compared with groundfish bottom trawl gear.

**__100-150 fm, 40° 10' N. latitude to 48° 10' N. latitude:__** Although this depth zone would not be opened under any of the alternatives analyzed, it may be useful to consider the amount of pink shrimp trawling occurring within this area when considering the impacts of groundfish trawling activities. ODFW logbook data (Table 3-8, Figure 3-19, Figure 3-20) suggest that there may be pink shrimp trawl effort in this depth zone, although WCGOP data (Table 3-8) suggest that shrimp trawl effort in this area is negligible between 100-125 fm, from 43° N. latitude to 46° N. latitude.

**__150-200 fm, 40° 10' N. latitude to 48° 10' N. latitude:__** Available observer and logbook data (Table 3-8, Figure 3-19, Figure 3-20) suggest that there is no pink shrimp trawl effort in the 150 to 200 fathom depth zones.

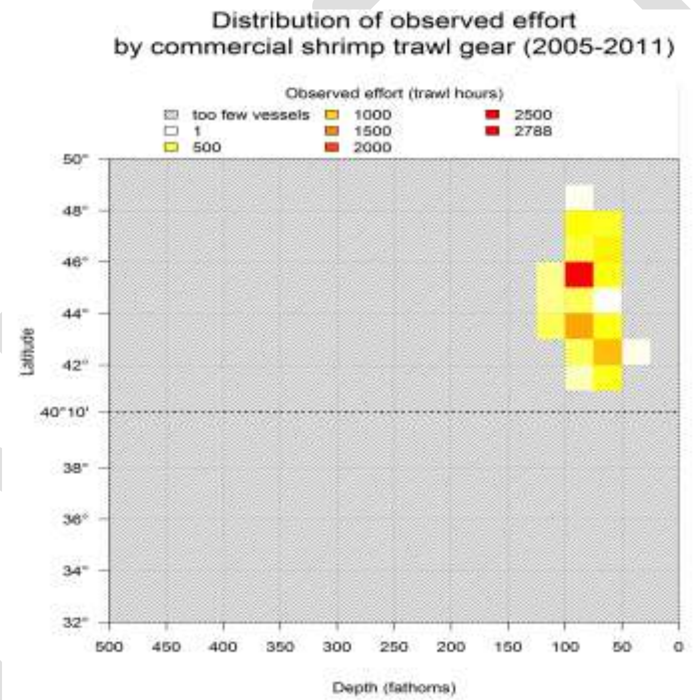



Figure 3-19: WCGOP distribution data of Pink Shrimp trawl observed trips from 2005-2011, by latitude, longitude, and effort hours under tow.

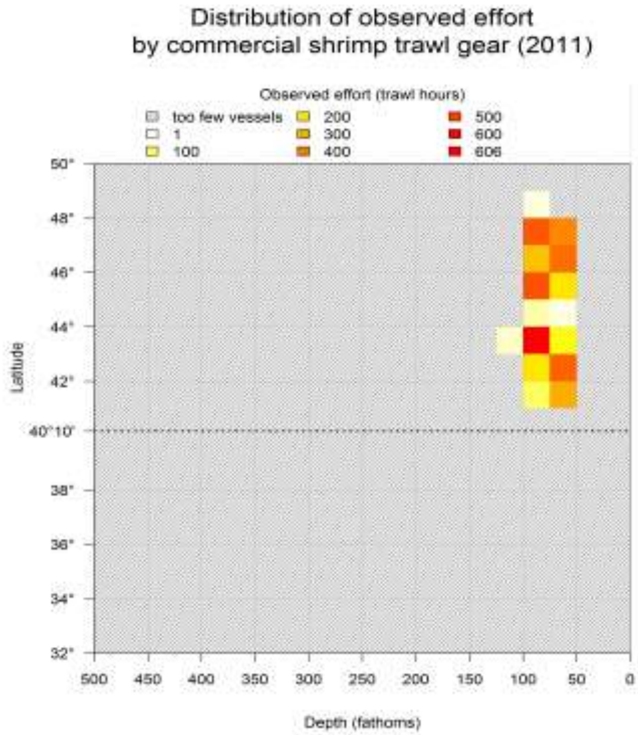



Figure 3-20: WCGOP distribution data of Pink Shrimp trawl observed trips from 2005-2011, by latitude, longitude, and effort hours under tow.

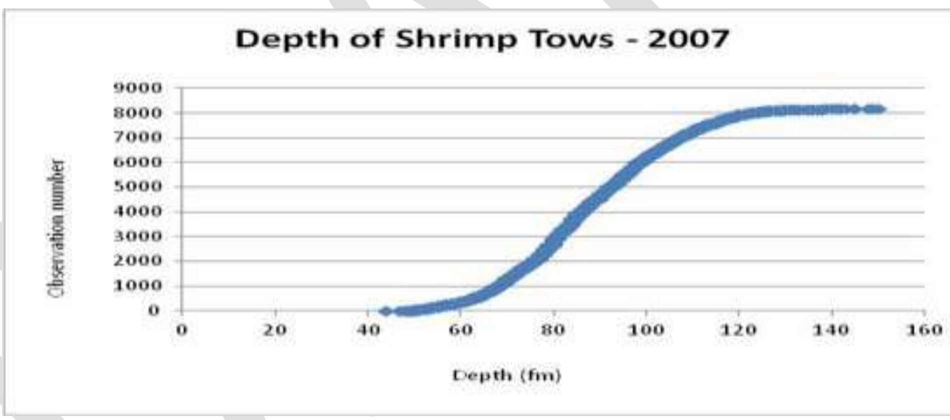



Figure 3-21: Oregon Department of Fish and Wildlife (ODFW) depth of shrimp tows compared with the number of observations in various recorded depths from ODFW logbooks.

Given the relatively low observer coverage rate of 4-14 percent between 2004 and 2011 (Table 3-9, below), as well as the secondary role BRDs may have in filtering large coral or sponges species, other inferences regarding pink shrimp bottom trawl impacts on groundfish EFH may be limited.

| | Observed | | | | Fleet Total | Coverage Rate |
|---|---|---|---|---|---|---|
| Year | # of trips | # of tows | # of vessels | Pink shrimp landings (mt) | Pink shrimp landings (mt) | % landings observed |
| 2002 | | | | | 25374.8 | |
| 2003 | | | | | 13886.6 | |
| 2004 | 57 | 1026 | 22 | 583.3 | 8974.3 | 6% |
| 2005 | 38 | 509 | 23 | 424.7 | 10861.9 | 4% |
| 2006 | | | | | 8399.8 | |
| 2007 | 63 | 951 | 30 | 672.7 | 10935.0 | 6% |
| 2008 | 55 | 840 | 31 | 805.8 | 15374.6 | 5% |
| 2009 | 59 | 708 | 36 | 881.6 | 14412.2 | 6% |
| 2010 | 126 | 1654 | 51 | 2365.3 | 20327.2 | 12% |
| 2011 | 186 | 2579 | 57 | 4103.8 | 29459.9 | 14% |

Table 3-9: Observer Coverage Rates. Total trips, tows, vessels and pink shrimp landings observed in the pink shrimp trawl fishery. Coverage rates are computed as the observed proportion of total pink shrimp landings, summarized from fish ticket landing receipts. Blank cells represent unobserved years. Source: WCGOP,

http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/shrimp_trawl.cfm

#### 3.3.4.4 Current Habitat as Affected by Dungeness Crab Pot Gear

Pot gear has been documented in various literature sources as having some impact to benthic habitat and sensitive coral, sponge, and sea whip species, although data are limited. The coastal states of Washington (WDFW), Oregon (ODFW), and California (CDFW) manage Dungeness crab fisheries. Available Washington and Oregon state logbook data (Table 3-10, below) suggests negligible impacts in the shoreward 75 fm to 100 fm, and 150-200 fathom depth areas between 40° 10' N. latitude and 48° 10' N. latitude.

Table 3-10: WA, OR, CA Dungeness crab pot gear sets by depth. Washington notes: Max pots that could be fished in 2011/12 if all of the vessels that made at least one landing fished all of their pots: 80,200. Oregon notes: Used averages for all available seasons of logbook data (07-08, 09-10, and 10-11). Average of max pots that could be fished if all of the vessels that made at least one landing fished all of there pots (by season): 117,900. Trend of increasing pots/season (from 114,400 to 121,900) and depth of fishing (75-100 fm bin from 0.21% to 0.5 %) over seasons.

| CRAB | | | |
|---|---|---|---|
| Depth | Washington | Oregon | California (North of 40° N. lat.) |
| 75-100 fathoms | 2.1% ~ 1,684 pot max | 0.33% ~ 391 pot max | N/A |
| 100-150 fathoms | 0.7% ~ 561 pot max | 0.01% ~ 8 pot max | N/A |
| 150-200 fathoms | 0 | 0 | N/A |

Information is not collected for Dungeness crab in California; logs are not required. Rock crab effort would be negligible in the region north of 40° 10' N. latitude. However, CDFW staff report heavy Dungeness crab effort north of 40°10 N. latitude, but from what is known of the fishery, very little of it would be deeper than 70 fm, (Peter Calvass, CDFW, Personal Communication). Impacts to overfished species are not expected in this fishery due to the selectivity of the gear (*2013-2014 FEIS, Appendix B*).

#### 3.3.4.5 Current Habitat as Affected by Spot Prawn Pot Gear

Pot gear has been documented in various literature sources as having some impact to benthic habitat and sensitive coral, sponge, and sea whip species, although data are limited. The spot prawn fishery is a state-permitted fishery that uses trap gear in Washington, Oregon, and California. Spot prawns inhabit rocky or hard bottoms including coral reefs, glass sponge reefs, and the edges of marine canyons. Spot prawns are hermaphroditic, with males maturing and metamorphosing to females around age four. Older females are the primary target of the fishery. The use of trawl gear to target spot prawns was phased out in all three states during the early 2000s due to catch of groundfish and undersized male spot prawns. In Washington spot prawn trawling was phased out in 2002 and closed in 2003, with fishermen allowed to transition to pot gear. In Oregon, spot prawn trawling was phased out and closed in 2004, with fishermen allowed to transition to pot gear. Off Oregon, catch per unit effort for spot prawns is much lower using pot gear, and much of the commercial effort has died out since 2004. Fishing grounds for spot prawns off Washington and Oregon are far offshore, sometimes 30 miles or more. This makes recreational fishing impractical.. Washington logbook data estimates that 87.5 percent of spot prawn effort may occur in the 75-100 fm depths, while 12.5 percent occur in the 100-150 fm depths (Dan Ayres, Personal Communication, WDFW). California does not have any spot prawn trap effort in the action area; the region between 40° 10’ N. latitude and 42° N. lat. (Peter Calvass, CDFW, Personal Communication).

### 3.3.4.6 Current Habitat as Affected by NMFS Bottom Trawl Surveys

NMFS conducts annual surveys of West Coast species abundance using bottom trawl gear, information of which is used for fisheries independent stock assessments, and cataloguing of species occurrences for fishery management units in and out of the Groundfish FMP. Samples are collected by trawling within randomly selected cells for a target fishing time of 15 minutes at a target speed of 2.2 knots (*Keller et al., in prep., 2013*). In order to answer the question of actual groundfish trawl survey impacts (*on habitat*) most accurately, one would have to map at the actual track lines of successful tows and calculate the total trawled area, taking into account any overlaps (*Whitmore, personal communication, July, 2013*). Impacts from NWFSC groundfish surveys (Figure 3-21, Figure 3-22, below) are expected to be extremely negligible, especially in context of the valuable information on target and non-target stock assessments these surveys provide the Council and the Agency in their decision-making. Because of the depth stratification used in the groundfish survey design, the greatest number of stations occurred in the region periodically closed to commercial bottom trawling (47980 $km^2$), despite the greater area of the region open to fishing (77058 $km^2$) (*Keller et al., in prep., 2013*).

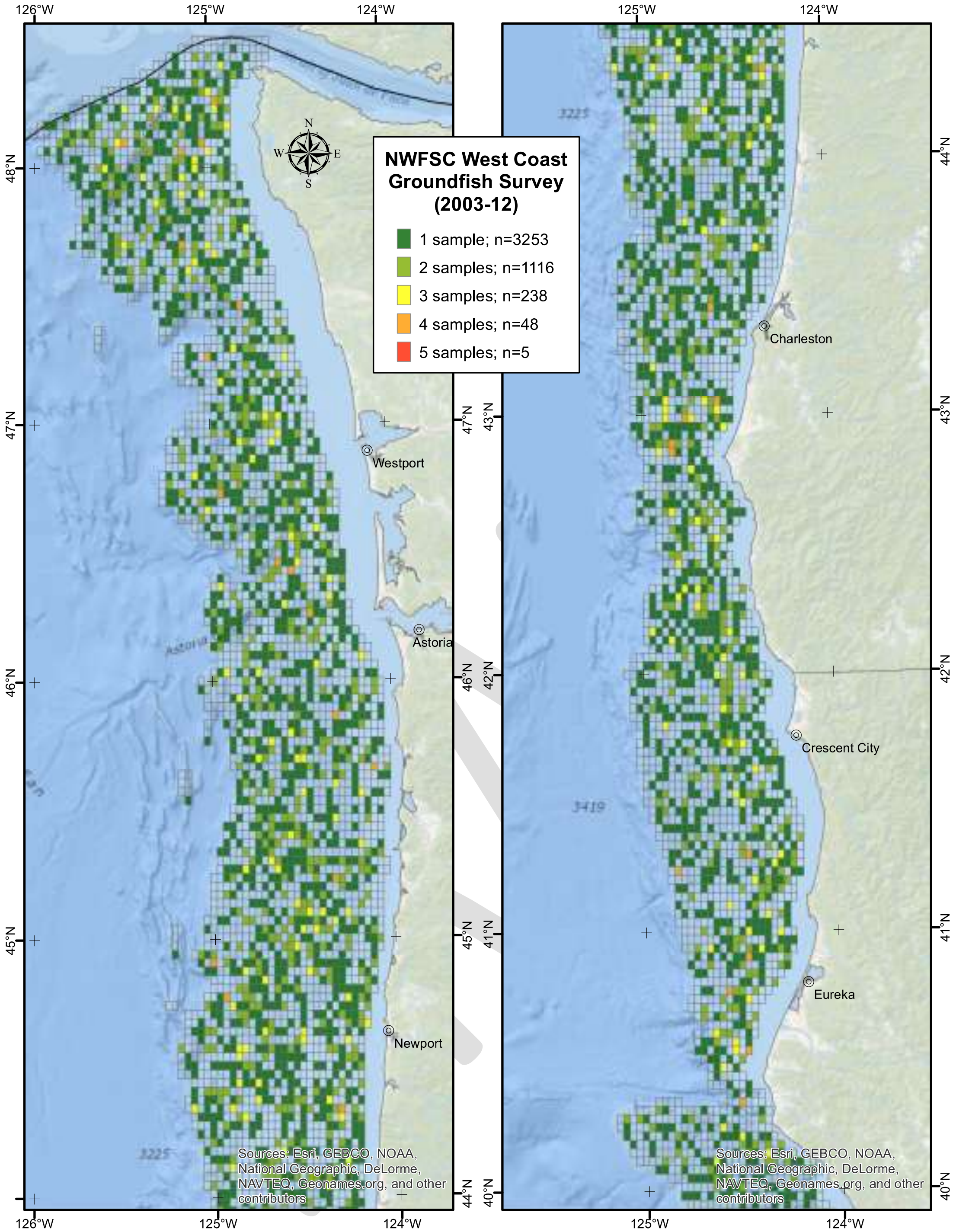



Figure 3-22: Map of the number of times per survey grid cell a successful tow was made by NWFSC West Coast Groundfish surveys (2003 to 2012). Inferences of NWFSC survey impacts within the proposed action area may be limited, as tow of average length covers <1% of the total cell area. However, this graphic is intended merely to offer a conceptual sense of potential impacts.

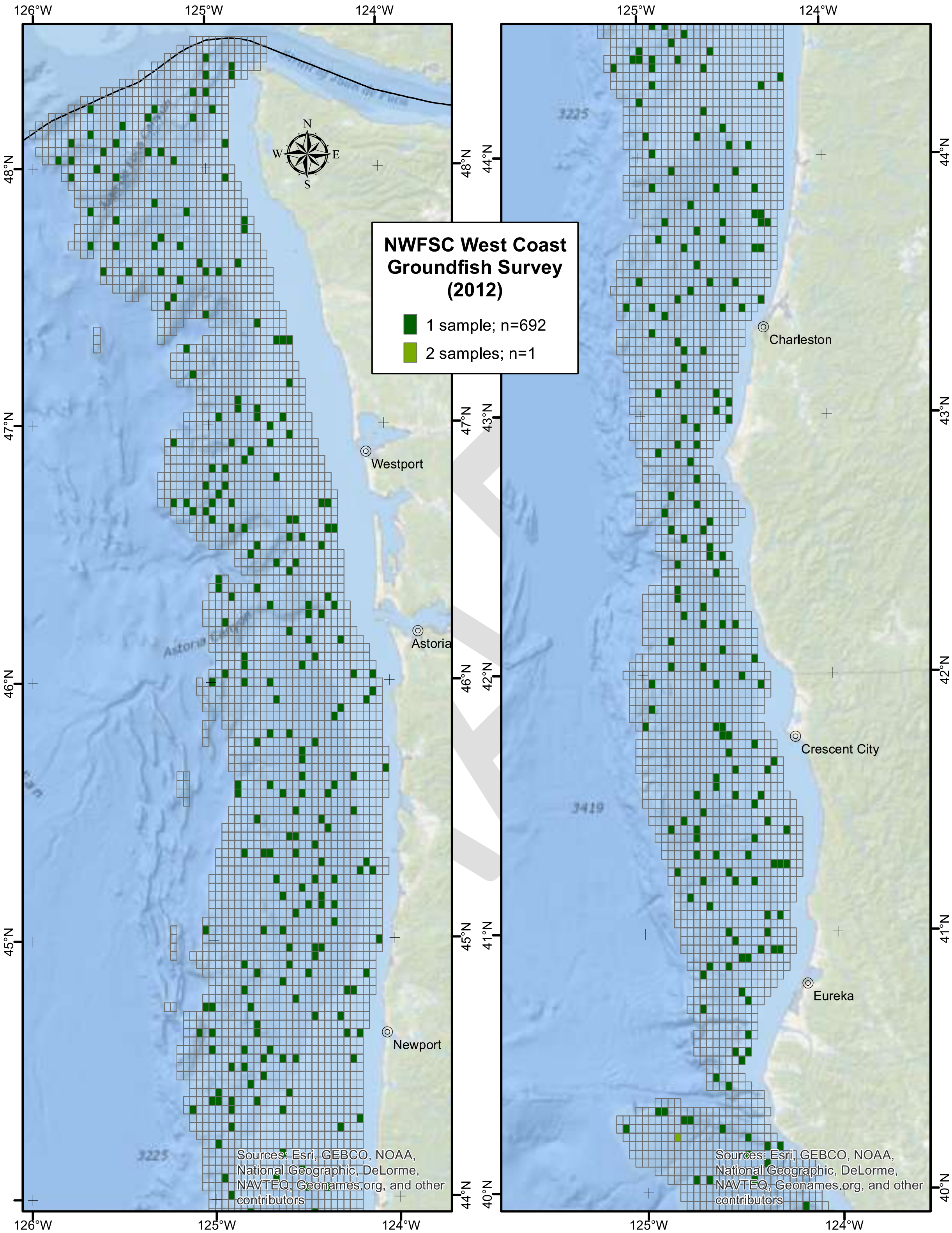



Figure 3-23: Map of the number of times per survey grid cell a successful tow was made by NWFSC West Coast Groundfish surveys (2012). Inferences of NWFSC survey impacts within the proposed action area may be limited, as tow of average length covers <1% of the total cell area. However, this graphic is intended merely to offer a conceptual sense of potential impacts.

## 3.4 Biological Resources

### *3.4.1* Groundfish Target Species

More than 90 species are managed under the Groundfish FMP (Table 3-11, below). These species include: 60-plus rockfish, including all genera and species from the family *Scorpaenidae* (*Sebastes*, *Scorpaena*, *Sebastolobus*, and *Scorpaenodes*); 12 flatfish species; 6 roundfish species; and 6 miscellaneous fish species that include sharks, skates, grenadiers, rattails, and morids.

Table 3-11: Latitudinal and depth distributions of groundfish species (adults) managed under the FMP. Source: 2013-14 Groundfish Harvest Specification FEIS, Chapter 3: Affected Environment.

| Common Name | Scientific Name | Latitudinal Distribution | | Depth Distribution (fm) | |
|---|---|---|---|---|---|
| | | Overall | Highest Density | Overall | Highest Density |
| **Flatfish Species** | | | | | |
| Arrowtooth flounder | *Atheresthes stomias* | N. 34º N lat. | N. 40º N lat. | 10-400 | 27-270 |
| Butter sole | *Isopsetta isolepis* | N. 34º N lat. | N. 34º N lat. | 0-200 | 0-100 |
| Curlfin sole | *Pleuronichthys decurrens* | Coastwide | Coastwide | 4-291 | 4-50 |
| Dover sole | *Microstomus pacificus* | Coastwide | Coastwide | 10-500 | 110-270 |
| English sole | *Parophrys vetulus* | Coastwide | Coastwide | 0-300 | 40-200 |
| Flathead sole | *Hippoglossoides elassodon* | N. 38º N lat. | N. 40º N lat. | 3-300 | 100-200 |
| Pacific sanddab | *Citharichthys sordidus* | Coastwide | Coastwide | 0-300 | 0-82 |
| Petrale sole | *Eopsetta jordani* | Coastwide | Coastwide | 10-250 | 160-250 |
| Rex sole | *Glyptocephalus zachirus* | Coastwide | Coastwide | 10-350 | 27-250 |
| Rock sole | *Lepidopsetta bilineata* | Coastwide | N. 32º30' N.lat. | 0-200 | summer 10-44 |
| Sand sole | *Psettichthys melanostictus* | Coastwide | N. 33º50' N.lat. | 0-100 | 0-44 |
| Starry flounder | *Platichthys stellatus* | Coastwide | N. 34º20' N.lat. | 0-150 | 0-82 |
| **Rockfish Species** [b/] | | | | | |
| Aurora rockfish | *Sebastes aurora* | Coastwide | Coastwide | 100-420 | 82-270 |
| Bank rockfish | *Sebastes rufus* | S. 39º30' N.lat. | S. 39º30' N.lat. | 17-140 | 115-140 |
| Black rockfish | *Sebastes melanops* | N. 34º N lat. | N. 34º N lat. | 0-200 | 0-30 |
| Black-and-yellow | *Sebastes chrysomelas* | S. 40º N lat. | S. 40º N lat. | 0-20 | 0-10 |
| Blackgill rockfish | *Sebastes melanostomus* | Coastwide | S. 40º N lat. | 48-420 | 125-300 |
| Blue rockfish | *Sebastes mystinus* | Coastwide | Coastwide | 0-300 | 13-21 |
| Bocaccio [c/] | *Sebastes paucispinis* | Coastwide | S. 40º N. lat., | 15-180 | 54-82 |
| Bronzespotted rockfish | *Sebastes gilli* | S. 37º N lat. | S. 37º N lat. | 41-205 | 110-160 |
| Brown rockfish | *Sebastes auriculatus* | Coastwide | S. 40º N lat. | 0-70 | 0-50 |
| Calico rockfish | *Sebastes dalli* | S. 38º N lat. | S. 33º N lat. | 10-140 | 33-50 |
| California scorpionfish | *Scorpaena gutatta* | S. 37º N lat. | S. 34º27' N.lat. | 0-100 | 0-100 |
| Canary rockfish | *Sebastes pinniger* | Coastwide | Coastwide | 27-460 | 50- |
| Chameleon rockfish | *Sebastes phillipsi* | 37º-33º N lat. | 37º-33º N lat. | 95-150 | 95- |
| Chilipepper rockfish | *Sebastes goodei* | Coastwide | 34º-40º N lat. | 27-190 | 27- |
| China rockfish | *Sebastes nebulosus* | N. 34º N lat. | N. 35º N lat. | 0-70 | 2-50 |
| Copper rockfish | *Sebastes caurinus* | Coastwide | S. 40º N lat. | 0-100 | 0-100 |
| Cowcod | *Sebastes levis* | S. 40º N lat. | S. 34º27' N.lat | 22-270 | 100- |

| Common Name | Scientific Name | Latitudinal Distribution | | Depth Distribution (fm) | |
|---|---|---|---|---|---|
| | | Overall | Highest Density | Overall | Highest Density |
| Darkblotched rockfish | *Sebastes crameri* | N. 33º N lat. | N. 38º N lat. | 16-300 | 96-220 |
| Dusky rockfish | *Sebastes ciliatus* | N. 55º N lat. | N. 55º N lat. | 0-150 | 0-150 |
| Dwarf-Red rockfish | *Sebastes rufinanus* | 33º N lat. | 33º N lat. | >100 | >100 |
| Flag rockfish | *Sebastes rubrivinctus* | S. 38º N lat. | S. 37º N lat. | 17-100 | shallow |
| Freckled rockfish | *Sebastes lentiginosus* | S. 33º N lat. | S. 33º N lat. | 22-92 | 22-92 |
| Gopher rockfish | *Sebastes carnatus* | S. 40º N lat. | S. 40º N lat. | 0-30 | 0-16 |
| Grass rockfish | *Sebastes rastrelliger* | S. 44º40' N.lat. | S. 40º N lat. | 0-25 | 0-8 |
| Greenblotched rockfish | *Sebastes rosenblatti* | S. 38º N lat. | S. 38º N lat. | 33-217 | 115-130 |
| Greenspotted rockfish | *Sebastes chlorostictus* | S. 47º N lat. | S. 40º N lat. | 27-110 | 50-100 |
| Greenstriped rockfish | *Sebastes elongatus* | Coastwide | Coastwide | 33-220 | 27-136 |
| Halfbanded rockfish | *Sebastes semicinctus* | S. 36º40' N.lat. | S. 36º40' N.lat. | 32-220 | 32-220 |
| Harlequin rockfish [d/] | *Sebastes variegatus* | N. 40 º N lat. | N. 51º N. lat. | 38-167 | 38-167 |
| Honeycomb rockfish | *Sebastes umbrosus* | S. 36º40' N.lat. | S. 34º27' N.lat. | 16-65 | 16-38 |
| Kelp rockfish | *Sebastes atrovirens* | S. 39º N lat. | S. 37º N lat. | 0-25 | 3-4 |
| Longspine thornyhead | *Sebastolobus altivelis* | Coastwide | Coastwide | 167->833 | 320-550 |
| Mexican rockfish | *Sebastes macdonaldi* | S. 36º20' N.lat. | S. 36º20' N.lat. | 50-140 | 50-140 |
| Olive rockfish | *Sebastes serranoides* | S. 41º20' N.lat. | S. 40º N lat. | 0-80 | 0-16 |
| Pacific ocean perch | *Sebastes alutus* | Coastwide | N. 42º N lat. | 30-350 | 110-220 |
| Pink rockfish | *Sebastes eos* | S. 37º N lat. | S. 35º N lat. | 40-200 | 40-200 |
| Pinkrose rockfish | *Sebastes simulator* | S. 34º N lat. | S. 34º N lat. | 54-160 | 108 |
| Puget Sound rockfish | *Sebastes emphaeus* | N. 40º N lat. | N. 40º N lat. | 6-200 | 6-200 |
| Pygmy rockfish | *Sebastes wilsoni* | N. 32º30' N.lat. | N. 32º30' N.lat. | 17-150 | 17-150 |
| Quillback rockfish | *Sebastes maliger* | N. 36º20' N.lat. | N. 40º N lat. | 0-150 | 22-33 |
| Redbanded rockfish | *Sebastes babcocki* | Coastwide | N. 37º N lat. | 50-260 | 82-245 |
| Redstripe rockfish | *Sebastes proriger* | N. 37º N lat. | N. 37º N lat. | 7-190 | 55-190 |
| Rosethorn rockfish | *Sebastes helvomaculatus* | Coastwide | N. 38º N lat. | 65-300 | 55-190 |
| Rosy rockfish | *Sebastes rosaceus* | S. 42º N lat. | S. 40º N lat. | 8-70 | 30-58 |
| Rougheye rockfish | *Sebastes aleutianus* | Coastwide | N. 40º N. lat. | 27-400 | 27-250 |
| Semaphore rockfish | *Sebastes melanosema* | S. 34º27' N.lat. | S. 34º27' N.lat. | 75-100 | 75-100 |
| Sharpchin rockfish | *Sebastes zacentrus* | Coastwide | Coastwide | 50-175 | 50-175 |
| Shortbelly rockfish | *Sebastes jordani* | Coastwide | S. 46º N lat. | 50-175 | 50-155 |
| Shortraker rockfish | *Sebastes borealis* | N. 39º30' N.lat. | N. 44º N lat. | 110-220 | 110-220 |
| Shortspine thornyhead | *Sebastolobus alascanus* | Coastwide | Coastwide | 14->833 | 55-550 |
| Silvergray rockfish | *Sebastes brevispinis* | Coastwide | N. 40º N lat. | 17-200 | 55-160 |
| Speckled rockfish | *Sebastes ovalis* | S. 38º N lat. | S. 37º N lat. | 17-200 | 41-83 |
| Splitnose rockfish | *Sebastes diploproa* | Coastwide | Coastwide | 50-317 | 55-250 |
| Squarespot rockfish | *Sebastes hopkinsi* | S. 38º N lat. | S. 36º N lat. | 10-100 | 10-100 |
| Starry rockfish | *Sebastes constellatus* | S. 38º N lat. | S. 37º N lat. | 13-150 | 13-150 |

| Common Name | Scientific Name | Latitudinal Distribution | | Depth Distribution (fm) | |
|---|---|---|---|---|---|
| | | Overall | Highest Density | Overall | Highest Density |
| Stripetail rockfish | *Sebastes saxicola* | Coastwide | Coastwide | 5-230 | 5-190 |
| Swordspine rockfish | *Sebastes ensifer* | S. 38º N lat. | S. 38º N lat. | 38-237 | 38-237 |
| Tiger rockfish | *Sebastes nigrocinctus* | N. 35º N lat. | N. 35º N lat. | 30-170 | 35-170 |
| Treefish | *Sebastes serriceps* | S. 38º N lat. | S. 34º27' N.lat. | 0-25 | 3-16 |
| Vermilion rockfish | *Sebastes miniatus* | Coastwide | Coastwide | 0-150 | 4-130 |
| Widow rockfish | *Sebastes entomelas* | Coastwide | N. 37º N lat. | 13-200 | 55-160 |
| Yelloweye rockfish | *Sebastes ruberrimus* | Coastwide | N. 36º N lat. | 25-300 | 27-220 |
| Yellowmouth rockfish | *Sebastes reedi* | N. 40º N lat. | N. 40º N lat. | 77-200 | 150-200 |
| Yellowtail rockfish | *Sebastes flavidus* | Coastwide | N. 37º N lat. | 27-300 | 27-160 |
| **Roundfish Species** | | | | | |
| Cabezon | *Scorpaenichthys* | Coastwide | Coastwide | 0-42 | 0-27 |
| Kelp greenling | *Hexagrammos* | Coastwide | N. 40º N lat. | 0-25 | 0-10 |
| Lingcod | *Ophiodon elongatus* | Coastwide | Coastwide | 0-233 | 0-40 |
| Pacific cod | *Gadus macrocephalus* | N. 34º N lat. | N. 40º N lat. | 7-300 | 27-160 |
| Pacific whiting | *Merluccius productus* | Coastwide | Coastwide | 20-500 | 27-270 |
| Sablefish | *Anoplopoma fimbria* | Coastwide | Coastwide | 27->1,000 | 110-550 |
| **Shark and Skate Species** | | | | | |
| Big skate | *Raja binoculata* | Coastwide | S. 46º N lat. | 2-110 | 27-110 |
| California skate | *Raja inornata* | Coastwide | S. 39º N lat. | 0-367 | 0-10 |
| Leopard shark | *Triakis semifasciata* | S. 46º N lat. | S. 46º N lat. | 0-50 | 0-2 |
| Longnose skate | *Raja rhina* | Coastwide | N. 46º N lat. | 30-410 | 30-340 |
| Soupfin shark | *Galeorhinus zyopterus* | Coastwide | Coastwide | 0-225 | 0-225 |
| Spiny dogfish | *Squalus suckleyi* | Coastwide | Coastwide | 0->640 | 0-190 |
| **Other Species** | | | | | |
| Finescale codling | *Antimora microlepis* | Coastwide | N. 38º N lat. | 190-1,588 | 190-470 |
| Pacific rattail | *Coryphaenoides acrolepis* | Coastwide | N. 38º N lat. | 85-1,350 | 500-1,350 |
| Ratfish | Hydrolagus colliei | Coastwide | Coastwide | 0-499 | 55-82 |

a/ Data from (Casillas, *et al.* 1998; Eschmeyer, *et al.* 1983; Hart 1988; Love, *et al.* 2002; Miller and Lea 1972), and NMFS survey data. Depth distributions refer to offshore distributions, not vertical distributions in the water column.

b/ The category "rockfish" includes all genera and species of the family *Scorpaenidae*, even if not listed, that occur in the Washington, Oregon, and California area.

c/ Only the southern stock of bocaccio south of 40º10' N. lat. is listed as depleted.

d/ Only two occurrences of harlequin rockfish south of 51° N. lat. (off Newport, OR and La Push, WA; (Casillas, *et al.* 1998)).

These species vary greatly in life history, relative abundance, and their spatial and temporal distribution. Spatial distribution of rockfish is highly linked to depth, and therefore most rockfish species are split into one of three depth-based categories; nearshore, shelf and slope. Flatfish species are most concentrated on the continental shelf, but vary in depth distribution depending on the specie. Roundfish vary in depth distribution and targeted roundfish species are discussed in more detail below. Most shark and skate species are not targeted and are caught incidentally with other groundfish species. Most shark and skate species in the FMP are widely distributed across depths, except for California skates and Leopard sharks which are most highly concentrated in the nearshore waters.

Additional information on target groundfish species is presented below; additional detailed information for all groundfish species can be found in Chapter 3 of the 2013-2014 Biennial harvest specifications and management measures FEIS (NMFS 2012).

Annual catch limits are established through the biennial harvest specifications and management measures. Under the Shorebased IFQ Program all catch of IFQ species (retained or discarded, target and non-target) must be covered by quota pounds. Fishermen are individually accountable for their catch of individual species (or stock complexes), and are subject to a 100 percent monitoring requirement. Non-IFQ species are managed with trip limits.

There are prominent species that are primary economic drivers for IFQ vessels using bottom trawl gear, and under trawl rationalization, underutilized species may have an increased opportunity for improved marketability. There have been several notable changes in attainment by species, between 2011 and 2012 (Matson, 2013). The largest increases in attainment include the following: minor slope rockfish, south of 40°10' N. lat., up 19 percent; Pacific cod, up 13 percent; canary rockfish, up 13 percent; minor shelf rockfish, south of 40°10' N. lat., up 10 percent; and minor slope rockfish, north of 40°10' N. lat., up nine percent. The largest decreases in attainment include the following: sablefish south of 36° N. lat., down 42 percent, and shortspine thornyheads south of 34°27' N. lat., down 16 percent; yelloweye rockfish attainment was down four percent.

*Rockfish Life History*

Larvae and pelagic juveniles of many rockfish species live in the upper 55 fm (100 m) of the water column for one to several months before settling to benthic habitats (*Johnson et al., 2001*). Timing and magnitude of recruitment could be influenced by either passive ocean transport or active swimming of pelagic or newly settled juveniles (*Johnson et al., 2001*). Density and size of fishes increasing with depth has been observed for some rockfish species within their range (*Johnson et al., 2001*). Video analysis has suggested that juvenile and adult rockfishes may be more abundant on the seafloor rocky ridge areas than on the surrounding sandy flats (*Rooper et al., 2010*). While on bottom, all rockfishes were found in rocky ridge habitats and rarely on sandy flat seafloor. Rockfishes in the water column were found predominantly over the rocky ridges rather than over the flats (*Rooper et al., 2010*). On the US West Coast, daytime pelagic behavior of rockfish is not as common, whereas nighttime forays into the water column are more prevalent (*Rooper et al., 2010*).

*Juveniles*

Juvenile habitats are important to determining recruitment to adult fish populations through density dependence that occurs in nursery areas (*C.N. Rooper et al., 2007*). Juvenile POP have been found to exist predominantly in mixed sand and boulder substrata to the exclusion of most other habitat types (*C.N. Rooper et al., 2007*). An examination of large-scale patterns of juvenile and adult POP distribution indicates that juveniles use shallower depth zones on the continental shelf (C.N. Rooper et al., 2007). Geographic separation has been observed in POP: juvenile POP use nursery habitats that are different from adult POP (*C.N. Rooper et al., 2007*). Juvenile POP were associated with upright sponges or corals attached to the seafloor, cobble with a coral and sponge assemblage, crevices, or in one case a tangle of derelict longline gear (*C.N. Rooper et al., 2007*). C.N. Rooper et al., (2007) found very specific habitat preferences for juvenile POP for mixed sand-boulder substratum compared to other available substratum types. Distinct juvenile nursery areas appear to be a common feature in marine fish populations, the case of juvenile POP, although unique in terms of their specific habitat requirements, may be mirrored in most commercial fish species (*C.N. Rooper et al., 2007*).

*Nearshore species*

Recent ROV observations have concluded the following: highest densities of small benthic rockfishes observations suggested that shallow, rocky portions of Heceta Bank were important nursery areas from juvenile rockfishes (*Tissot et al, 2008*); shallow diagonal rock ridges (less than 55 fm deep), dominated mostly by a mixture of deep cobbles and small boulders, were important habitats for some fishes, especially juvenile rockfishes. Outcrop ridges on the shallower bank tops, and the cobble-boulder fields, represented important habitats for species of rockfish and other groundfish (*Tissot et al, 2008*).

Common groundfish target species in the nearshore environment are kelp greenling, lingcod, black rockfish, China rockfish, copper rockfish, cabezon and blue rockfish. Overfished rockfish species such as young-of-the-year yelloweye and canary rockfish are encountered in nearshore environments.

*Prominent Nearshore Target Species*

- Lingcod- Lingcod are abundant on the West Coast, and inhabit mostly nearshore and shelf areas. At certain times of the year, these species are in high abundance in predictable areas and are targeted by bottom trawl vessels.
- Sanddabs- Pacific Sanddabs are a marketable flatfish that inhabit soft nearshore substrate. Other marketable flatfish are commonly encountered in all soft substrates.

*Shelf Species*

Common groundfish target species in the shelf environment are vermillion, chilipepper, redstripe, and yellowtail rockfish. Flatfish species are primarily found on the shelf, but vary in depth distribution (2013-2014 FEIS). In addition, overfished rockfish such as cowcod, yelloweye, canary rockfish, and bocaccio (south of 40° N. latitude) spend the majority of their adult life stages in the shelf depths. Canary rockfish may migrate longer distances, and in larger schools than cowcod and yelloweye rockfish, which exhibit higher site fidelity. Petrale sole flatfish are currently designated as an overfished species, but are scheduled to be rebuilt in 2014 based on the results of a recent STAR panel stock assessment review (2013). Petrale sole exhibit a seasonal pattern of migration, following increased prey availability onto the shelf in the summer months, while migrating in deep slope areas during the winter to form deep spawning aggregations.

*Prominent Shelf Target Species*

- Yellowtail rockfish- Yellowtail rockfish are a very marketable rockfish found in bottom and midwater groundfish trawl fisheries. Yellowtail biomass is healthy on the West Coast, and temporal and spatial schooling patterns can be somewhat predictable for fishing vessels in their targeting efforts.
- Pacific Cod- Pacific cod are found on the West Coast, but are more commonly found on the northern West Coast, and strong migrations of Pacific Cod can be intermittent, as the West Coast is on the outer range of the species, which has extremely high abundances in Canadian and Alaskan waters. Large aggregations of Pacific cod can be found in nearshore or shelf sand or mud substrates.
- Petrale- Petrale sole, an overfished species likely to be declared rebuilt by the end of 2014, can be found in abundance in shelf waters in summer months. Petrale sole are the most prized flatfish and marketable species among the West Coast sole species.
- English sole- English sole are abundant in shelf waters, stocks are healthy, and make up an important component of bottom trawl catch.
- Lingcod- Lingcod are abundant on the West Coast, and inhabit mostly nearshore and shelf areas. These species can be targeted by bottom trawl vessels in dense aggregations.

*Slope species*

Common groundfish target species in the slope environment are Dover sole, shortspine and longspine thornyheads, sablefish, and various other flatfish species, such as rex sole and bank rockfish. Shortraker rockfish, a long lived data-poor species is encountered in slope depths. Other slope species include aurora, rougheye, splitnose, and blackgill rockfish. Adult overfished slope rockfish such as darkblotched and Pacific ocean perch (POP) are found in slope depths.

*Prominent Slope Target Species*

The DTS complex is a primary economic driver for the IFQ bottom trawl fishery. These species inhabit soft slope mud and sand substrates, can be found in abundance, and ex-vessel price per pound on these species is high.

- Dover sole (*below*)- Dover sole are an abundant flatfish in deeper shelf and upper slope depths. Dover sole are abundant in soft substrates, and their marketability has been increasing in recent years.

- Shortspine and Longspine Thornyheads (*below*)- Longspine thornyhead are more abundant in the deeper waters characteristic of the area open to commercial bottom trawling while shortspine thornyhead were significantly more abundant in the continuously closed area of the RCA after accounting for depth (*Keller, et al., in prep., 2013*). The thornyhead subgroup exhibited significantly greater catch in both the open and closed areas relative to the periodically closed area depth (*Keller, et al., in prep., 2013*).

- Sablefish (*below*)- Sablefish are an important species and migrate long distances throughout the West Coast slope and shelf habitats, with some vertical migration between seasons (larger fish on the shelf in summer months). Sablefish prices saw record ex-vessel prices in recent years, but even during periods of low market prices, make up an important component in all groundfish vessels, and their profitability.

- Petrale sole- Petrale sole, an overfished species, is likely to be declared rebuilt by the end of 2014, can be found in great abundance in slope waters during winter months while forming dense spawning aggregations.

### *3.4.2* Non-target Species, including overfished groundfish

#### 3.4.2.1 Overfished Groundfish Species

The RCAs were intended, and have been used over the last 11 years, to limit catch of rebuilding rockfish stocks in an active trawl fishery. The RCAs were established and used to close and open areas in a frequent, time-varying manner. Over the history of RCAs being in place, inseason changes to their boundaries have been made frequently, with accompanying analysis, to enable catch of target species, while at the same time, keeping bycatch of rebuilding stocks within established catch limits to facilitate timely rebuilding.

Catch of current rebuilding groundfish species has been much lower on average during the first two years of the IFQ program, compared with the previous two years. Total annual catch of over fished rebuilding species 2011 and 2012 in the Shorebased IFQ Program decreased compared to 2009-2010 levels (*Source, WCGOP Groundfish Mortality Report 2009-2010, and the Shorebased IFQ Program, Vessel Accounts System 2011-2012*):

- **60%** decrease for yelloweye rockfish bycatch.
- **89.6%** decrease for cowcod rockfish bycatch (South of 40°10' N. latitude).
- **37.8%** decrease for canary rockfish bycatch.

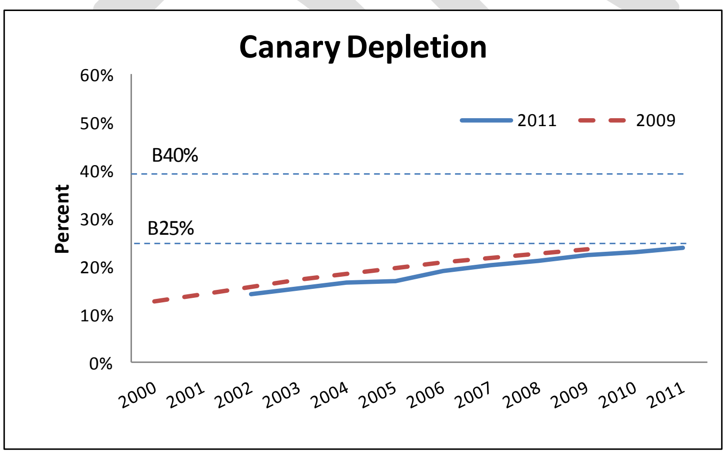
- **56.7%** decrease for bocaccio rockfish bycatch (South of 40°10' N).
- **68.1%** decrease for Pacific ocean perch bycatch (North of 40°10' N).
- **68%** decrease for Darkblotched rockfish bycatch.
- **32.8%** decrease for Petrale[2] sole bycatch.

Based on an analysis of the potential for incidental catch of overfished species occurring as a result of the proposed action, canary rockfish, darkblotched rockfish, and POP have the greatest potential for increased catch. These species descriptions are summarized from the 2013-2014 Harvest Specifications and Management Measures EIS. More details can also be found in the stock assessments.

*Canary Rockfish*

Wallace and Cope (2011) prepared a coastwide stock assessment update for canary rockfish. Based on a revised catch series, canary rockfish were very lightly exploited until the early 1940s, when catches increased and a decline in biomass began. The spawning biomass experienced an accelerated rate of decline during the late 1970s, and reached a low of 9.7 percent of unfished biomass in the mid-1990s. The current depletion is 24 percent of the unfished biomass level in 2011 (~95 percent confidence interval 18-30 percent) and is an estimated increase of over 50 percent since 2000. The stock was estimated to have been at 11.5 percent the unfished biomass level in 2000. The canary rockfish spawning stock biomass is gradually increasing in response to reductions in harvest and above-average recruitment in the preceding decade. However, this trend is very uncertain.

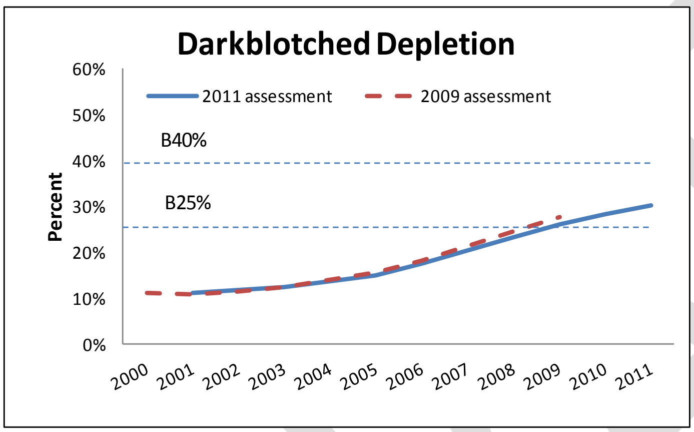
Recent year class strengths (1997-2008) have generally been low, with only 4 of the 12 years (1999, 2001, 2006, and 2007) estimated to have produced large recruitments. Unfished spawning stock biomass is estimated to be 33,512 mt under the base case model in the 2011 assessment. The new assessment estimates the spawning stock biomass to be 8,036 mt (~95 percent confidence interval: 5,719-10,353 mt).




*Darkblotched Rockfish*

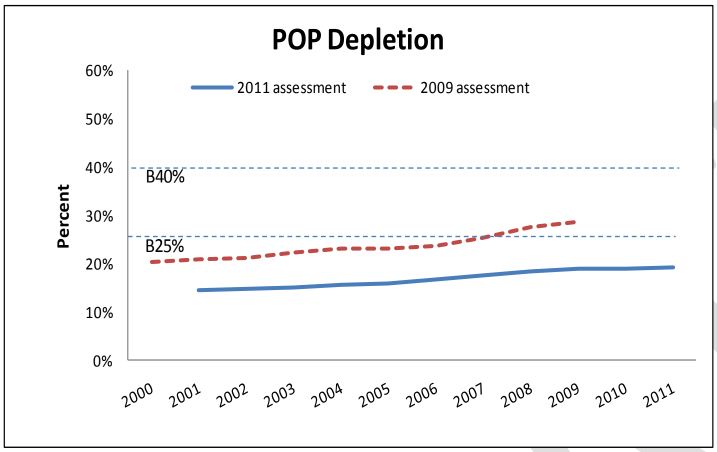
[2] Petrale sole harvest is close to being rebuilt (estimated 2014), and is currently managed as a target stock.

Stephens et al. (2011) prepared a stock assessment update for darkblotched rockfish in the U.S. Vancouver, Columbia, Eureka and Monterey areas. The darkblotched rockfish population in these areas was modeled as a single stock. The biomass (1+ age fish) in 2011 was estimated to be 13,926 mt. The recruitment pattern for darkblotched rockfish is highly variable between years. With the exception of the 1999, 2000, and 2008 year classes, recruitment levels (age-0 recruits) between the 1980s and 1990s were generally poor when compared with historical average recruitment levels. Darkblotched rockfish continues to show an increasing trend with the point estimate for the depletion of the spawning output at the start of 2011 at 30.2 percent of its unfished biomass. The assessment suggests that the west coast darkblotched stock is above the overfished threshold, but below the management target of B40%. The spawning output appears to have increased steadily over the past 10 years. Since 2003, overfishing is estimated to have occurred once, with estimated catch exceeding the ABC (now referred to as the OFL) by 1 mt in 2004.



*Pacific Ocean Perch*

Hamel and Ono (2011) prepared a stock assessment for POP in the waters off the U.S. West Coast from northern California to the U.S.-Canada border. The estimate of depletion of the spawning biomass at the start of 2011 is estimated to be 19.1 percent. The POP biomass shows an increasing trend. In 2011, the spawning output (3+ year-old fish) was estimated to be 25,482 mt. Because the estimated unfished biomass is estimated to be much larger in the 2011 stock assessment relative to past assessments (Hamel 2009), the estimated depletion of 19.1 percent in 2011 is lower than that estimated in 2009 (28.6 percent) in the 2009 assessment or the projected 2011 depletion (31.5 percent) in the 2009 assessment.




#### 3.4.2.2 Non-target Species

Most shark and skate species are caught incidentally while trawl vessels target other groundfish species. Most shark and skate species in the FMP are widely distributed across depths, except for California skates and Leopard sharks which are most highly concentrated in the nearshore waters. Additional detailed information on non-target groundfish species can be found in Chapter 3 of the 2013-2014 Biennial harvest specifications and management measures FEIS (NMFS 2012).

Some flatfish species, including some species that are in the groundfish FMP and some that are not, are caught incidentally by vessels targeting other groundfish species and are most vulnerable to the groundfish bottom trawl fishery.

Pacific halibut (*Hippoglossus stenolepis*) is a bottom-dwelling, right-eyed flatfish species. Pacific halibut are taken with trawl, as well as commercial and recreational fixed gears as they co-occur with groundfish stocks, including canary and yelloweye rockfish. The fixed gear sablefish fishery is responsible for the most catch of Pacific halibut (NMFS 2012). Pacific halibut catch has been restricted in the trawl fisheries through the issuance of bycatch allowances.

California halibut (*Paralichthys californicus*) are a left-eyed flatfish. They range from Northern Washington to southern Baja California, Mexico, (Eschmeyer, et al., 1983), but are most common south of Oregon. California halibut are taken incidentally in the groundfish fishery, but are most vulnerable to groundfish bottom trawl gear. Harvest of California halibut in the groundfish bottom trawl fishery has averaged 46 mt from 2007-2010, while catch in the non-trawl groundfish fishery has averaged less than 3 mt during the same time period (NMFS 2012).

Coastal pelagic species, such as smelt and herring, are taken incidentally in the groundfish fishery, and are believed to be most vulnerable to midwater trawl gear, with incidental take of coastal pelagic species documented in the midwater whiting fisheries. Given that coastal pelagic species are not associated with the ocean bottom, interactions with the groundfish bottom trawl fishery are expected to be minimal (NMFS 2012). Additional information on catch of coastal pelagic species in the midwater trawl fishery is available in Chapter 3 of the 2013-2014 Biennial harvest specifications and management measures FEIS (NMFS 2012).

Greenlings (other than kelp greenling), are caught incidentally with vessels targeting nearshore rockfish (NMFS 2012). Ocean whitefish are harvested using non-trawl gear, and are not generally caught incidentally in the groundfish bottom trawl fishery (NMFS 2012). California sheephead are not caught in the Shorebased IFQ Program, and additional information on bycatch of California sheephead is not available.

Highly migratory species, such as marlin, tuna and non-FMP sharks are largely pelagic, open ocean species. These species are very infrequently caught in groundfish directed fisheries off Washington and Oregon. In California, highly migratory species are occasionally taken by fisheries targeting groundfish. In 2009, about 100 kg of albacore were taken incidentally with groundfish trolling (non-trawl gear) for sablefish and rockfish. Thresher sharks are incidentally taken in trawl gear (HMS SAFE Document, 2010).

### *3.4.3* Invertebrates

Various types of bottom-dwelling invertebrates occur in the action area including crab, shrimp, coral and sponges. These include Dungeness crab, tanner crab, pink shrimp, ridgeback prawns, spot prawns, sea cucumbers, coral, and sponges.

Dungeness crab is taken incidentally, or harmed unintentionally, by groundfish gears. In some areas, interactions with Dungeness crab by nearshore flatfish trawls are a concern. Concentrating vessel effort in shallow water during the summer months (<75 fm) affects Dungeness crab in the north because they are less likely to survive discard during their summer molting season. Shrimp trawl nets are usually constructed with net mesh sizes smaller than the net mesh sizes for legal groundfish trawl gear. Thus, it is shrimp trawlers that commonly take groundfish in association with shrimp, rather than the reverse. Additional detailed information regarding these invertebrates can be found Chapter 3 of the 2013-2014 Biennial harvest specifications and management measures FEIS (NMFS 2012).

Additional information regarding structure-forming invertebrates, including corals, sponges and sea whips, is provided below.

#### 3.4.3.1 Coral

Coral species are most often observed in hard substrate, with some minor occurrences in mixed substrate on boulders; on mixed substrate, most are less than 30-50 cm in height. Coral species are not commonly found in sandy or mud substrate. In one ROV study off the West Coast of northern British Columbia, over half of primnoid corals over 30 cm tall had associated rockfish, less than 2% of the seafloor had large coral, and small coral had no associated rockfish, and no rockfish were associated with short corals between 10 and 30 cm height (Du Preez & Tunnicliffe, 2011).

Through stomach content analyses, Husebo et al. (2002) found rockfish are not linked to coral sites through feeding habits and suggest the physical structure of corals attracts rockfish, rather than some biological attribute (Du Preez & Tunnicliffe, 2011). Oceanographic factors, such as El Ninõ events could affect larval survival of octocorals (Troffe et al, 2005). Studies suggesting deep-sea coral reefs may be decades to hundreds of years old (Etnoyer and Morgan, 2003). Retrospective analysis and isotope dating techniques for Primnoa resdaeformis suggest that a 5 cm diameter sample may be as old as 500 years (Etnoyer and Morgan, 2003). Andrews (2002) estimated growth rates of 1.74 cm per year in height, suggesting the largest limb studied took approximately 112 yrs to grow from its initial settlement to a total height of 197.5 cm (Etnoyer and Morgan, 2003). Any benthic features sensitive to trawling, such as corals, have long since been impacted, and in trawl fisheries on complex structures, such as California, Oregon, Washington, and British Columbia, each vessel trawls the same set of "shots" year after year amounting to 10% of the total bottom (Hilborn, 2007). NMFS' bottom trawl survey has caught several coral species during their research surveys. Most of the corals encountered in those activities are Pennatulaceans, both in quantity and in frequency (Table 3-12). However, some coral species may have escaped damage from trawl gear which could potentially be impacted by the proposed action.

Table 3-12: General statistics on deep corals sampled during National Marine Fisheries Service (NMFS) bottom trawl surveys, which were conducted off the coasts of Washington, Oregon and California by the Alaska and Northwest Fisheries Science Centers between 1980 and 2005. A total of 10,526 trawl catch records were queried. Source: Whitmire and Clark, 2007, NMFS.

| | # Trawls with Corals | % Trawls with Corals | % Coral Records |
|---|---|---|---|
| **Pennatulaceans** | 1683 | 16.00% | 74.50% |
| **Gorgonians** | 202 | 1.90% | 8.90% |
| **Antipatharians** | 197 | 1.90% | 8.70% |
| **Alcyonaceans** | 150 | 1.40% | 6.60% |
| **Scleractinians** | 26 | 0.20% | 1.20% |
| **Stylasterids** | 1 | <0.1% | <0.1% |
| **Total** | 2259 | | 100.00% |

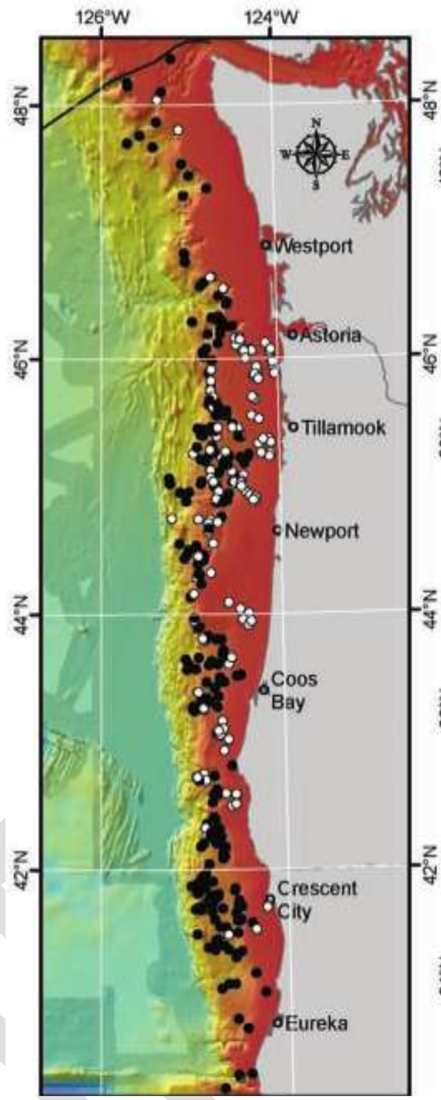



Figure 3-24: Map showing locations of deep coral bycatch recorded by fishery observers in the West Coast Groundfish Observer Program. All observed trips and gear types from August 2001 – August 2004 were queried. Due to limitations of specific identifications, coral bycatch was grouped into two classes: 1) gorgonians and stony corals, and 2) pennatulaceans. Point symbols represent start locations of bottom trawls or longline and pot sets. Source: Whitmire and Clark, 2007, NMFS.

For the most part, corals in the region do not build reefs with observations of only *L. pertusa* in the Olympic Coast National Marine Sanctuary (Whitmire and Clark, 2007, NMFS.). Although associations of corals with other invertebrates and fishes have been reported, there is no direct evidence that any of these represent obligate relationships between taxa (Whitmire and Clark, 2007, NMFS.). Much of the recent information on the regional zoogeography of higher-level coral taxa was collected during bottom trawl surveys (Whitmire and Clark, 2007, NMFS.). More detailed information, but in a limited geographic scope, has been collected using submersibles, remotely operated vehicles (ROVs) and more recently, autonomous underwater vehicles (AUVs). Information on the distribution of corals as well as monitoring fishing impacts can be gleaned from information collected by fisheries observers (Whitmire and Clark, 2007, NMFS.). General statistics on deep corals sampled during National Marine Fisheries Service (NMFS) bottom trawl surveys, which were conducted off the West Coast by the Alaska and Northwest Fisheries Science Centers between 1980 and 2005 have enabled cataloguing of coral species. Additionally, locations of deep coral bycatch have been recorded by fishery observers in the West Coast Groundfish Observer Program and have been mapped (Figure 3-24). With fishery management measures (e.g., area closures, gear restrictions), the risk posed by bottom trawling has been significantly reduced (Whitmire and Clark, 2007, NMFS.).

#### 3.4.3.2 Sponges

As mentioned above, sponge species are often observed with coral species mostly in hard substrate, with some minor occurrences in mixed substrate on boulders, and among those, most are less than 30-50 cm in height. Sponge species are not commonly found in sandy or mud substrate. Oceana has documented the presence of barrel, foliose, mound, branching, shelf, and vase sponges in 16 of 17 ROV dive sites (Cape Arago, Coquille Reef, Orford Reef) off the West Coast (Enticknap et al., 2013). Branching sponge was the most commonly observed morphology, followed by foliose and mound (Enticknap et al., 2013). Over 50% of the frames analyzed for the offshore cape arago site had branching sponges (Enticknap et al., 2013). Barrel, shelf, and vase sponges were the least observed morphologies (Enticknap et al., 2013). Inshore reefs at Cape Arago, Coquille, and Orford all have similar compositions of and sponges (Enticknap et al., 2013). In ROV surveys off the West Coast of northern British Columbia, the majority of rockfish (80%) occurred with sponges 50 cm in height (Du Preez & Tunnicliffe, 2011).

Table 3-13: Frequency of occurrence, depth, and latitudinal ranges for fish and invertebrate species, grouped by family (or higher taxonomic classification), caught during the 2005 NWFSC slope/shelf survey. Source, NOAA Technical Memorandum NMFS-NWFSC-93, 2008.

| Family and scientific name | Common name | Frequency of occurrence (No. hauls) | Depth (m) | | | Latitudinal range (dd) | |
|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Mean | South | North |
| **Porifera (phylum)** | | | | | | | |
| Hexactinellida | Glass sponge unident. | 2 | 937 | 1,063 | 1,000 | 33.75 | 43.58 |
| Porifera | Sponge unident. | 154 | 61 | 1,230 | 476 | 32.54 | 48.42 |
| Porifera | Vase sponge unident. | 9 | 70 | 984 | 450 | 32.72 | 45.20 |
| *Acanthascus* sp. | Chimney sponge unident. | 7 | 127 | 1,088 | 444 | 33.61 | 47.26 |
| *Aphrocallistes vastus* | Clay pipe sponge | 61 | 97 | 1,098 | 584 | 32.72 | 47.87 |
| *Chonelasma calyx* | Goblet sponge | 3 | 510 | 581 | 548 | 33.37 | 40.68 |
| *Farrea convolulus* | Crusty tube sponge | 5 | 307 | 1,083 | 768 | 32.94 | 47.68 |
| *Hyalonema* sp. | Fiber optic sponge unident. | 20 | 502 | 1,140 | 872 | 32.62 | 47.68 |
| *Leucandra heathi* | Spiny vase sponge | 1 | 256 | 256 | 256 | 44.63 | 44.63 |
| *Rhabdocalyptus* sp. | Cloud sponge unident. | 11 | 307 | 838 | 579 | 32.73 | 46.06 |
| *Staurocalyptus* sp. | Spiny vase sponge unident. | 15 | 336 | 1,140 | 680 | 32.73 | 47.69 |
| *Suberites ficus* | Hermit sponge | 1 | 87 | 87 | 87 | 33.84 | 33.84 |
| *Tethya* sp. | Ball sponge unident. | 6 | 71 | 826 | 358 | 32.72 | 34.38 |

Table 3-14: Summary of coral and sponge bycatch metrics for observed tows using bottom trawls as part of the West Coast Groundfish Observer Program (WCGOP), comparing two time periods: “Before” (3 Jan 2002 – 11 Jun 2006) and “After” (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations[a/.]

| | 2000-2005 | | | | 2006-2010 | | | | 2000-2010 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxon | # | FREQ | Wt | CPUE (per 1,000 km) | # | FREQ | Wt | CPUE (per 1,000 km) | # | FREQ | Wt | CPUE (per 1,000 km) |
| Coral | 319 | 2.00% | 9,309 | 49.00 | 335 | 1.80% | 2,197 | 9.00 | 654 | 1.90% | 11,507 | 27.00 |
| Sea pen/ whip | 198 | 1.30% | 232 | 1.20 | 474 | 2.50% | 145 | 0.59 | 672 | 1.90% | 377 | 0.87 |
| Sponge | 469 | 3.00% | 10,025 | 53.00 | 1,444 | 7.60% | 45,383 | 190.00 | 1,913 | 5.50% | 55,408 | 130.00 |
| Grand Total | 903 | 5.70% | 19,567 | 100.00 | 2,003 | 10.50% | 47,725 | 200.00 | 2,906 | 8.40% | 67,292 | 160.00 |

a/ "#" denotes number of hauls; "FREQ" denotes ratio of hauls with positive catch of taxon to total hauls observed; "Weight" denotes catch (kg); "CPUE" denotes catch per unit effort (units: lb/1,000 km). Haul counts represent only those hauls where corals or sponges were present in the catch. Annual WCGOP coverage of the limited-entry trawl sector can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm.

Not all bottom contact events shown for the bottom trawl fishery resulted in the capture of corals or sponges, as shown in Table 3-14 (above). During 2006-2010 the coral and sponge contact rate in the bottom trawl fishery sample was 10.5 percent of tows. Bottom trawling was conducted on the continental shelf and the continental slope, but was prohibited in the RCA during 2006-2010. Distribution data for corals and sponges show widespread patchy distributions (see Table 3-15, below). The bottom trawl data for 2006-2010 show a coral and sponge catch rate of 10.5 percent of tows (table 3-14, above). Most (62%) areas of coral and sponge presence are located within the upper slope, with 28% and 10% of presence in the shelf and lower slope, respectively (EFH synthesis report, 2013, NMFS). Table 3-15 below summarizes coral and sponge taxa recorded during tows as part of the West Coast Groundfish Bottom Trawl Survey (WCGBTS, Table 3-14, above), in which prevalence of sponge (Porifera) catch per unit of effort was highest.

Table 3-15: Summary of coral and sponge taxa recorded during tows as part of the West Coast Groundfish Bottom Trawl Survey (WCGBTS), comparing two time periods: "Before" (2003-05) and "After" (2006-10). "#" denotes number of tows with recorded bycatch; "FREQ" denotes ratio of tows with catch to total tows recorded; "CPUE" denotes catch per unit of effort (units: kg/ha). Tow counts represent only those where corals or sponges were present in the catch. Taxa are listed in descending order of CPUE for combined time period.

| | BEFORE | | | AFTER | | | BEFORE + AFTER | | |
|---|---|---|---|---|---|---|---|---|---|
| | **#** | **FREQ** | **CPUE** | **#** | **FREQ** | **CPUE** | **#** | **FREQ** | **CPUE** |
| **Porifera** | 359 | 21.7% | 1,852.90 | 647 | 19.0% | 2,297.41 | 1,006 | 19.9% | 4,150.31 |
| **Hexactinosida** | 103 | 6.2% | 810.13 | 295 | 8.7% | 2,371.76 | 398 | 7.9% | 3,181.89 |
| **Rossellinae** | 53 | 3.2% | 154.01 | 91 | 2.7% | 698.79 | 144 | 2.8% | 852.80 |
| ***Suberites* spp.** | 3 | 0.2% | 425.77 | 9 | 0.3% | 2.90 | 12 | 0.2% | 428.67 |
| ***Hyalonema* spp.** | 47 | 2.8% | 49.17 | 95 | 2.8% | 174.32 | 142 | 2.8% | 223.49 |
| **Hexactinellida** | 17 | 1.0% | 77.80 | 0 | 0.0% | 0.00 | 17 | 0.3% | 77.80 |
| **Pennatulacea** | 245 | 14.8% | 16.18 | 417 | 12.3% | 24.44 | 662 | 13.1% | 40.62 |
| ***Anthoptilum grandiflorum*** | 98 | 5.9% | 6.64 | 289 | 8.5% | 30.58 | 387 | 7.7% | 37.22 |
| ***Chrysopathes* spp.** | 0 | 0.0% | 0.00 | 31 | 0.9% | 29.24 | 31 | 0.6% | 29.24 |
| **Antipatharia** | 66 | 4.0% | 23.85 | 25 | 0.7% | 1.77 | 91 | 1.8% | 25.61 |
| ***Halipteris* spp.** | 0 | 0.0% | 0.00 | 161 | 4.7% | 13.11 | 161 | 3.2% | 13.11 |
| **Gorgonacea** | 58 | 3.5% | 2.56 | 82 | 2.4% | 10.34 | 140 | 2.8% | 12.90 |
| ***Anthomastus ritteri*** | 16 | 1.0% | 3.09 | 69 | 2.0% | 8.04 | 85 | 1.7% | 11.13 |
| ***Ptilosarcus gurneyi*** | 28 | 1.7% | 2.48 | 62 | 1.8% | 5.64 | 90 | 1.8% | 8.12 |
| **Alcyonacea** | 14 | 0.8% | 0.89 | 15 | 0.4% | 3.53 | 29 | 0.6% | 4.42 |
| ***Anthomastus* spp.** | 19 | 1.2% | 3.00 | 11 | 0.3% | 1.29 | 30 | 0.6% | 4.29 |
| ***Callogorgia kinoshitae*** | 4 | 0.2% | 0.06 | 22 | 0.6% | 4.09 | 26 | 0.5% | 4.15 |
| ***Umbellula* spp.** | 23 | 1.4% | 1.38 | 94 | 2.8% | 2.47 | 117 | 2.3% | 3.84 |
| ***Paragorgia* spp.** | 6 | 0.4% | 0.56 | 14 | 0.4% | 2.68 | 20 | 0.4% | 3.24 |
| ***Isidella* spp.** | 1 | 0.1% | 0.06 | 9 | 0.3% | 3.05 | 10 | 0.2% | 3.11 |
| **Scleractinia** | 4 | 0.2% | 2.43 | 3 | 0.1% | 0.14 | 7 | 0.1% | 2.57 |
| ***Farrea* spp.** | 5 | 0.3% | 0.76 | 3 | 0.1% | 0.85 | 8 | 0.2% | 1.61 |
| ***Anthoptilum murrayi*** | 4 | 0.2% | 0.06 | 29 | 0.9% | 1.01 | 33 | 0.7% | 1.07 |
| **Flabellidae** | 2 | 0.1% | 0.03 | 9 | 0.3% | 0.82 | 11 | 0.2% | 0.84 |
| **Caryophylliidae** | 1 | 0.1% | 0.09 | 5 | 0.1% | 0.35 | 6 | 0.1% | 0.45 |
| ***Bathypathes* spp.** | 6 | 0.4% | 0.05 | 25 | 0.7% | 0.37 | 31 | 0.6% | 0.42 |
| ***Keratoisis* spp.** | 2 | 0.1% | 0.41 | 0 | 0.0% | 0.00 | 2 | 0.0% | 0.41 |
| **Stylasteridae** | 1 | 0.1% | 0.00 | 4 | 0.1% | 0.37 | 5 | 0.1% | 0.37 |
| ***Lillipathes* spp.** | 3 | 0.2% | 0.08 | 9 | 0.3% | 0.20 | 12 | 0.2% | 0.28 |
| ***Callogorgia* spp.** | 1 | 0.1% | 0.02 | 4 | 0.1% | 0.17 | 5 | 0.1% | 0.19 |
| ***Pennatula phosphorea*** | 1 | 0.1% | 0.01 | 10 | 0.3% | 0.10 | 11 | 0.2% | 0.12 |
| **Acanthogorgiidae** | 0 | 0.0% | 0.00 | 1 | 0.0% | 0.01 | 1 | 0.0% | 0.01 |
| | **749** | **45.3%** | **3,434.45** | **1,554** | **45.7%** | **5,689.85** | **2,303** | **45.5%** | **9,124.30** |
| | **1,652** | | | **3,404** | | | **5,056** | | |

### 3.4.3.3 Sea Whips

Sea whips are pennatulacean octocorals that are broadly distributed across the continental shelf along the West Coast from depths of 10 to at least 500 fm (figure 3-16). Sea whips have a relatively simple morphology consisting of a basal peduncle that serve to anchor in soft sediment, and a verticle rachis extending distally from the peduncle (stem). The distal portion of the sea whip colony comprises a sheath-like tissue layer made up of multiple autozooid feeding polyps supported by an unbranched endoskeleton called an axial rod (Troffe et al, 2005). Juvenile sea whip density before and after trawling was not statistically significantly different (Troffe et al, 2005). For sea whips that are impacted by fishing gear, re-growth of young colonies may be slow at beginning life stages. Untrawled bottoms were strongly dominated numerically by 30–50 cm high sea pens (Stylatula spp.), which accounted for over 95% of all recorded invertebrates (Hixon and Tissot, 2007). However, at untrawled area, there was no correlation between sea-pen density and total fish density among transect segments (Hixon and Tissot, 2007). Sea pens do not provide an obvious biogenic habitat for demersal fishes (Hixon and Tissot, 2007).

Figure 3-25: Picture of sea whips on soft substrate. (Source: http://www.afsc.noaa.gov/ABL/MESA/archives/effects%20of%20trawl%20on%20seawhips.htm)

### *3.4.4* Protected Species, including ESA Species

A variety of species are protected by Federal law (other than the MSA) with the objective of sustaining, or rebuilding their populations from critically depleted levels.

#### 3.4.4.1 Species Protected by the Endangered Species Act, Marine Mammal Protection Act, and the Migratory Bird Treaty Act

NMFS issued Biological Opinions under the Endangered Species Act (ESA) on August 10, 1990, November 26, 1991, August 28, 1992, September 27, 1993, May 14, 1996, and December 15, 1999, pertaining to the effects of the Pacific Coast groundfish fisheries on Chinook salmon (Puget Sound, Snake River spring/summer, Snake River fall, upper Columbia River spring, lower Columbia River, upper Willamette River, Sacramento River winter, Central Valley spring, California coastal), coho salmon (Central California coastal, southern Oregon/northern California coastal), chum salmon (Hood Canal summer, Columbia

River), sockeye salmon (Snake River, Ozette Lake), and steelhead (upper, middle and lower Columbia River, Snake River Basin, upper Willamette River, central California coast, California Central Valley, south/central California, northern California, southern California). These biological opinions have concluded that implementation of the Pacific Coast groundfish fishery is not expected to jeopardize the continued existence of any endangered or threatened salmonid species under the jurisdiction of NMFS, or result in the destruction or adverse modification of critical habitat.

NMFS issued a Supplemental Biological Opinion on March 11, 2006, concluding that neither the higher observed bycatch of Chinook in the 2005 whiting fishery nor new data regarding salmon bycatch in the groundfish bottom trawl fishery required a reconsideration of its prior ''no jeopardy'' conclusion. NMFS also reaffirmed its prior determination that implementation of the Groundfish FMP is not likely to jeopardize the continued existence of any of the affected ESUs. Lower Columbia River coho (70 FR37160, June 28, 2005) and Oregon Coastal coho (73 FR 7816, February 11, 2008) were relisted as threatened under the ESA. The 1999 biological opinion concluded that the bycatch of salmonids in the Pacific whiting fishery were almost entirely Chinook salmon, with little or no bycatch of coho, chum, sockeye, and steelhead.

U.S. west coast waters support a variety of marine mammals. Approximately 30 species, including seals, sea lions, sea otters, whales, dolphins, and porpoise, occur within the EEZ. Many species seasonally migrate through west coast waters, while others are year-round residents. There are also several marine mammal species in the action area that are listed under the ESA (see NMFS 2012 FEIS for full list). With respect to species protected by the MMPA, the west coast groundfish trawl fisheries are Category III fisheries indicating a remote likelihood of, or no known, serious injuries or mortalities to marine mammals.

On December 7, 2012, NMFS completed a biological opinion concluding that the groundfish fishery is not likely to jeopardize non-salmonid marine species including listed eulachon, green sturgeon, humpback whales, Steller sea lions, and leatherback sea turtles. The opinion also concludes that the fishery is not likely to adversely modify critical habitat for green sturgeon and leatherback sea turtles.

An analysis included in the same document as the opinion concludes that the fishery is not likely to adversely affect green sea turtles, olive ridley sea turtles, or loggerhead sea Turtles, sei whales, North Pacific right whales, blue whales, fin whales, sperm whales, Southern Resident killer whales, Guadalupe fur seals, or the critical habitat for Steller sea lions.

The California current system supports a diverse array of seabird species. Species found on the west coast include resident species and transitory species (migrating or foraging). Several species of seabirds have had documented takes in the groundfish fishery, including black-footed albatross, common murres, other non-listed species, ESA-listed marbled murrelets and ESA-listed short-tailed albatross (for a full list of species see Table 3-19 and Table 3-20 in the NMFS 2012 FEIS). On November 21, 2012, the U.S. Fish and Wildlife Service (FWS) issued a biological opinion concluding that the groundfish fishery will not jeopardize the continued existence of the short-tailed albatross. The (FWS) also concurred that the fishery is not likely to adversely affect the marbled murrelet, California least tern, southern sea otter, bull trout, nor bull trout critical habitat.

## 3.5 Description of the Socio-economic Environment

### *3.5.1* Shorebased IFQ Program

The Shorebased IFQ fishery is managed with individual fishing quotas for most groundfish species, including whiting. Annually, quota pounds (QP) are allocated from the shorebased sector allocation based on the individual quota share (QS) of each QS owner. (QP is expressed as a weight and QS is expressed as a percent of the shorebased allocation for a given species or species group.) QP may be transferred from a QS account to a vessel account or from one vessel account to another vessel account. Vessel accounts are used to track how QP is harvested since QP is used to cover catch (landings and discards) by limited entry trawl vessels of all IFQ species/species groups. Shorebased IFQ catch must be landed at authorized first receiver sites. The IFQ whiting QS were allocated to a mixture of limited entry permit holders and shorebased processors. One non-profit organization received QS based on the ownership of multiple limited entry permits.

Although fixed gear and whiting (midwater trawl) groundfish fisheries are vital fisheries which make up a large portion of groundfish landings, the proposed action pertains to groundfish bottom trawl gear; therefore emphasis in this assessment is placed on groundfish bottom trawl gear and the non-whiting portion of the shorebased IFQ program. The number of non-whiting trawl vessels making at least one groundfish landing (Table 3-16, below) between 2005 to 2009 have ranged between 123 to 117, a declining trend over the years. It is expected that the number of non-whiting trawl vessels participating in the IFQ fishery may decrease to some extent after quota share trading is allowed starting January 1, 2014.

Table 3-16: Number of vessels making at least one groundfish landing each year by Port Group and Sector, 2005-2009. Source: 2011-2012 FEIS, Appendix F.

| Year | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| Nonwhiting trawl Vessels | 123 | 122 | 121 | 120 | 117 |

The nonwhiting bottom trawl fishery has a variety of targets and strategies, although there are particular seasonal strategies depending on the species being targeted.

Another important change as part of the IFQ program is that vessels participating in the program may use any legal groundfish gear. This offers these vessels the opportunity to switch to fixed gear for part or all of the year. These vessels do not compete directly with traditional groundfish fixed gear fisheries because their catch is debited to the IFQ sector's allocation through the QP held in a vessel's account.

The following summary of IFQ vessels utilizing "gear switching" provisions for fixed gear landings is excerpted from the Annual Catch Report for the Pacific Coast Groundfish Shorebased IFQ Program in 2012 (Matson, 2013, NMFS):

> Proportion of sablefish landed with fixed gear (in 2012) has increased in the shorebased IFQ program compared with 2011. As a result, 58 percent of the revenue from sablefish

> in this fishery is estimated to come from fixed gear (up ten percent from 2011), due to (IFQ) increases in landings using hook and line gear. These changes in gear use for sablefish translated in small overall changes to the distribution of aggregate landings of all groundfish species, and associated revenue among gear types for the entire non whiting fleet. Much lower prices were seen in 2012 for sablefish for hook and line, pot, and trawl gear, than during 2011. Fixed gear accounts for one fourth of the nonwhiting revenue in the fishery, although it currently makes up only seven percent of landings.

Five species accounted for just over 90 percent of ex-vessel revenue during 2006-2010: sablefish, 36 percent; Dover sole, 27 percent; petrale sole, 15 percent; thornyheads 9 percent; and rockfish 3 percent. Note that petrale sole was declared overfished in 2010 with a rebuilding plan implemented that requires reduced ACLs beginning in 2011 to rebuild the stock.

As stated in the Annual Catch Report for the Pacific Coast Groundfish Shorebased IFQ Program in 2012 (Matson, 2013, NMFS):

> Total catch of several valuable groundfish species in 2012 was less than 50 percent of the trawl allocation. Only 8 percent of the minor shelf rockfish complex north of 40°10' N. lat. was caught, leaving over 1 million pounds unharvested. Only 27 percent of the minor slope rockfish complex north of 40°10' N. lat. was caught, leaving over 1.3 million pounds unharvested. For flatfish, excluding petrale sole, no species had attainment of over 33 percent of the trawl allocation, with Dover sole being the highest. Over 33 million pounds of Dover sole was left unharvested in 2012. Only 21 percent of the trawl allocation of lingcod was caught in 2012, leaving over 3 million pounds of the allocation unharvested. Only 35 percent of the trawl allocation of Pacific cod was caught in 2012, leaving over 2.5 million pounds unharvested. Only 32 percent of the trawl allocation of yellowtail rockfish north of 40°10' N. lat. was caught, leaving over 4.5 million pounds unharvested.

Landings in the shorebased nonwhiting fleet were up slightly in 2012, at 101 percent of 2011 levels (40,892,262 pounds versus 40,610,190 pounds, respectively, **Error! Reference source ot found.**). Revenue in 2012 maintained 92 percent of 2011 levels (30,452,763 dollars in 2012 versus 32,935,934 dollars in 2011), despite a 56 cent per pound drop in sablefish prices, a six percent decrease in sablefish landings and a 24 percent decrease in revenue from sablefish, or 4.2 million dollars (17,614,666 dollars in 2011 versus 13,356,592 dollars in 2012). (Matson, 2013, NMFS):

Monthly trajectories of landings and revenue, by both the nonwhiting and shorebased whiting fleets for 2012 are also very similar to the previous year, although nonwhiting landings and revenue in December of 2012 returned to levels similar to pre-IFQ. Landings and revenue during December 2011 spiked much higher than typical December levels (**Error! Reference ource not found.**). (Matson, 2013, NMFS):

Considering the nonwhiting fleet for the two years before and the two years after trawl rationalization (Table 3-17), revenues have been 12.5 percent higher, although annual landings have on average been 24.8 percent lower. Total monthly landings and revenue have been somewhat more variable throughout the year, in the first two years following trawl rationalization, than before it. (Matson, 2013, NMFS):

Table 3-17: Monthly landings (left) and revenue (right) during 2011 and 2012, for nonwhiting trips in the Shorebased IFQ Program. The "land % 2011" column expresses 2012 landings as a percentage of 2011 landings; the "rev % 2011" column expresses 2012 revenue in the same way. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively), Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Matson 2013.

Non-whiting trips

| Month | 2011 landings | 2012 landings | 2011 revenue | 2012 revenue | Land. % 2011 | Rev. % 2011 |
|---|---|---|---|---|---|---|
| Jan | 1,324,638 | 1,490,200 | 902,457 | 1,142,266 | 112% | 127% |
| Feb | 2,564,693 | 2,404,286 | 1,719,893 | 1,658,043 | 94% | 96% |
| Mar | 3,360,889 | 3,332,948 | 1,991,797 | 2,120,942 | 99% | 106% |
| Apr | 3,942,465 | 5,080,809 | 2,443,745 | 3,165,779 | 129% | 130% |
| May | 3,884,997 | 4,415,608 | 2,395,262 | 2,744,210 | 114% | 115% |
| Jun | 4,446,585 | 3,280,997 | 3,293,042 | 2,402,746 | 74% | 73% |
| Jul | 3,258,118 | 3,204,170 | 2,312,914 | 2,433,846 | 98% | 105% |
| Aug | 3,785,242 | 4,150,441 | 3,122,361 | 3,194,306 | 110% | 102% |
| Sep | 3,310,686 | 3,832,257 | 3,715,231 | 3,598,502 | 116% | 97% |
| Oct | 3,601,682 | 3,857,524 | 4,618,719 | 3,348,731 | 107% | 73% |
| Nov | 2,467,760 | 2,976,381 | 2,531,797 | 2,438,940 | 121% | 96% |
| Dec | 4,662,435 | 2,866,641 | 3,888,717 | 2,204,455 | 61% | 57% |
| Total | 40,610,190 | 40,892,262 | 32,935,934 | 30,452,763 | 101% | 92% |

Table 3-18: Average monthly landings (left) and revenue (right) during 2009-2010 (green open circles, dashed lines), versus 2011-2012 (black squares, solid lines), for non-whiting trips in the Shorebased IFQ Program (limited entry non-whiting trawl fishery during 2009-10). Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively), Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Matson 2013.

| Month | Ave. landings | | | | Ave. revenue | | | |
|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2011-12 | S.E. 09-10 | S.E.11-12 | 2009-10 | 2011-12 | S.E. 09-10 | S.E. 11-12 |
| Jan | 3,733,887 | 1,407,419 | 1,364,374 | 82,781 | 2,294,354 | 1,022,362 | 828,414 | 119,905 |
| Feb | 5,465,840 | 2,484,490 | 271,688 | 80,204 | 2,594,130 | 1,688,968 | 45,615 | 30,925 |
| Mar | 5,292,810 | 3,346,919 | 197,724 | 13,971 | 2,425,697 | 2,056,370 | 98,008 | 64,573 |
| Apr | 5,910,014 | 4,511,637 | 740,500 | 569,172 | 2,655,967 | 2,804,762 | 307,524 | 361,017 |
| May | 5,145,447 | 4,150,302 | 43,541 | 265,306 | 2,574,902 | 2,569,736 | 6,390 | 174,474 |
| Jun | 4,810,159 | 3,863,791 | 423,942 | 582,794 | 2,459,182 | 2,847,894 | 305,222 | 445,148 |
| Jul | 4,797,831 | 3,231,144 | 186,138 | 26,974 | 2,652,528 | 2,373,380 | 98,298 | 60,466 |
| Aug | 4,680,382 | 3,967,842 | 391,565 | 182,599 | 2,446,505 | 3,158,333 | 360,699 | 35,972 |
| Sep | 3,962,316 | 3,571,471 | 82,693 | 260,786 | 2,320,270 | 3,656,866 | 132,905 | 58,365 |
| Oct | 4,005,163 | 3,729,603 | 270,234 | 127,921 | 2,211,774 | 3,983,725 | 85,991 | 634,994 |
| Nov | 3,710,737 | 2,722,071 | 309,909 | 254,311 | 2,150,959 | 2,485,368 | 189,229 | 46,428 |
| Dec | 2,465,411 | 3,764,538 | 840,322 | 897,897 | 1,391,174 | 3,046,586 | 442,372 | 842,131 |
| Annual | 54,161,633 | 40,751,226 | 3,872,352 | 141,036 | 28,177,442 | 31,694,349 | 2,509,429 | 1,241,585 |

## Vessel Accounts

The following license data and catch monitor plans do not include landings to determine if first receivers have actually received landings (or what type of landings) while they were licensed:

2011: 152 vessel accounts; 110 made IFQ landings
2012: 166 vessel accounts (total, but not all renewed/active); 108 made IFQ landings
2013: 172 vessel accounts (total, but not all renewed/active); 89 made IFQ landings* (note: this is a low estimate; many vessels come in to fish in September).

### *3.5.2* Processor Sector

The number of companies that reported having processed fish on the West Coast has increased slightly from 23 companies in 2009, to 25 companies in 2010, and 26 companies in 2011.

<u>First Receivers</u>
The following license data and catch monitor plans do not include landings to determine if first receivers have actually received landings (or what type of landings) while they were licensed:

2011: 51 first receivers; 5 whiting; 35 non-whiting; 11 both (whiting and non-whiting)
2012: 55 first receivers; 6 whiting; 38 non-whiting; 11 both (whiting and non-whiting)
2013: 54 first receivers; 6 whiting; 36 non-whiting; 12 both (whiting and non-whiting)* (note: this is a low estimate; many vessels come in to fish in September).

### *3.5.3* Communities

Federally managed Pacific groundfish fisheries occurring within the EEZ off the coasts of Washington, Oregon, and California establish the geographic context for the proposed action. West coast communities engaged in these fisheries are also part of the context (Figure 3-26). Although this is the Federal action area, the states manage the fisheries in the territorial sea to meet the goals and objectives of the Pacific Groundfish FMP.  At some level, when access to healthy stocks is limited, communities are impacted (*2013-2014 FEIS*).  The amount of allowable canary bycatch has socioeconomic impacts to fishing communities dependent on the shelf trawl fishery (i.e., shoreward of the RCA), (*2013-2014 FEIS*).  Fishing communities are described in terms of the port groups used in the IO Pac model (*2013-2014 FEIS*).

Community characteristics have been thoroughly investigated in the 2007-2008, 2011-2012, and 2013-2014 FEISs.


Figure 3-26: The action area, showing major coastal communities and management areas (*2013-2014 FEIS*).

# CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

A large portion of the RCA that would be opened under the proposed action is already open to bottom trawling at specific periods during the year, has been opened in the recent past, or is open to pink shrimp trawling, fixed gear effort, and other fisheries (including midwater trawling bottom contact events), and non-fisheries related pressures. Therefore, the action is not expected to cause significant impacts when compared to No-Action. The portion of the proposed action (alternative 1) that would modify the RCA from a seaward boundary line between 40° 10' N. lat. and 45° 46' N. latitude approximating 200 fm to a line approximating 150 fm, during periods 1-6 (note that the modified 200 fm line is currently in place in periods 1 and 6), would open an area that has been closed to bottom trawling for a longer period of time (approximately nine years for most of the area). Fixed gear/longline effort on hard and medium substrate in this area has likely already impacted this habitat to some extent. Unintentional incursions into the RCA and groundfish research surveys also have the potential to alter habitat despite the closure. Although localized effects to physical and biological resources caused by groundfish bottom trawling would occur under the action alternatives, when the context and intensity is considered, the impacts are unlikely to be significant. The socioeconomic environment would likely be beneficially affected to some degree by the proposed action.

## 4.1 Physical Environment

### *4.1.1* Physical Oceanography

#### 4.1.1.1 No-action, Alternative 1, and Alternative 2

None of the alternatives are expected have any impacts on physical oceanography because this proposed action will not affect natural phenomena such as upwelling, the North Pacific Gyre, Pacific decadal oscillation, global plate tectonics, and climate change, which are events that will continue to occur autonomously, regardless of groundfish bottom trawling within the West Coast exclusive economic zone.

## 4.2 West Coast Marine Ecosystems

### *4.2.1* No-action, Alternative 1, and Alternative 2

None of the alternatives are expected have significant impacts on West Coast marine ecosystems because this proposed action will not affect the fundamental integrity of food web linkages, or biodiversity of the California Current in general. Atlantis simulation models quantifying the effects of single fleets such as bottom trawl and fixed gear suggest they primarily have direct impacts on their target and bycatch species, and few indirect effects from these fleets extended through predator-prey links to other parts of the food web (*Kaplan et al., 2012*).

For other biodiversity and ecosystem function, no substantial change from No Action is expected because the majority of the area proposed to be open has been recently impacted by a combination of non-trawl gear, pink shrimp bottom trawl activity, and the groundfish bottom trawl fisheries and research. Any impacts to ecosystem function and biodiversity under both action alternatives 1 and 2 are anticipated to be minimal and similar to No-Action.

## 4.3 Essential Fish Habitat

Fish and other species rely on habitat characteristics to support primary ecological functions comprising spawning, breeding, feeding, and growth to maturity. Important secondary functions that may form part of one or more of these primary functions include migration and shelter. Most habitats provide only a subset of these functions. The type of habitat available, its attributes, and its functions are important to species productivity and the maintenance of healthy ecosystems. While we know that marine organisms require habitat, the relationship of habitat to population dynamics or ecological function is poorly understood.

Bottom trawling for groundfish is managed under the Pacific groundfish FMP. Fishing effects are generally limited to (1) removal of prey species, (2) direct removal of adult and juvenile groundfish, (3) contact with the bottom, and (4) effects resulting from loss of trawl gear, potentially resulting in impacts to bottom habitats and ghost fishing.

Specific offshore habitat types have been identified as ones most likely to be potentially negatively affected with implementation of any of the action alternatives compared to the No Action Alternative. These are discussed and analyzed in following sections.

### *4.3.1* No-action

Under the no-action alternative, impacts to groundfish EFH are not expected to change from the impacts that have been occurring in recent years.

All of the areas currently closed to groundfish bottom trawl gear would remain closed to vessels fishing with groundfish bottom trawl gear. This includes areas that have been closed to groundfish bottom trawling for long periods of time. Benthic habitat in areas that have been closed for extended periods of time are more likely to have recovered, to some extent, from impacts from groundfish bottom trawling that occurred in this area before the trawl RCA was implemented. However, other marine activities (e.g. pink shrimp trawling) are allowed inside the trawl RCA. Those activities, where they occur, could hinder recovery of benthic habitat, despite the overlapping trawl RCA closure. No-Action would not change the relative benefits of the trawl RCA closure to benthic habitats, or change the relative negative impacts to benthic habitats from other marine activities. If all of the areas currently open to groundfish bottom trawl gear remain open to fishing with groundfish bottom trawl gear, recovery of benthic habitat in those areas will continue to be hindered.

Specifically, the No-Action alternative would maintain trawl RCA boundaries of either 75fm-200fm or 100fm-150fm depending on the time of year. Groundfish bottom trawling would continue to be prohibited inside the trawl RCA, and effort would continue to be limited to areas seaward and shoreward of the trawl RCA. Under the No Action alternative, shoreward effort would likely continue to be concentrated in depths of 75fm-100fm between 42°N. lat. and 48°N. lat. (Figure 3-12). Under the No Action alternative, seaward effort would likely continue to be concentrated in depths of 175 fm-375fm (Figure 3-12). In the areas that have been open, regardless of substrate type, it is unlikely that there has been sufficient time for recovery because impacts of the groundfish bottom trawl fishery are ongoing in these areas. The No-Action alternative is not anticipated to change impacts to groundfish EFH of other marine activities that occur in the action area, including; fixed gear fishing for groundfish; pot fishing for groundfish; bottom trawling for pink shrimp; and bottom trawl surveys.

Fixed gear fishing for groundfish would continue to access mixed and hard substrate areas that may be untrawlable. Groundfish fishing with fixed gear would continue to be concentrated in depths between 100fm-225fm, between 42°N. lat. and the U.S.-Canada border (Figure 3-14). Pot fishing for groundfish can access mixed and hard substrate areas that may be untrawlable. Groundfish fishing with pot gear is concentrated in depths between 125fm-250fm, between 43°N. lat. and 47°N. lat. Therefore, fixed gear and pot gear fishing for groundfish would continue to be concentrated, in part, in the areas that are closed by the trawl RCA under the No-Action alternative.

Bottom trawling for pink shrimp would continue to be concentrated in depths between 50fm-125fm between 41°N. lat. and 48°N. lat. Most of the pink shrimp bottom trawl effort occurs shoreward of the trawl RCA, but some effort does occur deeper than 75 fm and 100fm. Bottom trawling in the groundfish surveys would continue as they have since 2003 under the No-Action alternative; survey tows would occur throughout the trawlable habitat inside the trawl RCA with the location selected at random. Therefore, some benthic habitats remaining closed under the No Action alternative would continue to be impacted by pink shrimp bottom trawl gear and the groundfish bottom trawl survey.

There have been few attempts to quantitatively estimate the effects of particular gear types on a broad suite of ecosystem attributes and to understand how those effects interact (Kaplan et al., 2012). However, a spatial evaluation of the effectiveness of management measures examined bottom trawl vessel logbook data to conduct a quantitative analysis of the changes in the spatial distribution of trawl fishing effort that resulted from the new management approach enacted in 2000 (*Hannah, 2008*). The results of that evaluation determined that footrope restrictions, in combination have had a substantial effect in reducing rockfish bycatch. No changes to gear restrictions are considered as part of this proposed action; therefore, the differential impacts of bottom trawl gear footrope size and other aspects of gear configurations are not anticipated to vary between any of the alternatives.

Therefore, the No-Action alternative is not expected change current groundfish fishery effects on groundfish EFH.

### *4.3.2* Alternative 1

Alternative 1 is anticipated to have a slightly higher degree of potential impact (in terms of substrate recovery rates) on EFH as described in the EFH EIS, EFH five year review, and EFH synthesis documents. Certainly, bottom trawling dramatically reduces the diversity of some kinds of habitat, particularly corals, but in other habitats, such as mud and sand bottoms, the impact on ecosystem structure and function is much less (Hilborn, 2007). Some areas that have been closed for long periods of time may have had a chance for benthic habitat recovery. The seaward area between the 150 fm and the modified 200 fm lines between 40° 10' N. lat. to 45° 03' N. lat. has not been trawled by commercial groundfish bottom trawl gear since October 2004. This depth range between 45° 03' N. lat. to 45° 46' N. lat. has not been trawled by commercial groundfish bottom trawl gear since August 2007.

Alternative 1 would open these areas to commercial groundfish bottom trawling. Therefore, impacts to groundfish EFH under Alternative 1 are expected to be greater than the no-action alternative, or Alternative 2. However, no significant impacts to soft, mixed, or hard benthic habitats, or to the continued existence of non-structure forming benthic invertebrate species such as sponges, corals, and sea whips are expected under this alternative, when taking into consideration the broader untrawlable habitat EFH in the marine environment of the California Current within the West Coast EEZ that will continue to provide a natural refuge for sensitive species and habitats. It is expected that impacts to benthic species such as coral, sponges, and sea whip colonies have already largely occurred within trawlable fishing grounds, particularly in the height of bottom trawl effort between 1980 to 2000, since some coral species may live up to 100 years. The possibility that some trawlable areas may have escaped impact from higher effort prior to 2000 may exist, although it is expected that these areas are less trawlable with modern gear restrictions, and these sensitive areas will largely remain untrawled from historical effort (prior to RCA closures). Mitigation of a closed area should be carefully weighed against the potential for redistribution of fishing effort (Bellman et al, 2005). To the extent that virgin coral or sponge may be impacted by this action, no significant impacts are expected, considering the broader EFH conservation areas remaining within the marine environment of the California Current within the West Coast EEZ. Additionally, these areas are open to groundfish fixed gear (longline, pot) and non-groundfish pot gear. Some research (Baer et al., 2010) found that bottom longlines can cause significant damage to sensitive habitats through entanglement, and ROV research surveys have observed fixed gear impacts on sensitive coral and sponge species (Brancato et al, 2007). Fixed gear vessels may target mixed and hard substrate areas seaward of 100 fm with some frequency of impact, as fish target species accessible to fixed gear types, particularly on untrawlable grounds.

Given that bottom trawlers will likely seek to avoid untrawlable fishing grounds, bottom trawl activity in the most sensitive areas, even those that have not been trawled since October 2004, are not likely to incur any significant impacts. Effects to biological and physical resources from the proposed action alternatives (1&2) are not anticipated to involve unique or unknown risks because the actions are likely to redistribute some existing trawl effort, with expected similar impacts to other areas that have been trawled in the past. To the extent liberalized RCA configurations result in more dispersed effort over a larger area, intensity of localized effects could be reduced. Although unlikely, it is possible that some large coral or sponge species have survived many years of targeting effort in nearshore, shelf, and slope substrates before regulatory changes to rockfish trip limits coupled with footrope restriction, and RCAs (trawl and non-trawl) in prime trawlable habitat near mixed or hard substrates. It is also feasible that even with footrope restrictions, rare encounters with hard or boulder/mixed habitat may occur.

The shoreward area from 40° 10’ N. lat. to 48° 10’ N. lat., 75 fm to 100 fm is not expected to have recovered, as these areas are being trawled throughout much of the year by pink shrimp trawl gear and groundfish bottom trawl gear throughout portions of each year under No-action activities.

### *4.3.3* Alternative 2

Under Alternative 2, effects on habitat are both predicted to be inconsequential, as commercial groundfish bottom trawling already occurs within the shoreward area (75-100 fm) between 40° 10’ N. lat. to 48° 10’ N. lat., and the seaward area (150-m200 fm) between 45° 46’ N. lat. to 48° 10’ N. lat. at some point in the year (including the area trawled within modified petrale cutouts). Therefore, impacts are expected to be similar between no-action and alternative 2.

As described in chapter 3, some of the areas that would be opened under alternative 1 would allow trawling in an area that has been closed since 2004, and to a lesser extent, 2007, but these areas would remain closed under this proposed Alternative. It is possible that increases in the spatial extent of the RCA could result in increased fishing intensity in other areas due to displaced fishing effort (2013-2014 FEIS). However, with this proposed action reducing the size of the RCA could potentially moderate fishing intensity in other areas as existing effort distributes, potentially diluting the impact to currently open areas. Some reductions in fleet size are also expected in the coming years (potentially aided in part from further quota share trading options that will be allowed as of January 1, 2014).

The liberalized RCA structure proposed in alternatives 1 and 2 would allow trawling in areas with benthic substrate and habitat characteristics typical of areas currently subject to trawl effort. Alternative 2, would maintain a temporary closure between 40 10' N. latitude and 45 46' N. latitude, from 150 to m200 fm.

Effects to biological and physical resources from the proposed action alternatives (1&2) are not anticipated to involve unique or unknown risks because the actions are likely to redistribute some existing trawl effort, with expected similar impacts to other areas that have been trawled in the past. To the extent liberalized RCA configurations result in more dispersed effort over a larger area, intensity of localized effects could be reduced. Although unlikely, it is possible that some large coral or sponge species have survived many years of targeting effort in nearshore, shelf, and slope substrates before regulatory changes to rockfish trip limits coupled with footrope restriction, and RCAs (trawl and non-trawl) in prime trawlable habitat near mixed or hard substrates. It is also feasible that even with footrope restrictions, rare encounters with hard or boulder/mixed habitat may occur.

Areas that have been closed to commercial groundfish bottom trawl gear for a long period of time may have had a chance for benthic habitat recovery. Alternative 2 will keep those areas closed; therefore, only marginally increased impacts to EFH are expected compared to the no-action alternative, specifically in the seaward area from 40° 10' N. lat. to 45° 46' N. lat., 150 fm to m200 fm.

No significant impacts to soft, mixed, or hard benthic habitats, or to benthic invertebrates sponges, corals, and sea whips are expected under this alternative, especially when taking into consideration that these species will continue benefit from untrawlable refuges within the marine environment of the California Current within the West Coast EEZ. It is expected that impacts to coral, sponges, and sea whip colonies have already occurred within trawlable fishing grounds, particularly in the height of bottom trawl effort between 1980 to 2000, since some coral species may live up to 100 years. The possibility that some trawlable areas may have escaped impact from higher effort prior to 2000 may exist, although it is expected that these areas are less trawlable with gear restrictions, and these areas will largely remain untrawled. To the extent that virgin coral or sponge may be impacted by this action, no significant impacts are expected, especially when taking into consideration the broader EFH within the marine environment of the California Current within the West Coast EEZ. Given that bottom trawlers will likely seek to avoid untrawlable fishing grounds, bottom trawl activity in the most sensitive areas are not likely to incure any significant impacts.

The shoreward area from 40° 10' N. lat. to 48° 10' N. lat., 75 fm to 100 fm is not expected to have recovered, as these areas are being trawled throughout much of the year by pink shrimp trawl gear and groundfish bottom trawl gear throughout portions of each year under No-action activities.

## 4.4 Biological Resources

The No-action, Alternative 1, and Alternative 2 proposed actions are not anticipated to have any substantial effect on biological resources in the nearshore, shelf, and slope regions of the California Current Ecosystem. Many heavily trawled regions of the world, particularly in areas where there is an abundance of soft substrate, continue to demonstrate record biomass abundance of target species. To the extent that the alternatives under consideration affect target and non-target species, these species will continue to be managed conservatively. Additionally, annual catch limits are established through the biennial harvest specifications and management measures. Under the Shorebased IFQ Program all catch of IFQ species (retained or discarded), including vessels using groundfish bottom trawl gear, must be covered by quota pounds. Fishermen are individually accountable for their catch of individual species (or species within a stock complex), and are subject to a 100 percent monitoring requirement. Non-IFQ species are managed by groundfish trip limits. Therefore, the proposed action is not expected to impact the sustainability of any target or non-target species.

### *4.4.1* Groundfish Target Species

#### 4.4.1.1 No-action,

All of the alternatives, including No-Action, would continue to allow the targeting of groundfish in the shorebased trawl IFQ program with 100 percent observer coverage and 100 percent dockside monitoring, with all catch of IFQ species required to be covered by quota pounds. The amount of quota pounds available each year is a result of the allocations established through the FMP and the 2013-2014 harvest specifications and management measures. The harvest specifications, including annual catch limits (ACLs), are established based on the best scientific information available about stock status and would not change as result of the proposed action. Under all of the alternatives, including the No Action alternative, the groundfish bottom trawl fleet would continue to be held to individual accountability from the IFQ program, which after two years of successful implementation has demonstrated that quota pounds can be managed within IFQ sector allocations and ACLs for target species.

With the poor sablefish market of the past two years (although still the most valuable species per pound in the fishery), and continued reduction in the northern sablefish ACL, there is evidence that fishermen have shifted some effort to other target species to compensate (*Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Agenda Item D.2.a, April, 2013 PFMC meeting*). Either Alternative 1 or 2 could make such a shift easier for fishers, according to the species cited in industry rationale (bycatch analysis section). There were increases in revenue from species such as yellowtail rockfish, Pacific cod, petrale sole, lingcod, and Dover sole from 2011 to 2012 in the IFQ program, together with a substantial drop in sablefish revenue (*Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Agenda Item D.2.a, April, 2013 PFMC meeting*). These species were cited as targets in the areas requested for opening by industry (bycatch analysis section).

In those southern ports, fishermen could still fish the seaward area between 150 and 200 fm using fixed gear, under the gear switching provision of IFQ regardless of this potential action. If the area is not opened to trawling, it is conceivable that fishermen may do so, to access some of the higher value targets that are often landed with fixed gear such as lingcod, sablefish, and Pacific cod (these species were cited in industry rationale). Given sufficient motivation to diversify their catch among species, it is conceivable that effort in the seaward area (150-200 fm, 40°10’ to 45°46’) could increase by use of fixed gear rather than trawl gear, even without the implementation of Alternative 2, under gear switching provisions in the IFQ program, especially upon recovery of sablefish markets and ex-vessel prices. However, this is speculative.

Impacts to target species under the no-action alternative are expected to continue in a similar manner to what has been seen since the implementation of the Shorebased IFQ Program in 2011. Vessels will continue efforts to maximize their harvest of target species quota pounds, and keep their bycatch of overfished species low. Additionally, beginning in 2014, quota shares will become transferrable and this might promote higher utilization of target species quota pounds.

Specifically, access to lingcod, sanddabs, yellowtail rockfish and Pacific cod in the nearshore and shelf areas could continue to be somewhat limited by the shoreward boundary of the trawl RCA remaining at the 75 fm line for some parts of the year under the No Action alternative. Access to petrale sole, English sole, Dover sole, sablefish and thornyheads in the shelf and slope areas continue to be somewhat limited by the seaward boundary of the trawl RCA remaining at the 200 fm line for some parts of the year under the No Action alternative.

If no new areas are opened to allow bottom trawling for IFQ species, fishermen that feel most affected may have increased incentives to sell their quota, or perhaps even switch to non-trawl gears to harvest their IFQ under the Shorebased IFQ Programs gear switching provisions. Vessels harvesting IFQ using non-trawl gears can currently fish seaward of the 100 fm line; in areas that would remain closed to bottom trawling under the No Action alternative. However, the extent of the motivation for these types of changes in behavior is unknown.

#### 4.4.1.2 Alternative 1

The most likely potential impacts to target species under the action alternatives are higher attainment of the trawl allocation. Levels of attainment of the trawl allocation for target groundfish species would likely be highest for Alternative 1. Alternative 1 is likely to increase attainment of prominent species such as English sole, lingcod, Pacific cod, Pacific sanddabs, yellowtail rockfish, rex sole, and other target species including the dover, thornyhead, sole (DTS) complex. Shortspine thornyhead would not be adversely affected by losses in biogenic structures such as sponges and corals and could even concentrate in areas of localized trawling or areas of low biogenic structure density (Du Preez & Tunnicliffe, 2011). Greater access to fishing grounds should increase benefit to the nation for food supply. When considering trawl RCAs, it may also be worthwhile to consider the larger volume and greater diversity of healthy groundfish stocks that can be intercepted uniquely by bottom trawl gear. Bottom trawl gear is able to intercept a wide variety of healthy species, (mostly various flatfish) which are encountered less commonly using all other well-tested groundfish gear types. Figure 4-1 (below) illustrates volume of fish landed on the west coast in 2011 (under the no-action alternative), bottom trawl gear landed catch (17,232 mt) was substantially higher than that seen with fixed gear groundfish gears (1,188 mt). Table 4-1 illustrates the estimated substrate miles (by substate type that would be accessed to bottom trawl fishing gear year round under Alternative 1 (3,042 sq. mi.), most of which is still open to bottom trawling activity at different periods throughout the year. In addition, this alternative would maintain 1,374 square miles of trawl RCA closed to bottom trawling (Table 4-2).

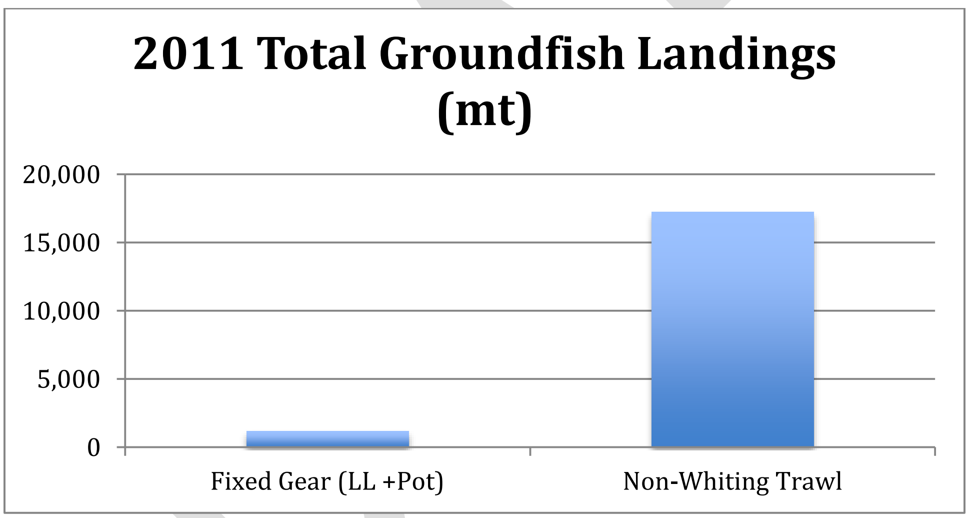



Figure 4-1. 2011 Fixed gear (longline and pot) groundfish landings and non-groundfish whiting trawl total landings (mt). Fixed Gear Source: 2011 TM report.

Alternative 1, Estimated Substrate Square Miles (not including EFH/GCA)

| | 75-100 fm | 150-200fm | Total |
|---|---|---|---|
| Soft | 1882 | 885 | 2767 |
| Mixed | 63 | 36 | 99 |
| Hard | 144 | 32 | 176 |
| Total | 2089 | 953 | 3042 |

Table 4-1: Estimated Substrate Square Miles within Alternative 1. Note: the majority of this area is already open throughout much of the year under the No-action Alternative.

| | 100-150fm |
|---|---|
| Soft | 1289 |
| Mixed | 47 |
| Hard | 38 |
| Total | 1374 |

Table 4-2: Estimated Substrate Square Miles maintained as Rockfish Conservation Areas under Alternative 1

#### 4.4.1.3 Alternative 2

The most likely potential impacts to target species under the action alternatives are higher attainment of the trawl allocation than would be expected under the no-action alternative. Alternative 2 opens some areas that have been intermittently closed, but not as much new areas as Alternative 1. Impacts to target species under Alternative 2 are anticipated to be similar to that described in Alternative 1, although to a lesser degree because depths between 150 fm and m200 fm would remain closed between 45°46' N. lat. and 40°10' N. lat.

### *4.4.2* Non-target Species, Including Overfished Groundfish

Since 2002 NMFS has used large-scale, depth-based, RCA closures to reduce catch of overfished rockfish in fisheries that take and retain groundfish, directing harvest of healthy stocks to areas that remained open.

#### 4.4.2.1 Overfished Species

##### No Action

Over the history of RCAs, inseason changes to their boundaries have been made frequently, with accompanying analysis, to enable catch of target species, while at the same time, keeping bycatch of rebuilding stocks within established catch limits to facilitate timely rebuilding. Under the No Action alternative, the RCAs are anticipated to keep bycatch of rebuilding stocks lower then Alternative 1 or Alternative 2.

Under all of the Alternatives, including the No-Action alternative, the advent of precise, near real-time data in the NMFS Vessel Account System, with which NMFS and the Council can both stay informed of daily changes in catch and attainment is also a tool that was not available under the previous trawl management regime. These important changes under trawl rationalization make all of the Alternatives a relatively low risk proposition to ACL accountability and rebuilding.

### Alternative 1

To assess the potential impacts of Alternative 1 on overfished groundfish species, NMFS undertook an analysis of fishery-dependent, weighted average, annual trawl bycatch rates, calculated from a combination of logbook, fish ticket, and observer data from five years previous to trawl rationalization. That analysis indicates that the probability of encountering canary rockfish, darkblotched rockfish, and Pacific ocean perch will likely be higher than under the No Action Alternative.

However, analysis of post-rationalization haul-level observer data, as well as aggregate total catch data from the two years before and the two years after trawl rationalization does not suggest any obvious danger of either extreme catch events, or accumulated aggregate high catch of rebuilding species that would exceed the trawl allocation, compared to the No Action alternative. For example, during 2011 the largest hauls of canary rockfish, and darkblotched rockfish, both traditionally strong limiting influences on attainment of target species in the trawl fishery, were just 1.21 percent, and 0.84 percent of each of their annual trawl allocations, respectively. Also, under the No Action alternative, several liberalizing changes to the trawl RCA have already been made since 2011 without conservation incident, under IFQ, and catch of rebuilding species remains much lower than during comparable pre-IFQ years.

Analysis of fishery-dependent, weighted average, annual trawl bycatch rates, calculated from a combination of logbook, fish ticket, and observer data from five years previous to trawl rationalization, indicates that the probability of encountering canary rockfish, darkblotched rockfish, and Pacific ocean perch will likely be higher than if the status quo shoreward boundary remained in place. However, analysis of post-rationalization haul-level observer data, as well as aggregate total catch data from the two years before and the two years after trawl rationalization does not suggest any obvious danger of either extreme catch events, or accumulated aggregate high catch of rebuilding species that would exceed the trawl allocation, by adopting proposed changes to the RCA boundaries. For example, during 2011 the largest hauls of canary rockfish, and darkblotched rockfish, both traditionally strong limiting influences on attainment of target species in the trawl fishery, were just 1.21 percent, and 0.84 percent of each of their annual trawl allocations, respectively. Also, several liberalizing changes to the trawl RCA have already been made since 2011 without conservation incident, under IFQ, and catch of rebuilding species remains much lower than during comparable pre-IFQ years.

Analysis of annual trawl bycatch rates (fishery-dependent, weighted average annual rates calculated from a combination of logbook, fish ticket, and observer data from five years previous to trawl rationalization), indicates that the probability of encountering canary rockfish (a main limiting bycatch species on the shoreward side) and darkblotched rockfish (historically, a primary limiting bycatch species on the seaward side), and Pacific ocean perch (another limiting bycatch species on the seaward side) will likely be higher than if the status quo boundaries remained in place.

However, analysis of post-rationalization haul-level observer data, as well as aggregate total catch data from the two years before and the two years after trawl rationalization does not suggest any obvious danger from either extreme catch events, or accumulated aggregate high catch of rebuilding species that would exceed the trawl allocation, as a result of making the proposed changes to the RCA boundaries. For example, during 2011, the largest hauls of canary rockfish, and darkblotched rockfish, both traditionally strong limiting influences on attainment of target species in the trawl fishery, were just 1.21 percent, and 0.84 percent of each of their annual trawl allocations, respectively. The most recent annual attainment rates available for these same species (in 2012) were quite low at 28 percent and 36 percent respectively.

Given the results of the bycatch analysis, consideration of change of management style from cumulative landing limits to IFQ, the precise individual accountability that this new management brings, and the continued availability of accountability measures under the new system, Alternative 1 should pose little risk to rebuilding species by way of individual fishers staying within their allocations, and the IFQ program staying within the trawl allocations of rebuilding species. Alternative 1 should provide additional fishing opportunity for valuable target species, with little conservation risk to rebuilding stocks of groundfish.

Attainment of rebuilding species was low under IFQ management in 2011 (Agenda Item F.6.b, Supplemental NMFS Report: *West Coast Groundfish IFQ Fishery Catch Summary for 2011: First Look*), at 14 percent, 36 percent, 39 percent and 10 percent respectively. It was also low during 2012, after other shoreward and seaward line changes to the trawl RCA were made during 2011 and early 2012. Attainment rates for these same species in 2012 were: 28 percent, 36 percent, 45 percent and 6 percent, respectively (Agenda Item D.2.a, April, 2013 PFMC meeting, *Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012*). Total catch of currently rebuilding species under IFQ was lower in 2011 than 2010 (pre-IFQ management).

Although catch and attainment has increased for rebuilding species between 2011 and 2012, attainment of all rebuilding species (except petrale sole, which is managed as a target species under the rebuilding program) is well below the sector allocation, after two years of IFQ management; average annual total catch of these rebuilding species is substantially lower for 2011 and 2012 than 2009 and 2010 (Figure 4-6, Table 4-4).

### *Analysis*

We analyzed three different data sets to gain insight into the potential effects of the proposed RCA boundary change on catch of rebuilding rockfish species: 1) Historical time-weighted average bycatch rates for rebuilding stocks. These latitude and depth-specific bycatch rates were derived from a combination of trawl logbooks and landings, both from the Pacific Fisheries Information Network (PacFIN) database, as well as observer data from the West Coast Groundfish Observer Program (WCGOP) of the NMFS Northwest Fishery Science Center (NWFSC), which covered the years 2006 through 2010. These data cover years before trawl rationalization, and were previously used as inputs for the trawl bycatch forecasting model, the primary tool for management of the groundfish bottom trawl fishery before IFQ management began in 2011. 2) The second data set consisted of total catch and attainment data for rebuilding stocks in the limited entry trawl sector, for two years before IFQ management, during 2009 and 2010, and the first two years of IFQ management, in 2011 and 2012; these historical total catch data were provided by WCGOP. Total catch data from the NMFS IFQ Vessel Accounts System were used for the first two years of IFQ management (2011 and 2012), in conjunction with the comparable WCGOP catch data. 3) Finally, the third data set was haul-level catch data from the IFQ program during 2011, from WCGOP. The 2011 fishing year was the most recent available at the time of this analysis. The 2012 haul-level data set will only be available in November of 2013.

We examined time-weighted average bycatch rates prior to rationalization from WCGOP, from 2006 to 2010, (Figure 4-2), which show increased bycatch rates of primarily canary rockfish, followed by darkblotched rockfish and Pacific ocean perch, in the area shoreward of 100 fm, versus the area shoreward of 75 fm; for yelloweye rockfish, the estimated bycatch rate is lower for the action alternatives. These data indicate that if the shoreward RCA were moved from 75 fm to 100 fm during periods 1, 2, and 6 of 2013 (Alternatives 1 and 2), that the probability of encountering canary rockfish, darkblotched rockfish, and Pacific ocean perch will likely be higher than under the No Action shoreward boundaries (Figure 4-3). Canary rockfish shows the largest change is historical bycatch rates on the shoreward side of the RCA. Canary rockfish is both distributed and managed as a rebuilding stock coastwide, including the area between 40°10’ and 48°10’ (PFMC SAFE 2008, Figure 4-3).

Similarly, if the seaward boundary was moved from the status quo configuration (Table 2-1) to the 150 fathom boundary year-round (under Alternative 1, Table 2-2), the probability of encountering darkblotched rockfish and POP would be higher (Figure 4-2, Table 4-3). For the proposed seaward boundary moves, the data are shown in three strata, according to season. These bycatch rates were available for major existing management areas only (i.e. from 40°10’ to 48°10’, 36° to 40°10’, and 34°27’ to 36° N. lat. Thus, the finer stratification necessary for a specific quantitative analysis of Alternative 2 was not possible using the currently available data. Thus, it is discussed in comparison with Alternative 1.

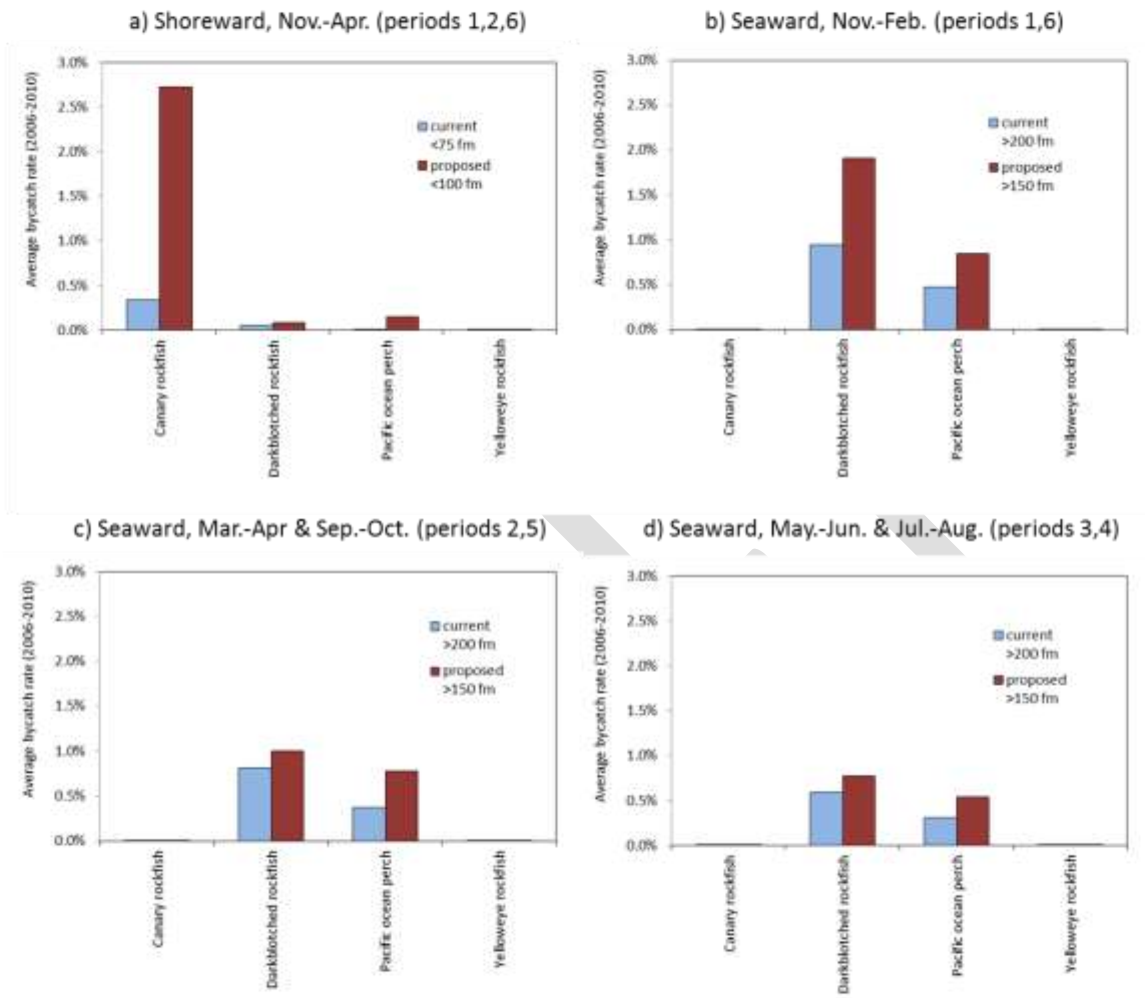



Figure 4-2 : Comparison of historical time-weighted average annual bycatch rates of rebuilding species (2006-2010, prior to trawl rationalization), under the current RCA configuration (No Action), versus the proposed configuration (Alternative 1), for the area between 40°10’ and 48°10’ N. lat., during the seasons listed. A substantial difference in historical bycatch rates is indicated for canary rockfish with movement of the shoreward boundary, and for the seaward boundary, the largest absolute differences in bycatch rates are seen for darkblotched rockfish, and less so for Pacific ocean perch.

Table 4-3: Historical time-weighted average annual bycatch rates of rebuilding species (2006-2010, prior to trawl rationalization), under the current RCA configuration (No Action), versus the proposed configuration (Alternative 1), for the area between 40°10' and 48°10' N. lat., during the seasons listed. A substantial difference in historical bycatch rates is indicated for canary rockfish with change in the shoreward boundary, and for the proposed seaward boundary change, the largest differences in bycatch rates are seen for darkblotched rockfish. The "proposed-current" field indicates the subtractive change in bycatch rate between areas (e.g. <100fm rate, minus <75fm rate).

a) Shoreward, November-April (periods 1,2,6)

| Species | Current <75 fm | Proposed <100 fm | Proposed - current |
|---|---|---|---|
| Canary rockfish | 0.3400% | 2.7210% | 2.3810% |
| Darkblotched rockfish | 0.0496% | 0.0793% | 0.0297% |
| Pacific ocean perch | 0.0005% | 0.1509% | 0.1504% |
| Yelloweye rockfish | 0.0105% | 0.0063% | -0.0042% |

b) Seaward, average seasonal bycatch rates and standard deviation among seasonal rate estimates.

| Species | Current >200 fm | S.D. >200 fm | Proposed >150 fm | S.D. >150 fm | Proposed - current |
|---|---|---|---|---|---|
| Canary rockfish | 0.0021% | 0.0020% | 0.0022% | 0.0015% | 0.0001% |
| Darkblotched rockfish | 0.7815% | 0.1811% | 1.2284% | 0.4451% | 0.4470% |
| Pacific ocean perch | 0.3830% | 0.0860% | 0.7203% | 0.0914% | 0.3374% |
| Yelloweye rockfish | 0.00013% | 0.00006% | 0.00027% | 0.00025% | 0.00013% |

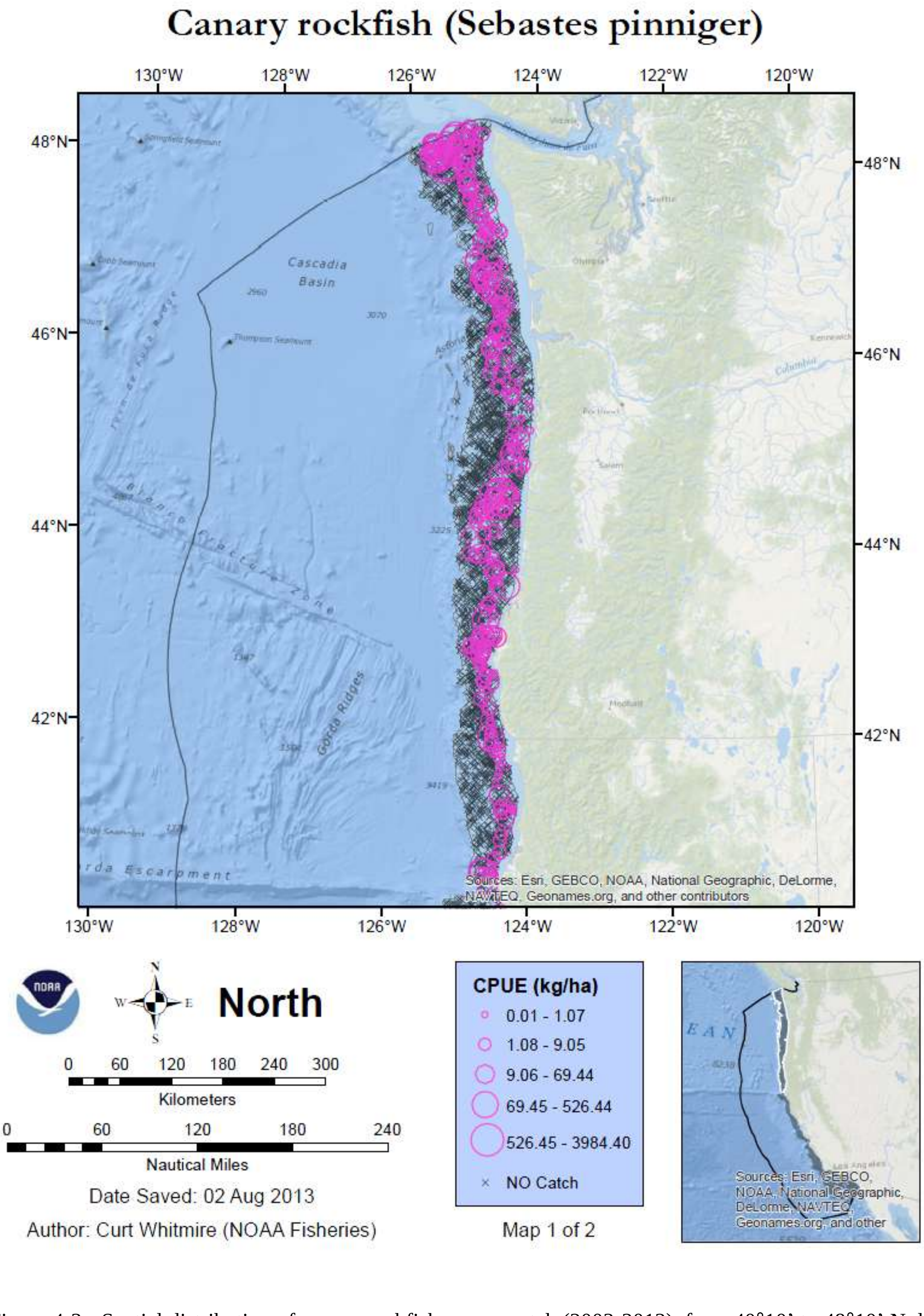



Figure 4-3. Spatial distribution of canary rockfish survey catch (2003-2012), from 40°10' to 48°10' N. lat. Data source: NWFSC Groundfish Bottom Trawl Survey.

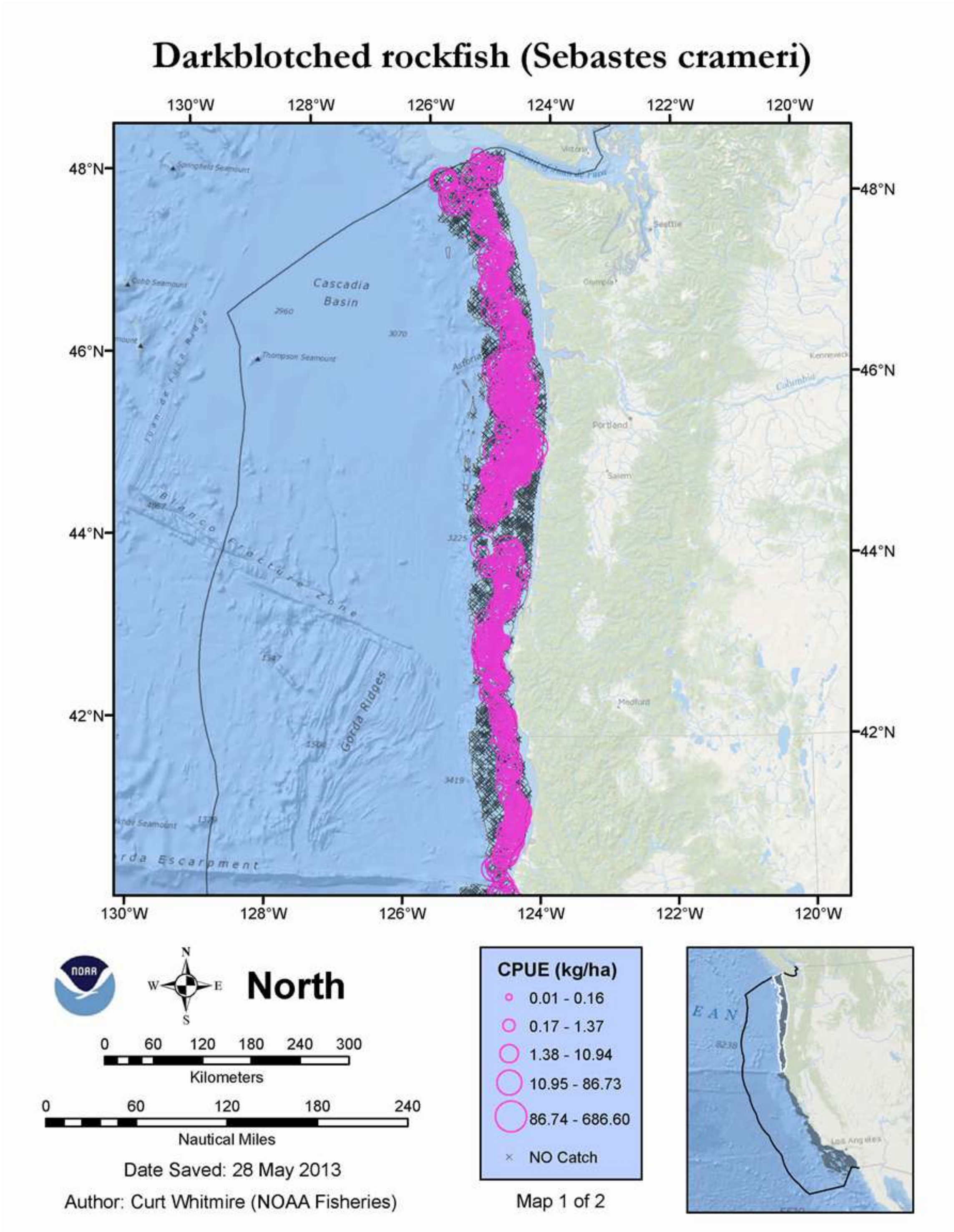



Figure 4-4. Spatial distribution of darkblotched rockfish survey catch (2003-2012), from 40°10’ to 48°10’ N. lat. Data source: NWFSC Groundfish Bottom Trawl Survey.

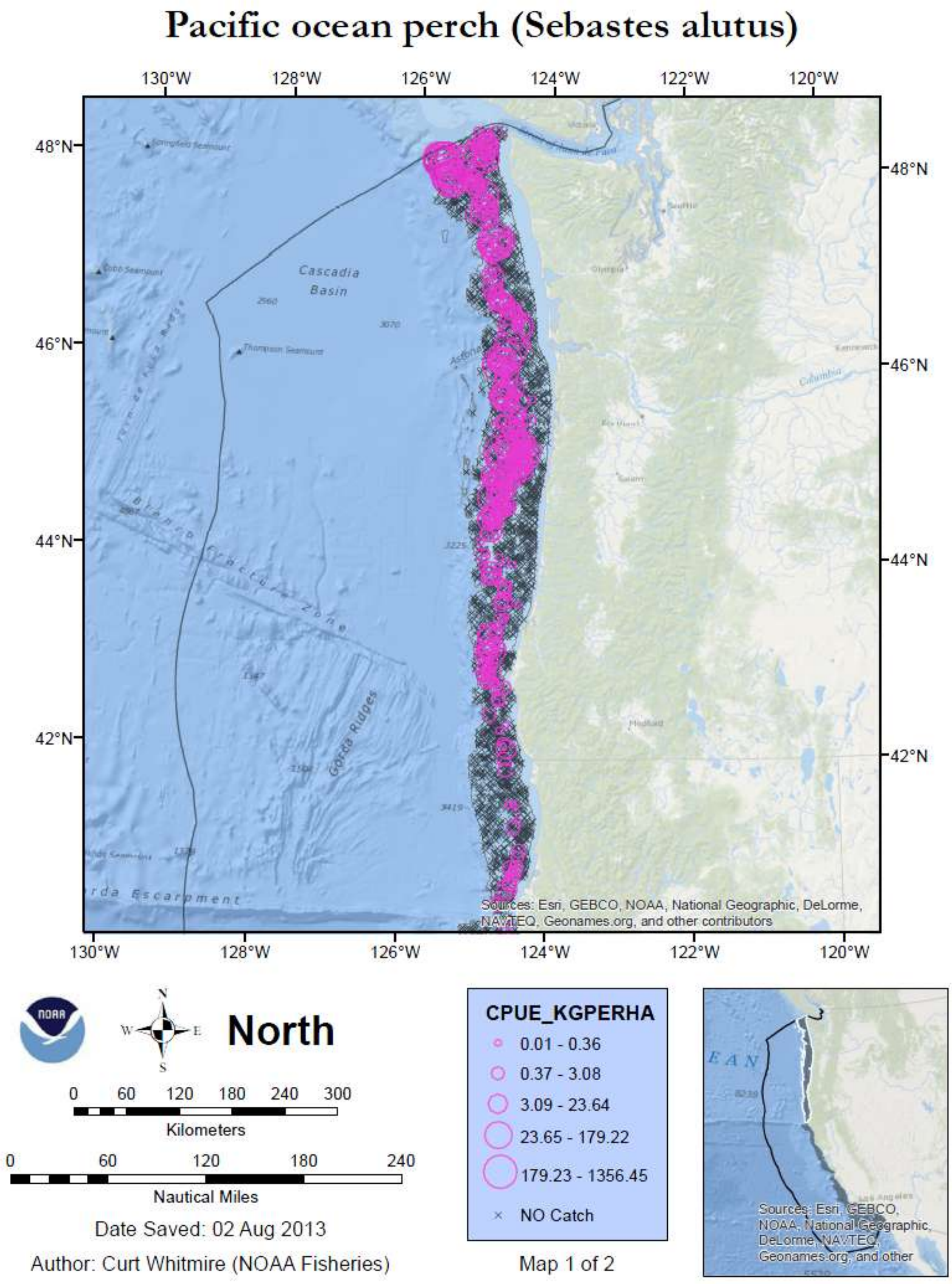



Figure 4-5. Spatial distribution of Pacific ocean perch rockfish survey catch (2003-2012), from 40°10’ to 48°10’ N. lat. Data source: NWFSC Groundfish Bottom Trawl Survey.

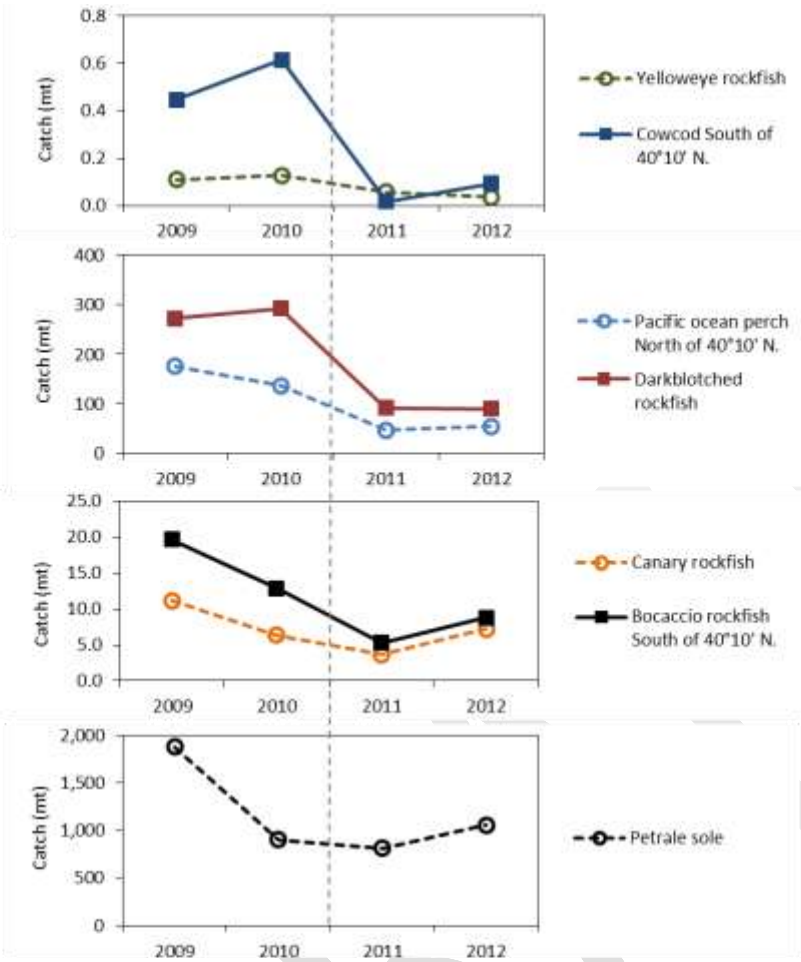



Figure 4-6. Total annual catch of rebuilding species from 2009 and 2010, in the limited entry (LE) trawl and shoreside whiting sectors, as well as 2011 and 2012, in the Shorebased IFQ Program, in metric tons. Source = WCGOP Groundfish Mortality Report (2009-2010) and the Shorebased IFQ Program, Vessel Accounts System (2011-2012). The grey, dashed, vertical line separates pre-IFQ years (left) from IFQ years (right) in this sector. The current IFQ program includes both LE trawl and shoreside whiting sectors. Taken from *Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012* (Agenda Item D.2.a, April, 2013 PFMC meeting).

Table 4-4: Total annual catch of rebuilding species from 2009 and 2010, in the limited entry trawl and shoreside whiting sectors, as well as 2011 and 2012, in the Shorebased IFQ Program, in metric tons. Two-year average catch, and average annual catch in 2011-12 as a percentage of that of 2009-10 is presented in the far right column ("post/pre IFQ"). Source = WCGOP Groundfish Mortality Report (2009-2010) and the Shorebased IFQ Program, vessel accounts system (2011-2012). The current IFQ program includes both LE trawl and shoreside whiting sectors. Taken from Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012 (Agenda Item D.2.a, April, 2013 PFMC meeting).

| Species | 2009 | 2010 | 2009-2010 avg. | 2011 | 2012 | 2011-2012 avg. | post/ pre % |
|---|---|---|---|---|---|---|---|
| Yelloweye rockfish | 0.11 | 0.13 | 0.12 | 0.06 | 0.03 | 0.05 | 39.3% |
| Cowcod S. of 40°10' N. | 0.45 | 0.61 | 0.53 | 0.02 | 0.09 | 0.06 | 10.4% |
| Canary rockfish | 11.16 | 6.39 | 8.78 | 3.69 | 7.23 | 5.46 | 62.2% |
| Bocaccio rockfish S. of 40°10' N. | 19.71 | 12.93 | 16.32 | 5.31 | 8.83 | 7.07 | 43.3% |
| Pacific ocean perch N. of 40°10' N. | 175.41 | 136.55 | 155.98 | 46.01 | 53.59 | 49.80 | 31.9% |
| Darkblotched rockfish | 272.32 | 291.84 | 282.08 | 90.84 | 89.64 | 90.24 | 32.0% |
| Petrale sole | 1881.91 | 900.37 | 1391.14 | 811.76 | 1057.54 | 934.65 | 67.2% |

### *Observer data*

#### *Shoreward boundary*

On the shoreward side, we focused further analysis on canary rockfish, because it showed the largest bycatch rate, the largest absolute difference in rates, and because it has been an important limiting influence on attainment of valuable target species in shallow waters. We examined observer data from 2011 for canary-positive hauls, by depth and latitude for inference of likelihood of an extreme catch event (often referred to as a "disaster tow"), given the available data (Figure 4-7). During 2011, the shoreward trawl RCA was only at 100 fm during Period 4 (July and August); aside from exceptions in depth due to RCA line routes; note that Figure 4-2 reflects this. We see that more than 96 percent (575 of 599) hauls shallower than 100 fm yielded less than 50 pounds of canary rockfish; 98 percent (587 of 599) of hauls shallower than 100 fm were smaller than 100 pounds. Only eleven hauls yielded more than 100 pounds, and the largest one yielded 693 pounds. The average haul weight was 10.94 pounds, minimum was 0.01 pounds, and the standard deviation was 36.11 pounds.

The largest haul, of 693 pounds was 1.21 percent of the canary rockfish IFQ allocation (57,100 pounds) in that year, 2011, when the annual IFQ attainment of this species was 14 percent (28 percent in 2012). The distribution of canary rockfish catch by haul depth is shown in Figure 4-8.

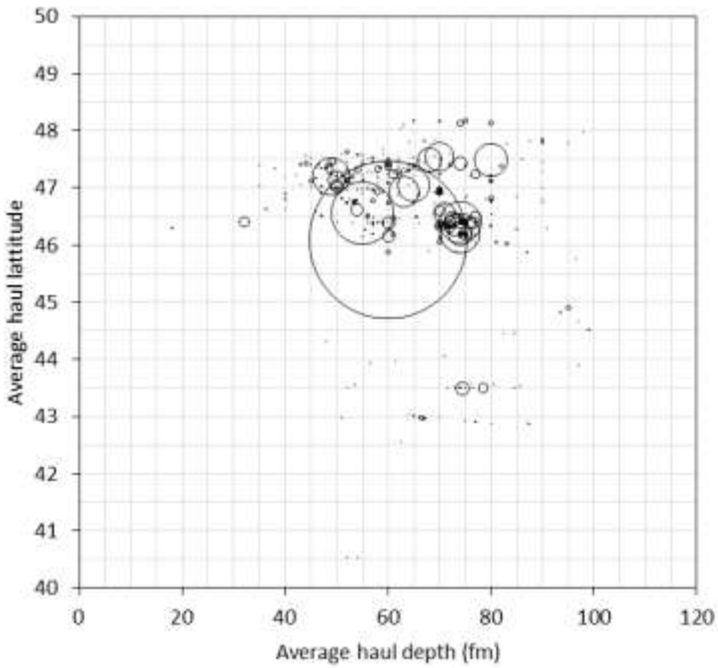



Figure 4-7. Relative weights of canary rockfish per haul using trawl gear, north of 40°10’ N. lat., shoreward of the RCA, during 2011 under IFQ, plotted versus average haul latitude and average haul depth (fm); bubble width represents weight of canary rockfish per haul.

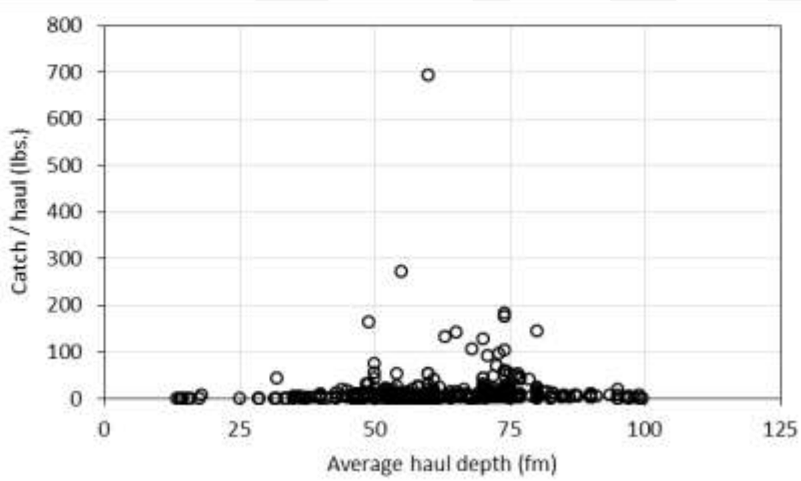



Figure 4-8. Distribution of canary rockfish catch by haul depth using trawl gear, north of 40°10’ N. lat., shoreward of the RCA, during 2011 in the IFQ fishery.

These data, together with low catch of rebuilding species during the first two years of IFQ, suggest that the probability of an extreme catch event, or “disaster tow”, i.e. one tow which would catch enough canary rockfish so that it would lead to exceeding the IFQ program allocation is relatively low, assuming similar fisher behavior as during 2011 and 2012.

The same shoreward boundary change was made for periods 3 through 5 during 2012 at the March 2012 Council meeting, without a subsequent conservation incident. It is important to note that the difference in historical canary rockfish bycatch rates between the area shoreward of 75 fm versus shoreward of 100 fm was smaller for the boundary change in periods 3 through 5 (*Agenda Item F.6.b Supplemental GMT Report, March 2012*) than the one currently proposed.

Fishing behavior, and bycatch rates in these areas and time periods, could potentially be different than those observed during pre-IFQ, or during 2011 the first year of the program, given the variation in catch among months that was observed for many species within and between years under IFQ management so far.

*Seaward boundary*

On the seaward side, we focused more closely on darkblotched rockfish because it showed the largest difference in average bycatch rate from the current to the proposed boundary, and it has traditionally been a strong limiting influence on access to seaward target species in the trawl fishery. Although yelloweye rockfish also showed a high difference in historical bycatch rate between the current and proposed seaward boundaries, it shows one of the lowest catch rates, and attainment rates in the trawl fishery, at just six percent of the allocation, in 2012.

We examined observer data from 2011 for darkblotched-positive hauls, by depth and latitude for inference of likelihood of a "disaster tow", given the available data (Figure 4-9). During 2011, the seaward trawl RCA was at 150 fm during periods 3-6 (May through December), for the area between 45°46' and 48°10' N. lat.; aside from exceptions in depth due to RCA line routes; note that Figure 4-4 reflects this. It should also be noted that during 2011, the seaward boundary was at the modified 200 fathom line during periods 1 and 2, north of 40°10' N. lat. as well as during Period 6 (except between 45°46' and 48°10' N. lat., where it was at 150fm). The modified 200 fathom line is modified to exclude certain petrale sole areas from the RCA, and thus it allows access in some shallower areas than the regular 200 fathom line.

For darkblotched rockfish, we see that 94.5 percent (2520 of 2667) hauls deeper than 150 fm yielded less than 250 pounds of darkblotched rockfish; 98 percent (2616 of 2667) of hauls deeper than 150 fm were smaller than 750 pounds. Fifty-one hauls yielded more than 750 pounds, and the largest one yielded 4641 pounds (0.84 percent of the trawl allocation, which was 552,997 pounds). During 2011, the total attainment of darkblotched rockfish in the IFQ program was 36 percent (it was the same in 2012 as well). The average haul weight was 67.1 pounds, minimum was 0.0003 pounds, and the standard deviation was 281.20 pounds. The distribution of darkblotched rockfish catch by haul depth is shown in Figure 4-10.

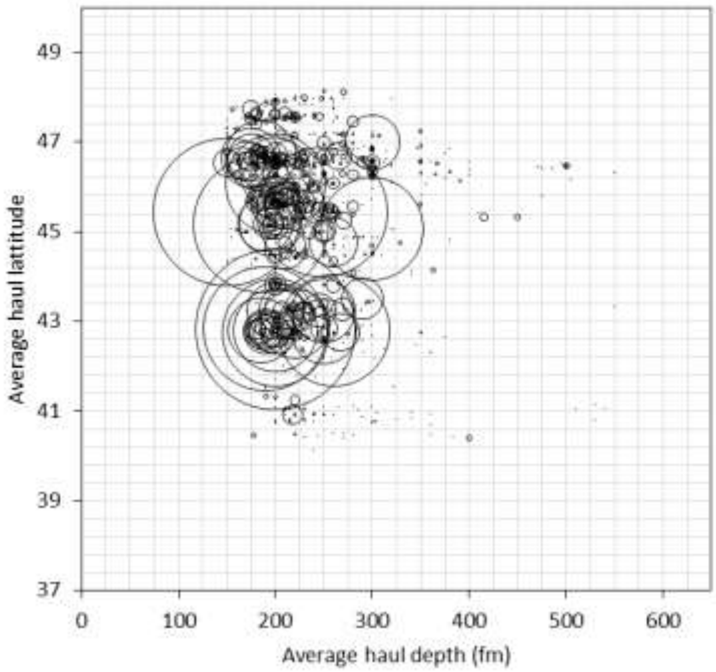



Figure 4-9. Relative weights of darkblotched rockfish per haul using trawl gear, north of 40°10' N. lat., seaward of the RCA, during 2011 under IFQ, plotted versus average haul latitude and average haul depth (fm); bubble width represents weight of canary rockfish per haul.

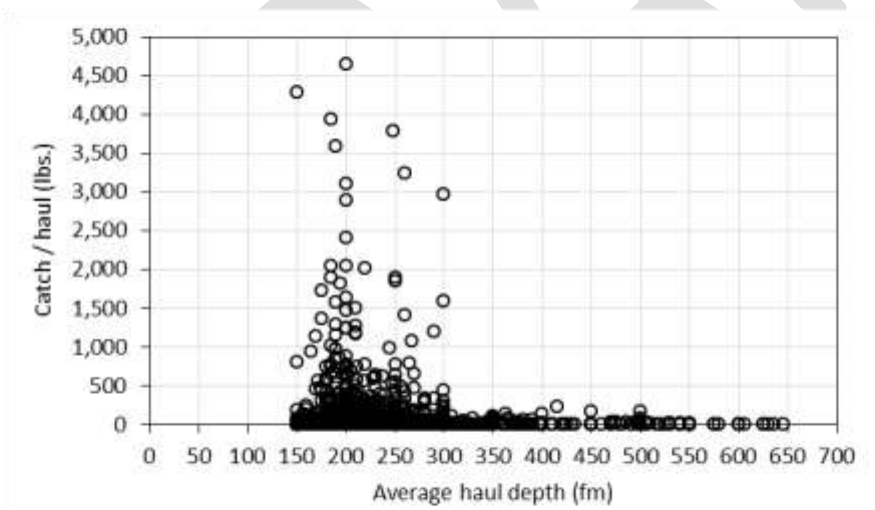



Figure 4-10. Distribution of darkblotched rockfish catch by haul depth using trawl gear, north of 40°10' N. lat., seaward of the RCA, during 2011 in the IFQ fishery.

### *IFQ management*

Additionally, the current catch share management system of Individual Fishing Quotas provides sufficient controls to prevent exceedence of either the trawl allocation or the Annual Catch Limit (ACL) for trawl-dominant species. This is accomplished by way of individual accountability of fishers themselves. Typical inseason accountability measures

(AMs) still exist, which include inseason adjustment of RCA boundaries as routine inseason measure

### *Accountability measures*

According to groundfish regulations , inseason accountability measures may be taken to prevent a trawl allocation or ACL from being exceeded, or to mitigate it. Under existing regulations at 50 CFR 660.140(a)(3), the Shorebased IFQ program may be restricted or closed as a result of projected overages within the Shorebased IFQ program. Area restrictions, season closures, or other measures can be used to prevent the shorebased IFQ sector from exceeding an ACL, OY, ACT or formal allocation. In addition, to prevent exceeding the ACL for a rebuilding stock such as canary or darkblotched rockfish, inseason action such as changes to the trawl RCA (e.g. push the seaward trawl RCA out to 250 fm for the remainder of the year to sharply restrict catch of darkblotched rockfish, or pull the shoreward trawl RCA into either 75 or 50 fm, or even to the shore, to sharply restrict catch of canary rockfish), maybe implemented quickly if necessary. 50 CFR 660.60(c). Other accountability measures, such as withholding surplus carryover of a species to restrict its catch in the coming year, are also available in the IFQ program.

### Alternative 2

Under Alternative 2, unlike Alternative 1, the seaward boundary from 45°46' to 40°10' N. lat. would be established year-round as the modified 200 fathom. Under Alternative 1, the seaward boundary would also be moved from 40°10' to 45°46' N. lat., from the current mix of 200 fathom and modified 200 fathom lines throughout the year, to the 150 fathom line year-round. Thus, one would expect substantially less potential for an increase in bycatch of these two rebuilding species due to implementing Alternative 2 versus Alternative 1; both the area affected by Alternative 2 and the additional time that area would be open relative to No Action are much smaller. The distribution patterns of these slope species are also relevant. Darkblotched rockfish is distributed fairly evenly along the coast, north of 40°10', with its highest density being concentrated north of 38° N. lat. (PFMC SAFE 2008, Figure 4-4); which also supports Alternative 2 incurring substantially less bycatch of darkblotched than Alternative 1. However, Pacific ocean perch shows a much more northerly distribution pattern within the area between 40°10' to 48°10' N. lat., with its highest density north of 42° N. lat. (PFMC SAFE 2008, Figure 4-5). This suggests that Alternative 2, which makes a smaller seaward boundary change from 40°10' to 45°46', would show less decrease from Alternative 1, in terms of expected change in bycatch of POP than that of darkblotched rockfish. Alternative 2 includes a much smaller change to the seaward boundary than Alternative 1, and thus would be expected to exert substantially less influence on bycatch of slope species on the seaward side.

Making the changes according to Alternative 2, which changes the seaward area between 40°10' and 45°46' N. lat. to the modified 200 fm line year-round (rather than moving it to 150 fm) presents even less of a risk in terms of bycatch of slope rockfish rebuilding species, such as darkblotched rockfish or Pacific ocean perch, than Alternative 1 (moving boundaries in all areas requested by industry).

#### 4.4.2.2 Bycatch of Other Non-target species

There is not anticipated to be a distinguishable difference among the No Action alternative, Alternative 1 and Alternative 2 on bycatch of non-groundfish, non-target species. Under all of the alternatives, the Shorebased IFQ Program will continue to be monitored with 100 percent monitoring requirement. Under either Alternative 1 or Alternative 2, overall fishing effort is not likely to increase or change significantly from No Action. Instead, some dispersal of existing effort is likely. Changes in effort location are difficult to predict but are not anticipated to increase impacts to incidentally caught non-groundfish species.

### *4.4.3* Invertebrates

#### 4.4.3.1 No-action, Alternative 1, and Alternative 2

Invertebrate richness was less on untrawled bottoms, and a greater diversity of epibenthic macroinvertebrates was documented in trawled areas (Hixon and Tissot, 2007). Any impact changes to corals, sponges, or other biogenic habitat are considered as mentioned as potential EFH considerations (3.3.4 and 4.3).

### *4.4.4* Protected Species, Including ESA listed species

#### 4.4.4.1 Summary

No significant impacts are expected on listed species or their critical habitat outside of the scope of what has been analyzed in existing biological opinions. Any encounters by IFQ vessels will continue to be monitored with 100 percent monitoring requirement of the IFQ program. Gathered data will be utilized by the Council's newly forming Endangered Species Groundfish Workgroup to advise the Council on how to improve avoidance of protected species. Under the proposed action, overall fishing effort is not likely to increase or change significantly. Instead, some dispersal of existing effort is likely. Changes in effort location are difficult to predict, but are not anticipated to increase impacts to non-target species, including listed species and marine mammals.

#### 4.4.4.2 ESA-Listed Species

The fisheries undertaken under the Pacific coast groundfish FMP are not likely to jeopardize the continued existence of ESA-listed salmonids in the action area (NMFS 2006, NMFS 2009, NMFS 1999, NMFS 1996, NMFS 1993).

##### No-action

The no-action Alternative is not expected to have substantial negative effects on any ESA-listed species occurring in the action area. The no-action Alternative would keep the same areas closed to bottom trawling that are currently closed. There would be no redistribution of current fishing effort, therefore impacts to ESA-listed salmonids are not expected to increase above those considered in past biological opinions.

Additionally, catch per unit effort is not expected to increase under the no-action alternative, the number of hours bottom trawl gear is deployed would likely remain similar to that in recent years.

Continued operation of the groundfish fishery is not likely to adversely affect ESA-listed seabirds in the action area (USFWS 2012). Though trawl cables are a possible hazard to ESA-listed seabirds, no takes have been documented and no reasonable and prudent measures were recommended for vessels using bottom trawl gear to harvest groundfish in the 2012 biological opinion (USFWS 2012). The no-action Alternative is not anticipated to change fishing behaviors such that it would increase chances for interactions with ESA-listed seabirds. Furthermore, investigations by Guy et al. (2013) suggest that any seabird interactions with non-whiting bottom trawl groundfish fisheries are rare and not essential to the survival of rebuilding seabird species.

Continued operation of the groundfish fishery is not likely to adversely affect southern sea otters (USFWS 2012). The no-action Alternative will likely see a similar potential for indirect impacts to southern sea otters from recent years, although potentially less that that under Alternative 1 and 2, as transiting time will be unaffected by keeping areas closer to shore closed which will not result in a change in boat traffic; the primary impact, though not a threat, to southern sea otters.

Continued operation of the groundfish fishery is not likely to adversely affect bull trout (USFWS 2012). The no-action alternative is not anticipated to change fishing behaviors such that it would increase chances for interactions with bull trout or their designated critical habitat.

Continued operation of the groundfish fishery is not likely to jeopardize the southern distinct population segment of eulachon (NMFS 2012). A majority of eulachon encounters in the groundfish bottom trawl fishery occur off Oregon. The no-action alternative is not anticipated to change fishing behaviors such that it would increase chances for interactions with eulachon but is instead anticipated to experience similar impacts as the current fishing effort in recent years.

Continued operation of the groundfish fishery is not likely to jeopardize the southern distinct population segment of green sturgeon or adversely modify their designated critical habitat (NMFS 2012). The no-action alternative is not anticipated to change fishing behaviors such that it would increase chances for interactions with green sturgeon or their designated critical habitat. The no-action Alternative is not anticipated to displace and redistribute current fishing effort.

Continued operation of the groundfish fishery is not likely to jeopardize humpback whales (NMFS 2012). Under the no-action Alternative the groundfish bottom trawl fishery should not vary from what has been seen in the recent past and no increased risk to humpback whales is anticipated.

Continued operation of the groundfish fishery is not likely to jeopardize leatherback sea turtles or adversely modify their designated critical habitat (NMFS 2012). The no-action alternative is not anticipated to change fishing behaviors such that it would increase chances for interactions with leatherback sea turtles or their designated critical habitat. The no-action Alternative is not anticipated to displace or redistribute current fishing effort.

At their September 2012 meeting, formation of a West Coast Endangered Species Workgroup was explored and recommended by the Council. Further improvements in data collection for ESA-listed species will be recommended and continually updated upon formation of this workgroup, including from WCGOP 100 percent monitored trawl rationalization data.

### Alternative 1, and Alternative 2

Neither of the action alternatives (1 or 2) are expected to have substantial negative effects on any ESA-listed species occurring in the action area.

Alternative 1 would open areas to bottom trawling that have been fairly consistently closed since 2004. However, it is unlikely that the redistribution of current fishing effort under either alternative will cause impacts to ESA-listed salmonids to increase above those considered in past biological opinions. Additionally, if catch per unit effort is increased under either of the action altenratives, the number of hours bottom trawl gear is deployed could decrease, lowering impacts to ESA listed salmonids. Alternative 1 could see slightly higher catch per unit effort than Alternative 2 because it opens additional fishing areas.

Continued operation of the groundfish fishery is not likely to adversely affect ESA-listed seabirds in the action area (USFWS 2012). Though trawl cables are a possible hazard to ESA-listed seabirds, no takes have been documented and no reasonable and prudent measures were recommended for vessels using bottom trawl gear to harvest groundfish in the 2012 biological opinion (USFWS 2012). Neither of the alternatives is anticipated to change fishing behaviors such that it would increase chances for interactions with ESA-listed seabirds. Furthermore, investigations by Guy et al. (2013) suggest that any seabird interactions with non-whiting bottom trawl groundfish fisheries are rare and not essential to the survival of rebuilding seabird species.

Continued operation of the groundfish fishery is not likely to adversely affect southern sea otters (USFWS 2012). Alternative 1 may actually reduce the potential for indirect impacts to southern sea otters, as reductions in transiting time by opening areas closer to shore may result in a net decrease in boat traffic; the primary impact, though not a threat, to southern sea otters. Alternative 2 may also result in a small net decrease in boat traffic, but to a lesser effect than Alternative 1 compared to No-Action.

Continued operation of the groundfish fishery is not likely to adversely affect bull trout (USFWS 2012). Neither of the alternatives is anticipated to change fishing behaviors such that it would increase chances for interactions with bull trout or their designated critical habitat compared to No-Action.

Continued operation of the groundfish fishery is not likely to jeopardize the southern distinct population segment of eulachon (NMFS 2012). A majority of eulachon encounters in the groundfish bottom trawl fishery occur off Oregon. Alternative 1 would open additional areas to bottom trawling off the entire Oregon coast. Alternative 2 would open additional shoreward areas off the entire Oregon coast but only off a portion of the coast at depths deeper than 150 fm. However, neither alternative is anticipated to change fishing behaviors such that it would increase chances for interactions with eulachon but is instead anticipated to displace and redistribute current fishing effort.

Continued operation of the groundfish fishery is not likely to jeopardize the southern distinct population segment of green sturgeon or adversely modify their designated critical habitat (NMFS 2012). Neither of the alternatives is anticipated to change fishing behaviors such that it would increase chances for interactions with green sturgeon or their designated critical habitat. Both alternatives are anticipated to displace and redistribute current fishing effort.

Continued operation of the groundfish fishery is not likely to jeopardize humpback whales (NMFS 2012). The 2012 biological opinion also issued a provisional take statement. See below under 4.4.4.3.

Continued operation of the groundfish fishery is not likely to jeopardize leatherback sea turtles or adversely modify their designated critical habitat (NMFS 2012). Neither of the alternatives are anticipated to change fishing behaviors such that it would increase chances for interactions with leatherback sea turtles or their designated critical habitat. Both alternatives are anticipated to displace and redistribute current fishing effort.

At their September 2012 meeting, formation of a West Coast Endangered Species Workgroup was explored and recommended by the Council. Further improvements in data collection for ESA-listed species will be recommended and continually updated upon formation of this workgroup, including from WCGOP 100 percent monitored trawl rationalization data.

#### 4.4.4.3 Marine Mammals and Sea Birds

##### No-action, Alternative 1, and Alternative 2

The groundfish bottom trawl fishery is a Category III fishery, where take of marine mammals is extremely rare (78 FR 23708, April 22, 2013). In addition, investigations by Guy et al. (2013) suggest that any seabird interactions with non-whiting bottom trawl groundfish fisheries are rare.

No change in impacts to these animals is projected for any of the alternatives compared to the baseline No Action Alternative, as overall effort is not expected to increase substantially from the proposed action alternatives but is instead anticipated to displace and redistribute current fishing effort. None of the action alternatives (1 or 2) are expected to have any discernible impact on marine mammals. Any incidental takes of marine mammals or seabirds (an extremely rare event in the groundfish bottom trawl fishery) will continue to be subject to 100% monitoring requirements in the trawl rationalization program.

At the June 2013 Council meeting, a draft EA was presented for consideration of a proposed recommendation to require groundfish vessels over 55’ in length to use mandatory seabird streamer lines, which have been shown to dramatically reduce seabird take in the groundfish longline fisheries, and would pertain to IFQ vessels while utilizing gear switching provisions of the IFQ program. The Council reviewed the draft EA, and is expected to provide recommendations on this proposed action in the immediate future.

## 4.5 Socio-economic Impacts

### *4.5.1* Shorebased IFQ Program

#### 4.3.2.1. No-action, Alternative 1, and Alternative 2

##### Summary

Either of the two action alternatives is expected to have some favorable economic impact for fishing vessels that harvest, purchase, or resell groundfish bottom trawl landings, within the area of this potential action compared to the No-action alternative. New opportunities for trawling on additional grounds (currently closed to this gear) may then translate into additional landings and revenue from those valuable target species which were specified in the industry rationale for this request (e.g. lingcod, Dover sole, yellowtail rockfish, petrale sole, etc). The amount of expected economic benefit should differ according to alternative, area and thereby principal port of landing. Both the seaward and shoreward proposed changes would mean more fishing opportunities closer to shore, and in areas that have not been trawled recently, which may result in economic benefits in the form of fuel savings from fishing closer to port, additional fish on newly opened grounds, or both.

None of the alternatives in the proposed action are expected to have a negative effect on fishing vessels, processors, or communities which are dependent on groundfish fishing, compared to the no-action alternative.

##### Differences among alternatives and areas

There are some differences among the alternatives, in their potential amount of economic benefit to different coastal communities. Either Alternative 1 or 2 is expected to benefit IFQ vessels using groundfish bottom trawl gear when fishing between 45° 46’and 48° 10’ N. latitude, by opening additional areas to fishing on both the seaward and shoreward side of the existing (No Action) RCA configuration. However, under Alternative 2, vessels fishing in the area between 40° 10’ N. latitude to 45° 46’ N. latitude would see less of an increase in fishing opportunity on the seaward side.

At the same time, the difference in time of additional seaward fishing area access (and thereby potential for additional landings and revenue) between No Action and Alternative

1 is small for the northern area, while it is much larger for the southern area. Under Alternative 2, there is again a small difference (two months) in the northern area between No Action and Alternative 2, but no difference for the southern area; No Action and Alternative 2 are the same in this respect. There is no difference in the time of additional shoreward fishing access between the northern and southern areas, among any of the alternatives.  Both action alternatives offer six months additional access in the shoreward area between 75 and 100 fm, compared with the No Action Alternative.

### Differences in alternatives among ports and coastal communities

Medium to small ports between 45° 46' and 40° 10' N. lat., including Newport, Coos Bay, Brookings, Crescent City, and Eureka would stand to benefit from the increased seaward opportunity of Alternative 1, but not from Alternative 2. The port with the highest revenue from IFQ landings is Astoria by far (Figure 4-11, Table 4-5), which would benefit equally from either Alternative 1 or 2, since it is north of 45° 46' N. lat. Table X, shows the percentage distribution of revenue from non-whiting groundfish in the IFQ fishery between the northern and southern areas of this action during 2011 and 2012. Table 4-6 shows that the percentage of non-whiting IFQ revenue is very similar between the two areas considered in this action, for both 2011 and 2012, with the southern area showing slightly more revenue from non-whiting trips. For shorebased whiting landings, the northern area shows substantially more revenue than the southern area.

### Considerations of species and gear type

With the poor sablefish market of the past two years (although still the most valuable species per pound in the fishery), and continued reduction in the northern sablefish ACL, there is evidence that fishermen have shifted some effort to other target species in order to compensate (*Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Agenda Item D.2.a, April, 2013 PFMC meeting*). Either Alternative 1 or 2 could make such a shift easier for fishers, according to the species cited in industry rationale (bycatch analysis section). There were increases in revenue from species such as yellowtail rockfish, Pacific cod, petrale sole, lingcod, and Dover sole from 2011 to 2012 in the IFQ program, together with a substantial drop in sablefish revenue (*Annual Catch Report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012, Agenda Item D.2.a, April, 2013 PFMC meeting*). These species were cited as targets in the areas requested for opening by industry (bycatch analysis section).

In those southern ports, fishermen could still fish the seaward area between 150 and 200 fm using fixed gear, under the gear switching provision of IFQ regardless of this potential action. If the area is not opened to trawling, it is conceivable that fishermen may do so, to access some of the higher value targets that are often landed with fixed gear such as lingcod, sablefish, and Pacific cod (these species were cited in industry rationale). Given sufficient motivation to diversify their catch among species, it is conceivable that effort in the seaward area (150-200 fm, 40°10' to 45°46') could increase by use of fixed gear rather than trawl gear, even without the implementation of Alternative 2, under gear switching provisions in the IFQ program, especially upon recovery of sablefish markets and ex-vessel prices. However, this is speculative.

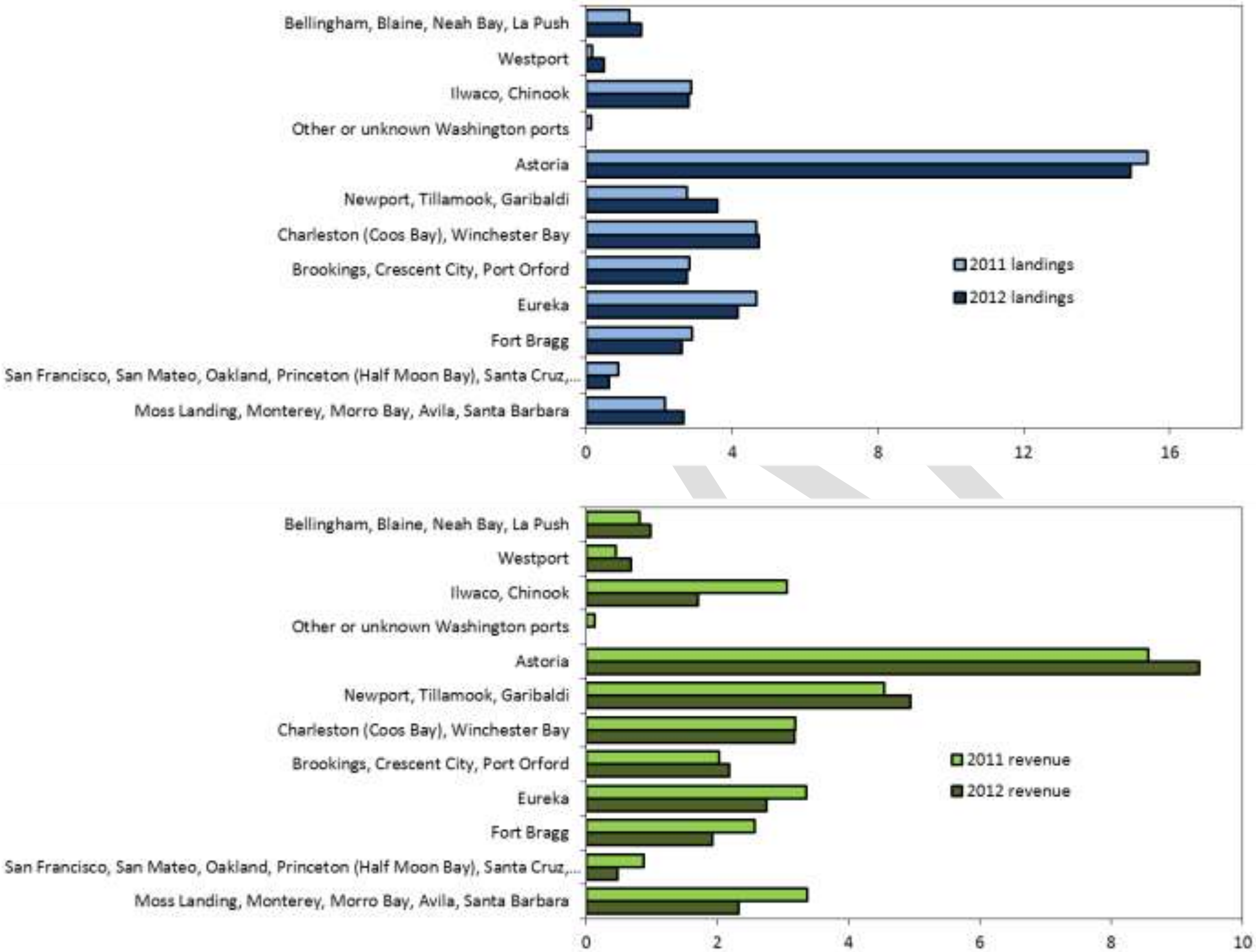



Figure 4-11: Landings and revenue by port group, for non-whiting trips, in the Shorebased IFQ Program. Port groups are arranged by latitude. Source = paper and electronic landing receipt data (PacFIN and PSMFC, respectively).

Table 4-5: Annual landings and revenue, distributed by port group, for non-whiting trips (top) and directed whiting trips (bottom), in the Shorebased IFQ Program, for 2011 and 2012. Port groups are arranged by latitude. Columns labeled "percent" express either 2012 landings or revenue (corresponding to the column appearing to left) as a percent of 2011 values. Columns labeled "dist." show the distribution of annual landings or revenue among port groups (%).

| **Port group (non-whiting trips)** | **2011 landings** | **2012 landings** | **2011 dist.** | **2012 dist.** | **Land. difference** | **Land. percent** | **2011 revenue** | **2012 revenue** | **2011 dist.** | **2012 dist.** | **Rev. difference** | **Rev. percent** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bellingham, Blaine, Neah Bay, La Push | 1,185,687 | 1,500,658 | 3% | 4% | 314,971 | 127% | 816,996 | 977,857 | 2% | 3% | 160,861 | 120% |
| Westport | 162,774 | 494,278 | 0% | 1% | 331,504 | 304% | 450,500 | 680,484 | 1% | 2% | 229,984 | 151% |
| Ilwaco, Chinook | 2,882,683 | 2,809,640 | 7% | 7% | -73,043 | 97% | 3,051,630 | 1,700,006 | 9% | 6% | -1,351,624 | 56% |
| Other or unknown Washington ports | 130,220 | | 0% | 0% | -130,220 | 0% | 127,621 | | 0% | 0% | -127,621 | 0% |
| Astoria | 15,398,437 | 14,929,115 | 38% | 37% | -469,322 | 97% | 8,567,173 | 9,338,689 | 26% | 31% | 771,516 | 109% |
| Newport, Tillamook, Garibaldi | 2,759,574 | 3,590,916 | 7% | 9% | 831,342 | 130% | 4,538,783 | 4,935,313 | 14% | 16% | 396,530 | 109% |
| Charleston (Coos Bay), Winchester Bay | 4,665,899 | 4,744,945 | 11% | 12% | 79,046 | 102% | 3,187,748 | 3,171,837 | 10% | 10% | -15,911 | 100% |
| Brookings, Crescent City, Port Orford | 2,833,395 | 2,752,902 | 7% | 7% | -80,493 | 97% | 2,021,490 | 2,177,826 | 6% | 7% | 156,336 | 108% |
| Eureka | 4,671,640 | 4,159,850 | 12% | 10% | -511,790 | 89% | 3,355,484 | 2,753,363 | 10% | 9% | -602,120 | 82% |
| Fort Bragg | 2,897,221 | 2,623,714 | 7% | 6% | -273,507 | 91% | 2,570,326 | 1,916,710 | 8% | 6% | -653,616 | 75% |
| San Francisco, San Mateo, Oakland, Princeton (Half Moon Bay), Santa Cruz, Bodega Bay | 869,663 | 621,684 | 2% | 2% | -247,979 | 71% | 878,513 | 476,211 | 3% | 2% | -402,302 | 54% |
| Moss Landing, Monterey, Morro Bay, Avila, Santa Barbara | 2,152,997 | 2,664,560 | 5% | 7% | 511,563 | 124% | 3,369,670 | 2,324,466 | 10% | 8% | -1,045,203 | 69% |
| Sum | 40,610,190 | 40,892,262 | 100% | 100% | 282,072 | 101% | 32,935,934 | 30,452,763 | 100% | 100% | -2,483,170 | 92% |

| **Port group (whiting trips)** | **2011 landings** | **2012 landings** | **2011 dist.** | **2012 dist.** | **Land. difference** | **Land. percent** | **2011 revenue** | **2012 revenue** | **2011 dist.** | **2012 dist.** | **Rev. difference** | **Rev. percent** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Westport, Ilwaco, Chinook | 50,597,855 | 37,654,325 | 25% | 26% | -12,943,530 | 74% | 5,700,215 | 5,848,889 | 25% | 28% | 148,674 | 103% |
| Astoria | 94,478,623 | 52,460,824 | 46% | 36% | -42,017,799 | 56% | 10,537,842 | 7,786,722 | 46% | 37% | -2,751,120 | 74% |
| Newport, Tillamook, Garibaldi, Charleston (Coos Bay), Winchester Bay | 58,167,274 | 56,240,192 | 29% | 38% | -1,927,082 | 97% | 6,572,762 | 7,323,068 | 29% | 35% | 750,306 | 111% |
| Sum | 203,243,752 | 146,355,341 | 100% | 100% | -56,888,411 | 72% | 22,810,819 | 20,958,679 | 100% | 100% | -1,852,140 | 92% |

Table 4-6: Ex-vessel revenue from shorebased non-whiting and whiting trips in the IFQ program, during 2011 and 2012, only for the area between 40° 10’ N. latitude to 48° 10’ N. lat. The “North” area includes ports Westport, Ilwaco/Chinook, “other or unknown Washington ports” and Astoria; the “South” area includes the ports Newport, Tillamook, Garibaldi, Charleston, Winchester Bay, Brookings, Crescent City, Port Orford, and Eureka.

| Non-whiting trips | 2011 | 2012 | 2011 | 2012 |
|---|---|---|---|---|
| North | 12,196,924 | 11,719,179 | 48% | 47% |
| South | 13,103,505 | 13,038,340 | 52% | 53% |
| Sum | 25,300,429 | 24,757,519 | 100% | 100% |

| Whiting trips | 2011 | 2012 | 2011 | 2012 |
|---|---|---|---|---|
| North | 16,238,057 | 13,635,611 | 71% | 65% |
| South | 6,572,762 | 7,323,068 | 29% | 35% |
| Sum | 22,810,819 | 20,958,679 | 100% | 100% |

In the industry request to move the shoreward and seaward boundaries of the trawl RCA, the GAP cited in public comment, in meeting with the GMT at the March and April 2013 meetings of the PFMC, as well as in their team statements (Agenda Item H.3.b, Supplemental GAP Report, March 2013; Agenda Item D.8.b, Supplemental GAP Report, April 2013), industry’s need to gain additional access target species including Dover sole, petrale sole, and other flatfish in the shoreward area, which they estimate will increase otherwise low overall attainment in the fishery, and make fishing substantially more economically viable. They related that this would be accomplished through increased efficiency and reduced fuel costs for some species that could be accessed closer to shore, and fishing in areas of higher density for valuable target species. They spoke to trawl fishers’ intent to use selective flatfish trawl gear in order to access these target species, and avoid canary rockfish, and other rebuilding rockfish species. The GAP stated they believe their complete request would also enable higher attainment of other valuable species including lingcod, true cod, yellowtail rockfish, particularly in the seaward area. The GAP also spoke about industry members’ desire to exercise the individual accountability which is inherent in the Individual Fishing Quota (IFQ) program, and pointed out that several modifications to the RCA structure have already been made in the first two years of the program, while maintaining very low harvest levels of rebuilding species. Finally, industry members stated that more regular RCA boundaries make those boundaries easier to comply with and to enforce.

### *4.5.2* Processor Sector

#### 4.5.2.1 No-action

There are no expected impacts to processor sectors from the no-action Alternative. The fishermen would continue to have the same access to fishing grounds as currently in place.

#### 4.5.2.2 Alternative 1

There may be increased landings at processors expected from Alternative 1 to the extent fishermen are able to increase their attainment levels of underutilized species. Fishermen would gain increased access both shoreward and seaward of the current RCA between 40° 10’ N. lat. and 48° 10’ N. lat.

#### 4.5.2.3 Alternative 2

There may be increased landings at processors expected from Alternative 2 to the extent fishermen are able to increase their attainment levels of underutilized species, although landings are expected to slightly less than those under Alternative 1. Fishermen would gain increased access both shoreward and seaward of the current RCA between 40° 10’ N. lat. and 48° 10’ N. lat., although somewhat less access seaward than under Alternative 1. Landings to processors south of 45° 46’ N. lat. may be less than those under Alternative 1.

### *4.5.3* Communities

#### 4.5.3.1 No-action

There are no expected impacts to communities from the no-action Alternative. Fishermen would continue to have the same access to fishing grounds as currently in place, and therefore processors and communities are not anticipated to be affected differently than what is currently occurring.

#### 4.5.3.2 Alternative 1

There may be increased landings in communities expected from Alternative 1 to the extent fishermen are able to increase their attainment levels of underutilized species. Fishermen would gain increased access both shoreward and seaward of the current RCA between 40° 10’ N. lat. and 48° 10’ N. lat., potentially benefitting processors. Therefore, communities are expected to benefit from Alternative 1.

#### 4.5.3.3 Alternative 2

There may be increased landings in communities expected from Alternative 2 to the extent fishermen are able to increase their attainment levels of underutilized species, although opportunities are expected to slightly less than those under Alternative 1. Fishermen would gain increased access both shoreward and seaward of the current RCA between 40° 10’ N. lat. and 48° 10’ N. lat., potentially benefitting processors, although somewhat less than under Alternative 1. Landings to processors south of 45° 46’ N. lat. may be less than those under Alternative 1. Therefore, communities are expected to benefit from Alternative 2, although to some extent less than under Alternative 1, particularly for communities south of 45° 46’ N. lat.

### 4.6 Cumulative Impacts

A cumulative effects analysis is required by the Council on Environmental Quality (CEQ) (40 CFR part 1508.7). The purpose of a cumulative effects analysis is to consider the combined effects of many actions on the human environment over time that would be missed if each action were evaluated separately. CEQ guidelines recognize that it is not practical to analyze the cumulative effects of an action from every conceivable perspective, but rather, the intent is to focus on those effects that are truly meaningful. A formal cumulative impact assessment is not necessarily required as part of an EA under NEPA as long as the significance of cumulative impacts have been considered (U.S. EPA 1999). The following addresses the significance of the expected cumulative impacts as they relate to the federally managed groundfish fishery.

#### *4.6.1* Consideration of the Affected Resources

In Chapter 3 (Status of the Affected Environment), the affected resources that exist within the non-whiting bottom trawl IFQ fishery environment are identified. Therefore, the significance of the cumulative effects will be discussed in relation to these affected resources listed below.

1. Physical Environment, including Ecosystem and Essential Fish Habitat
2. Biological Environment, including:
    - Groundfish
    - Non-target Species
    - Protected Species, including ESA, MMPA, and MBTA
    - Marine Mammals and Seabirds
3. Socioeconomic Environment

#### *4.6.2* Geographic Boundaries

The analysis of impacts focuses on actions related to the harvest of non-whiting groundfish species. The core geographic scope for each of the affected resources listed above is focused on the Eastern Pacific Ocean (Chapter 3) north of 40° 10’ N. lat. The coastal stocks of some groundfish species, such as blackcod, are highly migratory in nature, whereas other rockfish species have varying degrees of migratory behavior, with some species such as yelloweye rockfish exhibiting high site fidelity in offshore waters of Oregon, Washington, and Vancouver Island, Canada. For habitat, the core geographic scope is focused on EFH within the EEZ, and particularly within the areas for RCA boundary modification, (75 to 200 fm, 40° 10’ N. lat. to 48° 10’ N. lat.), but includes all habitat utilized by demersal (bottom dwelling) groundfish and non-target species in the Eastern Pacific Ocean. Rockfish species tend to be more localized although their young may distribute widely within the large California current system, and across different depth stratifications at different stages in their life history. For non-target species, those ranges may be expanded and would depend on the biological range of each individual non-target species in the Eastern Pacific Ocean. The core geographic scope for endangered and protected resources can be considered the overall range of these resources in the Eastern Pacific Ocean. For human communities, the core geographic boundaries are defined as those U.S. fishing communities directly involved in the harvest or processing of the managed resources, which were found to occur in coastal states most notably from Westport, Washington to Eureka, California.

### *4.6.3* Temporal Boundaries

The temporal scope of past and present actions for the affected resources is primarily focused on actions that have occurred after FMP implementation (1982) and more importantly, since implementation of the trawl rationalization program in 2011. For endangered species and other protected resources, the scope of past and present actions is on a species-by-species basis (Section 3.2.3) and is largely focused on the 1980s and 1990s through the present, when NMFS began generating stock assessments for marine mammals and sea turtles that inhabit waters of the U.S. EEZ. The temporal scope of future actions for all affected resources extends through December 31, 2018.

#### 4.6.3.1 Actions Other than the Proposed Action

#### 4.6.3.2 Past, Present, and Reasonably Foreseeable Future Actions

##### Fishery-related Actions

The historical management practices of PFMC have resulted in positive impacts on the health of the groundfish stocks and demersal rockfish complex species. Numerous actions have been taken to manage the fisheries for these species through amendment and specifications actions. In addition, the nature of the fishery management process is intended to provide the opportunity for PFMC and NMFS to regularly assess the status of the fisheries and to make necessary adjustments to ensure that there is a reasonable expectation of meeting the objectives of the FMP and the targets associated with any rebuilding programs under the FMP. The statutory basis for Federal fisheries management is the Magnuson-Stevens Act. To the degree with which this regulatory regime is complied, the cumulative impacts of past, present, and reasonably foreseeable future Federal fishery management actions on the affected resources should generally be associated with positive long-term outcomes. Constraining fishing effort through regulatory actions can often have negative short-term socioeconomic impacts. These impacts are usually necessary to bring about long-term sustainability of a given resource, which should, in the long-term, promote positive effects on human communities, especially those that are economically dependent upon groundfish stocks and demersal rockfish complex species.

In addition, PFMC has developed harvest specifications for 2013 and 2014 for groundfish stocks, which was implemented in January 2013 by NMFS. It is noted that the levels of groundfish harvest are not expected to fluctuate dramatically in the near future for the short term (see 2013-2014 harvest specifications), but ACLs for some demersal rockfish species may be slightly increased as overfished species continue upward trends in biomass from rebuilding plan consequences, and subsequently, are intercepted into the fishery. In the long term, it is important to evaluate the impacts on shares of total harvest allocated to entities rather than the allocation poundage.

There has likely been substantial habitat recovery within RCAs that have not been trawled within the 2.8 years or more (see section 3.1, above), stemming from prohibition on bottom trawling and low ACLs for demersal rockfish complex species since 2002. Increased bottom trawling for demersal rockfish species within RCAs will result in occasional (but increased) gear contacts with bottom habitats, mixed and hard bottom habitat in particular, which is where demersal rockfish are typically found. There are important disincentives associated with gear contact with mixed and hard demersal habitats due to various gear restriction implementation, which are discussed in Section 3.1.3.4.1, beginning on page 31. These include the high cost of net repair or replacement if the net is damaged and the reduced fishing efficiency and increased operating cost that occurs when the net makes contact with the mixed boulder or hard ocean bottom substrates. Gear restrictions have been implemented that further reduce the incentive to make bottom contact with bottom trawl gear on mixed and hard substrates including the small footrope requirement not to exceed 8 inches on all bottom trawl nets shoreward of 100 fm, and the requirement for bottom trawl large footrope not to exceed 18 inches. Catch share implementation is likely to consolidate fishing with fewer boats than in the past. This may result in further reduction in bottom trawl gear contacts with demersal habitats because the more efficient vessels will likely be doing most of the fishing and it is likely that the most efficient vessels may reduce effort on bottom contact.

PFMC and NMFS continue to work together on the trawl rationalization trailing actions. All of these actions are expected to increase benefits from the fishery and are not expected to appreciably interact with the action considered here, except as noted in the following list. Details on each action are available on the PFMC website (http://www.pcouncil.org/groundfish/fishery-management-plan/trailing-actions/). The main trailing actions are as follows:

*Trawl/Fixed gear permit stacking (*final PFMC action taken, not yet implemented) — This action allows fixed gear and trawl permits to be registered to the same vessel at the same time.

*Gear Issues (under PFMC consideration, deliberations delayed)* -- Gear issues include multiple gears on a trip, gear modifications to increase efficiency, and restrictions on areas in which gears may be used. Consideration on this issue has been delayed until September 2013.

*Cost Recovery* (PFMC action completed, not yet implemented) – Cost recovery will be implemented at the beginning of 2014 resulting in the collection of additional fees in amounts of 3 percent of exvessel value for the shoreside fishery. For details see: http://www.pcouncil.org/wp-content/uploads/H2a_ATT1_COSTRECOV_FNL_SEP2012BB.pdf. In the context of this additional cost, alternatives which increase the efficiency of fishing operations from increased access to fishing grounds (alternative 1 and 2) may be more beneficial to stability in the industry than would be the case under the no-action alternative.

*Risk Pools* (PFMC action completed, not yet implemented) —PFMC has recommended a number of provisions to facilitate fishers working together in risk pools. These actions include providing a safe harbor from limits on the accumulation of control over QS.

*Lender Safe Harbor from Control Rules* (PFMC action completed, not yet implemented) --- This action clarified who qualifies for the lender safe harbor exception and the activities for which an exception is provided.

*Whiting Season and Southern Allocation* (PFMC action complete, not yet implemented) – This action will set a common start date for all shoreside fisheries which matches the start date for the at-sea fishery (May 15) and eliminate the cap on early season harvest in the south. While not changing the total amount of trawling with midwater gear and total amount of the target species caught, it may alter the timing of that harvest, advancing some of the harvest by one month, and subsequently have some effect on the timing of bottom trawl fishing activities. The expected change in impact of the trawl season date movement as a result of the Rockfish Conservation Area regulations would be minimal.

*Pacific Whiting Surplus Carryover Implementation* (PFMC action completed) - This provision, which would allow up to 10 percent of unused whiting QP to be carried from one year to the next, has not been implemented due to legal criteria related to treaty issues with Canada. PFMC's SSC has determined that from a scientific perspective, the surplus carryover provision does not have a biological impact. On that basis, changes to the bottom trawl Rockfish Conservation Area boundaries would not have an interaction with this provision that would have any appreciable impact.

*Electronic Monitoring as a Replacement for the 100 percent Observer Coverage Requirement* (under PFMC consideration) — This proposal is under preliminary study, and options have yet to be developed. Interaction with this proposed Rockfish Conservation Area action will depend on the nature of the alternative monitoring system developed. If full retention is required with electronic monitoring, the combination of that requirement with the Rockfish Conservation Areas could affect the amount of small fish and nonmarketable fish brought to shore but will not alter estimated total mortality.

Furthermore, PFMC has adopted a Fishery Ecosystem Plan (FEP), which will broaden its current authority to species and issues not currently addressed in existing FMPs, including the groundfish plan. The scope of the plan is still under consideration. The guidance provided to the plan development team thus far has included:

1. Development of an FEP that would primarily be advisory in nature with the potential to expand in the future.
2. Amend existing FMPs to include management measures for forage fish as the Council deems appropriate.
3. Develop a list of species not included in any FMP and that are not being managed to define their trophic associations and ecological roles.
4. Complete an analysis of unmanaged species and potential processes for their management.

Implementation of an FEP could have positive environmental and biological impacts associated with forage fish and unmanaged fish protection. Such protections could accrue benefits to managed species such as groundfish which depend on forage fish and some unmanaged fish for their survival and reproduction. While adverse impacts on forage fish and unmanaged fish under either of the alternatives are expected to be minimal, actions taken under the FEP are expected to further benefit these resources, helping to offset any negative impacts. It could potentially have negative short-term socioeconomic impacts if actions taken to protect forage species and unmanaged species resulted in reduced harvest opportunity for managed species. In the context of regulations that may impose further restrictions on harvest, alternatives which alleviate production costs may be more beneficial to stability in the industry than would be the case if harvest conditions were expected to remain stable.

### 4.4.1 Non-fishing Actions

Non-fishing activities that introduce chemical pollutants, sewage, changes in water temperature, salinity, dissolved oxygen, and suspended sediment into the marine environment pose a risk to all of the identified affected resources. Human-induced non-fishing activities tend to be localized in nearshore areas and marine project areas where they occur. Examples of these activities include, but are not limited to, agriculture, port maintenance, coastal development, marine transportation, marine mining, dredging, and the disposal of dredged material. Wherever these activities co-occur, they are likely to work additively or synergistically to decrease habitat quality and may indirectly constrain the sustainability of the managed resources, non-target species, and protected resources. Decreased habitat suitability would tend to reduce the tolerance of these species to the impacts of fishing effort. Mitigation of this outcome through regulations that would reduce fishing effort could then negatively impact human communities. The overall impact to the affected species and their habitats on a population level is unknown, but likely neutral to low negative, since a large portion of these species have a limited or minor exposure to these local non-fishing perturbations.

In addition to guidelines mandated by the Magnuson-Stevens Act, NMFS reviews these types of effects through the review processes required by Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, for certain activities that are regulated by Federal, state, and local authorities. The jurisdiction of these activities is in "waters of the U.S." and includes both river and marine habitats.

For many of the proposed non-fishing activities to be permitted under other Federal agencies (such as offshore energy facilities, etc.), those agencies would conduct examinations of potential impacts on the affected resources. The Magnuson-Stevens Act (50 CFR 600.930) imposes an obligation on other Federal agencies to consult with the Secretary of Commerce on actions that may adversely affect EFH. The eight fishery management councils are engaged in this review process by making comments and recommendations on any Federal or state action that may affect habitat, including EFH, for their managed species and by commenting on actions likely to substantially affect habitat, including EFH.

In addition, under the Fish and Wildlife Coordination Act (Section 662), “whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the U.S., or by any public or private agency under Federal permit or license, such department or agency first shall consult with the U.S. Fish and Wildlife Service (USFWS), Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular state wherein the" activity is taking place. This act provides another avenue for review of actions by other Federal and state agencies that may impact resources that NMFS manages in the reasonably foreseeable future. In addition, NMFS and the USFWS share responsibility for implementing the ESA. ESA requires NMFS to designate "critical habitat" for any species it lists under the ESA (i.e., areas that contain physical or biological features essential to conservation, which may require special management considerations or protection) and to develop and implement recovery plans for threatened and endangered species. The ESA provides another avenue for NMFS to review actions by other entities that may impact endangered and protected resources whose management units are under NMFS' jurisdiction.

The effects of climate on the biota of the California Current ecosystem have been recognized for some time. The El Niño/Southern Oscillation (ENSO) is widely recognized to be the dominant mode of interannual variability in the equatorial Pacific, with impacts throughout the rest of the Pacific basin and the globe. During the negative (El Niño) phase of the ENSO cycle, jet stream winds are typically diverted northward, often resulting in increased exposure of the west coast of the U.S. to subtropical weather systems. The impacts of these events to the coastal ocean generally include reduced upwelling winds, deepening of the thermocline, intrusion of offshore (subtropical) waters, dramatic declines in primary and secondary production, poor recruitment, reduced growth and survival of many resident species (such as salmon and groundfish), and northward extensions in the range of many tropical species. Concurrently, top predators such as seabirds and pinnipeds often exhibit reproductive failure. In addition to interannual variability in ocean conditions, the North Pacific seems to exhibit substantial interdecadal variability, which is referred to as the Pacific (inter) Decadal Oscillation (PDO).

Within the California Current itself, Mendelssohn, et al. (2003) described long-term warming trends in the upper 50 to 75 m of the water column. Recent paleoecological studies from marine sediments have indicated that 20th century warming trend in the California Current have exceeded natural variability in ocean temperatures over the last 1,400 years. Statistical analyses of past climate data have improved our understanding of how climate has affected North Pacific ecosystems and associated marine species productivities. Our ability to predict future impacts on the ecosystem stemming from climate forcing events remains poor at best.

### 4.4.2 Magnitude and Significance of Cumulative Effects

In determining the magnitude and significance of the cumulative effects, the additive and synergistic effects of the proposed action, as well as past, present, and future actions, must be taken into account. The following section discusses the effects of these actions on each of the managed resources.

#### 4.4.2.1 Physical Environment, including Habitat and Ecosystem

Those past, present, and reasonably foreseeable future actions, whose effects may impact habitat (including EFH) and the direction of those potential impacts, are listed in table 4-24, below. The direct and indirect negative actions described in table 4-24 are localized in nearshore areas and marine project areas where they occur. Therefore, the magnitude of those impacts on habitat is expected to be limited due to a lack of exposure to habitat at large. Agricultural runoff may be much broader in scope, and the impacts of nutrient inputs to the coastal system may be of a larger magnitude, although the impact on habitat and EFH is unquantifiable. As described above (Section 4.4.1), NMFS has several means under which it can review non-fishing actions of other Federal or state agencies that may impact NMFS' managed resources and the habitat on which they rely prior to permitting or implementation of those projects. This serves to minimize the extent and magnitude of direct and indirect negative impacts those actions could have on habitat utilized by resources under NMFS' jurisdiction.

Past fishery management actions taken through the FMP process have had a positive cumulative effect on habitat and EFH. It is anticipated that the future management actions will result in additional direct or indirect positive effects on habitat through actions which protect EFH for federally-managed species and protect ecosystem services on which these species' productivity depends. These impacts could be broad in scope. All of the affected resources are interrelated; therefore, the linkages among habitat quality and EFH, managed resources and non-target species productivity, and associated fishery yields should be considered. For habitat and EFH, there are direct and indirect negative effects from actions which may be localized or broad in scope; however, positive actions that have broad implications have been, and it is anticipated will continue to be, taken to improve the condition of habitat. There are some actions, which are beyond the scope of NMFS and PFMC management such as coastal population growth and climate change, which may indirectly impact habitat and ecosystem productivity. Overall, the past, present, and reasonably foreseeable future actions that are truly meaningful to habitat have had a neutral to positive cumulative effect.

Table 4-7:  Summary of the effects of past, present, and reasonably foreseeable future actions on habitat.

<table>
<tr><th>Action</th><th>Past to the Present</th><th>Reasonably Foreseeable Future</th></tr>
<tr><td>Original FMP and subsequent Amendments to the FMP</td><td>Indirect Positive</td><td></td></tr>
<tr><td>Agricultural runoff</td><td colspan="2">Direct Negative</td></tr>
<tr><td>Port maintenance</td><td colspan="2">Uncertain – Likely Direct Negative</td></tr>
<tr><td>Offshore disposal of dredged materials</td><td colspan="2">Direct Negative</td></tr>
<tr><td>Marine transportation</td><td colspan="2">Direct Negative</td></tr>
<tr><td>Installation of pipelines, utility lines and cables</td><td colspan="2">Uncertain – Likely Direct Negative</td></tr>
<tr><td>Offshore Energy Facilities (wind, tidal, etc.)</td><td></td><td>Potentially Direct Negative</td></tr>
<tr><td>2013-2014 Biennial Harvest Specifications</td><td></td><td>Positive</td></tr>
<tr><td>Trawl Rationalization Trailing Actions</td><td></td><td>Uncertain – Likely Positive</td></tr>
<tr><td>Summary of past, present, and future actions excluding those proposed in this document</td><td colspan="2">Overall, actions have had, or will have, neutral to positive impacts on habitat, including EFH</td></tr>
</table>

#### 4.6.3.3 Biological Environment

Those past, present, and reasonably foreseeable future actions, whose effects may impact groundfish resources and the direction of those potential impacts, are summarized in Table 4-25, below. The indirectly negative actions described in Table 4-25 are localized in nearshore areas and marine project areas where they occur. Therefore, the magnitude of those impacts on the managed resources is expected to be limited due to a lack of exposure to the population at large. Agricultural runoff may be much broader in scope, and the impacts of nutrient inputs to the coastal system may be of a larger magnitude, although the impact on productivity of the managed resources is unquantifiable. As described above (Section 4.6.3.1), NMFS has several means under which it can review non-fishing actions of other Federal or state agencies that may impact NMFS' managed resources prior to permitting or implementation of those projects. This serves to minimize the extent and magnitude of indirect negative impacts those actions could have on resources under NMFS' jurisdiction.

Past fishery management actions taken through the FMP have had a positive cumulative effect on the managed resources. It is anticipated that the future management actions, described in Table 4-25, will result in additional indirect positive effects on the managed resources through actions which reduce and monitor bycatch, protect habitat, and protect ecosystem services on which groundfish and demersal rockfish complex species productivities depend. In addition, past fishery management actions taken through the FMP process have had a positive cumulative effect on ESA-listed and MMPA-protected species through the reduction of fishing effort (potential interactions) and implementation of gear requirements. It is anticipated that the future management actions will continue to result in additional indirect positive effects on protected resources. The impacts of these future actions could be broad in scope, and it should be noted the biological resources are often coupled in that they utilize similar habitat areas and ecosystem resources on which they depend. Overall, the past, present, and reasonably foreseeable future actions that are truly meaningful to the biological resources have had a positive cumulative effect.

Table 4-8: Summary of the effects of past, present, and reasonably foreseeable future actions on biological resources

| Action | Past to the Present | Reasonably Foreseeable Future |
|---|---|---|
| Original FMP and subsequent Amendments to the FMP | **Indirect Positive** | |
| Agricultural runoff | **Indirect Negative** | |
| Port maintenance | **Uncertain – Likely Indirect Negative** | |
| Offshore disposal of dredged materials | **Indirect Negative** | |
| Marine transportation | **Indirect Negative** | |
| Installation of pipelines, utility lines and cables | **Uncertain – Likely Negative** | |
| Offshore Energy Facilities (wind, tidal, etc.) | | **Uncertain – Likely Indirect Negative** |
| 2013-2014 Biennial Harvest Specifications | | **Indirect Positive** |
| Trawl Rationalization Trailing Actions | | **Uncertain – Likely Positive** |
| **Summary of past, present, and future actions excluding those proposed in this document** | **Overall, actions have had, or will have, positive impacts on the biological resources** | |

### 4.6.3.4 Socio-Economic Environment

Those past, present, and reasonably foreseeable future actions, whose effects may impact the soci-economic environment and the direction of those potential impacts, are summarized in Table **4-9**: below. The indirectly negative actions described in Table 4-26 are localized where they occur. Therefore, the magnitude of those impacts on the managed resources is expected to be limited due to a lack of exposure to the population at large. Agricultural runoff may be much broader in scope, and the impacts of nutrient inputs to the coastal system may be of a larger magnitude, although the impact on productivity of the managed resources is unquantifiable. As described above (Section 4.4.4), NMFS has several means under which it can review non-fishing actions of other Federal or state agencies that may impact NMFS' managed resources prior to permitting or implementation of those projects. This serves to minimize the extent and magnitude of indirect negative impacts those actions could have on resources under NMFS' jurisdiction.

Past fishery management actions taken through the FMP have had a positive cumulative effect on the managed resources. It is anticipated that the future management actions, described in Table 4-26,will result in additional indirect positive effects on the managed resources through actions which reduce and monitor bycatch, protect habitat, and protect ecosystem services on which groundfish and demersal rockfish complex species productivities depend. In addition, past fishery management actions taken through the FMP process have had a positive cumulative effect on ESA-listed and MMPA-protected species through the reduction of fishing effort (potential interactions) and implementation of gear requirements. It is anticipated that the future management actions will continue to result in additional indirect positive effects on protected resources. The impacts of these future actions could be broad in scope, and it should be noted the biological resources are often coupled in that they utilize similar habitat areas and ecosystem resources on which they depend. Overall, the past, present, and reasonably foreseeable future actions that are truly meaningful to the biological resources have had a positive cumulative effect.

Table 4-9: Summary of the effects of past, present, and reasonably foreseeable future actions on human communities

| **Action** | **Past to the Present** | **Reasonably Foreseeable Future** |
| --- | --- | --- |
| Original FMP and subsequent Amendments to the FMP | **Indirect Positive** | |
| Agricultural runoff | **Indirect Negative** | |
| Port maintenance | **Uncertain – Likely Mixed** | |
| Offshore disposal of dredged materials | **Indirect Negative** | |
| Marine transportation | **Mixed** | |
| Installation of pipelines, utility lines and cables | **Uncertain – Likely Mixed** | |
| Offshore Energy Facilities (wind, tidal, etc.) | | **Uncertain – Likely Mixed** |
| 2013-2014 Biennial Harvest Specifications | | **Indirect Positive** |
| Trawl Rationalization Trailing Actions | | **Uncertain – Likely Positive** |
| **Summary of past, present, and future actions excluding those proposed in this document** | **Overall, actions have had, or will have, positive impacts on human communities** | |

### 4.6.4 Proposed Action on all of the Affected Resources

The magnitude and significance of the cumulative effects, which include the additive and synergistic effects of the proposed action, as well as past, present, and reasonably foreseeable future actions, have been taken into account throughout this section.

Impacts to the physical environment are between slightly negative to neutral compared to the No Action Alternative. The potential for greater bottom contact in the groundfish bottom trawl fishery compared to the No Action Alternative is due to concentrated effort causing the vessel operator to fish within a larger range of bottom habitat. Under No Action or action Alternatives (1&2), groundfish bottom trawl gear could continue to be deployed in untrawlable habitat where groundfish bottom trawl fishing is allowed, by which contact could damage the net, and endanger the safety of the crew; two behaviors bottom trawl vessels are likely to avoid when possible. Most of the increased bottom contact compared to the No Action Alternative will be to soft sedimentary and mud bottom habitat (over 90 percent); no significant difference in impacts is projected among the alternatives with regard to impact to hard bottom habitats, when considering the amount of untrawlable hard bottom habitat in California Current Ecosystem within the entire West Coast EEZ which bottom trawl fishing vessels will likely continue to avoid to avoid harm to their gear and to reduce safety risks onboard the vessel. However, under the No-action Alternative, there is already a great disincentive to allow groundfish bottom trawl gear to come into contact with sensitive mixed/boulder and hard benthic habitats, such that the additional disincentive from increased accessibility to fishing grounds may not have a substantial impact on behavior from areas that are currently untrawled within open habitat (outside of existing trawl RCAs). Further, under catch share management, bottom contact rate in the groundfish bottom trawl fishery is expected to decline as catch is consolidated with the more efficient harvesters[3].

Since 2002, NMFS has used large-scale, depth-based, closures to reduce catch of overfished rockfish in fisheries that take and retain groundfish, directing harvest of healthy stocks to areas that remained open. Impacts on the biological resources are primarily a function of the areas fished, gear types used, and level of effort; and of these, area fished is the only factor that might be affected. The levels of dermersal harvests will be variable. However declining trends in sablfish ex-vessel price per pound coupled with lower biomass trajectories from historical levels in the near future, at least for the short term (see 2013-2014 biennial specifications for the groundfish fishery, discussed in Section 4.2.1 of this EA). This reduced population size will result in reduced harvest opportunity for sablefish by all groundfish fishers and may shift effort to other fisheries to the degree that fishery or individual fisher quotas allow. Processors and communities will also have reduced product and fishery income, respectively, from the prominent sablefish resource and they too will have to depend on other fisheries or income sources to make up for the reduced landings. In the context of this downturn, alternatives which alleviate dependence on the sablefish resource, allowing increased underutilized harvest may be more beneficial to the long-term stability in the industry than would be the case if harvest levels were expected to remain stable, as underutilized species markets will continue to improve under trawl rationalization.

In addition, the assumption is that small fish (i.e., non-target species) are able to escape codend meshes improves small fish escapement and survival. While it is possible that under the No Action Alternative there could be a decreased impact relative to the action alternatives, that impact is quite

[3] Starting on January 1, 2014, all IFQ quota share permit holders may trade quota share pounds. Thus far, annual sales of quota pounds is allowed, but not of quota shares from individual permits.

small.  In addition, minimally increased impacts to eulachon due to increased shoreward (75fm to 100fm) trawling opportunity compared to No Action conditions may occur.  There is no difference in impacts to listed species or to eulachon in particular because fishery impacts on eulachon have been very small or negligible.  In addition, the eulachon Biological Opinion concludes that West Coast groundfish fisheries have minimal impact to the eulachon population growth rate.  No changes in impacts to target species, marine mammals, and seabirds compared to No Action are expected among the action alternatives.  Overall, the impacts on biological resources are neutral when compared to the No Action Alternative.

In addition, West coast trawl vessels engage in other fisheries and derive substantial revenues from those fisheries.  Notable ones include shrimp and albacore.  The income that trawlers receive from these other fisheries is far from stable and as a result can be expected to fluctuate in future years depending on the abundance or availability of these other resources to harvest.  The availability of these other fishing opportunities somewhat diminishes the importance of any gain in economic efficiencies under the action alternatives, as compared to a situation in which vessels relied only on the groundfish bottom trawl fishery.

For impacts to human communities, greater revenues from increased opportunity to fishing grounds, with potentially a wider range of available opportunities to harvest target and underutilized species compared to the No Action Alternative.  The other action alternatives (1 and 2) have minimal impacts compared to the No Action Alternative.  Thus, expected impacts are beneficial in comparison to the baseline.

Therefore, when this proposed action is considered in conjunction with all the other pressures placed on fisheries by past, present, and reasonably foreseeable future actions, it is not expected to result in any significant impacts, positive or negative.  Based on the information and analyses presented in these past FMP documents and this document, there are no significant cumulative effects associated with the action proposed in this document.

# CHAPTER 5 STATUTORY REQUIREMENTS AND APPLICABLE LAW

## 5.1 FMP Goals and Objectives and National Standards

The proposed action should further the goals and objectives of, and be consistent with, the Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP), and also be consistent with the National Standards (NS) contained in the Magnuson-Stevens Act. The Groundfish FMP contains three broad goals and 17 objectives intended to achieve those goals. As briefly described below, the proposed action should:

- Minimize bycatch, and mortality to bycatch, by demonstrating the effectiveness of individual accountability under the Shorebased IFQ Program, even with increased access to fishing grounds (NS 9, NS 1; FMP goal 3; FMP objectives 6, 9, 11,).
- Improve safety at sea through reduced transiting requirements (NS 10; FMP objective 17).
- Reduce regulatory complexity for industry and management (FMP objectives 15, 16)
- Increase access to target stocks, while ensuring all other statutory requirements are met (NS 1, FMP Goals 1–3).

**NATIONAL STANDARD 1**

*National Standard 1 states that conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.*

The groundfish harvest specifications and management measures are implemented every two years and incorporate the most recent scientific information, including new stock assessments. The most recent harvest specifications cover 2013-2014 (78 FR 580, January 3, 2013). The harvest specifications establish, in generally decreasing order, overfishing limits, acceptable biological catch limits, annual catch limits, and harvest guidelines. In addition, for some species, the harvest specifications also establish sector-specific allocations. Under the Groundfish FMP, the annual catch limits are established in a manner to prevent overfishing while achieving optimum yield (OY).

For the shorebased trawl fishery, the IFQ program increases individual accountability for total catch, including bycatch, and gives fishermen greater discretion as to when and how to fish. This provides greater opportunity to extract the full optimum yield while avoiding overfished species. The 100 percent monitoring and increased accountability further reduces the risk of overfishing. The proposed action would increase access to fishing grounds and contribute to achieving OY.

Because this action would not change the overall amount of groundfish available to the trawl fishery, and considering the increased accountability under the shorebased IFQ program, the proposed action would continue to prevent overfishing while achieving OY. As the EA demonstrates, the risk of exceeding an ACL or trawl sector allocation is low.

**NATIONAL STANDARD 2**

*National Standard 2 states that conservation and management measures shall be based upon the best scientific information available.*

The EA and supporting analyses are based upon the best scientific information available. The EA used data from various sources or summaries of that data, including data from the Pacific Fisheries Information Network (PacFIN), Federal electronic fish tickets, the NMFS limited entry permit database, West Coast Groundfish Observer Program (WCGOP) data, state logbooks, and NMFS vessel monitoring systems and declarations data.

**NATIONAL STANDARD 3**

*National Standard 3 states that, to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.*

The environmental impact statement for the 2013-2014 Groundfish Harvest Specifications and Management Measures described the management units for Pacific coast groundfish. This action would not modify those management units.

**NATIONAL STANDARD 4**

*National Standard 4 states that conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.*

The proposed action does not discriminate between residents of different states. The trawl RCA boundaries could have incidental allocative effect, but the proposed action is not a direct assignment of fishing privileges.

**NATIONAL STANDARD 5**

*National Standard 5 states that conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.*

The shorebased IFQ program was designed, in part, to reduce fleet capacity and to economically rationalize the groundfish trawl fishery. The trawl fleet will likely consolidate and fewer vessels will be used to harvest the available allocations, especially once quota share trading is allowed. Reducing excess capacity is expected to improve the efficiency in the utilization of fishery resources as well as reduce the levels of incidental catch. In addition, once quota trading begins, quota is expected to move over the long-term to owners with more efficient fishing operations. The proposed action would not alter these components of the shorebased IFQ program. The proposed action should also increase the amount of fishing grounds available shoreward and seaward of the current RCA boundaries, reducing fuel costs and transiting time. The proposed action would also result in a simpler RCA configuration for enforcement and management purposes.

**NATIONAL STANDARD 6**

*National Standard 6 states that conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.*

The shorebased IFQ program provides greater flexibility to individual fishermen to determine when and how to fish. This flexibility enhances the ability of fishermen and managers to respond to unexpected circumstances. The program also provides for variations and contingencies in the fishery by allowing transfer of quota through leasing and sales. In addition, the Council retains the flexibility to act inseason to modify RCA boundaries in response to new information should it be necessary.

**NATIONAL STANDARD 7**

*National Standard 7 states that conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.*

The proposed action should minimize costs by simplifying RCA boundaries, increasing access to fishing grounds, and reducing vessel transiting time. Generally, by coordinating management, monitoring, and enforcement activities between NMFS, the Council, and the States, duplication, and thus cost, is minimized. The proposed action would not introduce any new measures that duplicate those already in place.

**NATIONAL STANDARD 8**

*National Standard 8 states that conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.*

The proposed action alternatives would benefit fishing communities by increasing access to target stocks and are not expected to have adverse economic impacts.

## NATIONAL STANDARD 9

*National Standard 9 states that conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.*

The shorebased IFQ program was designed to improve total catch accounting (with 100% observer coverage in all sectors and 100% dockside monitoring), reduce bycatch, increase target catches, and promote greater individual responsibility. The proposed action would open areas where some overfished species are more likely to be encountered. However, the action is not anticipated to increase the amount of bycatch and fishermen are expected to avoid overfished species due to the limited amount of quota pounds available.

## NATIONAL STANDARD 10

*National Standard 10 states that conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.*

The shorebased IFQ program provides fishermen with increased flexibility in determining when, where, and how to fish. This is expected to reduce incentives to fish in unsafe conditions. Some safety benefits were also expected to the degree that the fishery is more profitable and more money is put into vessel maintenance. Less efficient vessels are expected to leave the trawl fishery, which may eliminate older, less safe vessels. RCAs could affect safety if more vessels elect to fish seaward of the closed areas and are more exposed to bad weather conditions. The proposed action would increase the amount of fishing grounds both shoreward and seaward of the RCAs, potentially reducing transit time and increasing safety.

## 5.2 Other Applicable MSA Provisions

NMFS prepared an EIS evaluating programmatic measures designed to identify and describe west coast groundfish EFH (NMFS 2005), and minimize to the extent practicable, adverse effects of fishing on west coast groundfish EFH. The Council took final action amending the groundfish FMP to incorporate new EFH provisions in November 2005. NMFS partially approved the amendment in March 2006. Implementing regulations became effective in June 2006. The EA describes impacts of the proposed action on EFH, consistent with the EFH assessment requirements of 50 CFR 600.920 (e)(3). The proposed action is not anticipated to result in substantial adverse effects to groundfish EFH and is not anticipated to affect EFH designated for other species. No additional EFH conservation recommendations are provided. The Council is currently undertaking a review of its groundfish EFH designations and may take further steps to minimize adverse effects of fishing on groundfish EFH at that time, if practicable.

# CHAPTER 6 OTHER APPLICABLE LAW

## 6.1 Other Federal Laws

### *6.1.1* Coastal Zone Management Act

Section 307(c)(1) of the Federal Coastal Zone Management Act (CZMA) of 1972 requires all Federal activities that directly affect the coastal zone be consistent with approved state coastal zone management programs to the maximum extent practicable. The proposed action would be implemented in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved coastal zone management programs of Washington, Oregon, and California. This determination has been submitted to the responsible state agencies for review under Section 307(c)(1) of the CZMA.

### *6.1.2* Endangered Species Act

The Endangered Species Act of 1973 (ESA) was signed on December 28, 1973, and provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The ESA replaced the Endangered Species Conservation Act of 1969; it has been amended several times.

A "species" is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future.

Federal agencies are directed, under section 7(a)(1) of the ESA, to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Federal agencies must also consult with NMFS or USFWS, under section 7(a)(2) of the ESA, on activities that may affect a listed species. These interagency consultations, or section 7 consultations, are designed to assist Federal agencies in fulfilling their duty to ensure Federal actions do not jeopardize the continued existence of a species or destroy or adversely modify critical habitat. Should an action be determined to jeopardize a species or result in the destruction or adverse modification of critical habitat, NMFS or USFWS will suggest Reasonable and Prudent Alternatives (RPAs) that would not violate section 7(a)(2).

Biological opinions document whether the Federal action is likely to jeopardize the continued existence of listed species, or result in the destruction or adverse modification of critical habitat. Where appropriate, biological opinions provide an exemption for the "take" of listed species while specifying the extent of take allowed, the Reasonable and Prudent Measures (RPMs) necessary to minimize impacts from the Federal action, and the Terms and Conditions with which the action agency must comply.

NMFS issued Biological Opinions under the Endangered Species Act (ESA) on August 10, 1990, November 26, 1991, August 28, 1992, September 27, 1993, May 14, 1996, and December 15, 1999 pertaining to the effects of the PCGFMP fisheries on Chinook salmon (Puget Sound, Snake River spring/summer, Snake River fall, upper Columbia River spring, lower Columbia River, upper Willamette River, Sacramento River winter, Central Valley spring, California coastal), coho salmon (Central California coastal, southern Oregon/northern California coastal), chum salmon (Hood Canal summer, Columbia River), sockeye salmon (Snake River, Ozette Lake), and steelhead (upper, middle and lower Columbia River, Snake River Basin, upper Willamette River, central California coast, California Central Valley, south/central California, northern California, southern California). These biological opinions have concluded that implementation of the PCGFMP is not expected to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS, or result in the destruction or adverse modification of critical habitat.

NMFS issued a Supplemental Biological Opinion on March 11, 2006 concluding that neither the higher observed bycatch of Chinook in the 2005 whiting fishery nor new data regarding salmon bycatch in the groundfish bottom trawl fishery required a reconsideration of its prior ''no jeopardy'' conclusion. NMFS also reaffirmed its prior determination that implementation of the PCGFMP is not likely to jeopardize the continued existence of any of the affected ESUs. Lower Columbia River coho (70 FR 37160, June 28, 2005) and Oregon Coastal coho (73 FR 7816, February 11, 2008) were recently relisted as threatened under the ESA. The 1999 biological opinion concluded that the bycatch of salmonids in the Pacific whiting fishery were almost entirely Chinook salmon, with little or no bycatch of coho, chum, sockeye, and steelhead.

On November 21, 2012, the U.S. Fish and Wildlife Service (FWS) issued a biological opinion concluding that the groundfish fishery will not jeopardize the continued existence of the short-tailed albatross. The (FWS) also concurred that the fishery is not likely to adversely affect the marbled murrelet, California least tern, southern sea otter, bull trout, nor bull trout critical habitat.

On December 7, 2012, NMFS completed a biological opinion concluding that the groundfish fishery is not likely to jeopardize non-salmonid marine species including listed eulachon, green sturgeon, humpback whales, Steller sea lions, and leatherback sea turtles. The opinion also concludes that the fishery is not likely to adversely modify critical habitat for green sturgeon and leatherback sea turtles. An analysis included in the same document as the opinion concludes that the fishery is not likely to adversely affect green sea turtles, olive ridley sea turtles, loggerhead sea turtles, sei whales, North Pacific right whales, blue whales, fin whales, sperm whales, Southern Resident killer whales, Guadalupe fur seals, or the critical habitat for Steller sea lions.

### *6.1.3* Marine Mammal Protection Act

The MMPA of 1972 is the principle Federal legislation that guides marine mammal species protection and conservation policy in the United States. Under the MMPA, NMFS is responsible for the management and conservation of 153 stocks of whales, dolphins, porpoise, as well as seals, sea lions, and fur seals; while the U.S. Fish and Wildlife Service is responsible for walrus, sea otters, and the West Indian manatee. Off the west coast, the Steller sea lion (Eumetopias jubatus) eastern stock, Guadalupe fur seal (Arctocephalus townsendi), and Southern sea otter (Enhydra lutris) California stock are listed as threatened under the ESA. The sperm whale (Physeter macrocephalus) Washington, Oregon, and California stock, humpback whale (Megaptera novaeangliae) Washington, Oregon, and California - Mexico Stock, blue whale (Balaenoptera musculus) eastern north Pacific stock, and Fin whale (Balaenoptera physalus) Washington, Oregon, and California stock are listed as depleted under the MMPA. Any species listed as endangered or threatened under the ESA is automatically considered depleted under the MMPA.

The west coast groundfish trawl fisheries are category III fisheries indicating a remote likelihood of or no known serious injuries or mortalities to marine mammals. The proposed action could affect the intensity, duration, and location of the groundfish bottom trawl fishery through changes to RCA boundaries. But these changes are not anticipated to change the effects of the groundfish fisheries on marine mammals.

### *6.1.4* Migratory Bird Treaty Act

The MBTA of 1918 was designed to end the commercial trade of migratory birds and their feathers that, by the early years of the 20th century, had diminished the populations of many native bird species. The MBTA states that it is unlawful to take, kill, or possess migratory birds and their parts (including eggs, nests, and feathers) and is a shared agreement between the United States, Canada, Japan, Mexico, and Russia to protect a common migratory bird resource. The MBTA prohibits the directed take of seabirds, but the incidental take of seabirds does occur. The proposed action is unlikely to affect the incidental take of seabirds protected by the MBTA.

### *6.1.5* Paperwork Reduction Act

The proposed action, as implemented by any of the alternatives considered, does not require collection-of-information subject to the Paperwork Reduction Act.

### *6.1.6* Regulatory Flexibility Act

The purpose of the Regulatory Flexibility Analysis (RFA) is to relieve small businesses, small organizations, and small governmental entities of burdensome regulations and record-keeping requirements. Major goals of the RFA are; (1) to increase agency awareness and understanding of the impact of their regulations on small business, (2) to require agencies to communicate and explain their findings to the public, and (3) to encourage agencies to use flexibility and to provide regulatory relief to small entities. The RFA emphasizes predicting impacts on small entities as a group distinct from other entities and the consideration of alternatives that may minimize the impacts while still achieving the stated objective of the action. An initial regulatory flexibility analysis (IRFA) is conducted unless it is determined that an action will not have a "significant economic impact on a substantial number of small entities." The RFA requires that an IRFA include elements that are similar to those required by EO 12866 and NEPA. NMFS prepared an IRFA.

### 6.1.7 National Environmental Policy Act

The CEQ has issued regulations specifying the requirements for NEPA documents (40 CFR 1500 – 1508), and NOAA's agency policy and procedures for NEPA can be found in NOAA Administrative Order 216-6 (NAO 216-6). The following are core elements of an EA (40 CFR § 1508.9):

1. The need for the proposal,
2. Alternatives as required by NEPA § 102(2)(E),
3. The environmental impacts of the proposed action and the alternatives, and
4. The agencies and persons consulted.

**Related NEPA Documents**

The following NEPA documents provide information and analyses related to the effects of this proposed action:

- Proposed Harvest Specifications and Management Measures for the 2013-2014 Pacific Coast Groundfish Fishery and Amendment 21-2 to the Pacific Coast Groundfish Fishery Management Plan; Final Environmental Impact Statement. Published by PFMC and NMFS in October 2012. (http://www.pcouncil.org/wp-content/uploads/September_2012_Main_Document_13-14_FEIS_SPEX.pdf)
- Proposed Harvest Specifications and Management Measures for the 2011-2012 Pacific Coast Groundfish Fishery and Amendment 16-5 to the Pacific Coast Groundfish Fishery Management Plan to Update Existing Rebuilding Plans and Adopt a Rebuilding Plan for Petrale Sole; Final Environmental Impact Statement. Published by PFMC and NMFS in February 2011. (http://www.pcouncil.org/groundfish/fishery-management-plan/fmp-amendment-16-5/#16-5)

- Rationalization of the Pacific Coast Groundfish Limited Entry Trawl Fishery (Amendment 20 to the Groundfish FMP); Final Environmental Impact Statement Including Regulatory Impact Review and Initial Regulatory Flexibility Analysis. Published by the Pacific Fishery Management Council and NMFS in June 2010. (http://www.pcouncil.org/groundfish/fishery-management-plan/fmp-amendment-20/#EIS)
- PFMC (Pacific Fishery Management Council) and NMFS (National Marine Fisheries Service). Pacific Coast Groundfish Essential Fish Habitat, Final Environmental Impact Statement. Pacific Fishery Management Council, Portland, OR. December 2005. (http://www.nwr.noaa.gov/publications/nepa/groundfish/final_groundfish_efh_eis.html)

Information may be incorporated by reference from these documents into this EIS. Council on Environmental Quality (CEQ) regulations (40 CFR 1502.21) state "Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described." When information from the above documents is incorporated, these procedures are followed within the body of this EIS.

## 6.2 Executive Orders

### *6.2.1* EO 12866 (Regulatory Impact Review)

EO 12866, Regulatory Planning and Review, was signed on September 30, 1993, and established guidelines for promulgating new regulations and reviewing existing regulations. The EO covers a variety of regulatory policy considerations and establishes procedural requirements for analysis of the benefits and costs of regulatory actions. Section 1 of the EO deals with the regulatory philosophy and principles that are to guide agency development of regulations. It stresses that in deciding whether and how to regulate, agencies should assess all of the costs and benefits across all regulatory alternatives. Based on this analysis, NMFS should choose those approaches that maximize net benefits to society, unless a statute requires another regulatory approach.

6.2.2 EO 12898 (Environmental Justice)

EO 12898 obligates Federal agencies to identify and address "disproportionately high adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations in the United States" as part of any overall environmental impact analysis associated with an action. NOAA guidance, NAO 216-6, at Section 7.02, states that "consideration of EO 12898 should be specifically included in the NEPA documentation for decision-making purposes."

6.2.3 EO 13132 (Federalism)

EO 13132, which revoked EO 12612, an earlier federalism EO, enumerates eight “fundamental federalism principles.” The first of these principles states “Federalism is rooted in the belief that issues that are not national in scope or significance are most appropriately addressed by the level of government closest to the people.” In this spirit, the EO directs agencies to consider the implications of policies that may limit the scope of or preempt states’ legal authority. Preemptive action having such “federalism implications” is subject to a consultation process with the states; such actions should not create unfunded mandates for the states; and any final rule published must be accompanied by a “federalism summary impact statement.” The Council process offers many opportunities for states (through their agencies, Council appointees, consultations, and meetings) to participate in the formulation of management measures. This process encourages states to institute complementary measures to manage fisheries under their jurisdiction that may affect federally-managed stocks. The proposed action does not have federalism implications subject to EO 13132.

6.2.4 EO 13175 (Consultation and Coordination with Indian Tribal Government)

EO 13175 is intended to ensure regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes.

The Secretary recognizes the sovereign status and co-manager role of Indian tribes over shared Federal and tribal fishery resources. In Section 302(b)(5), the MSA reserves a seat on the Council for a representative of an Indian tribe with Federally-recognized fishing rights from California, Oregon, Washington, or Idaho. The U.S. government formally recognizes the four Washington coastal tribes (Makah, Quileute, Hoh, and Quinault) have treaty rights to fish for groundfish. In general terms, the quantification of those rights is 50 percent of the harvestable surplus of groundfish available in the tribes’ U and A fishing areas (described at 50 CFR 660.324). Each of the treaty tribes has the discretion to administer their fisheries and to establish their own policies to achieve program objectives.

6.2.5 EO 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds)

EO 13186 supplements the MBTA (above) by requiring Federal agencies to work with the U.S. Fish and Wildlife Service (USFWS) to develop memoranda of agreement to conserve migratory birds. NMFS is in the process of implementing a memorandum of understanding. The protocols developed by this consultation will guide agency regulatory actions and policy decisions in order to address this conservation goal. The EO also directs agencies to evaluate the effects of their actions on migratory birds in environmental documents prepared pursuant to the NEPA. Past EISs evaluating the impact of groundfish harvest specifications (PFMC 2004b; PFMC 2006; PFMC 2008a) evaluated impacts to seabirds and concluded that the proposed action will not significantly impact seabirds. There is no new information to indicate that the current proposed action would result in greater impacts to seabirds.

# CHAPTER 7 LIST OF AGENCIES AND PERSONS CONSULTED AND PREPARERS

**Agencies and Persons Consulted**

Ryan Couch (NMFS; GCNW)
Sarah Biegel (NMFS; NWR NEPA)
Ian Taylor (NMFS; NWFSC)
Dr. Steve Freese (NMFS; NWR)
Dan Ayres (WDFW)
Lorna Wargo (WDFW)
Dan Erikson (ODFW)
Dr. Bob Hannah (ODFW)
Peter Calvass (CDFW)

**Preparers**

Colby Brady (NMFS; NWR)
Sean Matson (NMFS; NWR)
Barbara Seekins (NMFS; NWR)
Gretchen Hanshew (NMFS; NWR)

**Point of Contact for Additional Copies of this Environmental Assessment or Questions**

Colby Brady (NMFS; NWR), Colby.brady@noaa.gov, (206) 526-6117

# CHAPTER 8 **REFERENCES**

### 8.1 Council and NMFS related document references:

PFMC and NMFS. 2002. Environmental Assessent/Regulatory Impact Review for Proposed 2002 Groundfish Acceptable Biological Catch and Optimum Yield Specification and Management Measures for the Pacific Coast Groundfish Fishery, Pacific Fishery Management Council, Portland, OR. October 2001.

Pacific Fishery Management Council (PFMC). 2003. Final Environmental Impact Statement for the Proposed Groundfish Acceptable Biological Catch and Optimum Yield Specifications and Management Measures: 2003 Pacific Coast Groundfish Fishery. Pacific Fishery Management Council, Portland, OR.

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# CHAPTER 9 FINDING OF NO SIGNIFICANT IMPACT

National Oceanic and Atmospheric Administration Administrative Order 216-6 (NAO 216-6) (May 20, 1999) contains criteria for determining the significance of the impacts of a proposed action. In addition, the Council on Environmental Quality regulations at 40 C.F.R. 1508.27 state that the significance of an action should be analyzed both in terms of "context" and "intensity". Each criterion listed below is relevant in making a finding of no significant impact and has been considered individually, as well as in combination with the others. The significance of this action is analyzed based on the NAO 216-6 criteria and CEQ's context and intensity criteria.

These include:

*(1) Can the proposed action be reasonably expected to jeopardize the sustainability of any target species that may be affected by the action?*

The proposed action is not expected to jeopardize the sustainability of groundfish target species because the proposed action will not affect the manner by which annual catch limits are established through the biennial harvest specifications and management measures. Under the shorebased IFQ program, all catch of IFQ species, retained or discarded, must be covered by quota pounds. Fishermen are individually accountable for their catch, and are subject to a 100 percent monitoring requirement. Non-IFQ species are managed by groundfish trip limits. Therefore, the proposed action is not expected to jeopardize the sustainability of any target species (see chapter 4 for additional discussion).

*(2) Can the proposed action be reasonably expected to jeopardize the sustainability of any non-target species?*

This action cannot reasonably be expected to jeopardize the sustainability of any non-target species because as mentioned above, the proposed action is anticipated to allow members of industry greater flexibility in attaining their target catch. Catch of non-groundfish species (i.e., CPS, HMS, etc.) are accounted for in set asides in their FMPs. Catch of non-Groundfish FMP species are also reviewed and accounted for in annual WCGOP Groundfish Mortality Reports. Under the proposed action, overall fishing effort is not likely to increase or change significantly. Changes in effort location are not anticipated to increase impacts to non-target species to the extent that their sustainability would be jeopardized.

*(3) Can the proposed action be reasonably expected to allow substantial damage to the ocean and coastal habitats and/or EFH as defined under the Magnuson-Stevens Fishery Conservation and Management Act and identified in FMPs?*

As discussed in Sections 4.1 and 4.2, the action proposed cannot reasonably be expected to allow substantial damage to the ocean and coastal habitats and/or EFH as defined under the Magnuson-Stevens Fishery Conservation and Management Act and identified in the FMP because the coastal habitats are not affected since the action is in the open ocean. For non-groundfish FMPs, EFH is pelagic; therefore, the proposed action is not expected to affect non-groundfish EFH. Only groundfish EFH would likely be affected.

The Council identified Groundfish EFH, and minimized to the extent practicable adverse effects on such habitat caused by fishing, through the adoption of Amendment 19 to the Groundfish FMP in 2005. Amendment 19, which NMFS partially approved in 2006, recognized that the trawl RCA closures are established and modified on a continuing basis to reduce bycatch of overfished species, although some habitat benefits may accrue incidentally. A large portion of the RCA that would be opened under the proposed action is already open to bottom trawling at specific periods during the year or has been opened in the recent past. Therefore, the action is unlikely to cause substantial damage when compared to the No Action. The portion of the proposed action that would modify the RCA from a seaward boundary line between 40° 10' N. lat. and 45° 46' N. lat. approximating 200 fm to a line approximating 150 fm, during periods 1-6 (note that the modified 200 fm line is currently in place in periods 1 and 6), would open an area that has been closed to bottom trawling for a longer period of time. Fixed gear/longline effort on hard and medium substrate in this area has likely already impacted this habitat. Unintentional incursions into the RCA or effort in other fisheries also have the potential to alter habitat despite the closure. At this point, no substantial damage from the proposed action is anticipated when viewed in the context of the action.

Additional GIS analysis has been conducted for the area that may have had a greater opportunity to recover (150 fm-200 fm, 40 10’ to 45 46’) to more precisely determine the localized intensity of any habitat impacts that would occur. All existing closures established through Amendment 19 and gear requirements that minimize impacts to habitat remain in place under the proposed action. In addition, the core RCA area between the 100 fm and 150 fm boundary lines would remain in place.



*(4) Can the proposed action be reasonably expected to have a substantial adverse impact on public health or safety?*

This action is not expected to have substantial adverse impacts on public health or safety because the program as implemented in 2011 provides fishermen with increased flexibility in determining when, where, and how to fish. This is expected to reduce incentives to fish in unsafe conditions. Some safety benefits were also expected to the degree that the fishery is more profitable and more money is put into vessel maintenance. Less efficient vessels are expected to leave the trawl fishery, which may eliminate older, less safe vessels. The proposed action boundaries will reduce transit distance and therefore, potentially benefit safety of fishing crews by reducing time on the water.

*(5) Can the proposed action be reasonably expected to adversely affect endangered or threatened species, marine mammals, or critical habitat of these species?*

The proposed action cannot reasonably be expected to adversely affect endangered or threatened species, marine mammals, or the critical habitat of these species because the activities to be conducted under the proposed action are within the scope of the FMP and do not change the basis for the determinations made in previous consultations. Impacts of this action on these resources were assessed in Sections 4.3 and 4.6 of this document. No significant impacts are expected on listed species or critical habitat outside of the scope of what has been analyzed in existing biological opinions. Any encounters will continue to be monitored with 100 percent monitoring requirement of the IFQ program. Gathered data will be utilized by the Council's Endangered Species Groundfish Workgroup to advise the Council on how to improve avoidance of protected species. Under the proposed action, overall fishing effort is not likely to increase or change significantly. Instead, some dispersal of existing effort is likely. Changes in effort location are difficult to predict but are not anticipated to increase impacts to non-target species, including listed species and marine mammals.

*(6) Can the proposed action be expected to have a substantial impact on biodiversity and ecosystem function within the affected area (e.g., benthic productivity, predator-prey relationships)?*

The proposed action cannot be expected to have a substantial impact on biodiversity and ecosystem function within the affected area because, as described in Chapter 4, minimal, if any, impacts are expected from implementation of the proposed Alternatives. No significant change from status quo is expected because the area proposed to be open has been recently impacted by non-trawl gear, pink shrimp bottom trawl activity, groundfish fixed gear, and groundfish bottom trawl activities. Any impacts to ecosystem function and biodiversity are anticipated to be similar to No Action.

*(7) Are significant social or economic impacts interrelated with significant natural or physical environmental effects?*

As discussed in Chapter 4 of this EA, there are no significant social or economic impacts interrelated with significant natural or physical environmental effects because the implementation of the proposed action will not result in significant natural or physical environmental effects. To the extent increased access to fishing grounds allows fishermen to more successfully harvest target stocks and minimize transit time, the proposed action could result in some beneficial economic effects.

*(8) To what degree are the effects on the quality of human environment expected to be highly controversial?*

There is some scientific literature suggesting that invertebrate communities are healthier in non-trawled habitat compared with trawled habitat. The effects of the proposed action on the quality of human environment are not expected to be highly controversial because this action is spatial in nature and is not expected to have any scientific controversy associated with it.

*(9) Can the proposed action reasonably be expected to result in substantial impacts on unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers or ecologically critical areas?*

The Pacific coast groundfish fishery is not known to take place in any unique areas such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas. The proposed action is not anticipated to affect unique characteristics of the geographic area. The liberalized RCA structure would allow trawling in areas with benthic substrate and habitat characteristics typical of areas currently subject to trawl effort. Therefore, the proposed action is not expected to have a substantial impact on any of these areas.

*(10) Are the effects on the human environment likely to be highly uncertain or involve unique or unknown risks?*

The effects of the proposed action on the human environment, which are described in Chapter 4 of the EA, are not likely to be highly uncertain or involve unique or unknown risks because the action is not expected to significantly alter fishing methods or activities that would have a significant impact on the human environment. Trawl RCA boundaries have been routinely adjusted over various depths through various inseason actions since their inception in 2002, with catch documented (including habitat substrate data) by the West Coast Groundfish Observer Program, and the effects of such catch have been analyzed. Accordingly, highly uncertain, unique, or unknown risks are anticipated to be minimal based on previous experience. Additionally, routine inseason action authority will allow the Council and NMFS to revert to more restrictive RCA boundaries if warranted, based on new biological or physical information. Effects to biological and physical resources are not anticipated to involve unique or unknown risks because this action is likely to redistribute some existing trawl effort, with expected similar impacts to other areas that have been trawled in the past. To the extent liberalized RCA configurations result in more dispersed effort over a larger area, intensity of localized effects could be reduced.

*(11) Is the proposed action related to other actions with individually insignificant, but cumulatively significant impacts?*

The proposed action, together with past, present, and reasonably foreseeable future actions, is not expected to result in significant cumulative impacts on the biological and physical components of the environment or on human communities. This proposed action is not related to any other actions that could, together, have cumulatively significant impacts (see Cumulative Effects Summary in Section 4.6).

*(12) Is the proposed action likely to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural or historical resources?*

The proposed action will not affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or cause the loss or destruction of significant scientific, cultural, or historical resources because the Pacific coast groundfish fishery does not take place in the vicinity of any of these areas or resources.

*(13) Can the proposed action reasonably be expected to result in the introduction or spread of a non-indigenous species?*

The proposed action cannot reasonably be expected to result in the introduction or spread of a non-indigenous species because the activities under the proposed action will not involve the transport of non-indigenous species. The fishing vessels participating in the proposed action would not increase the risk of introduction through ballast water or hull fouling. Disposition of the catch does not include any translocation of living marine resources, nor use of any non-indigenous species as bait.

*(14) Is the proposed action likely to establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration?*

The proposed action is not anticipated to establish a precedent for future actions with significant effects. The Council is currently undertaking a five-year review of groundfish EFH. The ability for the Council to take additional practicable measures to minimize adverse effects to EFH, should it be determined necessary through the EFH review, will not be precluded by this proposed action. Most of the areas that would be opened under the proposed action are already subject to trawl or other fishery effort at various times during the year. Some of the preliminary EFH review documentation considers the core RCA closure between the 100 fm and 150 fm boundary lines to be a Marine Protected Area of unknown duration. This action would maintain that core closed area.

*(15) Can the proposed action reasonably be expected to threaten a violation of Federal, state, or local law or requirements imposed for the protection of the environment?*

This action is not expected to alter fishing methods or activities such that they threaten a violation of Federal, state, or local law or requirements imposed for the protection of the environment because this action is not expected to alter fishing methods in any way except to change the level of catch or landings that are permitted for the fishery as a whole.

*(16) Can the proposed action reasonably be expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species?*

As detailed in Section 4.6, the proposed action is not expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species because the proposed action is anticipated to allow members of industry greater flexibility in attaining their target catch by increasing the flexibility of groundfish bottom trawl fishing activities. Impacts on target and non-target species are primarily a function of the areas fished, gear types used, and level of effort; and, of these, area fished is the only factor that might be affected as a result of the proposed action. No change is being made to the allocation of quota; therefore, this action is not expected to jeopardize the sustainability of the target or non-target species.

**DETERMINATION**

In view of the information presented in this document and the analysis contained in the supporting Environmental Assessment, it is hereby determined that the proposed action will not significantly impact the quality of the human environment as described above and in the Environmental Assessment. In addition, all beneficial and adverse impacts of the proposed action have been addressed to reach the conclusion of no significant impacts. Accordingly, preparation of an Environmental Impact Statement for this action is not necessary.

________________________________ ______________

Deputy Regional Administrator, Northwest Region, NMFS Date

Agenda Item G.6.b
Supplemental EC Report
September 2013

# ENFORCEMENT CONSULTANTS REPORT ON CONSIDERATION OF TRAWL ROCKFISH CONSERVATION AREA (RCA) BOOUNDARY MODIFICATIONS

The Enforcement Consultants, (EC) have received numerous requests to comment on the enforceability of Alternatives 1 and 2 as defined on pages 15-17 in Agenda Item G.6.b, Draft EA, September 2013. Alternative 1 proposes one shoreward and one seaward line between 48° 10' N. Latitude and 40°10' N. Latitude for period 6 of 2013 and all of 2014. Alternative 2 proposes splitting this area into 2 areas at 45°46' N. Latitude with differing RCA lines, thus doubling the number of RCA lines. The Office of Law Enforcement Northwest Division Vessel Monitoring System Program and its technicians are fully capable of monitoring both options as are state enforcement and the U.S. Coast Guard. So in this regard, there are no enforceability concerns.

The EC suggests the Council may want to consider this issue under the auspices of regulatory complexity and the potential confusion for fishers. Alternatives 1 and 2 are less complex than the status quo alternative, with Alternative 1 being less complex than Alternative 2.

PFMC
09/13/13

# GROUNFISH ADVISORY SUBPANEL REPORT ON CONSIDERATION OF TRAWL ROCKFISH CONSERVATION AREA (RCA) BOUNDARY MODIFICATIONS

The Groundfish Advisory Subpanel (GAP) heard a presentation from Mr. Colby Brady walking though the key elements of the draft Environmental Assessment (EA) analyzing effects from potential changes to the trawl Rockfish Conservation Area (RCA) boundaries. The GAP commends Mr. Brady and his fellow authors on the thoroughness of the document, which was completed in a relatively short time frame and which contains a lot of helpful information and analysis. The GAP was also made aware of the proposed rule on this topic which was published in the federal register on Thursday, September 14th.

The GAP continues to support the Council's recommended changes to the trawl RCA boundaries made at the June meeting, which is reflected in Alternative 1 in the EA and described in detail in the federal register proposed rule:

| Area | Boundary | Line |
|---|---|---|
| 40°10' -48°10' | Seaward | 150 fathoms |
| 40°10' -48°10' | Shoreward | 100 fathoms |

**Need For Action**

As stated in the Purpose and Need section from the EA (Section 1.2 on page 11): "The action is needed to enable participants the ability to more fully and efficiently utilize their quota pounds while still meeting the Council's and Agency's goal for sustainability of the Pacific Coast groundfish fishery."

Specifically, the fleet is not achieving annual catch limits (ACLs) for many important groundfish target species. This is due, in part, to restrictions imposed by current trawl RCA boundaries. While aggregate attainment for all non-whiting IFQ groundfish species increased 5% in 2012 (29% versus 24% in 2011), there is clearly room for significant improvement on several economically important species:

| Species | 2012 Allocation | 2012 Landings | 2012 Attainment |
|---|---|---|---|
| Dover Sole | 49,018,682 lbs | 16,051,104 lbs | 33% |
| Lingcod | 3,991,800 lbs | 839,096 lbs | 21% |
| Pacific Cod | 2,502,247 lbs | 873,674 lbs | 35% |
| Yellowtail | 6,850,556 lbs | 2,194,137 lbs | 32% |
| Minor Shelf Rockfish N | 1,150,813 lbs | 87,528 lbs | 8% |
| Minor Slope Rockfish N | 1,828,779 lbs | 485,108 lbs | 27% |

*Source: Annual Catch Report for the Pacific Coast Groundfish Shorebased IFQ Program in 2012 (NOAA) page 25*

There are many costs for participating in the trawl catch share program (monitoring & observers, cost recovery, buyback loan payments and state landings taxes) and some of these costs continue to increase. The ability for the fleet to increase ACL attainments and generate additional economic value from the non-whiting groundfish fishery is imperative. Implementing the boundaries represented in Alternative 1 is a good step forward.

**Rationale For Alternative 1**

The EA does an excellent job of laying out the risks and opportunities associated with the three alternatives. Alternative 1 offers the most opportunity to the fleet when compared with the other two options. The risks associated with all three alternatives are fairly consistent. Conservation risks are negligible. The GAP believes that the fleet will realize significant benefits from Alternative 1.

*Impacts to Species of Concern*

When the RCA was initially implemented there were no other tools available to the Council that would accomplish the objective of minimizing catch of certain rockfish species. Since that time the trawl rationalization program was developed and implemented and particular characteristics of the catch share program provide much better tools to address catch of species of concern. The 100% monitoring and the personal accountability afforded through the program have reduced catch of species of concern significantly as reported beginning on page 60 of the draft EA.

- 60% decrease for yelloweye rockfish bycatch
- 37.8% decrease for canary rockfish bycatch
- 68.1% decrease for Pacific Ocean Perch bycatch
- 68% decrease for darkblotched rockfish

These reductions are post implementation of the catch share program and the savings outlined above are direct results of the individual accountability required in the rationalization program NOT because of the RCA itself.

The EA further analyzes the potential effects on species of concern based on the various options and concludes in Section 4.4.2.1 that for Alternative 1 "based on analysis of post-rationalization haul-level observer data, as well as aggregate total catch data from the two years before and the two years after trawl rationalization does not suggest any obvious danger of either extreme catch events, or accumulated aggregate high catch of rebuilding species that would exceed the trawl allocation, compared to the No Action alternative."

*Other Potential Impacts*

The EA finds that none of the alternatives will have a significant impact on physical oceanography, west coast marine ecosystems, or on biological resources in the nearshore, shelf, and slope regions of the California Current Ecosystem. Section 4.4.1.2 reports that the expected impact on target species is higher attainment of ACLs, which is the primary goal of this action.

*Economic Impacts*

The EA recognizes that Alternatives 1 and 2 both provide increased access to target species and will result in higher ACL attainments and presumably this will result in increased economic opportunities for harvesters and processors both. Quantifying the potential economic benefit is a challenge because there are many factors that will influence the economic opportunity.

Using the Oregon average ex-vessel value for trawl caught species – increases in revenue could be expected to range as follows:

| Species | Average OR ex-vessel value to-date in 2013 | Additional metric tons | Potential additional value |
|---|---|---|---|
| Dover sole | $0.45 / pound | 4,000 mt (8,816,000 lbs) | $3,967,200.00 |
| Yellowtail rockfish | $0.54 / pound | 1,000 mt (2,204,000 lbs) | $1,190,160.00 |
| Lingcod | $0.93 / pound | 1,000 mt (2,204,000 lbs) | $2,049,720.00 |
| Pacific cod | $0.57 / pound | 700 mt (1,542,800 lbs) | $879,396.00 |
| Total | | 6,700 mt (14,766,800 lbs) | $8,086,476.00 |

**Essential Fish Habitat Versus Rockfish Conservation Area**

As clearly stated in the EA, the trawl RCA was implemented to minimize the catch of species of concern – initially canary and darkblotched rockfish. Areas where higher bycatch events had occurred or where larger densities of fish were suspected to live were identified. Large boxes were created around these areas and they included additional ground in order to facilitate easier enforcement: straight lines versus discrete and specific areas. At the time, this was the only tool available to address the catch of overfished species in this area.

Habitat designation was not the impetus for designating these areas. The GAP believes it is important not to confuse the EFH process with the action being taken at this time to modify the RCA boundaries. This action does not affect any of the existing EFH designations or closed areas or the ongoing EFH designation process. Approximately 5% of the ground that would be opened up under Alternative 1 is included in proposals being considered in the EFH review process over the next year- this action does not change or affect that process.

We would also like to point out that this area is fished with other gear, which has effects on the bottom – including pot and long-line gear. In addition, this area is bottom-trawled on an annual basis during the NOAA slope survey – so to assert that this ground is not “affected” by fishing gear is untrue. Current gear restrictions that will remain in place will prevent the fleet from fishing in all of the area opened up under Alternative 1. In addition, the incentives to avoid overfished species afforded through the catch-share program that tend to congregate around high-relief habitat will keep them out of sensitive areas. Finally, Alternative 1 continues to prohibit bottom trawling by the fleet in over 1,300 square miles of ground.

**Alternative 2**
The GAP appreciates that NMFS added an additional option to the draft EA for consideration. This makes the EA and analysis much more robust and meets the need to examine a reasonable range of alternatives. Alternative 2 allows more opportunity than no action, but the benefits to the fleet will be less with essentially the same risk to rebuilding species as Alternative 1 and the no action alternative.

**Bottom Line**
The GAP believes that Alternative 1 is a prudent first step. We believe the EA adequately analyzed the affects of each of the options as well as the potential benefits to the fleet of adjusting the RCA boundaries. In summary:

- The EA demonstrates no harm to rebuilding species by implementing Alternative 1, including minimal chance of "disaster tows" that exceed the trawl allocation or an individual's allocation
- The EA demonstrates positive economic benefit to the fleet and subsequently processors and coastal communities
- There is no change to existing EFH closed areas or the ongoing EFH designation process
- Over 1300 square miles of ocean is still off-limits to bottom trawling by the fleet as a result of the RCA boundaries in Alternative 1.
- Single boundary lines for all periods results in less confusion among the fleet and is easier to abide by as well as enforce
- Administrative burden on the agency will be less to manage
- The EA demonstrates that annual ACL attainment rates will likely increase meeting the requirements of National Standard 1 of the Magnuson Act as well as one of the goals of Amendment 20.
- Allowing the fleet to exercise their personal accountability afforded and mandated by the catch share program and 100% monitoring will keep catch of rebuilding species low as has been demonstrated in the first two years of the program
- Inseason adjustments to RCA boundaries are still an available tool if unintended consequences of this action occur (which is not anticipated or expected)

Further, the GAP is supportive of a comprehensive approach to RCA reform that will hopefully take place over the next few years under the T-Flex or Trawl Trailing Amendment Process. The GAP believes that this current rulemaking process is cumbersome and not the preferred method for modifying RCA boundaries in the future. However we do agree that this approach has been worthwhile in terms of understanding the affected environment and the positive impacts that can accrue to the fleet.

PFMC
09/14/13

# GROUNDFISH MANAGEMENT TEAM REPORT ON CONSIDERATION OF CHANGES TO THE TRAWL ROCKFISH CONSERVATION AREA BOUNDARY MODIFICATIONS

The Groundfish Management Team (GMT) heard a brief presentation from National Marine Fisheries Service (NMFS) Northwest Region staff on the environmental assessment (EA) (Agenda Item G.6.b, Draft EA) for trawl rockfish conservation area (RCA) boundary modifications. We offer the following considerations.

The GMT thinks that it is useful to consider the risk of RCA boundary modifications in terms of possible impacts both individually and cumulatively. Most of these impacts cannot be quantified, but we list the following thoughts to try to put them in context. Below are some of the relevant categories of impacts from the EA:

- Essential fish habitat (EFH). It appears from the available information that the effect of permanent actions taken in 2005 to "freeze" the trawl footprint likely overwhelm any protections provided by the trawl RCA. While there is no quantitative measure of significance, from a National Environmental Policy Act (NEPA) standpoint, the protections put in place under Amendment 19 to the Groundfish Fishery Management Plan (FMP) protect some 130,000 square miles of EFH from fishing impacts. Alternative 1 would open approximately 740 square miles more than Alternative 2, which is a very small percentage of the designated EFH and the existing protections. This type of back-of-the-envelope comparison does not account for habitat by type, or its impact on groundfish productivity, and only covers areal extent (i.e. this may underestimate rugose or highly sloped habitats and doesn't compare the amount of rocky, mixed or mud habitat that is protected).

- Recovery time. The recovery index referenced in the EA is based on the original risk assessment used to inform Amendment 19. The index is informed by a great deal of expert opinion on relative impact comparing gears but is based on relatively few studies (most cells are the result of few studies). So, while they may provide some guidance on relative recovery times by habitat type, the use of point estimates for recovery times should carry the understanding that they may be highly uncertain for the habitats affected by the proposed action.

- Bycatch and possibility of exceeding annual catch limits (ACLs). The RCAs were established because the available survey and logbook data indicated that closing the depths of greatest interaction would lead to significantly lower bycatch rates for overfished species. There has been concern expressed that allowing trawling in the areas of highest overfished species density could result in "lightning strike" tows. The GMT notes that the individual accountability and other incentives in the Individual Fishing Quota (IFQ) program greatly decrease the likelihood that a vessel will catch enough of an overfished species to exceed the ACL or severely disrupt the fishery. This is true under both Alternative 1 and Alternative 2 RCA boundaries. Catches from the rationalized fishery show very low attainment of all overfished species' ACLs in the first 2 ½ years of the program (https://www.webapps.nwfsc.noaa.gov/ifq/).

- Gear conflicts. One issue not addressed in the EA is the possibility of gear conflicts by having grounds that previously excluded trawl now open to both fixed gear and trawl. This could be a consideration under both Alternative 1 and Alternative 2. We did not have time to analyze this in detail, but we have heard anecdotally that communication among vessels on the grounds can largely prevent such gear conflicts.

The following table (Table 1) provides a summary comparison of some potential impacts. It is important to note that for brevity we list those impacts as “higher” or “highest” or “less than Alternative 1” in the table; however, we cannot know that target species catch and revenue will increase by opening more RCA. Likewise, we don’t know that impacts to overfished species will be higher. Increasing access to areas previously closed by the RCA is expected to provide increased flexibility for fishing operations (e.g. a vessel could get the same targets with the same bycatch but closer to home port), could increase harvest of target species where catch has been below the allocation, and may result in the relative change in impacts listed.

Table 1. Relative potential impacts by Alternative for groundfish and Essential Fish Habitat.

| | | No Action | Alternative 1 | Alternative 2 |
|---|---|---|---|---|
| RCA boundaries | | See Table 2-1 of the Draft EA | 100 fm line - 150 fm line | 100 fm line - modified 200 fm line |
| **Relative Impacts to:** | | | | |
| **Target Groundfish** | | | | |
| | Increase in estimated revenue | No change | Highest | Higher |
| | Increase access to nearshore/shelf species | No change | Yes | Yes |
| | Increase access to slope species | No change | Yes | Yes, but less than Alt. 1 |
| **Overfished Groundfish** | | | | |
| | Qualitiative estimates for impacts to nearshore and shelf OFS | No change | Higher impacts | Higher impacts |
| | Qualitiative estimates for impacts to slope OFS | No change | Higher impacts | Higher impacts; but less than Alt. 1 |
| **Groundfish EFH** | | | | |
| | Opens any areas closed to groundfish bottom trawling for >9 years | No | Yes (between 45°03' N. lat. and 40°10' N. ) | No |
| | Opens any areas closed to groundfish bottom trawling for >6 years | No | Yes (between 45°46' N. lat. and 45°03' N. lat. ) | No |

Agenda Item G.6.b
Supplemental NMFS PowerPoint (Brady)
September 2013

NOAA FISHERIES
Northwest Region

# Non-Whiting Bottom Trawl Rockfish Conservation Areas (RCA)

## Environmental Assessment (EA) Summary

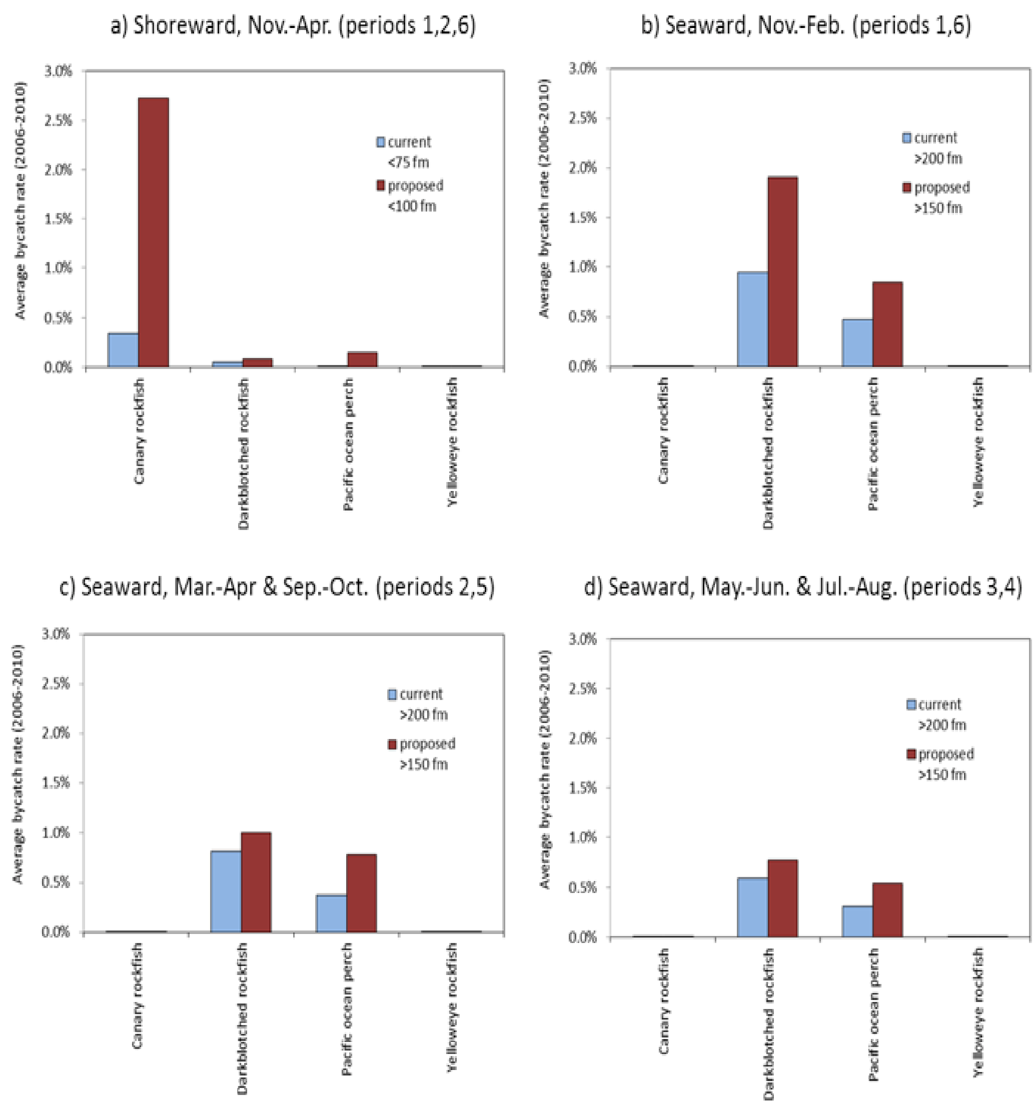
September, 15, 2013

# Alternative 1

Table 1. Proposed trawl RCA boundaries between 48°10' N. lat. and 40°10' N. lat., as recommended by the Council in April 2013.

| | JAN-FEB | MAR-APR | MAY-JUN | JUL-AUG | SEP-OCT | NOV-DEC |
|---|---|---|---|---|---|---|
| WA and Northern OR (48°10' N. lat. - 45°46' N. lat.) | 100 fm line - 150 fm line | | | | | |
| Southern OR and Northern CA (45°46' N. lat. - 40°10' N. lat.) | 100 fm line - 150 fm line | | | | | |

# Bycatch Rates of OFS



# Bycatch Rates of OFS

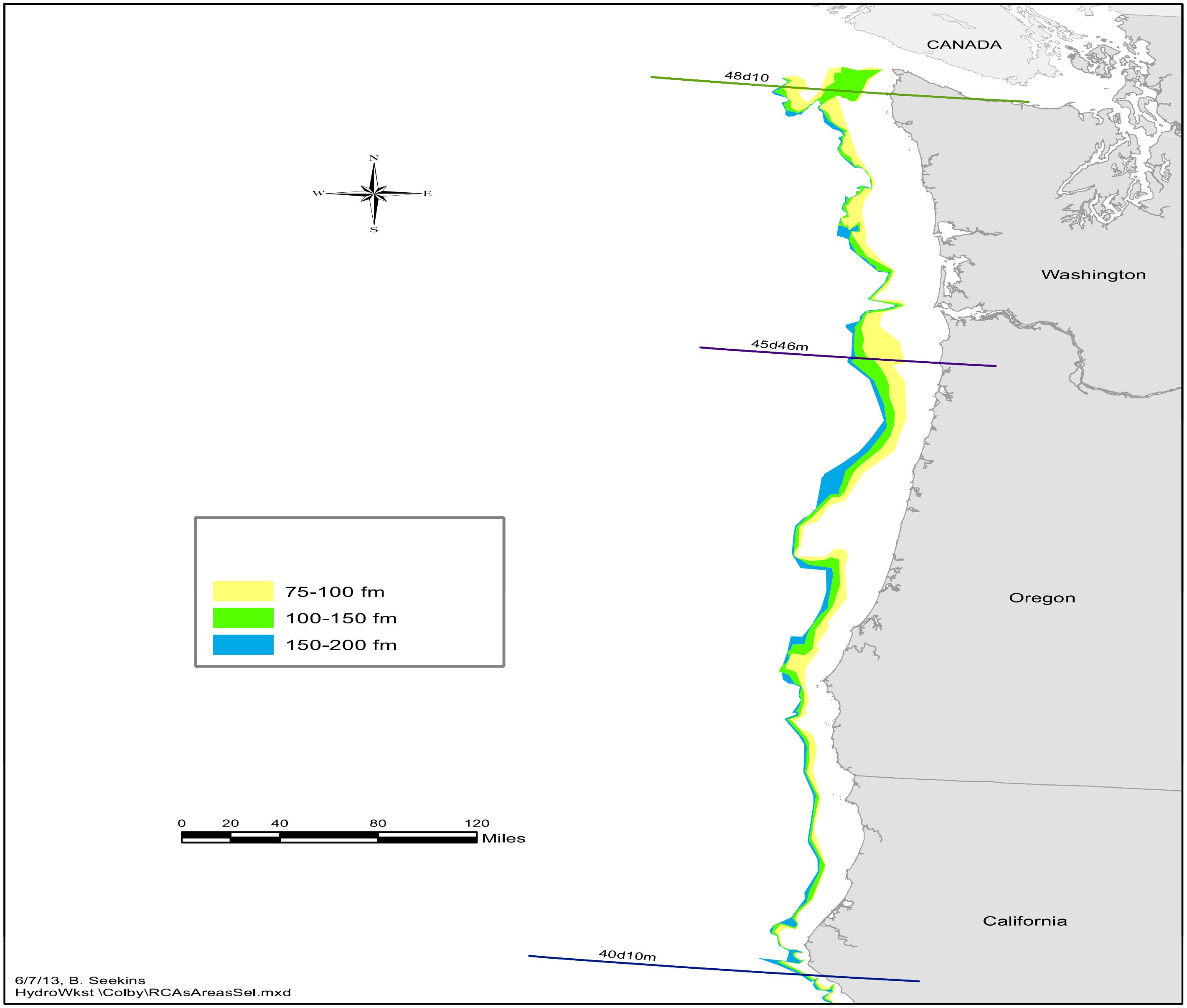
a) Shoreward, November-April (periods 1,2,6)

| Species | Current <75 fm | Proposed <100 fm | Proposed - current |
|---|---|---|---|
| Canary rockfish | 0.3400% | 2.7210% | 2.3810% |
| Darkblotched rockfish | 0.0496% | 0.0793% | 0.0297% |
| Pacific ocean perch | 0.0005% | 0.1509% | 0.1504% |
| Yelloweye rockfish | 0.0105% | 0.0063% | -0.0042% |

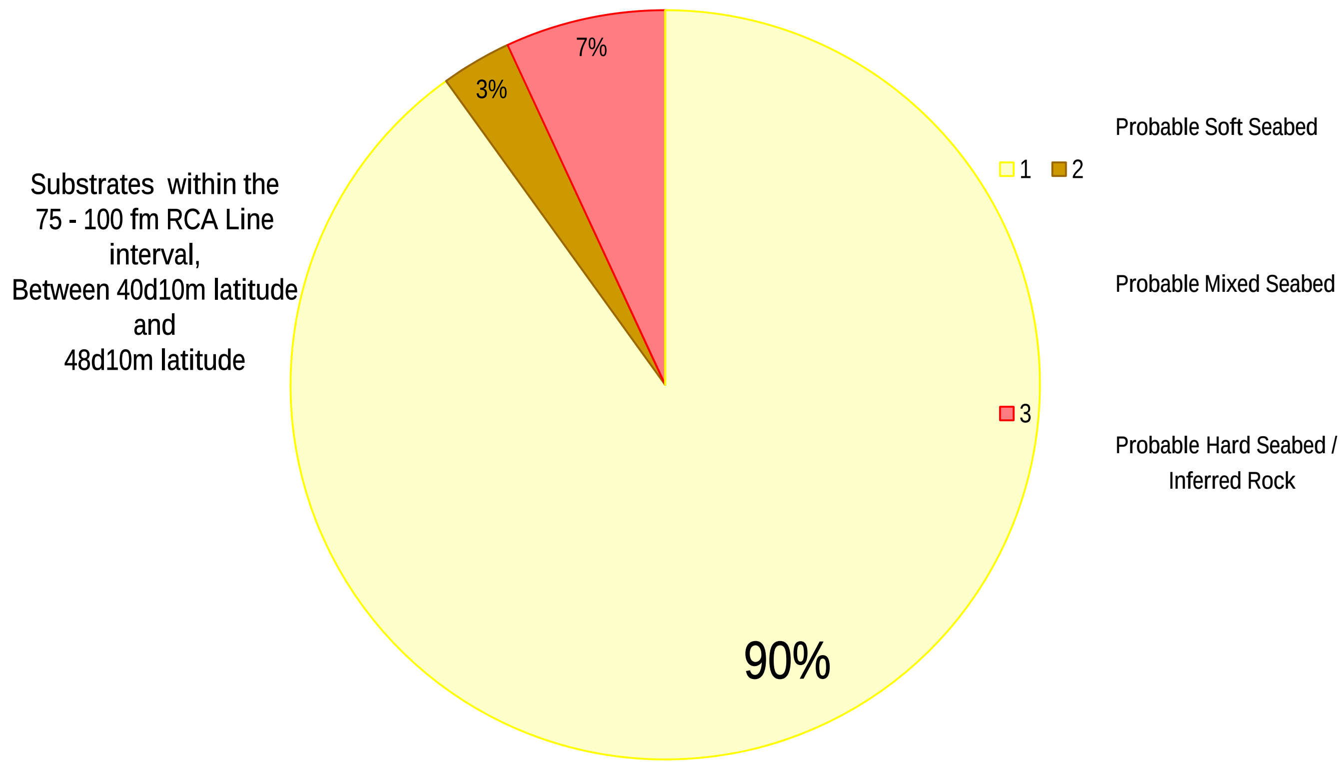
b) Seaward, average seasonal bycatch rates and standard deviation among seasonal rate estimates.

| Species | Current >200 fm | S.D. >200 fm | Proposed >150 fm | S.D. >150 fm | Proposed - current |
|---|---|---|---|---|---|
| Canary rockfish | 0.0021% | 0.0020% | 0.0022% | 0.0015% | 0.0001% |
| Darkblotched rockfish | 0.7815% | 0.1811% | 1.2284% | 0.4451% | 0.4470% |
| Pacific ocean perch | 0.3830% | 0.0860% | 0.7203% | 0.0914% | 0.3374% |
| Yelloweye rockfish | 0.00013% | 0.00006% | 0.00027% | 0.00025% | 0.00013% |

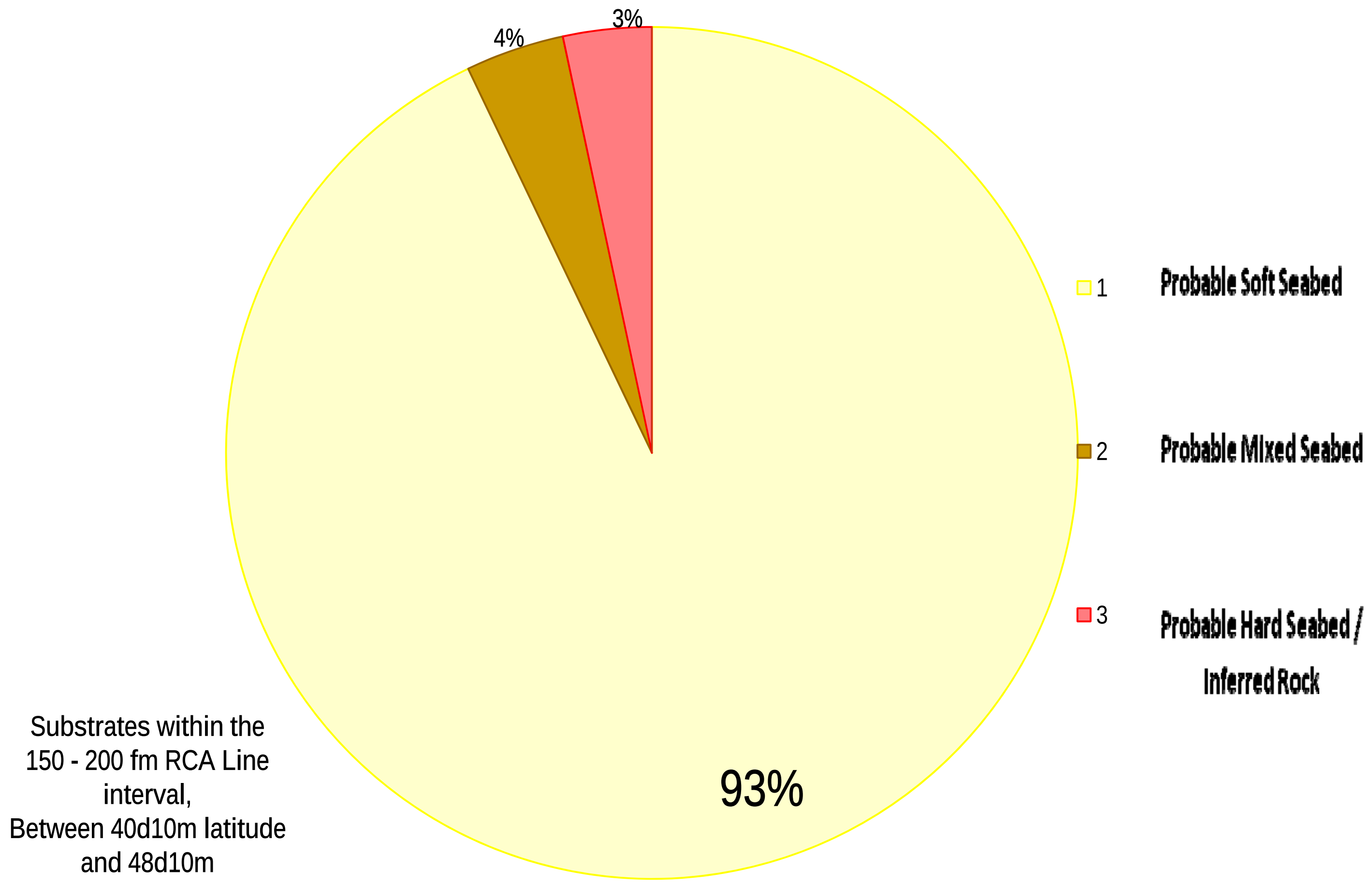
# Alternative 1



# Substrate types (Shoreward)



# Substrate types (Seaward)



# Alternative 2

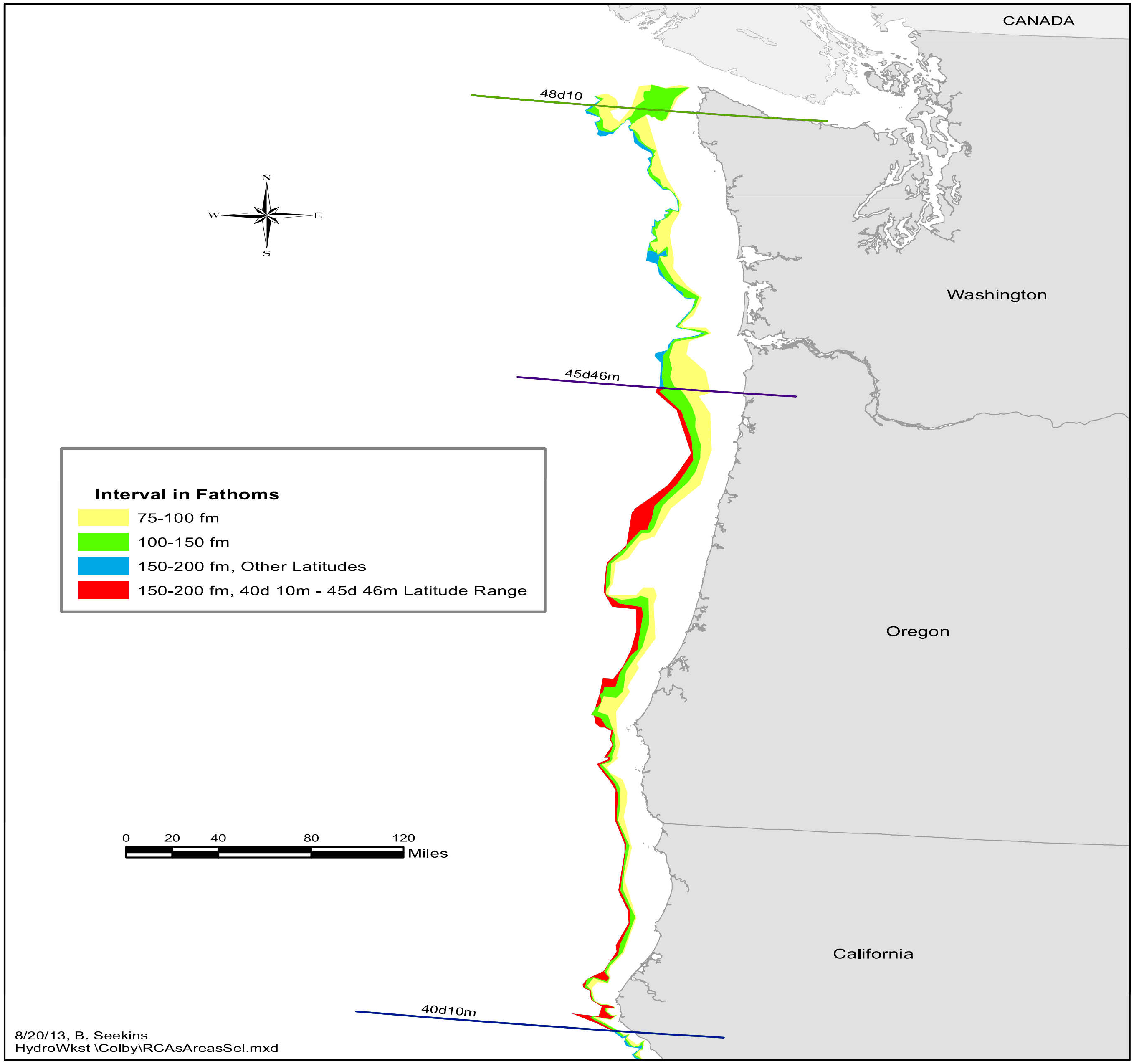
Table 2. Alternative trawl RCA boundaries between 48°10' N. lat. and 40°10' N. lat., considered by NMFS.

| | JAN-FEB | MAR-APR | MAY-JUN | JUL-AUG | SEP-OCT | NOV-DEC |
|---|---|---|---|---|---|---|
| 48°10' N. lat. - 45°46' N. lat. | 100 fm line - 150 fm line | | | | | |
| 45°46' N. lat. - 40°10' N. lat. | 100 fm line – modified 200 fm line | | | | | |

# Alternative 2

a. Attempts to keep closed sensitive biogenic habitat which may have had a greater chance to recover from fishing gear impacts.

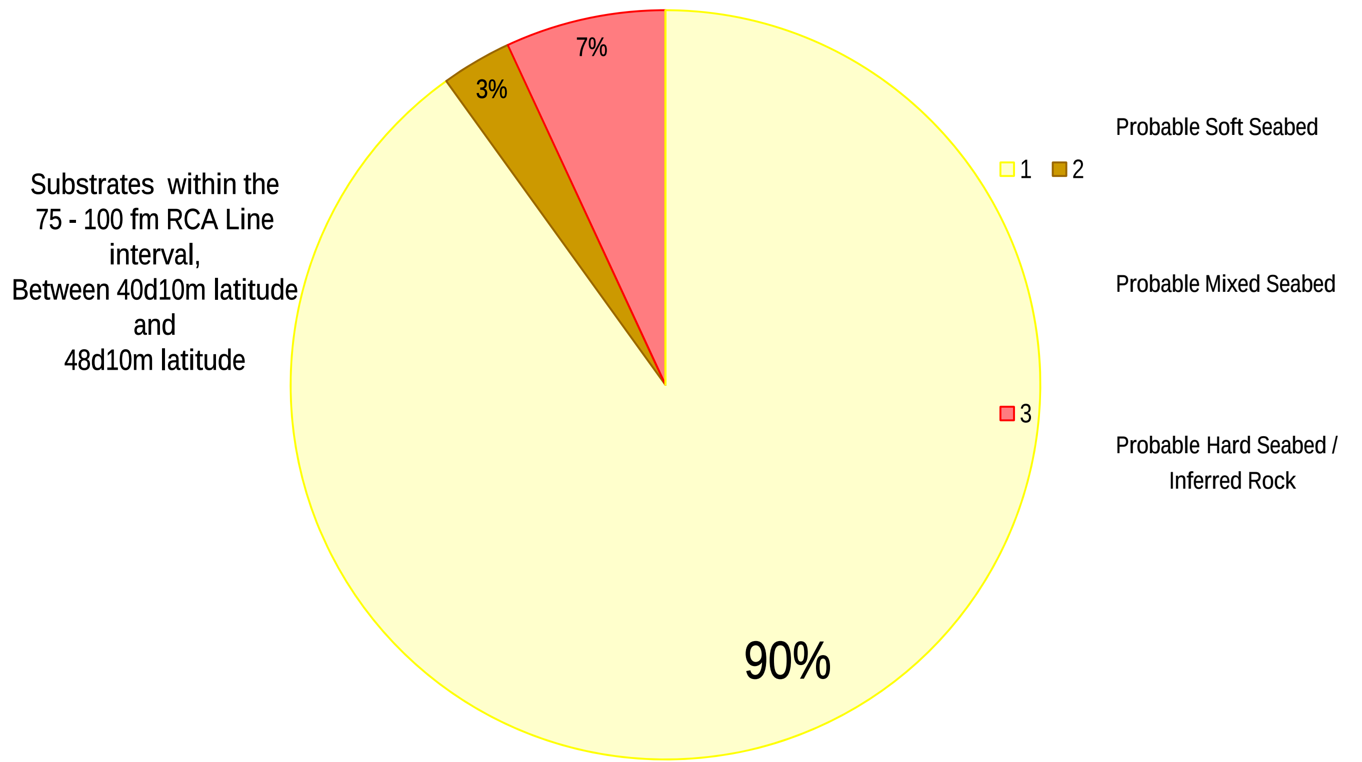
b. More Restrictive, pending EFH RFP review.



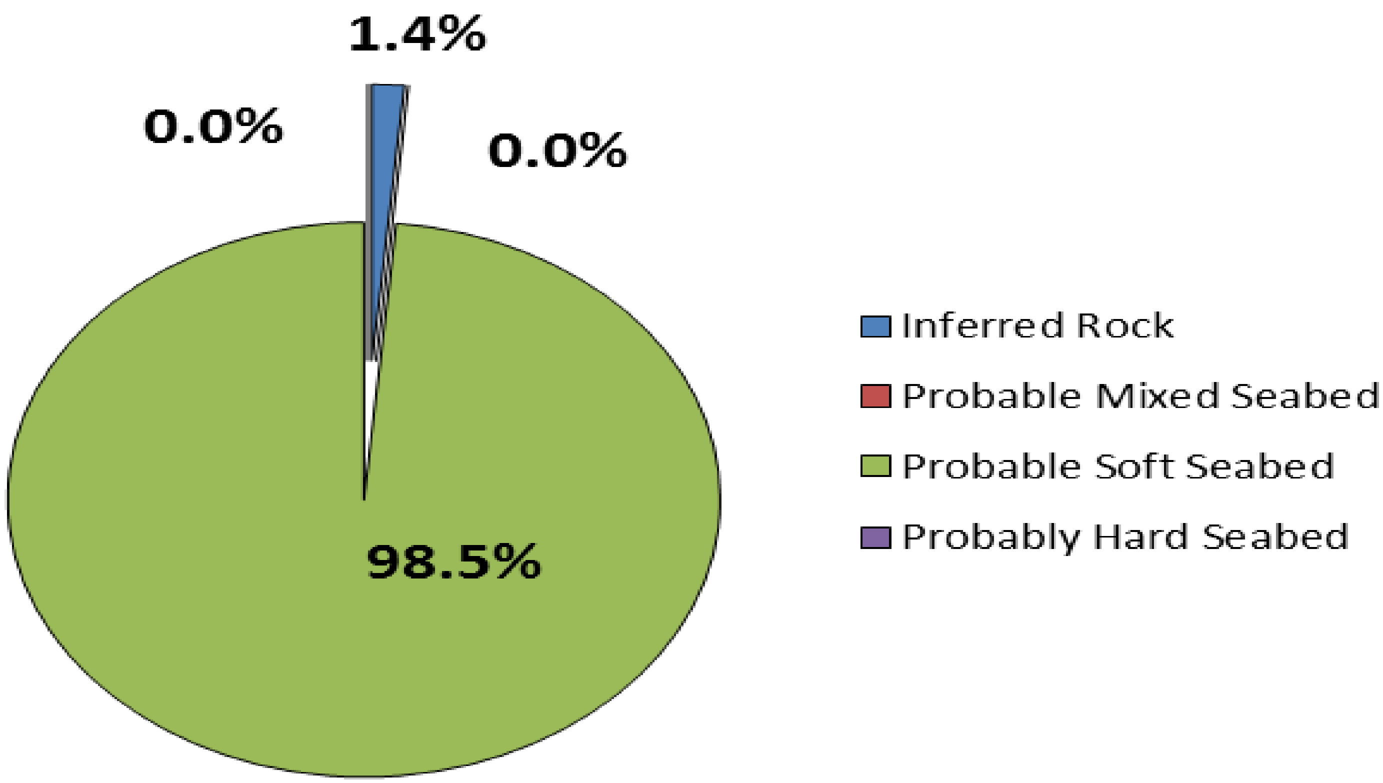
# Recovery Index, not including large biogenic habitat such as coral and sponges

| Part B Recovery Times | Bottom Trawl | Midwater Trawl | Fixed Gear Distance | Fixed Gear Point |
|---|---|---|---|---|
| | | | | |
| Hard shelf | 2.8 | na | 0.1 | 0.1 |
| Hard upper slope | 2.8 | na | 0.3 | 0.1 |
| Hard lower slope | 2.8 | na | 0.3 | 0.1 |
| | | | | |
| Mixed shelf | 2.8 | na | 0.4 | 0.1 |
| Mixed upper slope | 2.8 | na | 0.4 | 0.1 |
| Mixed lower slope | 2.8 | na | 0.4 | 0.1 |
| | | | | |
| Soft shelf | 0.4 | na | 0.4 | 0.1 |
| Soft upper slope | 1 | na | 0.4 | 0.1 |
| Soft lower slope | 1 | na | 0.4 | 0.1 |

# Substrate types (Shoreward, same as Alternative 1)



# Substrates (Seaward, Alternative 2, south of 45°46’ N. lat. remains closed)




Proportional distribution of different substrate types in the area between the 150 and 200 fathom RCA boundaries, between 45°46’ N. lat. and 48°10’ N. lat.

# Square mileage

## Alternative 1

| Fathom_Range | Latitude_Span | Area_SqMiles |
|---|---|---|
| 75-100 fm | 40d10m - 48d10m | 2091 |
| 150-200 fm | 40d10m - 48d10m | 953 |
| | **Total Sq Mi** | **3,044** |

## Alternative 2

| Fathom_Range | Latitude_Span | Area_SqMiles |
|---|---|---|
| 75-100 fm | 40d10m - 48d10m | 2091 |
| 150-200 fm | 45d46m - 48d10m | 208 |
| m200-200 fm | 45d46m - 48d10m | 211 |
| | **Total Sq Mi** | **2,510** |

**Difference between Alt 1- Alt 2= 534 Sq Mi**

Additional Questions?

Please contact Colby Brady:

colby.brady@noaa.gov

## DEPARTMENT OF COMMERCE

## National Oceanic and Atmospheric Administration

## 50 CFR Part 660

**[Docket No. 130808694–3694–01]**

**RIN 0648–BD37**

## Fisheries Off West Coast States; Pacific Coast Groundfish Fishery Management Plan; Commercial Groundfish Fishery Management Measures; Rockfish Conservation Area Boundaries for Vessels Using Bottom Trawl Gear

**AGENCY:** National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

**ACTION:** Proposed rule; request for comments.

**SUMMARY:** This proposed action would implement revisions to the boundaries of the Rockfish Conservation Area (RCA) that is closed to vessels fishing groundfish with bottom trawl gear. This proposed rule would affect the limited entry bottom trawl sector managed under the Pacific Coast Groundfish Fishery Management Plan (FMP) by liberalizing RCA boundaries in order to improve utilization of target species.

**DATES:** Submit comments on or before October 15, 2013

**ADDRESSES:** You may submit comments on this document, identified by NOAA–NMFS–2013–BD37, by any of the following methods:

- *Electronic Submission:* Submit all electronic public comments via the Federal e-Rulemaking Portal. Go to *www.regulations.gov/#!docketDetail;D=NOAA-NMFS-2013-0134,* click the ''Comment Now!'' icon, complete the required fields, and enter or attach your comments.
- *Mail:* Submit written comments to William W. Stelle, Jr., Regional Administrator, Northwest Region, NMFS, 7600 Sand Point Way NE., Seattle, WA 98115–0070; Attn: Colby Brady.
- *Fax:* 206–526–6736; Attn: Colby Brady.

*Instructions:* Comments sent by any other method, to any other address or individual, or received after the end of the comment period, may not be considered by NMFS. All comments received are a part of the public record and will generally be posted for public viewing on *www.regulations.gov* without change. All personal identifying information (e.g., name, address, etc.), confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. NMFS will accept anonymous comments (enter ''N/A'' in the required fields if you wish to remain anonymous). Attachments to electronic comments will be accepted in Microsoft Word, Excel, or Adobe PDF file formats only.

**FOR FURTHER INFORMATION CONTACT:** Colby Brady, 206–526–6117; (fax) 206–526–6736; *Colby.Brady@noaa.gov.*

**SUPPLEMENTARY INFORMATION:**

### Background

Since 2002 NMFS has used large-scale, depth-based closures to reduce catch of overfished groundfish, while still allowing the harvest of healthy stocks to the extent possible. RCAs are gear specific closures, and apply to vessels that take and retain groundfish species. NMFS is proposing to change portions of the boundaries defining the RCA that is closed to vessels fishing for groundfish with bottom trawl gear, or the ''trawl RCA.'' This proposed rule would not change how the trawl RCA applies to vessels fishing for groundfish using bottom trawl gear. Rather, it would only make changes to the boundaries of the trawl RCA.

Vessels targeting groundfish with bottom trawl gear are participants in the shorebased individual fishing quota (IFQ) program, which began in 2011 (75 FR 78344, December 15, 2010). Catch of groundfish by these vessels is primarily regulated with quota pounds. All catch of IFQ species, retained or discarded, must be covered by equivalent quota pounds, and participants are subject to a 100 percent monitoring requirement that includes at-sea observers and dockside catch monitors. Accordingly, fishermen are individually accountable for their catch, including any catch of overfished species.

The currently scheduled trawl RCA boundaries for 2013 and 2014 were established through the 2013–2014 harvest specifications and management measures in a proposed and final rule, 77 FR 67974, November 14, 2012 and 78 FR 580, January 3, 2013, respectively. However, RCA boundaries are routinely modified inseason in response to new information. Early in 2013, industry requested that the Pacific Fishery Management Council (Council) and NMFS consider opening some areas that were closed by the trawl RCA off Washington, Oregon and northern California (between 40°10′ N. lat. and 48°10′ N. lat.).

### Increasing Harvest Opportunities in the Shorebased IFQ Program

The trawl rationalization program, including the shorebased IFQ program, was intended to increase net economic benefits, create individual economic stability, provide full utilization of the trawl sector allocation, consider environmental impacts, and achieve individual accountability of catch and bycatch. Since the implementation of the program, catch of many overfished species has declined and revenues increased in 2011. In 2012 non-whiting revenue dropped slightly, most likely due to decreases in sablefish prices. However, in the 2012 shorebased IFQ program, catch of several marketable target species was well below the available shorebased trawl allocation. Over 33 million pounds of flatfish, including Dover sole, went unharvested in 2012. Over 5.5 million pounds of Pacific cod and lingcod went unharvested in 2012. For rockfish, over 6.7 million pounds of minor shelf, minor slope and yellowtail rockfish went unharvested.

This proposed rule would increase access to fishing grounds in a fishery where participants are motivated by IFQ to keep bycatch of overfished species low, irrespective of trawl RCA boundaries. The proposed changes to the trawl RCA boundaries would continue to refine groundfish fishery management measures to enable higher attainment of available quota pounds for several valuable species, while still protecting overfished species.

### Changes to the Trawl Rockfish Conservation Area

*Proposed Boundaries*

At its March 7–11, 2013, meeting in Tacoma, Washington and its April 6–11, 2013, meeting in Portland, Oregon the Council received requests from the Groundfish Advisory Sub-panel (GAP) to open some areas that were closed by the trawl RCA in the area north of 40°10′ N. lat. to increase access to target species such as yellowtail rockfish, Dover sole, lingcod and Pacific cod (March 2013, Agenda Item H.3.b, Supplemental GAP Report; April 2013, Agenda Item D.8.b, Supplemental GAP Report). The Council made an initial recommendation in March to open some shoreward areas during March and April (Period 2) of 2013. However, NMFS recommended that liberalizations to the 2013–2014 trawl RCA boundaries be implemented through a notice and comment rulemaking rather than through a single **Federal Register** notice. Therefore, the Council reconsidered and refined its recommendation for changes to the trawl RCA at its April 2013 meeting.

After considering performance of the rationalized fishery in the last two years and how the RCA boundaries have varied through time, the Council recommended reducing the trawl RCA between 48°10′ N. lat. and 40°10′ N. lat. to the area between the boundary line approximating the 100 fathom (fm) (183-m) depth contour and the boundary line approximating the 150 fm (274-m) depth contour beginning in November 2013 and for all of 2014, or until revised through inseason action (Table 1). Initial trawl RCA boundaries for 2015–2016 will likely be developed through the 2015–2016 harvest specifications and management measures process. The RCA boundary lines approximate depth contours and are defined by latitude and longitude coordinates in Federal regulations at 50 CFR 660.71–74. Although the lines are generalized approximations of depth, the trawl RCA is not defined by actual depth contours and could close areas deeper or shallower than the actual depths indicated.

Specifically, this proposed rule would change the trawl RCA boundaries that are found in Table 1 (North), subpart D, as follows: (1) Between 48°10′ N. lat. and 40°10′ N. lat., from a shoreward boundary line approximating 75 fm (137-m) to a line approximating 100 fm (183-m) during in periods 1, 2, and 6; (2) between 45°46′ N. lat. and 40°10′ N. lat., from a seaward boundary line approximating 200 fm (366-m) to a line approximating 150 fm (274-m), during periods 1–6 (note that the ''modified 200 fm (366-m)'' line, which is a version of 200 fm (366-m) line modified to increase access to stocks such as petrale sole, is currently in place in periods 1 and 6), and; (3) between 48°10′ N. lat. and 45°46′ N. lat., from a seaward boundary line approximating the modified 200 fm (366-m) to a line approximating 150 fm (274-m), during period 1.

TABLE 1—PROPOSED TRAWL RCA BOUNDARIES BETWEEN 48°10′ N. LAT. AND 40°10′ N. LAT., AS RECOMMENDED BY THE COUNCIL IN APRIL 2013

| | Jan–Feb | Mar–Apr | May–Jun | Jul–Aug | Sep–Oct | Nov–Dec |
|---|---|---|---|---|---|---|
| 48°10′ N. lat.–45°46′ N. lat | 100 fm line—150 fm line. | | | | | |
| 45°46′ N. lat.–40°10′ N. lat | 100 fm line—150 fm line. | | | | | |

The proposed change to open the area shoreward of the trawl RCA, between the 75 fm (137-m) line to the 100 fm (183-m) line, will provide additional harvest opportunities closer to shore, which could reduce fuel costs incurred from transiting to deeper-water fishing grounds, and potentially improve the at-sea safety for groundfish bottom trawl vessels and their crews. The shoreward boundary change would also provide additional access to lingcod, Pacific cod and yellowtail rockfish and would likely have a favorable economic impact to groundfish fishing vessels and to businesses and ports where groundfish are landed. The proposed change to open areas seaward of the trawl RCA, between the 150 fm (274-m) line and the 200 fm (366-m) line, will shorten the distance vessels must travel to harvest underutilized slope species such as Dover sole, slope rockfish, and other flatfish species and should also have beneficial economic effects. Finally, the boundary changes could simplify management and enforcement by creating a coast-wide 100 fm (183-m) to 150 fm (274-m) closure.

NMFS and the Council assessed the risks of exceeding the trawl allocation or the annual catch limit (ACL) for any overfished species under the proposed action. Based on an analysis of observed bycatch rates (amount of overfished species caught proportionate to the amount of target species) from the years 2006–2010, increases in bycatch rates for canary rockfish, darkblotched rockfish and Pacific ocean perch would be expected when these areas are opened. However, harvest in 2011 and 2012, the first two years of the shorebased IFQ program, did not exceed 50 percent of the trawl allocation for the four overfished rockfish species likely to be impacted by this action. In addition, based on 2011 observer data documenting the depth, latitude, frequency and magnitude of overfished species catch in the first year of the shorebased IFQ program, the probability of an extreme catch event, or ''disaster tow'', i.e. one tow that it would lead to exceeding the IFQ program allocation, is relatively low assuming similar fishing behavior as during 2011 and 2012. The analysis showed that tows harvesting more than 1 percent of the trawl allocation were rare, and none exceeded 2 percent.

The combined analysis of pre-IFQ bycatch rates, haul-level IFQ observer data, and aggregate IFQ catch data for overfished species illustrates that while bycatch or encounter rates are likely to increase to some degree with the proposed boundary changes, these moves are unlikely to result in increases in catch of rebuilding species to such a degree that it would result in the fleet exceeding their annual allocations. Harvest of overfished species in the Shorebased IFQ Program has been well below the allocations, likely, in part, due to individual accountability and incentives to keep harvest of overfished species low. Given the low harvest levels of overfished species relative to the trawl allocation, even if one or more rare, extremely high single catch events were to occur, it is very unlikely that it would cause the trawl allocation to be exceeded. Moreover, IFQ catch data are available in near real-time and inseason changes to management measures could be considered as needed to ensure catch remains below the trawl allocation and below the ACLs.

In addition to the proposed trawl RCA boundaries, NMFS is considering alternative boundaries that are somewhat different from what the Council recommended in April 2013. The alternative trawl RCA boundaries are described below. NMFS intends to take into consideration further comments and recommendations from the Council, as well as comments from Council advisory bodies, industry and the public prior to making a final decision regarding the boundaries for the trawl RCA between 48°10′ N. lat. and 40°10′ N. lat. for 2013–2014.

*Alternative Boundaries*

During development of the environmental assessment for this action, NMFS explored an alternative set of trawl RCA boundaries. The alternative trawl RCA boundaries would be the same as the proposed trawl RCA boundaries except that they would keep closed the area between the boundary line approximating the 150 fm (274-m) depth contour and the boundary line approximating the modified 200 fm (366-m) depth contour off Southern Oregon and Northern California; an area that has been largely closed since 2004 and that would be opened under the initial recommendations of the Council from its April 2013 meeting. This alternative set of trawl RCA boundaries carries forward the intent of the Council to open additional fishing areas, while keeping closed the areas that have been essentially closed to groundfish bottom trawling since 2004 (with the only exception being an opening for one two-month period in 2007 between 45°03′ N. lat. and 45°46′ N. lat.).

The alternative trawl RCA boundaries that NMFS is considering and is soliciting public comment on would be identical to the proposed boundaries between 48°10′ N. lat. and 45°46′ N. lat. However, between 45°46′ N. lat. and 40°10′ N. lat., the alternative would open shoreward areas, the same as the proposed boundaries, but would change the seaward boundary to a year-round modified 200 fm (366-m) line. Relative to current regulations in Table 1 (North), subpart D, the alternative RCA boundaries would: Shift the shoreward boundary line between 48°10′ N. lat. and 40°10′ N. lat. from the 75 fm (137-m) line to the 100 fm (183-m) line during periods 1, 2, and 6; shift the seaward boundary line between 48°10′ N. lat. and 45°46′ N. lat. from the modified 200 fm (366-m) line to the 150 fm (274-m) line during period 1 (January–February); and shift the seaward boundary line between 45°46′ N. lat. and 40°10′ N. lat. from the 200 fm (366-m) line to the modified 200 fm (366-m) line during periods 2–5. These alternative trawl RCA boundaries were designed to take effect in November 2013 and continue until subsequently revised through an inseason action. Initial trawl RCA boundaries for 2015–2016 will likely be developed through the 2015–2016 harvest specifications and management measures process.

TABLE 2—ALTERNATIVE TRAWL RCA BOUNDARIES BETWEEN 48°10′ N. LAT. AND 40°10′ N. LAT., CONSIDERED BY NMFS

| | Jan–Feb | Mar–Apr | May–Jun | Jul–Aug | Sep–Oct | Nov–Dec |
|---|---|---|---|---|---|---|
| 48°10′ N. lat.–45°46′ N. lat | 100 fm line—150 fm line. | | | | | |
| 45°46′ N. lat.–40°10′ N. lat | 100 fm line—modified 200 fm line. | | | | | |

The alternative trawl RCA boundaries being considered are expected to also have a favorable economic impact on groundfish fishing vessels and for businesses and ports where groundfish are landed. However, the benefits would not be as high, particularly between 45°46′ N. lat. and 40°10′ N. lat., because smaller changes would be made to open seaward areas between 45°46′ N. lat. and 40°10′ N. lat. Accordingly, the potential cost and safety benefits and the increased access to target stocks on the slope would be somewhat reduced as compared to the proposed boundaries.

The alternative trawl RCA boundaries would open less area seaward of the current RCA than the proposed trawl RCA boundaries; therefore, any increased impacts to overfished species by opening new fishing areas are expected to be lower in frequency and magnitude under the alternative trawl RCA boundaries, particularly for slope species, than under the proposed action. However, as indicated above, the proposed boundaries present little risk with respect to overfished species catch.

*Impacts to Benthic Habitat*

The Council recommended proposed boundaries and the additional alternative being considered would retain all other existing Federal areas that restrict or prohibit fishing by various gear types, such as the essential fish habitat conservation areas established through Amendment 19 to the Groundfish FMP (71 FR 27408, May 11, 2006). In addition, the proposed rule would not modify any existing trawl gear requirements. Trawl RCAs were established to minimize catch of overfished species while still allowing the harvest of target stocks to the extent possible. Despite the fact that the trawl RCAs were not established to serve as habitat protection, the seaward areas between 45°46′ N. lat. and 40°10′ N. lat., between the 150 fm (274-m) and modified 200 fm (366-m) line have largely been closed since 2004. The environmental assessment for this action indicates that this is the only large-scale area that would be opened under the proposed boundaries where benthic habitats may have, to some extent, recovered from previous groundfish bottom trawling impacts. The draft environmental assessment can be found at *www.pcouncil.org.* Even though this area has been closed to groundfish bottom trawling, it is open to vessels fishing groundfish and non-groundfish with longline and pot gears and to other fishing and non-fishing activities that may impact benthic habitat. The Council and NMFS are currently undertaking a review of the 2006 groundfish EFH designations. Regardless of the final trawl RCA boundary modifications resulting from this proposed rule, the Council and NMFS retain the ability to modify existing EFH designations and closures as a result of the EFH review should it be deemed warranted and practicable.

The Council will consider the alternative RCA boundaries described above at its September 12–17, 2013 meeting in Boise, Idaho (*www.pcouncil.org*). NMFS encourages public participation, both by providing comments on this proposed rule through the methods described under **ADDRESSES**, and through participation at the Council's September meeting. Specifically, NMFS encourages industry to provide public comments regarding the effects that the proposed trawl RCA boundaries compared to the alternative trawl RCA boundaries might have on future fishing opportunities and business plans. NMFS also encourages the general public and non-governmental organizations to provide comments regarding the proposed trawl RCA boundaries and the alternative trawl RCA boundaries that are described in this proposed rule.

## Classification

Pursuant to section 304(b)(1)(A) of the MSA, the NMFS Assistant Administrator has determined that this proposed rule is consistent with the Pacific Coast Groundfish FMP, other provisions of the MSA, and other applicable law, subject to further consideration after public comment.

A draft Environmental Assessment (EA) was prepared for this action. The draft EA includes socio-economic information that was used to prepare the RIR and IRFA. A copy of the draft EA is available online at *www.pcouncil.org.*

A Regulatory Impact Review (RIR) was prepared on the action in its entirety and is included as part of the initial regulatory flexibility analysis (IRFA) on the proposed regulatory changes. The IRFA and RIR describe the impact this proposed rule, if adopted, would have on small entities. A description of the action, why it is being considered, and the legal basis for this action are contained at the beginning of this section in the preamble and in the **SUMMARY** section of the preamble. A copy of the IRFA is available from NMFS (see **ADDRESSES**) and a summary of the IRFA, per the requirements of 5 U.S.C. 603(a), follows:

This proposed action revises the bimonthly boundaries of the trawl RCA.

This area is currently closed to vessels fishing groundfish with bottom trawl gear. This rule affects the limited entry bottom trawl sector managed under the Pacific Coast Groundfish FMP. The purpose of these regulations is to make short term reductions in the size of the trawl RCA beginning in November 2013 and for all of 2014, or until revised through inseason action. Initial trawl RCA boundaries for 2015–2016 will likely be developed through the 2015–2016 harvest specifications and management measures process. By reducing the size of the RCA, trawlers will have a better chance of harvesting more of their IFQ pounds. The Council and NMFS designed the RCA to reduce bycatch of overfished species. However, the RCA was established before implementation of IFQs. Prior to the IFQ program, the fleet fished under fleet wide trip limits, and there were occasional overages in the harvests of overfished rockfish. Such overages threatened the entire sector. Under IFQs, the catch of bycatch species has decreased significantly. Participants now fish within their individual quotas and have incentives to reduce bycatch. If they exceed an individual species quota, they cannot return to fishing within the year unless they purchase quota pounds from other fishermen. Many individual participants have formed risk-pools to help minimize the bycatch of overfished species or to minimize the chance they will need to shut down for the year if they exceed their individual allocations. They are sharing real time information on bycatch. The Risk Pool assesses penalties on members that violate risk-pool regulations. Therefore, there is not as strong a need for a large RCA as a means to reduce bycatch. This rule proposes alternatives that decrease the size of the RCA because participants have shown, under the IFQ Program, that they have reduced their bycatch of overfished species.

All catch of IFQ species, retained or discarded, must be covered by equivalent quota pounds, and participants are subject to a 100 percent monitoring requirement that includes at-sea observers and dockside catch monitors. Accordingly, fishermen are individually accountable for their catch, including any catch of overfished species. Additionally, beginning in 2014, quota shares will become transferrable and this might promote higher utilization of target species quota pounds.

Since the implementation of the program, catch of many overfished species has declined and revenues increased in 2011. In 2012 non-whiting revenue dropped slightly, most likely due to decreases in sablefish prices. Depending on the target species, the amount of fish harvested primarily depends not on available markets but rather on the available amount of bycatch species. In the 2012 shorebased IFQ program, catch of several marketable target species was well below the available shorebased trawl allocation. Over 33 million pounds of flatfish, including Dover sole, went unharvested in 2012. Over 5.5 million pounds of Pacific cod and lingcod went unharvested in 2012. For rockfish, over 6.7 million pounds of minor shelf, minor slope and yellowtail rockfish went unharvested. Total groundfish landed by bottom trawl gear was up slightly in 2012, at 101 percent of 2011 levels (40.9 million lbs versus 40,6 million lbs, respectively). Aggregate attainment (the difference between the total shorebased trawl harvests and the shorebased trawl allocation) of all species categories, other than Pacific whiting, increased by five percent in 2012, to 29 percent, from 24 percent in 2011. Revenue in 2012 maintained 92 percent of 2011 levels (30.4 million in 2012 versus 32.9 million).

NMFS considered three alternative trawl RCA boundary configurations, as described above: The current trawl RCA boundaries for 2013 and 2014 (no action), the Council recommended proposed trawl RCA boundaries between 48°10′ N. lat. and 40°10′ N. lat. (Alternative 1, Table 1), and alternative trawl RCA boundaries between 48°10′ N. lat. and 40°10′ N. lat. added by NMFS (Alternative 2, Table 2).

The amount of increased catch and reduced costs created by the proposed alternative is not known. Given available data and models, NMFS cannot qualitatively predict the increased catch and reduced costs by the proposed changes, although the qualitiative impacts are clear. The regulatory changes associated with Alternative 1 and Alternative 2 will have positive economic effects as discussed above—reduced fuel, improved safety, and increased access to important target species. Overall, the most likely potential impacts are higher attainments of the trawl allocations than would be expected under the No-Action alternative. Alternative 2 is more restrictive compared to Alternative 1; Alternative 2 opens some areas that have been intermittently closed, but not as much new area as Alternative 1.

This rulemaking directly affects bottom trawlers participating in the IFQ fishery. To fish in the IFQ fishery, the vessel must have a vessel account. As part of this year's permit application processes for the non-tribal fisheries, applicants indicate if they are ''small'' business based on a review of the Small Business Administration (SBA) size criteria. These criteria have recently changed. On June 20, 2013, the SBA issued a final rule revising the small business size standards for several industries effective July 22, 2013 (78 FR 37398, June 20, 2013). The rule increased the size standard for Finfish Fishing from $ 4.0 to 19.0 million, for Shellfish Fishing from $ 4.0 to 5.0 million, and for Other Marine Fishing from $4.0 to 7.0 million (Id. at 37400–Table 1). Based on the new size standard ($19 million), NMFS reassessed those businesses considered large under the old size standard ($4 million) based on information provided by these companies under the NMFS Northwest Fisheries Science Center's Economic Data Collection Program. After taking into account NWFSC economic data, NMFS permit and ownership information, PacFIN landings data for 2012, and affiliation between entities, NMFS estimates that there are 66 entities affected by these proposed regulations, of which 56 are ''small'' businesses. NMFS believes that this rule will have a positive economic impact on small entities and will not have significant adverse economic impacts on a substantial number of small entities.

This proposed rule was developed after meaningful consultation and collaboration, through the Council process, with the tribal representative on the Council.

No Federal rules have been identified that duplicate, overlap, or conflict with the proposed action. Public comment is hereby solicited, identifying such rules. A copy of this analysis is available from NMFS (see **ADDRESSES**).

This proposed rule has been determined to be not significant for purposes of Executive Order 12866.

**List of Subjects in 50 CFR Part 660**

Fisheries, Fishing, and Indian fisheries.

Dated: September 10, 2013.

**Samuel D. Rauch III,**

*Deputy Assistant Administrator for Regulatory Programs, performing the functions and duties of the Assistant Administrator for Fisheries, National Marine Fisheries Service.*

For the reasons stated in the preamble, 50 CFR part 660 is proposed to be amended as follows:

## PART 660—FISHERIES OFF WEST COAST STATES

■ 1. The authority citation for part 660 continues to read as follows:

**Authority:** 16 U.S.C. 1801 *et seq.,* 16 U.S.C. 773 *et seq.,* and 16 U.S.C. 7001 *et seq.*

■ 2. Table 1 (North) to part 660, subpart D, is revised to read as follows:

**Table 1 (North) to Part 660, Subpart D -- Limited Entry Trawl Rockfish Conservation Areas and Landing Allowances for non-IFQ Species and Pacific Whiting North of 40°10' N. Lat.**

**This table describes Rockfish Conservation Areas for vessels using groundfish trawl gear. This table describes incidental landing allowances for vessels registered to a Federal limited entry trawl permit and using groundfish trawl or groundfish non-trawl gears to harvest individual fishing quota (IFQ) species.**

**Other Limits and Requirements Apply -- Read § 660.10 - § 660.399 before using this table**

11012013

| | | JAN-FEB | MAR-APR | MAY-JUN | JUL-AUG | SEP-OCT | NOV-DEC |
|---|---|---|---|---|---|---|---|
| | **Rockfish Conservation Area (RCA)**[1/]**:** | | | | | | |
| 1 | North of 48°10' N. lat. | shore - modified[2/] 200 fm line[1/] | shore - 200 fm line[1/] | shore - 150 fm line[1/] | | shore - 200 fm line[1/] | shore - modified[2/] 200 fm line[1/] |
| 2 | 48°10' N. lat. - 40°10' N. lat. | 100 fm line1/ - 150 fm line1 | | | | | |

Selective flatfish trawl gear is required shoreward of the RCA; all bottom trawl gear (large footrope, selective flatfish trawl, and small footrope trawl gear) is permitted seaward of the RCA. Large footrope and small footrope trawl gears (except for selective flatfish trawl gear) are prohibited shoreward of the RCA. Midwater trawl gear is permitted only for vessels participating in the primary whiting season. **Vessels fishing groundfish trawl quota pounds with groundfish non-trawl gears, under gear switching provisions at § 660.140, are subject to the limited entry groundfish trawl fishery landing allowances in this table, regardless of the type of fishing gear used. Vessels fishing groundfish trawl quota pounds with groundfish non-trawl gears, under gear switching provisions at § 660.140, are subject to the limited entry fixed gear non-trawl RCA, as described in Tables 1 (North) and 1 (South) to Part 660, Subpart E.**

**See § 660.60, § 660.130, and § 660.140 for Additional Gear, Trip Limit, and Conservation Area Requirements and Restrictions. See §§ 660.70-660.74 and §§ 660.76-660.79 for Conservation Area Descriptions and Coordinates (including RCAs, YRCA, CCAs, Farallon Islands, Cordell Banks, and EFHCAs).**

State trip limits and seasons may be more restrictive than federal trip limits, particularly in waters off Oregon and California.

| | | |
|---|---|---|
| 3 | **Minor nearshore rockfish & Black rockfish** | 300 lb/ month |
| 4 | **Whiting** | |
| 5 | midwater trawl | Before the primary whiting season: CLOSED. -- During the primary season: mid-water trawl permitted in the RCA. See §660.131 for season and trip limit details. -- After the primary whiting season: CLOSED. |
| 6 | large & small footrope gear | Before the primary whiting season: 20,000 lb/trip. -- During the primary season: 10,000 lb/trip. -- After the primary whiting season: 10,000 lb/trip. |
| 7 | **Cabezon** | |
| 8 | North of 46°16' N. lat. | Unlimited |
| 9 | 46°16' N. lat. - 40°10' N. lat. | 50 lb/ month |
| 10 | **Shortbelly** | Unlimited |
| 11 | **Spiny dogfish** | 60,000 lb/ month |
| 12 | **Longnose skate** | Unlimited |
| 13 | **Other Fish** [3/] | Unlimited |

**TABLE 1 (North)**

1/ The Rockfish Conservation Area is an area closed to fishing by particular gear types, bounded by lines specifically defined by latitude and longitude coordinates set out at §§ 660.71-660.74. This RCA is not defined by depth contours, and the boundary lines that define the RCA may close areas that are deeper or shallower than the depth contour. Vessels that are subject to the RCA restrictions may not fish in the RCA, or operate in the RCA for any purpose other than transiting.

2/ The "modified" fathom lines are modified to exclude certain petrale sole areas from the RCA.

3/ "Other fish" are defined at § 660.11 and include sharks (except spiny dogfish), skates (except longnose skate), ratfish, morids, grenadiers, and kelp greenling.

**To convert pounds to kilograms, divide by 2.20462, the number of pounds in one kilogram.**

[FR Doc. 2013–22359 Filed 9–12–13; 8:45 am]

BILLING CODE 3510–22–P

MIDWATER TRAWLERS COOPERATIVE
PO Box 2352, Newport, Oregon • 97365 • 541.272.4544

September 4, 2013

Ms. Dorothy Lowman, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

RE: Agenda Item G.6.b Consideration of Trawl Rockfish Conservation Area Boundary Modifications

Dear Madame Chair & Council Members,

**The Oregon Trawl Commission (OTC), the Fishermen's Marketing Association (FMA), The Coos Bay Trawlers Association (CBTA), Midwater Trawlers Cooperative (MTC) and the West Coast Seafood Processors Association (WCSPA) support modifying the trawl Rockfish Conservation Area (RCA) boundaries represented by Alternative 1 from the draft Environmental Assessment (EA).** OTC, FMA, CBTA and MTC collectively represent a majority of the trawl fishermen who participate in the west coast trawl catch share fishery. WCSPA represents a major portion of seafood processors in California, Oregon and Washington that process trawl caught groundfish.

***Need for Action***

Harvesters are unable to access healthy target groundfish stocks that are economically viable due to the restrictions imposed by the trawl RCA. Current management measures are not allowing Optimum Yield to be achieved as required by National Standard 1 of the Magnuson Stevens Fishery and Conservation Act. Attainment of annual catch limits (ACLs) for all but a few non-whiting species of groundfish is non-existent. Cumulative landings and revenue numbers distort what is actually happening and individual species ACL attainment is abysmal. At the same time the costs for participating in the west coast groundfish trawl fishery continue to increase. With the cost of observers and monitoring being borne increasingly by the industry, the pending annual 3% cost recovery fee (on gross ex-vessel value), the annual 5% Buyback Loan payments (on gross ex-vessel value) and individual state landings taxes it is becoming more and more difficult for trawl groundfish businesses to stay both profitable and sustainable. Traditional groundfish trawlers are also faced with the real possibility that 10% of their ITQ pounds will be siphoned away from them to fuel an Adaptive Management Plan that no trawl industry participant really wants. Modifying the boundaries of the RCA to allow harvesters access to economically viable and healthy target stocks will allow the fleet more opportunities to increase the value of this fishery and to help trawl groundfish businesses stay competitive and sustainable over the long-term.

***Rationale***

The trawl RCA has been in place since 2002. It was implemented primarily to reduce the catch of rebuilding rockfish stocks (canary and darkblotched) by closing off areas to bottom trawl activity where these species of concern were found in higher densities and/or where larger bycatch events had previously occurred. At the same time that these large-scale closures were being implemented the trawl rationalization process was underway. Rationalization offered a way for harvesters to move away from trip limit management (use it or lose it), increase their operational flexibility and extract more value out of the groundfish fishery while simultaneously taking personal responsibility for all the fish that they caught. Personal responsibility (and the associated regulation that requires quota pound coverage for all species caught) has become the primary incentive to reduce unwanted bycatch. After the ITQ program was implemented, fishermen found themselves personally accountable for their catch but also found themselves still hampered by regulations in place from the pre-ITQ management regime. These regulations, one of which is the trawl RCA, have prevented fishermen from realizing increased attainment of annual catch limits for economically important groundfish species which means that their businesses, seafood processors and coastal communities are not realizing the increased value that should be afforded to them through the ITQ program.

We believe that this action is justified for several reasons, not the least of which is the fundamentally different management program which now governs the west coast trawl groundfish fishery. The individual accountability afforded by the trawl ITQ program has proven that fishing behavior can and does change when harvesters are held personally responsible for their catch. This fact is clearly demonstrated when comparing bycatch data on rebuilding species from the first few years of the ITQ program following implementation with the pre-implementation data as outlined in section 4.4.2 of the draft EA beginning on page 86. Further the analysis demonstrates that after ITQ implementation there have been extreme declines in catches of rebuilding species:

- 60% decrease for yelloweye rockfish bycatch
- 37.8% decrease for canary rockfish bycatch
- 68.1% decrease for pacific ocean perch bycatch
- 68% decrease for darkbloctched rockfish bycatch

These reductions are not attributed to RCA restrictions but rather to behavioral changes and alternative fishing strategies employed by fishermen under the ITQ system.

RCA's were a blunt instrument utilized by the Council and the National Marine Fisheries Service (NMFS) to stem the catch of rebuilding rockfish species. They were implemented at a time when more selective and targeted incentives to reduce bycatch of these species was unavailable. Over a decade later, we now have more sophisticated and refined tools available to us and we should take advantage of all the management facets that rationalization allows. To take that premise further – based on all the sacrifices and burdens that the trawl fleet has shouldered over the last decade to ensure the sustainability of this fishery– and with much more to come in terms of the financial burden of participating in the fishery - the fleet deserves the opportunity to take advantage of all the tools that the trawl ITQ program is supposed to offer. Let's end the lip service and stop micro-managing these fishermen and allow them to be personally accountable for what they catch – this is one reason they supported this fundamental shift in the way that this fishery is managed.

***Broad Support***

The Council approved changes to the RCA boundaries at the March, 2013 meeting. They reaffirmed their decision at the April 2013 meetings. NMFS subsequently determined that the public would be better served if the boundary modifications were addressed through normal rulemaking channels rather than under inseason adjustments via an automatic action. The industry agreed to work with the agency and Council to go through the rule making process. At the April meeting the Groundfish Advisory Panel and Groundfish Management Team provided guidance, analysis, and justification for making small changes to the boundaries that would allow opportunities for the fleet to gain economic value while still ensuring that stocks were managed sustainably. The industry has demonstrated broad support for this action on multiple occasions. The Council unanimously approved the recommendation to NMFS reflected in Alternative 1.

***EFH Confusion***

Unfortunately, at the June 2013 Council meeting others began to purposefully confuse the issue contending that the RCA should be transformed into essential fish habitat (EFH) and that the area should continue to be closed to the fleet. This is rubbish and purposely molests the original intent of the RCA. The RCAs were put in place for one reason – to stem the catch of rebuilding species – it was a blunt instrument available to managers at a time when other more refined tools were not. As stated in the EA on page 13 – "While the majority of U.S. protected areas were established to conserve biodiversity or ecosystem structure, the management goal of the RCA was to aid in rebuilding overfish rockfish species." We have an amazing tool now to decrease bycatch and that is the individual accountability afforded by the trawl ITQ program. And the analysis and the evidence it is based on clearly shows that current management is working in terms of reducing unwanted bycatch. Further, this action in no way jeopardizes or changes any of the other existing closed areas (including EFH conservation areas) and it would maintain all existing gear requirements. Alternative 1 still includes a large closed area covering 1,374 square miles of soft, hard and mixed substrate ocean bottom where bottom trawling would be prohibited.

***The Dreaded "Lightning Strike"***

The question often arises – what if the Council were to allow changes to the RCA boundaries and a fisherman were to have a lightning strike of rebuilding species large enough to close down the entire trawl sector. The chances of this actually happening are slim to none and in fact, have as much chance of happening outside of the RCA as within especially under the conditions of the rebuilding paradox. In both the preliminary GMT analysis from the March Council meeting and the much more detailed analysis from the draft EA it is clear that the likelihood of this happening is really non-existent. Existing closed areas and gear restrictions also play a part in reducing the risk. Analysis of the total catch data from the two years before and the two years after trawl rationalization "does not suggest any obvious danger of either extreme catch events, or accumulated aggregate high catch of rebuilding species that would exceed the trawl allocation, by adopting the proposed changes to the RCA boundaries." The analysis further states, "Alternative 1 should pose little risk to rebuilding species by way of individual fishers staying within their allocations, and the IFQ program staying within the trawl allocations of rebuilding species. Alternative 1 should provide additional fishing opportunity for valuable target species, with little conservation risk to rebuilding stocks of groundfish." It is also important to remember that bottom trawl activity is currently occurring in most of these areas at some point during the year- whether it is by the trawl fleet when the boundaries are adjusted for certain management periods or during the annual NMFS slope survey which operates in all portions of the RCA on an annual basis. No disastrous catch events have occurred – and presumably the slope survey is not attempting to avoid unwanted bycatch in the same way that the trawl fleet is.

***Why Alternative 2 Falls Short***
We appreciate that the agency considered additional options (and rejected some as is outlined in the draft EA) as is required by NEPA for a robust analysis. We believe that the analysis for Alternative 2 demonstrates that its provisions fall short of providing meaningful access to healthy target species. Implementing only the modified 200-fathom line falls well short of the opportunity that industry would like to see. Adjusting the seaward boundary to the 150-fathom line opens up additional area and provides opportunities for additional species that the shoreward boundary relaxation does not. In addition, it opens up additional space for vessels that are able to fish seaward and avoids potential crowding and effort shoreward. Repeatedly the draft EA indicates that the benefit to the fleet afforded by Alternative 2 is much less than Alternative 1. But the risks associated with both are virtually the same. It is prudent to provide the fleet with as much access to healthy stocks as the analysis deems safe in terms of effects on rebuilding species. And again, this area is routinely bottom trawled by the slope survey operation as well as by other activities like shrimping. Alternative 2 simply falls short in benefits to the fleet with no demonstrated savings for conservation.

***Conclusion***
OTC, FMA, MTC and CBTA have all signed onto a joint letter advocating for comprehensive RCA reform under agenda item G.9. : Trawl Rationalization Trailing Amendment Scoping Process. It is clear that comprehensive reform will take time and resources over the long term. In the meantime we strongly support moving forward with the RCA boundary modifications that are outlined in Alternative 1 of the draft EA. We believe the move will provide harvesters with additional opportunity that will benefit the fleet while also helping managers to achieve National Standard 1 of the Magnuson Act. This can be accomplished with little or no risk to rebuilding species as clearly identified in the analysis. We urge the Council and the National Marine Fisheries Service to move forward in this direction without delay so that the changes can be in regulation for period 6 (November & December) of 2013.

Thank you for your consideration.

Sincerely,

Brad Pettinger, Administrator
Oregon Trawl Commission

Pete Leipzig, Executive Director
Fishermen's Marketing Association

Heather Munro Mann, Executive Director
Midwater Trawlers Cooperative

Steve Bodnar, Executive Director
Coos Bay Trawlers Association

Rod Moore, Executive Director
West Coast Seafood Processors Association

Comprehensive Conservation Proposal
Oceana, Natural Resources Defense Council, and Ocean Conservancy
July 31, 2013

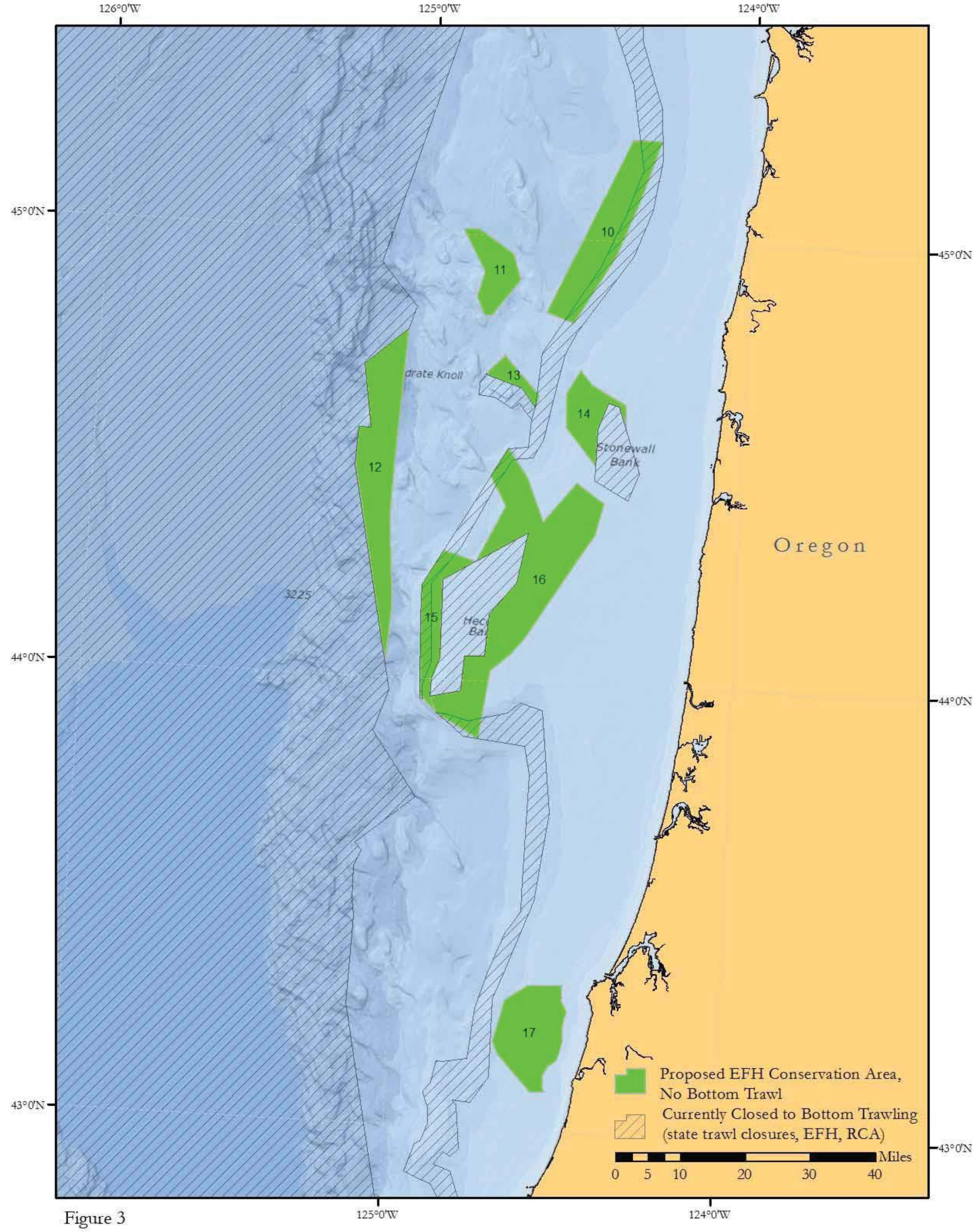
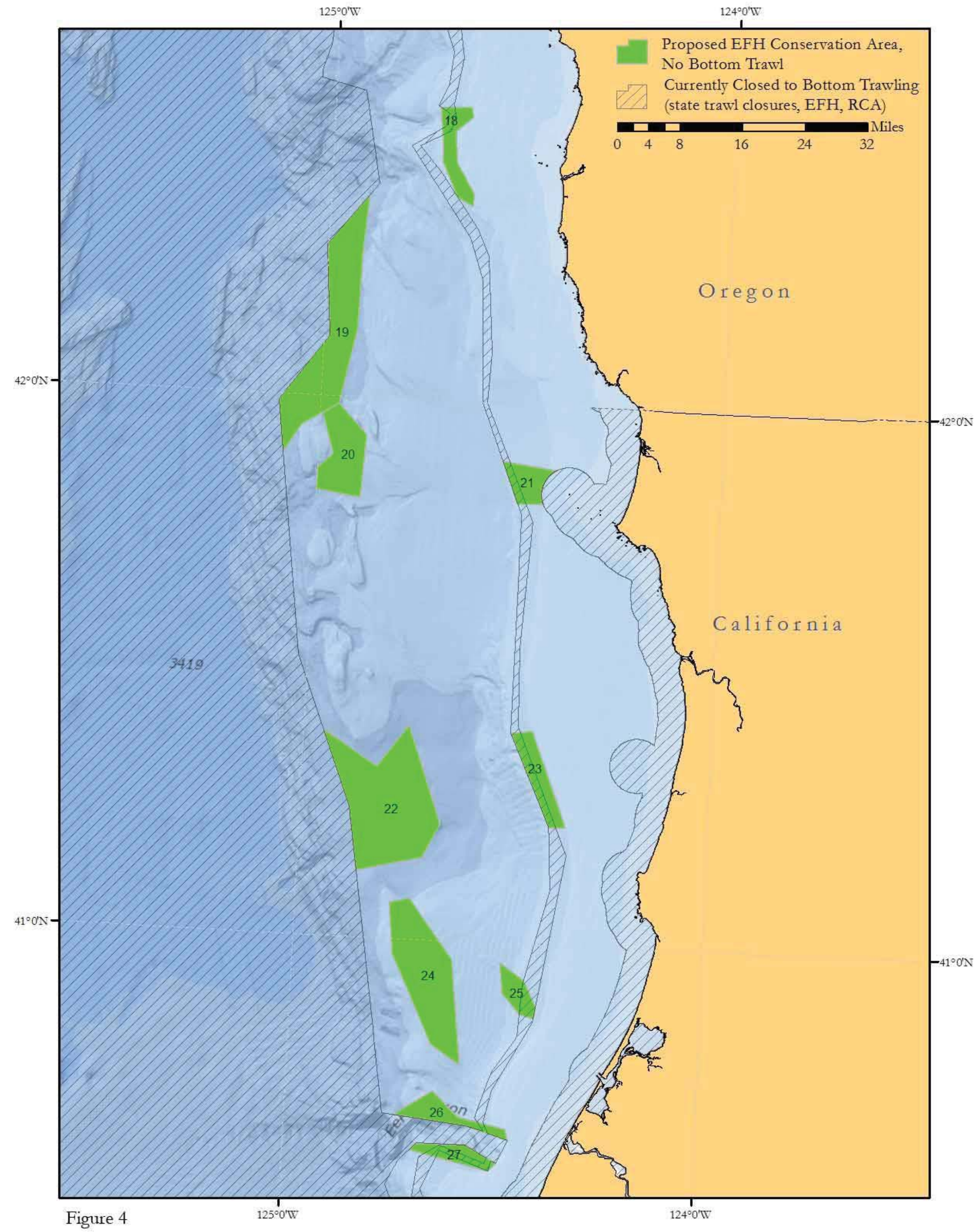



Figure 3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Proposed EFH Conservation Area, No Bottom Trawl
Currently Closed to Bottom Trawling (state trawl closures, EFH, RCA)
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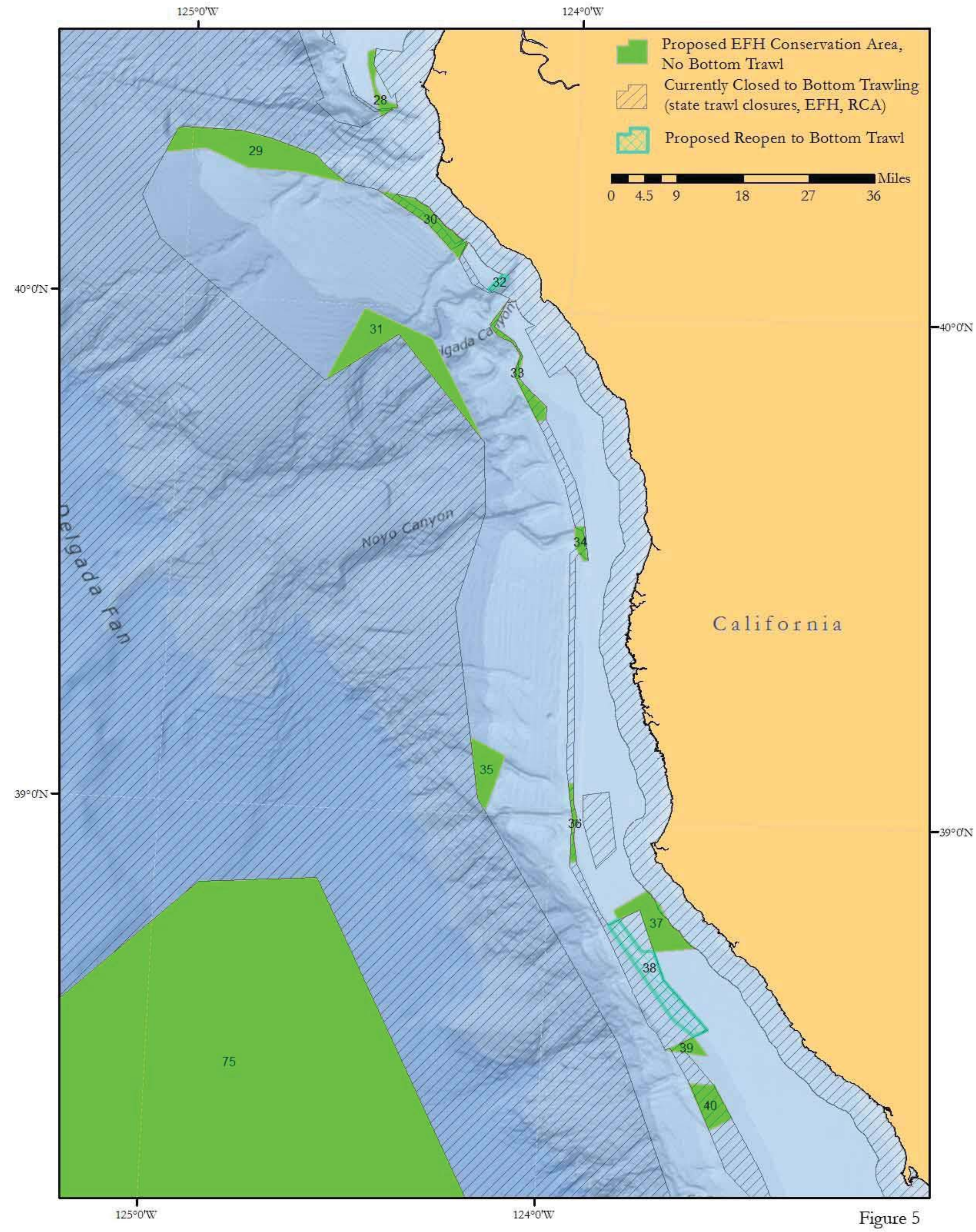
Figure 4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Currently Closed to Bottom Trawling (state trawl closures, EFH, RCA)
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Noyo Canyon
Delgada Fan
California
Figure 5

**Figure 5**.

# INITIAL ACTIONS FOR SETTING 2015-2016 GROUNDFISH FISHERIES

In June, the Council adopted a process and schedule for deciding harvest specifications and management measures for 2015 and beyond groundfish fisheries (see Agenda Item F.7.a, Attachment 3, June 2013). Based on this schedule, the Council will begin deciding groundfish harvest specifications and new management measures for 2015-2016 (and beyond) groundfish fisheries at this meeting. Specifically, the Council is tasked with adopting overfishing limits (OFLs), a preliminary range of acceptable biological catches (ABCs), and a preliminary range of new management measures for 2015-2016 fisheries.

Proposed 2015-2016 OFLs and matrices of potential 2015 and 2016 ABCs based on the Scientific and Statistical Committee's (SSC's) estimated sigmas for each stock/stock category and a range of overfishing probabilities (P*s) are provided in tables in Attachment 1. The SSC will review these proposed harvest specifications, stock categories, and sigma values and make their recommendations to the Council. Additionally, the SSC Groundfish Subcommittee met via teleconference this summer to discuss their analysis and recommendations concerning the proxy $F_{MSY}$ spawning potential ratio (SPR) for elasmobranchs. Their report is provided as Agenda Item G.7.b, SSC Groundfish Subcommittee Report. The Council should review these proposed harvest specifications and adopt those OFLs, stock categories, and stock/stock category sigma values recommended by the SSC. Additionally, the Council should adopt a preliminary range of ABCs based on their P* choice for more detailed analysis.

The Council has committed to narrowing the scope of management measures for consideration during the biennial process (see Council Meeting Minutes from March 2013). Eligible actions include adjusting existing management measures, including routine measures[1], and analyzing new management measures[2] that are necessary to keep catch within the ACL or address a habitat or protected resources concern. At June Council meetings in even years, the Council would decide which of the new management measures that did not meet the above-mentioned criteria would instead be considered in a subsequent, separate two-meeting process. These Council-recommended changes to the process are captured in a draft revision of the Council Operating Procedure (COP) 9 (Attachment 2). While the Council will formally adopt COP 9 under Agenda Item H.4, the proposed revisions are introduced here to allow the Council and its advisory bodies the opportunity to provide substantive input under this agenda item. In the time between the agenda items, a revised draft could be prepared for adoption under Agenda Item H.4.

Additionally, under this agenda item, the Council should adopt a preliminary range of new management measures that meet the above-mentioned criteria for analysis in the biennial process. Attachment 3 provides examples of how management measures might be categorized, which may help the Council determine the proposals for inclusion in the biennial process.

[1] Routine measures are those currently established in regulation. For example, adjustments to bag and trip limits could be increased or decreased as necessary to achieve but not exceed the ACL.
[2] New measures are those that have not previously been analyzed or implemented in regulation.

At its November 2013 meeting, the Council is scheduled to review preliminary analysis of the new management measures and provide guidance on adjustments to routine measures, including two-year allocations, to be analyzed in the Environmental Impact Statement. The Council is scheduled to select preliminary preferred management measures at the April 2014 Council meeting and take final action in June 2014. As noted above, at its June 2014 meeting, the Council will also consider those management measures determined to be ineligible for consideration in the biennial process. If selected, the Council schedule for considering the management measures would be developed at that time.

**Council Action:**

1. **Adopt those 2015-2016 OFLs, stock categories, and sigma values recommended by the SSC.**
2. **Adopt a preliminary range of 2015-2016 P*s/ABCs for more detailed analysis.**
3. **Review and discuss proposed revisions to Council Operating Procedure 9 based on Council action taken thus far under Amendment 24.**
4. **Adopt a prioritized range of new management measures for preliminary analysis.**

Reference Materials:

1. Agenda Item G.7.a, Attachment 1: Proposed Overfishing Limits and Potential Acceptable Biological Catches for 2015 and 2016 Groundfish Fisheries.
2. Agenda Item G.7.a, Attachment 2: Briefing paper authored by Dr. Andrè Punt: Management Strategy Evaluation for Rebuilding Revision Rules: A Proof of Concept.
3. Agenda Item G.7.a, Attachment 3: Proposed Revisions to COP 9.
4. Agenda Item G.7.a, Attachment 4: New Management Measures Process.
5. Agenda Item G.7.b, SSC Groundfish Subcommittee Report: SSC Groundfish Subcommittee Statement Regarding a Change in Target SPR Rate for West Coast Elasmobranch Species.
6. Agenda Item G.7.c, Public Comment.

Agenda Order:

a. Agenda Item Overview — John DeVore & Kelly Ames
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt Final Overfishing Limits and Preliminary P*s/Acceptable Biological Catches, Consider New Management Measures and Modifications to Council Operating Procedure 9

PFMC
08/22/13

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# PROPOSED OVERFISHING LIMITS AND POTENTIAL ACCEPTABLE BIOLOGICAL CATCHES FOR 2015 AND 2016 GROUNDFISH FISHERIES

Tables provided in this attachment:

- Table 1. 2014 OFLs (mt) and proposed 2015 and 2016 OFLs (mt) for west coast groundfish stocks.
- Table 2. The basis for proposed 2015 and 2016 OFLs for west coast groundfish stocks.
- Table 3. Relationship between the overfishing probability (P*) and the percent reduction of the OFL for deciding the 2015 and 2016 ABCs for category 1, aurora rockfish, widow rockfish, shortspine thornyhead, category 2, and category 3 stocks based on sigma (σ) values (i.e., biomass variances) of 0.36, 0.39, 0.41, 0.45, 0.72, and 1.44, respectively.
- Table 4. Proposed stock categories and a range of alternative 2015 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.
- Table 5. Proposed stock categories and a range of alternative 2016 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.

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Table 1. 2014 OFLs (mt) and proposed 2015 and 2016 OFLs (mt) for west coast groundfish stocks (overfished stocks in CAPS; stocks with new assessments in **bold**; component stocks in status quo stock complexes in *italics*).

| Stock | 2014 OFL | Category | Sub-category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|---|
| | | | | | |
| **OVERFISHED STOCKS** | | | | | |
| **BOCACCIO S. of 40°10' N. latitude** | **881** | **1** | | **874** | **871** |
| CANARY | 741 | 1 | | 733 | 729 |
| COWCOD S. of 40°10' N. latitude | 12 | | | **NA** | **NA** |
| ***COWCOD (Conception)*** | **7** | **2** | **c** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | 5 | 3 | d | ***NA*** | ***NA*** |
| **DARKBLOTCHED** | **553** | **1** | | **560** | **563** |
| PACIFIC OCEAN PERCH | 838 | 1 | | 842 | 850 |
| **PETRALE SOLE** | **2,774** | **1** | | **2,738** | **2,660** |
| YELLOWEYE | 51 | 2 | | 52 | 52 |
| **NON-OVERFISHED STOCKS** | | | | | |
| Arrowtooth Flounder | 6,912 | 2 | d | 6,599 | 6,396 |
| Black Rockfish (OR-CA) | 1,166 | 1 | | 1,176 | 1,183 |
| Black Rockfish (WA) | 428 | 1 | | 421 | 423 |
| Cabezon (CA) | 165 | 1 | | 161 | 158 |
| Cabezon (OR) | 49 | 1 | | 49 | 49 |
| California scorpionfish | 122 | 1 | | 119 | 117 |
| Chilipepper S. of 40°10' N. latitude | 1,722 | 1 | | 1,703 | 1,694 |
| Dover Sole | 77,774 | 1 | | 66,871 | 59,221 |
| **English Sole** | **5,906** | **2** | | **12,092** | **8,493** |
| Lingcod N. of 40º10' N. latitude | 3,162 | 1 | | 3,010 | 2,891 |
| Lingcod S. of 40º10' N. latitude | 1,276 | 2 | d | 1,205 | 1,136 |
| Longnose skate | 2,816 | 1 | | 2,449 | 2,405 |
| **Longspine Thornyhead (coastwide)** | **3,304** | **1** | | **4,405** | **4,190** |
| Pacific Cod | 3,200 | 3 | b | 3,200 | 3,200 |
| Sablefish (coastwide) | 7,158 | 1 | | 7,857 | 8,526 |
| Shortbelly | 6,950 | 2 | d | 6,950 | 6,950 |
| **Shortspine Thornyhead (coastwide)** | 2,310 | **1** | | **3,204** | **3,168** |
| Splitnose S. of 40°10' N. latitude | 1,747 | 1 | | 1,794 | 1,826 |
| Starry Flounder | 1,834 | 2 | d | 1,841 | 1,847 |
| Widow | 4,435 | 1 | | 4,137 | 3,990 |
| **Yellowtail N. of 40°10' N. latitude** | **4,584** | **2** | | **12,281** | **11,647** |
| **STOCK COMPLEXES** | | | | | |
| Minor Nearshore Rockfish North | 110 | | | 68 | 69 |
| *Black and yellow* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Blue (CA)* | *27.4* | 2 | d | *27.4* | *27.7* |
| *Blue (OR & WA)* | *32.3* | 3 | d | *32.3* | *32.3* |
| ***Brown*** | ***5.5*** | **2** | | ***NA*** | ***NA*** |
| *Calico* | *0.0* | 3 | a | *0.0* | *0.0* |
| ***China*** | ***9.8*** | **2** | | ***NA*** | ***NA*** |
| ***Copper*** | ***26.0*** | **2** | | ***NA*** | ***NA*** |
| *Gopher* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Grass* | *0.7* | 3 | d | *0.7* | *0.7* |
| *Kelp* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Olive* | *0.3* | 3 | d | *0.3* | *0.3* |

| Stock | 2014 OFL | Category | Sub-category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|---|
| *Quillback* | *7.4* | 3 | d | *7.4* | *7.4* |
| *Treefish* | *0.2* | 3 | d | *0.2* | *0.2* |
| Minor Shelf Rockfish North | 2,195 | | | 2,207 | 2,217 |
| *Bronzespotted* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Bocaccio* | *284.0* | 3 | d | *284.0* | *284.0* |
| *Chameleon* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Chilipepper* | *129.6* | 3 | d | *128.2* | *127.5* |
| *Cowcod* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Flag* | *0.1* | 3 | d | *0.1* | *0.1* |
| *Freckled* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Greenblotched* | *1.3* | 3 | c | *1.3* | *1.3* |
| *Greenspotted 40°10' to 42° N. latitude* | *9.4* | 2 | | *9.3* | *9.3* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | d | *6.1* | *6.1* |
| *Greenstriped* | *1,268.3* | 2 | d | *1,281.9* | *1,292.0* |
| *Halfbanded* | *0.0* | 3 | b | *0.0* | *0.0* |
| *Harlequin* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Honeycomb* | *0.0* | 3 | c | *0.0* | *0.0* |
| *Mexican* | *0.0* | 3 | c | *0.0* | *0.0* |
| *Pink* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Pinkrose* | *0.0* | 3 | b | *0.0* | *0.0* |
| *Puget Sound* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Pygmy* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Redstripe* | *269.9* | 3 | d | *269.9* | *269.9* |
| *Rosethorn* | *12.9* | 3 | d | *12.9* | *12.9* |
| *Rosy* | *3.0* | 3 | d | *3.0* | *3.0* |
| *Silvergray* | *159.4* | 3 | d | *159.4* | *159.4* |
| *Speckled* | *0.2* | 3 | d | *0.2* | *0.2* |
| *Squarespot* | *0.2* | 3 | c | *0.2* | *0.2* |
| *Starry* | *0.0* | 3 | d | *0.0* | *0.0* |
| ***Stripetail*** | ***40.4*** | **3** | **d** | ***40.4*** | ***40.4*** |
| *Swordspine* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Tiger* | *1.0* | 3 | d | *1.0* | *1.0* |
| *Vermilion* | *9.7* | 3 | c | *9.7* | *9.7* |
| Minor Slope Rockfish North | 1,553 | | | 1,804 | 1,817 |
| ***Aurora*** | ***15.4*** | **1** | | ***17.4*** | ***17.5*** |
| *Bank* | *17.2* | 3 | d | *17.2* | *17.2* |
| *Blackgill* | *4.7* | 3 | c | *4.7* | *4.7* |
| *Redbanded* | *45.3* | 3 | d | *45.3* | *45.3* |
| ***Rougheye*** | ***71.1*** | **1** | | ***201.9*** | ***205.8*** |
| ***Sharpchin*** | ***214.5*** | **2** | | ***305.6*** | ***297.6*** |
| *Shortraker* | *18.7* | 3 | d | *18.7* | *18.7* |
| *Splitnose* | *974.1* | 1 | | *1,000.6* | *1,018.2* |
| *Yellowmouth* | *192.4* | 3 | d | *192.4* | *192.4* |
| Minor Nearshore Rockfish South | 1,160 | | | 793 | 791 |
| *Shallow Nearshore Species* | NA | NA | NA | NA | NA |
| *Black and yellow* | *27.5* | 3 | c | *27.5* | *27.5* |
| ***China*** | ***16.6*** | **2** | **c** | ***NA*** | ***NA*** |
| *Gopher (N of Pt. Conception)* | *153.0* | 1 | | *148.0* | *144.0* |
| *Gopher (S of Pt. Conception)* | *25.6* | 3 | c | *25.6* | *25.6* |

| Stock | 2014 OFL | Category | Sub-category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|---|
| *Grass* | *59.6* | 3 | d | *59.6* | *59.6* |
| *Kelp* | *27.7* | 3 | d | *27.7* | *27.7* |
| *Deeper Nearshore Species* | NA | NA | NA | NA | NA |
| *Blue (assessed area)* | *187.8* | 2 | d | *188.6* | *190.3* |
| *Blue (S of 34 °27' N. latitude)* | *72.9* | 3 | c | *72.9* | *72.9* |
| ***Brown*** | ***204.6*** | **2** | | ***NA*** | ***NA*** |
| *Calico* | *0.0* | 3 | b | *0.0* | *0.0* |
| ***Copper*** | ***141.5*** | **2** | | ***NA*** | ***NA*** |
| *Olive* | *224.6* | 3 | d | *224.6* | *224.6* |
| *Quillback* | *5.4* | 3 | d | *5.4* | *5.4* |
| *Treefish* | *13.2* | 3 | d | *13.2* | *13.2* |
| Minor Shelf Rockfish South | 1,912.9 | | | 1,914.1 | 1,915.4 |
| *Bronzespotted* | *3.6* | 3 | c | *3.6* | *3.6* |
| *Chameleon* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Flag* | *23.4* | 3 | c | *23.4* | *23.4* |
| *Freckled* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Greenblotched* | *23.1* | 3 | d | *23.1* | *23.1* |
| *Greenspotted* | *80.3* | 2 | d | *79.0* | *78.4* |
| *Greenstriped* | *232.7* | 2 | d | *235.1* | *237.0* |
| *Halfbanded* | *0.0* | 3 | b | *0.0* | *0.0* |
| *Harlequin* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Honeycomb* | *9.9* | 3 | c | *9.9* | *9.9* |
| *Mexican* | *5.1* | 3 | c | *5.1* | *5.1* |
| *Pink* | *2.5* | 3 | d | *2.5* | *2.5* |
| *Pinkrose* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Pygmy* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Redstripe* | *0.5* | 3 | d | *0.5* | *0.5* |
| *Rosethorn* | *2.1* | 3 | d | *2.1* | *2.1* |
| *Rosy* | *44.5* | 3 | d | *44.5* | *44.5* |
| *Silvergray* | *0.5* | 3 | d | *0.5* | *0.5* |
| *Speckled* | *39.4* | 3 | d | *39.4* | *39.4* |
| *Squarespot* | *11.1* | 3 | c | *11.1* | *11.1* |
| *Starry* | *62.6* | 3 | d | *62.6* | *62.6* |
| ***Stripetail*** | ***23.6*** | **3** | **d** | ***23.6*** | ***23.6*** |
| *Swordspine* | *14.2* | 3 | d | *14.2* | *14.2* |
| *Tiger* | *0.0* | 3 | d | *0.0* | *0.0* |
| *Vermilion* | *269.3* | 3 | d | *269.3* | *269.3* |
| *Yellowtail* | *1,064.4* | 3 | d | *1,064.4* | *1,064.4* |
| Minor Slope Rockfish South | 685 | | | 806 | 807 |
| ***Aurora*** | ***26.1*** | **1** | | ***74.3*** | ***74.3*** |
| *Bank* | *503.2* | 3 | d | *503.2* | *503.2* |
| *Blackgill* | *134.0* | 1 | | *137.0* | *140.0* |
| *Pacific ocean perch* | *0.0* | 3 | a | *0.0* | *0.0* |
| *Redbanded* | *10.4* | 3 | d | *10.4* | *10.4* |
| ***Rougheye*** | ***0.4*** | **1** | | ***4.1*** | ***4.2*** |
| ***Sharpchin*** | ***9.8*** | **2** | | ***76.4*** | ***74.4*** |
| *Shortraker* | *0.1* | 3 | d | *0.1* | *0.1* |
| *Yellowmouth* | *0.8* | 3 | d | *0.8* | *0.8* |
| Other Flatfish | 10,060 | | | 11,298 | 9,948 |
| *Butter sole* | *4.6* | 3 | b | *4.6* | *4.6* |

| Stock | 2014 OFL | Category | Sub-category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|---|
| *Curlfin sole* | *8.2* | 3 | b | *8.2* | *8.2* |
| *Flathead sole* | *35.0* | 3 | b | *35.0* | *35.0* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | | ***4,801.0*** | ***4,801.0*** |
| ***Rex sole*** | ***4,371.5*** | **2** | | ***5,609.0*** | ***4,259.0*** |
| *Rock sole* | *66.7* | 3 | c | *66.7* | *66.7* |
| *Sand sole* | *773.2* | 3 | c | *773.2* | *773.2* |
| Other Fish a/ | 6,802 | 3 | | 6,374 | 6,355 |
| *Big skate* | *458.0* | 3 | | *458.0* | *458.0* |
| *Cabezon (WA)* | *b/* | 3 | | *b/* | *b/* |
| *California skate* | *86.0* | 3 | | *86.0* | *86.0* |
| *Finescale codling* | *b/* | 3 | | *b/* | *b/* |
| *Kelp greenling (CA)* | *118.9* | 3 | d | *118.9* | *118.9* |
| *Kelp greenling (OR & WA)* | *b/* | 3 | | *b/* | *b/* |
| *Leopard shark* | *167.1* | 3 | d | *167.1* | *167.1* |
| *Pacific grenadier* | *1,519.0* | 3 | c | *1,519.0* | *1,519.0* |
| *Ratfish* | *1,441.0* | 3 | | *1,441.0* | *1,441.0* |
| *Soupfin shark* | *61.6* | 3 | c | *61.6* | *61.6* |
| *Spiny dogfish* | *2,950.0* | 2 | d | *2,522.7* | *2,503.3* |

a/ Values for these specifications are the sum of known contributions of component stocks.
b/ No OFL contribution for these stocks given the lack of an approved method.

Table 2. The basis for proposed 2015 and 2016 OFLs for west coast groundfish stocks.

| Stock | Comments |
|---|---|
| | |
| **OVERFISHED STOCKS** | |
| **BOCACCIO S. of 40°10' N. latitude** | **Projected using a 50% SPR from the 2011 rebuilding analysis with a 6% reduction to subtract the portion of the assessed stock north of 40°10' N. lat.** |
| CANARY | Projected using a 50% SPR from the 2011 rebuilding analysis. |
| COWCOD S. of 40°10' N. latitude | Sum of Conception and Monterey OFLs. |
| ***COWCOD (Conception)*** | **Not available pending provision of a 2013 rebuilding analysis in Nov. Projected using a 50% SPR from the 2009 rebuilding analysis.** |
| *COWCOD (Monterey)* | Not yet available. Revised DB-SRA estimate. |
| **DARKBLOTCHED** | **Projected using a 50% SPR from the 2011 rebuilding analysis.** |
| PACIFIC OCEAN PERCH | Projected using a 50% SPR from the 2011 rebuilding analysis. |
| **PETRALE SOLE** | **Projected using a 30% SPR from the 2011 rebuilding analysis.** |
| YELLOWEYE | Projected using a 50% SPR from the 2011 rebuilding analysis. |
| **NON-OVERFISHED STOCKS** | |
| Arrowtooth Flounder | Projected using a 30% SPR from the 2007 full assessment. |
| Black Rockfish (OR-CA) | Projected using a 50% SPR from the 2007 full assessment with the addition of the northern OFL 3% reduction to account for the portion of the stock estimated between Cape Falcon and the Columbia River. |
| Black Rockfish (WA) | Projected using a 50% SPR from the 2007 full assessment with a 3% reduction to account for the portion of the stock estimated between Cape Falcon and the Columbia River. |
| Cabezon (CA) | Projected using a 45% SPR from the 2009 full assessment. |
| Cabezon (OR) | Projected using a 45% SPR from the 2009 full assessment. |
| California scorpionfish | Projected using a 45% SPR from the 2005 full assessment. |
| Chilipepper S. of 40°10' N. latitude | Projected using a 50% SPR from the 2007 full assessment. The portion of the coastwide stock south of 40°10' N. lat. (93%) is based on average historical landings. |
| Dover Sole | Projected using a 30% SPR from the 2011 full assessment. |
| **English Sole** | **Projected using a 30% SPR from the 2013 data-moderate assessment.** |
| Lingcod N. of 40°10' N. latitude | Projected using a 45% SPR from the 2009 full assessment with 48% of the OFL S. of 42° N. latitude added to account for line shift. |
| Lingcod S. of 40°10' N. latitude | Projected using a 45% SPR from the 2009 full assessment with 48% of the OFL S. of 42° N. latitude subtracted to account for line shift. |
| Longnose skate | Projected using a 50% SPR from the 2007 full assessment. 2015 and 2016 OFLs projected using the status quo 45% SPR rate are 2,745 and 2,686 mt, respectively. |
| **Longspine Thornyhead (coastwide)** | **Projected using a 50% SPR from the 2013 full assessment.** |
| Pacific Cod | Status quo OFL. |
| Sablefish (coastwide) | Projected using a 45% SPR from the 2011 full assessment. |
| Shortbelly | MSY estimated from 2007 assessment. |
| **Shortspine Thornyhead** | **Projected using a 50% SPR from the 2013 full assessment.** |

| Stock | Comments |
|---|---|
| **(coastwide)** | |
| Splitnose S. of 40°10' N. latitude | Projected using a 50% SPR from the 2009 full assessment. The portion of the coastwide stock south of 40°10' N. lat. (64.2%) is based on average historical (1916-2008) landings. |
| Starry Flounder | Projected using a 30% SPR from the 2005 full assessment. |
| Widow | Projected using a 50% SPR from the 2011 full assessment. |
| **Yellowtail N. of 40°10' N. latitude** | **Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| **STOCK COMPLEXES** | |
| Minor Nearshore Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| *Black and yellow* | *DB-SRA estimate.* |
| *Blue (CA)* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the assessed stock in CA north of 40°10' N. lat. (12.7%) is based on average historical landings.* |
| *Blue (OR & WA)* | *DCAC estimate.* |
| ***Brown*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Calico* | *DB-SRA estimate.* |
| ***China*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| ***Copper*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Gopher* | *No harvest contribution (3a stock).* |
| *Grass* | *DB-SRA estimate.* |
| *Kelp* | *DB-SRA estimate.* |
| *Olive* | *DB-SRA estimate.* |
| *Quillback* | *DB-SRA estimate.* |
| *Treefish* | *DB-SRA estimate.* |
| Minor Shelf Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| *Bronzespotted* | *DB-SRA estimate.* |
| *Bocaccio* | *DB-SRA estimate.* |
| *Chameleon* | *No harvest contribution (3a stock).* |
| *Chilipepper* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the coastwide stock north of 40°10' N. lat. (7%) is based on average historical landings.* |
| *Cowcod* | *No harvest contribution (3a stock).* |
| *Flag* | *DB-SRA estimate.* |
| *Freckled* | *No harvest contribution (3a stock).* |
| *Greenblotched* | *DB-SRA estimate.* |
| *Greenspotted 40°10' to 42° N. latitude* | *Projection using a 50% SPR from the full 2011 assessment. The portion of the assessed area north of 40°10' N lat. (22.2% of OFL from northern California model) based on average historical catch.* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *DCAC estimate* |
| *Greenstriped* | *Projected using a 50% SPR from the full 2009 assessment. The portion of the coastwide stock north of 40°10' N. lat. (84.5%) is based on the* |

| Stock | Comments |
|---|---|
| | |
| | *mean of the 2003-2008 swept area biomass estimates from the NMFS trawl survey.* |
| *Halfbanded* | *No harvest contribution (3a stock).* |
| *Harlequin* | *DB-SRA estimate.* |
| *Honeycomb* | *DB-SRA estimate.* |
| *Mexican* | *DB-SRA estimate.* |
| *Pink* | *DB-SRA estimate.* |
| *Pinkrose* | *DB-SRA estimate.* |
| *Puget Sound* | *No harvest contribution (3a stock).* |
| *Pygmy* | *No harvest contribution (3a stock).* |
| *Redstripe* | *DB-SRA estimate.* |
| *Rosethorn* | *DB-SRA estimate.* |
| *Rosy* | *DB-SRA estimate.* |
| *Silvergray* | *DB-SRA estimate.* |
| *Speckled* | *DB-SRA estimate.* |
| *Squarespot* | *DB-SRA estimate.* |
| *Starry* | *DB-SRA estimate.* |
| ***Stripetail*** | ***DB-SRA estimate. Only status determined from 2013 data-moderate assessment, so presumed to remain a cat. 3 stock.*** |
| *Swordspine* | *DB-SRA estimate.* |
| *Tiger* | *DB-SRA estimate.* |
| *Vermilion* | *DB-SRA estimate.* |
| Minor Slope Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| ***Aurora*** | ***Projected using a 50% SPR from the 2013 full assessment. The portion of the coastwide stock north of 40º10' N lat. (19%) is based on average survey biomass.*** |
| *Bank* | *DB-SRA estimate.* |
| *Blackgill* | *DCAC estimate.* |
| *Redbanded* | *DB-SRA estimate.* |
| ***Rougheye*** | ***Projected using a 50% SPR from the 2013 full assessment. The coastwide OFLs are apportioned north (98%) and south (2%) based on average landings during 1985-2012.*** |
| ***Sharpchin*** | ***Coastwide OFLs projected using a 50% SPR from the 2013 data-moderate assessment. OFLs are apportioned north and south of 40º10' N lat. (80%N, 20% S) based on average swept area biomass estimates from the triennial survey.*** |
| *Shortraker* | *DB-SRA estimate.* |
| *Splitnose* | *Projected using a 50% SPR from the 2009 full assessment. The portion of the coastwide stock north of 40°10' N. lat. (35.8%) is based on average historical (1916-2008) landings.* |
| *Yellowmouth* | *DB-SRA estimate.* |
| Minor Nearshore Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| *Shallow Nearshore Species* | |
| *Black and yellow* | *DB-SRA estimate.* |

| Stock | Comments |
|---|---|
| ***China*** | **Not yet available.  Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Gopher (N of Pt. Conception)* | *Projected using a 50% SPR from the 2005 full assessment.* |
| *Gopher (S of Pt. Conception)* | *DCAC estimate.* |
| *Grass* | *DB-SRA estimate.* |
| *Kelp* | *DB-SRA estimate.* |
| *Deeper Nearshore Species* | |
| *Blue (assessed area)* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the assessed stock in CA south of 40°10' N. lat. (87.3%) is based on average historical landings.* |
| *Blue (S of 34 °27' N. latitude)* | *DCAC estimate.* |
| ***Brown*** | **Not yet available.  Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Calico* | *DB-SRA estimate.* |
| ***Copper*** | **Not yet available.  Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Olive* | *DB-SRA estimate.* |
| *Quillback* | *DB-SRA estimate.* |
| *Treefish* | *DB-SRA estimate.* |
| Minor Shelf Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| *Bronzespotted* | *DB-SRA estimate.* |
| *Chameleon* | *No harvest contribution (3a stock).* |
| *Flag* | *DB-SRA estimate.* |
| *Freckled* | *No harvest contribution (3a stock).* |
| *Greenblotched* | *DB-SRA estimate.* |
| *Greenspotted* | *Projection using a 50% SPR from the full 2011 assessment. The portion of the assessed area south of 40°10' N lat. (77.8% of OFL from northern California model from average historical catch + the OFL from the southern California model)* |
| *Greenstriped* | *Projected using a 50% SPR from the full 2009 assessment.  The portion of the coastwide stock south of 40°10' N. lat. (15.5%) is based on the mean of the 2003-2008 swept area biomass estimates from the NMFS trawl survey.* |
| *Halfbanded* | *No harvest contribution (3a stock).* |
| *Harlequin* | *DB-SRA estimate.* |
| *Honeycomb* | *DB-SRA estimate.* |
| *Mexican* | *DB-SRA estimate.* |
| *Pink* | *DB-SRA estimate.* |
| *Pinkrose* | *DB-SRA estimate.* |
| *Pygmy* | *No harvest contribution (3a stock).* |
| *Redstripe* | *DB-SRA estimate.* |
| *Rosethorn* | *DB-SRA estimate.* |
| *Rosy* | *DB-SRA estimate.* |
| *Silvergray* | *DB-SRA estimate.* |

| Stock | Comments |
|---|---|
| *Speckled* | *DB-SRA estimate.* |
| *Squarespot* | *DB-SRA estimate.* |
| *Starry* | *DB-SRA estimate.* |
| ***Stripetail*** | ***DB-SRA estimate. Only status determined from 2013 data-moderate assessment, so presumed to remain a cat. 3 stock.*** |
| *Swordspine* | *DB-SRA estimate.* |
| *Tiger* | *DB-SRA estimate.* |
| *Vermilion* | *DB-SRA estimate.* |
| *Yellowtail* | *DB-SRA estimate.* |
| Minor Slope Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| ***Aurora*** | ***Projected using a 50% SPR from the 2013 full assessment. The portion of the coastwide stock south of 40º10' N lat. (81%) is based on average survey biomass.*** |
| *Bank* | *DB-SRA estimate.* |
| *Blackgill* | *Projected using a 50% SPR from the 2011 full assessment.* |
| *Pacific ocean perch* | *No harvest contribution (3a stock).* |
| *Redbanded* | *DB-SRA estimate.* |
| ***Rougheye*** | ***Projected using a 50% SPR from the 2013 full assessment. The coastwide OFLs are apportioned north (98%) and south (2%) based on average landings during 1985-2012.*** |
| ***Sharpchin*** | ***Coastwide OFLs projected using a 50% SPR from the 2013 data-moderate assessment. OFLs are apportioned north and south of 40º10' N lat. (80%N, 20% S) based on average swept area biomass estimates from the triennial survey.*** |
| *Shortraker* | *DB-SRA estimate.* |
| *Yellowmouth* | *DB-SRA estimate.* |
| Other Flatfish | Sum of OFL contributions of component stocks in the complex. |
| *Butter sole* | *Based on the average catch during 1994-1998 + a 60% discard rate estimated from the EDCP study.* |
| *Curlfin sole* | *Based on the average catch during 1994-1998 + a 60% discard rate estimated from the EDCP study.* |
| *Flathead sole* | *Max. catch = 35 mt in 2005* |
| ***Pacific sanddab*** | ***DB-SRA estimate. Only status determined from 2013 full assessment, so presumed to remain a cat. 3 stock.*** |
| ***Rex sole*** | ***Projected using a 50% SPR from the 2013 data-moderate assessment.*** |
| *Rock sole* | *DB-SRA estimate.* |
| *Sand sole* | *DB-SRA estimate.* |
| Other Fish a/ | No analytical basis for the status quo OFL. |
| *Big skate* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Cabezon (WA)* | |
| *California skate* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Finescale codling* | |
| *Kelp greenling (CA)* | *DB-SRA estimate.* |
| *Kelp greenling (OR & WA)* | |
| *Leopard shark* | *DB-SRA estimate.* |
| *Pacific grenadier* | *Derived from survey biomass and MSY harvest rate estimates* |

| Stock | Comments |
|---|---|
| *Ratfish* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Soupfin shark* | *DCAC estimate.* |
| *Spiny dogfish* | *Projected using a 50% SPR from the 2011 full assessment.  2015 and 2016 OFLs projected using the status quo 50% SPR rate are 2,921 and 2,893 mt, respectively.* |

Table 3. Relationship between the overfishing probability (P*) and the percent reduction of the OFL for deciding the 2015 and 2016 ABCs for category 1, aurora rockfish, widow rockfish, shortspine thornyhead, category 2, and category 3 stocks based on sigma (σ) values (i.e., biomass variances) of 0.36, 0.39, 0.41, 0.45, 0.72, and 1.44, respectively.

| P* | Assessment Uncertainty (σ) | | | | | |
|---|---|---|---|---|---|---|
| | Cat. 1<br>0.36 | Aurora<br>0.39 | Widow<br>0.41 | Shortspine<br>0.45 | Cat. 2<br>0.72 | Cat. 3<br>1.44 |
| 0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.45 | 4.4% | 4.8% | 5.0% | 5.5% | 8.7% | 16.6% |
| 0.44 | 5.3% | | 6.0% | | 10.3% | 19.5% |
| 0.43 | 6.2% | | 7.0% | | 11.9% | 22.4% |
| 0.42 | 7.0% | | 7.9% | | 13.5% | 25.2% |
| 0.41 | 7.9% | | 8.9% | | 15.1% | 27.9% |
| 0.4 | 8.7% | 9.4% | 9.9% | 10.8% | 16.7% | 30.6% |
| 0.39 | 9.6% | | 10.8% | | 18.2% | 33.1% |
| 0.38 | 10.4% | | 11.8% | | 19.7% | 35.6% |
| 0.37 | 11.3% | | 12.7% | | 21.3% | 38.0% |
| 0.36 | 12.1% | | 13.7% | | 22.7% | 40.3% |
| 0.35 | 13.0% | 14.0% | 14.6% | 16.0% | 24.2% | 42.6% |
| 0.34 | 13.8% | | 15.6% | | 25.7% | 44.8% |
| 0.33 | 14.6% | | 16.5% | | 27.1% | 46.9% |
| 0.32 | 15.5% | | 17.4% | | 28.6% | 49.0% |
| 0.31 | 16.3% | | 18.4% | | 30.0% | 51.0% |
| 0.3 | 17.2% | 18.5% | 19.3% | 21.0% | 31.4% | 53.0% |
| 0.29 | 18.1% | | 20.3% | | 32.9% | 54.9% |
| 0.28 | 18.9% | | 21.3% | | 34.3% | 56.8% |
| 0.27 | 19.8% | | 22.2% | | 35.7% | 58.6% |
| 0.26 | 20.7% | | 23.2% | | 37.1% | 60.4% |
| 0.25 | 21.6% | 23.1% | 24.2% | 26.2% | 38.5% | 62.1% |
| 0.24 | 22.5% | | 25.1% | | 39.9% | 63.8% |
| 0.23 | 23.4% | | 26.1% | | 41.3% | 65.5% |
| 0.22 | 24.3% | | 27.1% | | 42.6% | 67.1% |
| 0.21 | 25.2% | | 28.2% | | 44.0% | 68.7% |
| 0.2 | 26.1% | 28.0% | 29.2% | 31.5% | 45.4% | 70.2% |
| 0.19 | 27.1% | | 30.2% | | 46.9% | 71.8% |
| 0.18 | 28.1% | | 31.3% | | 48.3% | 73.2% |
| 0.17 | 29.1% | | 32.4% | | 49.7% | 74.7% |
| 0.16 | 30.1% | | 33.5% | | 51.1% | 76.1% |
| 0.15 | 31.1% | 33.2% | 34.6% | 37.3% | 52.6% | 77.5% |
| 0.14 | 32.2% | | 35.8% | | 54.1% | 78.9% |
| 0.13 | 33.3% | | 37.0% | | 55.6% | 80.2% |
| 0.12 | 34.5% | | 38.2% | | 57.1% | 81.6% |
| 0.11 | 35.7% | | 39.5% | | 58.7% | 82.9% |
| 0.1 | 37.0% | 39.3% | 40.9% | 43.8% | 60.3% | 84.2% |
| 0.09 | 38.3% | | 42.3% | | 61.9% | 85.5% |
| 0.08 | 39.7% | | 43.8% | | 63.6% | 86.8% |
| 0.07 | 41.2% | | 45.4% | | 65.4% | 88.1% |
| 0.06 | 42.9% | | 47.1% | | 67.4% | 89.3% |
| 0.05 | 44.7% | 47.3% | 49.1% | 52.3% | 69.4% | 90.6% |

Table 4. Proposed stock categories and a range of alternative 2015 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| **OVERFISHED STOCKS** | | | | | | | | | | |
| **BOCACCIO S. of 40⁰10' N. latitude** | **874** | **1** | **836** | **798** | **761** | **724** | **685** | **646** | **602** | **551** |
| CANARY | 733 | 1 | 701 | 669 | 638 | 607 | 575 | 542 | 505 | 462 |
| COWCOD S. of 40⁰10' N. latitude | NA | | NA | NA | NA | NA | NA | NA | NA | NA |
| ***COWCOD (Conception)*** | ***NA*** | ***2*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | *NA* | *3* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| **DARKBLOTCHED** | **560** | **1** | **535** | **511** | **487** | **464** | **439** | **414** | **386** | **353** |
| PACIFIC OCEAN PERCH | 842 | 1 | 805 | 769 | 733 | 697 | 660 | 622 | 580 | 530 |
| **PETRALE SOLE** | **2,738** | **1** | **2,618** | **2,500** | **2,382** | **2,267** | **2,147** | **2,023** | **1,886** | **1,725** |
| YELLOWEYE | 52 | 2 | 47 | 43 | 39 | 35 | 32 | 28 | 24 | 20 |
| **NON-OVERFISHED STOCKS** | | | | | | | | | | |
| Arrowtooth Flounder | 6,599 | 2 | 6,025 | 5,497 | 5,002 | 4,527 | 4,058 | 3,603 | 3,128 | 2,620 |
| Black Rockfish (OR-CA) | 1,176 | 1 | 1,124 | 1,074 | 1,023 | 974 | 922 | 869 | 810 | 741 |
| Black Rockfish (WA) | 421 | 1 | 402 | 384 | 366 | 349 | 330 | 311 | 290 | 265 |
| Cabezon (CA) | 161 | 1 | 154 | 147 | 140 | 133 | 126 | 119 | 111 | 101 |
| Cabezon (OR) | 49 | 1 | 47 | 45 | 43 | 41 | 38 | 36 | 34 | 31 |
| California scorpionfish | 119 | 1 | 114 | 109 | 104 | 99 | 93 | 88 | 82 | 75 |
| Chilipepper S. of 40⁰10' N. latitude | 1,703 | 1 | 1,628 | 1,555 | 1,482 | 1,410 | 1,335 | 1,259 | 1,173 | 1,073 |
| Dover Sole | 66,871 | 1 | 63,929 | 61,053 | 58,178 | 55,369 | 52,427 | 49,418 | 46,074 | 42,129 |
| **English Sole** | **12,092** | **2** | **11,040** | **10,073** | **9,166** | **8,295** | **7,437** | **6,602** | **5,732** | **4,801** |
| Lingcod N. of 40º10' N. latitude | 3,010 | 1 | 2,830 | 2,659 | 2,494 | 2,334 | 2,172 | 2,010 | 1,835 | 1,637 |
| Lingcod S. of 40º10' N. latitude | 1,205 | 2 | 1,100 | 1,004 | 913 | 827 | 741 | 658 | 571 | 478 |
| Longnose skate | 2,449 | 1 | 2,341 | 2,236 | 2,130 | 2,027 | 1,920 | 1,810 | 1,687 | 1,543 |
| **Longspine Thornyhead (coastwide)** | **4,405** | **1** | **4,211** | **4,022** | **3,832** | **3,647** | **3,454** | **3,255** | **3,035** | **2,775** |
| Pacific Cod | 3,200 | 3 | 2,669 | 2,221 | 1,837 | 1,504 | 1,213 | 954 | 720 | 506 |
| Sablefish (coastwide) | 7,857 | 1 | 7,511 | 7,173 | 6,836 | 6,506 | 6,160 | 5,806 | 5,413 | 4,950 |
| Shortbelly | 6,950 | 2 | 6,345 | 5,789 | 5,268 | 4,768 | 4,274 | 3,795 | 3,294 | 2,759 |
| **Shortspine Thornyhead (coastwide)** | **3,204** | **1** | **3,028** | **2,858** | **2,691** | **2,531** | **2,365** | **2,195** | **2,009** | **1,801** |
| Splitnose S. of 40⁰10' N. latitude | 1,794 | 1 | 1,715 | 1,638 | 1,561 | 1,485 | 1,406 | 1,326 | 1,236 | 1,130 |
| Starry Flounder | 1,841 | 2 | 1,681 | 1,534 | 1,395 | 1,263 | 1,132 | 1,005 | 873 | 731 |
| Widow | 4,137 | 1 | 3,929 | 3,729 | 3,532 | 3,337 | 3,138 | 2,930 | 2,705 | 2,446 |
| **Yellowtail N. of 40⁰10' N. latitude** | **12,281** | **2** | **11,213** | **10,230** | **9,309** | **8,425** | **7,553** | **6,705** | **5,821** | **4,876** |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **STOCK COMPLEXES** | | | | | | | | | | |
| Minor Nearshore Rockfish North | 68 | | 59 | 51 | 44 | 38 | 32 | 27 | 22 | 17 |
| *Black and yellow* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Blue (CA)* | *27.4* | 2 | *25.0* | *22.9* | 20.8 | 18.8 | 16.9 | 15.0 | 13.0 | 10.9 |
| *Blue (OR & WA)* | *32.3* | 3 | *26.9* | *22.4* | 18.5 | 15.2 | 12.2 | 9.6 | 7.3 | 5.1 |
| ***Brown*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Calico* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***China*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Grass* | *0.7* | 3 | *0.5* | *0.5* | 0.4 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 |
| *Kelp* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Olive* | *0.3* | 3 | *0.3* | *0.2* | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| *Quillback* | *7.4* | 3 | *6.2* | *5.1* | 4.2 | 3.5 | 2.8 | 2.2 | 1.7 | 1.2 |
| *Treefish* | *0.2* | 3 | *0.2* | *0.2* | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Minor Shelf Rockfish North | 2,207 | | 1,943 | 1,711 | 1,505 | 1,316 | 1,141 | 978 | 818 | 657 |
| *Bronzespotted* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Bocaccio* | *284.0* | 3 | *236.9* | *197.1* | 163.0 | 133.5 | 107.6 | 84.6 | 63.9 | 44.9 |
| *Chameleon* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Chilipepper* | *128.2* | 3 | *106.9* | *88.9* | 73.6 | 60.2 | 48.6 | 38.2 | 28.8 | 20.3 |
| *Cowcod* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Flag* | *0.1* | 3 | *0.1* | *0.1* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Freckled* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Greenblotched* | *1.3* | 3 | *1.1* | *0.9* | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 |
| *Greenspotted 40°10' to 42° N. latitude* | *9.3* | 2 | 8.5 | 7.7 | 7.0 | 6.4 | 5.7 | 5.1 | 4.4 | 3.7 |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | *5.1* | *4.2* | 3.5 | 2.9 | 2.3 | 1.8 | 1.4 | 1.0 |
| *Greenstriped* | *1,281.9* | 2 | *1,170.3* | *1,067.8* | 971.7 | 879.4 | 788.3 | 699.9 | 607.6 | 508.9 |
| *Halfbanded* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Harlequin* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Honeycomb* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Mexican* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pink* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pinkrose* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Puget Sound* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Pygmy* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Redstripe* | *269.9* | 3 | *225.1* | *187.3* | 154.9 | 126.9 | 102.3 | 80.4 | 60.7 | 42.6 |
| *Rosethorn* | *12.9* | 3 | *10.8* | *9.0* | 7.4 | 6.1 | 4.9 | 3.8 | 2.9 | 2.0 |
| *Rosy* | *3.0* | 3 | *2.5* | *2.1* | 1.7 | 1.4 | 1.1 | 0.9 | 0.7 | 0.5 |
| *Silvergray* | *159.4* | 3 | *133.0* | *110.6* | 91.5 | 74.9 | 60.4 | 47.5 | 35.9 | 25.2 |
| *Speckled* | *0.2* | 3 | *0.1* | *0.1* | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| *Squarespot* | *0.2* | 3 | *0.1* | *0.1* | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| *Starry* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Stripetail*** | ***40.4*** | **3** | ***33.7*** | ***28.0*** | **23.2** | **19.0** | **15.3** | **12.0** | **9.1** | **6.4** |
| *Swordspine* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Tiger* | *1.0* | 3 | *0.8* | *0.7* | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.2 |
| *Vermilion* | *9.7* | 3 | *8.1* | *6.7* | 5.6 | 4.6 | 3.7 | 2.9 | 2.2 | 1.5 |
| Minor Slope Rockfish North | 1,804 | | 1,677 | 1,561 | 1,453 | 1,350 | 1,250 | 1,151 | 1,048 | 933 |
| ***Aurora*** | ***17.4*** | ***1*** | ***16.6*** | ***15.8*** | ***15.0*** | ***14.2*** | ***13.4*** | ***12.5*** | ***11.6*** | ***10.6*** |
| *Bank* | *17.2* | 3 | *14.4* | *12.0* | 9.9 | 8.1 | 6.5 | 5.1 | 3.9 | 2.7 |
| *Blackgill* | *4.7* | 3 | *3.9* | *3.3* | 2.7 | 2.2 | 1.8 | 1.4 | 1.1 | 0.7 |
| *Redbanded* | *45.3* | 3 | *37.7* | *31.4* | 26.0 | 21.3 | 17.2 | 13.5 | 10.2 | 7.2 |
| ***Rougheye*** | ***201.9*** | **1** | ***193*** | ***184*** | ***176*** | ***167*** | ***158*** | ***149*** | ***139*** | ***127*** |
| ***Sharpchin*** | ***305.6*** | ***2*** | ***279.0*** | ***254.6*** | ***231.6*** | ***209.6*** | ***187.9*** | ***166.9*** | ***144.9*** | ***121.3*** |
| *Shortraker* | *18.7* | 3 | *15.6* | *13.0* | 10.7 | 8.8 | 7.1 | 5.6 | 4.2 | 3.0 |
| *Splitnose* | *1,000.6* | 1 | *956.6* | *913.6* | 870.5 | 828.5 | 784.5 | 739.5 | 689.4 | 630.4 |
| *Yellowmouth* | *192.4* | 3 | *160.5* | *133.6* | 110.5 | 90.4 | 72.9 | 57.3 | 43.3 | 30.4 |
| Minor Nearshore Rockfish South | 793 | | 694 | 609 | 534 | 466 | 405 | 348 | 294 | 240 |
| *Shallow Nearshore Species* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Black and yellow* | 28 | 3 | *23.0* | *19.1* | *15.8* | *12.9* | *10.4* | *8.2* | *6.2* | *4.4* |
| ***China*** | **NA** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher (N of Pt. Conception)* | 148 | 1 | *141.5* | *135.1* | *128.8* | *122.5* | *116.0* | *109.4* | *102.0* | *93.2* |
| *Gopher (S of Pt. Conception)* | 26 | 3 | *21.4* | *17.8* | *14.7* | *12.0* | *9.7* | *7.6* | *5.8* | *4.0* |
| *Grass* | 60 | 3 | *49.7* | *41.4* | *34.2* | *28.0* | *22.6* | *17.8* | *13.4* | *9.4* |
| *Kelp* | 28 | 3 | *23.1* | *19.2* | *15.9* | *13.0* | *10.5* | *8.2* | *6.2* | *4.4* |
| *Deeper Nearshore Species* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Blue (assessed area)* | 189 | 2 | *172.2* | *157.1* | 142.9 | 129.4 | 116.0 | 103.0 | 89.4 | 74.9 |
| *Blue (S of 34 $^{o}$27' N. latitude)* | 73 | 3 | *60.8* | *50.6* | 41.8 | 34.3 | 27.6 | 21.7 | 16.4 | 11.5 |
| ***Brown*** | **NA** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Calico* | 0 | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Copper*** | **NA** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Olive* | 225 | 3 | *187.4* | *155.9* | 128.9 | 105.6 | 85.1 | 66.9 | 50.5 | 35.5 |
| *Quillback* | 5 | 3 | *4.5* | *3.7* | 3.1 | 2.5 | 2.0 | 1.6 | 1.2 | 0.9 |
| *Treefish* | 13 | 3 | *11.0* | *9.2* | 7.6 | 6.2 | 5.0 | 3.9 | 3.0 | 2.1 |
| Minor Shelf Rockfish South | 1,914 | | 1,621 | 1,372 | 1,156 | 967 | 800 | 648 | 509 | 378 |
| *Bronzespotted* | *3.6* | 3 | *3.0* | *2.5* | 2.1 | 1.7 | 1.4 | 1.1 | 0.8 | 0.6 |
| *Chameleon* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Flag* | *23.4* | 3 | *19.5* | *16.3* | 13.4 | 11.0 | 8.9 | 7.0 | 5.3 | 3.7 |
| *Freckled* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Greenblotched* | *23.1* | 3 | *19.3* | *16.1* | 13.3 | 10.9 | 8.8 | 6.9 | 5.2 | 3.7 |
| *Greenspotted* | *79.0* | 2 | *72.1* | *65.8* | *59.9* | *54.2* | *48.6* | *43.1* | *37.4* | *31.4* |
| *Greenstriped* | *235.1* | 2 | *214.7* | *195.9* | 178.2 | 161.3 | 144.6 | 128.4 | 111.5 | 93.3 |
| *Halfbanded* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Harlequin* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Honeycomb* | *9.9* | 3 | *8.2* | *6.8* | 5.7 | 4.6 | 3.7 | 2.9 | 2.2 | 1.6 |
| *Mexican* | *5.1* | 3 | *4.2* | *3.5* | 2.9 | 2.4 | 1.9 | 1.5 | 1.1 | 0.8 |
| *Pink* | *2.5* | 3 | *2.1* | *1.8* | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.4 |
| *Pinkrose* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pygmy* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Redstripe* | *0.5* | 3 | *0.4* | *0.3* | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| *Rosethorn* | *2.1* | 3 | *1.8* | *1.5* | 1.2 | 1.0 | 0.8 | 0.6 | 0.5 | 0.3 |
| *Rosy* | *44.5* | 3 | *37.1* | *30.9* | 25.5 | 20.9 | 16.9 | 13.3 | 10.0 | 7.0 |
| *Silvergray* | *0.5* | 3 | *0.4* | *0.4* | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 |
| *Speckled* | *39.4* | 3 | *32.8* | *27.3* | 22.6 | 18.5 | 14.9 | 11.7 | 8.9 | 6.2 |
| *Squarespot* | *11.1* | 3 | *9.2* | *7.7* | 6.4 | 5.2 | 4.2 | 3.3 | 2.5 | 1.8 |
| *Starry* | *62.6* | 3 | *52.2* | *43.4* | 35.9 | 29.4 | 23.7 | 18.6 | 14.1 | 9.9 |
| ***Stripetail*** | ***23.6*** | **3** | ***19.7*** | ***16.4*** | **13.6** | **11.1** | **9.0** | **7.0** | **5.3** | **3.7** |
| *Swordspine* | *14.2* | 3 | *11.9* | *9.9* | 8.2 | 6.7 | 5.4 | 4.2 | 3.2 | 2.2 |
| *Tiger* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Vermilion* | *269.3* | 3 | *224.6* | *186.9* | 154.6 | 126.6 | 102.1 | 80.2 | 60.6 | 42.5 |
| *Yellowtail* | *1,064.4* | 3 | *887.7* | *738.7* | 611.0 | 500.3 | 403.4 | 317.2 | 239.5 | 168.2 |
| Minor Slope Rockfish South | 806 | | 705 | 617 | 540 | 472 | 410 | 353 | 299 | 246 |
| ***Aurora*** | ***74.3*** | **1** | ***70.7*** | ***67.3*** | ***63.9*** | ***60.6*** | ***57.1*** | ***53.5*** | ***49.6*** | ***45.1*** |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Bank* | *503.2* | 3 | *419.7* | *349.2* | *288.8* | *236.5* | *190.7* | *150.0* | *113.2* | *79.5* |
| *Blackgill* | *137.0* | 1 | *131.0* | *125.1* | *119.2* | *113.4* | *107.4* | *101.2* | *94.4* | *86.3* |
| *Pacific ocean perch* | *0.0* | 3 | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| *Redbanded* | *10.4* | 3 | *8.7* | *7.2* | *6.0* | *4.9* | *3.9* | *3.1* | *2.3* | *1.6* |
| ***Rougheye*** | ***4.1*** | **1** | ***3.9*** | ***3.8*** | ***3.6*** | ***3.4*** | ***3.2*** | ***3.0*** | ***2.8*** | ***2.6*** |
| ***Sharpchin*** | ***76.4*** | **2** | ***69.8*** | ***63.6*** | ***57.9*** | ***52.4*** | ***47.0*** | ***41.7*** | ***36.2*** | ***30.3*** |
| *Shortraker* | *0.1* | 3 | *0.1* | *0.1* | *0.1* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| *Yellowmouth* | *0.8* | 3 | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.3* | *0.2* | *0.1* |
| Other Flatfish | 11,298 | | 9,865 | 8,620 | 7,517 | 6,521 | 5,606 | 4,758 | 3,939 | 3,126 |
| *Butter sole* | *4.6* | 3 | *3.9* | *3.2* | *2.7* | *2.2* | *1.8* | *1.4* | *1.0* | *0.7* |
| *Curlfin sole* | *8.2* | 3 | *6.9* | *5.7* | *4.7* | *3.9* | *3.1* | *2.5* | *1.9* | *1.3* |
| *Flathead sole* | *35.0* | 3 | *29.2* | *24.3* | *20.1* | *16.5* | *13.3* | *10.4* | *7.9* | *5.5* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | ***4,004.0*** | ***3,331.9*** | ***2,755.8*** | ***2,256.5*** | ***1,819.6*** | ***1,430.7*** | ***1,080.2*** | ***758.6*** |
| ***Rex sole*** | ***5,609.0*** | **2** | ***5,121.0*** | ***4,672.3*** | ***4,251.6*** | ***3,847.8*** | ***3,449.5*** | ***3,062.5*** | ***2,658.7*** | ***2,226.8*** |
| *Rock sole* | *66.7* | 3 | *55.6* | *46.3* | *38.3* | *31.3* | *25.3* | *19.9* | *15.0* | *10.5* |
| *Sand sole* | *773.2* | 3 | *644.8* | *536.6* | *443.8* | *363.4* | *293.0* | *230.4* | *174.0* | *122.2* |
| Other Fish | 6,374 | | 5,515 | 4,774 | 4,123 | 3,541 | 3,011 | 2,525 | 2,062 | 1,610 |
| *Big skate* | *458.0* | 3 | *382.0* | *317.9* | *262.9* | *215.3* | *173.6* | *136.5* | *103.1* | *72.4* |
| *Cabezon (WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *California skate* | *86.0* | 3 | *71.7* | *59.7* | *49.4* | *40.4* | *32.6* | *25.6* | *19.4* | *13.6* |
| *Finescale codling* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Kelp greenling (CA)* | *118.9* | 3 | *99.2* | *82.5* | *68.2* | *55.9* | *45.1* | *35.4* | *26.8* | *18.8* |
| *Kelp greenling (OR & WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Leopard shark* | *167.1* | 3 | *139.4* | *116.0* | *95.9* | *78.5* | *63.3* | *49.8* | *37.6* | *26.4* |
| *Pacific grenadier* | *1,519.0* | 3 | *1,266.8* | *1,054.2* | *871.9* | *713.9* | *575.7* | *452.7* | *341.8* | *240.0* |
| *Ratfish* | *1,441.0* | 3 | *1,201.8* | *1,000.1* | *827.1* | *677.3* | *546.1* | *429.4* | *324.2* | *227.7* |
| *Soupfin shark* | *61.6* | 3 | *51.4* | *42.8* | *35.4* | *29.0* | *23.3* | *18.4* | *13.9* | *9.7* |
| *Spiny dogfish* | *2,522.7* | 2 | *2,303.2* | *2,101.4* | *1,912.2* | *1,730.6* | *1,551.5* | *1,377.4* | *1,195.8* | *1,001.5* |

a/ No ABC contribution for these stocks given the lack of an approved method for estimating the OFL.

Table 5. Proposed stock categories and a range of alternative 2016 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.

| **Stock** | **2016 OFL** | **Category** | **Range of Alternative 2016 ABCs Overfishing Probability (P*)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **0.45** | **0.40** | **0.35** | **0.30** | **0.25** | **0.20** | **0.15** | **0.10** |
| | | | | | | | | | | |
| **OVERFISHED STOCKS** | | | | | | | | | | |
| **BOCACCIO S. of 40⁰10' N. latitude** | **871** | **1** | **833** | **796** | **758** | **722** | **683** | **644** | **600** | **549** |
| CANARY | 729 | 1 | 697 | 666 | 634 | 604 | 572 | 539 | 502 | 459 |
| COWCOD S. of 40⁰10' N. latitude | NA | | NA | NA | NA | NA | NA | NA | NA | NA |
| ***COWCOD (Conception)*** | ***NA*** | ***2*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | *NA* | *3* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| **DARKBLOTCHED** | **563** | **1** | **538** | **514** | **490** | **466** | **441** | **416** | **388** | **355** |
| PACIFIC OCEAN PERCH | 850 | 1 | 813 | 776 | 740 | 704 | 666 | 628 | 586 | 536 |
| **PETRALE SOLE** | **2,660** | **1** | **2,543** | **2,429** | **2,314** | **2,202** | **2,085** | **1,966** | **1,833** | **1,676** |
| YELLOWEYE | 52 | 2 | 47 | 43 | 39 | 35 | 32 | 28 | 24 | 20 |
| **NON-OVERFISHED STOCKS** | | | | | | | | | | |
| Arrowtooth Flounder | 6,396 | 2 | 5,840 | 5,328 | 4,848 | 4,388 | 3,934 | 3,492 | 3,032 | 2,539 |
| Black Rockfish (OR-CA) | 1,183 | 1 | 1,131 | 1,080 | 1,029 | 980 | 927 | 874 | 815 | 745 |
| Black Rockfish (WA) | 423 | 1 | 404 | 386 | 368 | 350 | 332 | 313 | 291 | 266 |
| Cabezon (CA) | 158 | 1 | 151 | 144 | 137 | 131 | 124 | 117 | 109 | 100 |
| Cabezon (OR) | 49 | 1 | 47 | 45 | 43 | 41 | 38 | 36 | 34 | 31 |
| California scorpionfish | 117 | 1 | 111 | 106 | 101 | 97 | 91 | 86 | 80 | 73 |
| Chilipepper S. of 40⁰10' N. latitude | 1,694 | 1 | 1,619 | 1,547 | 1,474 | 1,403 | 1,328 | 1,252 | 1,167 | 1,067 |
| Dover Sole | 59,221 | 1 | 56,615 | 54,069 | 51,522 | 49,035 | 46,429 | 43,764 | 40,803 | 37,309 |
| **English Sole** | **8,493** | **2** | **7,754** | **7,075** | **6,438** | **5,826** | **5,223** | **4,637** | **4,026** | **3,372** |
| Lingcod N. of 40º10' N. latitude | 2,891 | 1 | 2,719 | 2,555 | 2,398 | 2,245 | 2,089 | 1,934 | 1,766 | 1,577 |
| Lingcod S. of 40º10' N. latitude | 1,136 | 2 | 1,037 | 946 | 861 | 779 | 699 | 620 | 539 | 451 |
| Longnose skate | 2,405 | 1 | 2,299 | 2,196 | 2,092 | 1,991 | 1,885 | 1,777 | 1,657 | 1,515 |
| **Longspine Thornyhead (coastwide)** | **4,190** | **1** | **4,006** | **3,825** | **3,645** | **3,469** | **3,285** | **3,096** | **2,887** | **2,640** |
| Pacific Cod | 3,200 | 3 | 2,669 | 2,221 | 1,837 | 1,504 | 1,213 | 954 | 720 | 506 |
| Sablefish (coastwide) | 8,526 | 1 | 8,151 | 7,784 | 7,418 | 7,060 | 6,684 | 6,301 | 5,874 | 5,371 |
| Shortbelly | 6,950 | 2 | 6,345 | 5,789 | 5,268 | 4,768 | 4,274 | 3,795 | 3,294 | 2,759 |
| **Shortspine Thornyhead (coastwide)** | **3,168** | **1** | **2,994** | **2,826** | **2,661** | **2,503** | **2,338** | **2,170** | **1,986** | **1,780** |
| Splitnose S. of 40⁰10' N. latitude | 1,826 | 1 | 1,746 | 1,667 | 1,589 | 1,512 | 1,432 | 1,349 | 1,258 | 1,150 |
| Starry Flounder | 1,847 | 2 | 1,686 | 1,539 | 1,400 | 1,267 | 1,136 | 1,008 | 875 | 733 |
| Widow | 3,990 | 1 | 3,790 | 3,596 | 3,407 | 3,218 | 3,026 | 2,826 | 2,609 | 2,359 |
| **Yellowtail N. of 40⁰10' N. latitude** | **11,647** | **2** | **10,634** | **9,702** | **8,828** | **7,990** | **7,163** | **6,359** | **5,521** | **4,624** |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **STOCK COMPLEXES** | | | | | | | | | | |
| Minor Nearshore Rockfish North | 69 | | 59 | 51 | 44 | 38 | 33 | 27 | 22 | 17 |
| *Black and yellow* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Blue (CA)* | *27.7* | 2 | *25.3* | *23.1* | 21.0 | 19.0 | 17.0 | 15.1 | 13.1 | 11.0 |
| *Blue (OR & WA)* | *32.3* | 3 | *26.9* | *22.4* | 18.5 | 15.2 | 12.2 | 9.6 | 7.3 | 5.1 |
| ***Brown*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Calico* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***China*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Grass* | *0.7* | 3 | *0.5* | *0.5* | 0.4 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 |
| *Kelp* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Olive* | *0.3* | 3 | *0.3* | *0.2* | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| *Quillback* | *7.4* | 3 | *6.2* | *5.1* | 4.2 | 3.5 | 2.8 | 2.2 | 1.7 | 1.2 |
| *Treefish* | *0.2* | 3 | *0.2* | *0.2* | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| Minor Shelf Rockfish North | 2,217 | | 1,952 | 1,719 | 1,512 | 1,323 | 1,147 | 983 | 823 | 661 |
| *Bronzespotted* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Bocaccio* | *284.0* | 3 | *236.9* | *197.1* | 163.0 | 133.5 | 107.6 | 84.6 | 63.9 | 44.9 |
| *Chameleon* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Chilipepper* | *127.5* | 3 | *106.4* | *88.5* | 73.2 | 59.9 | 48.3 | 38.0 | 28.7 | 20.2 |
| *Cowcod* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Flag* | *0.1* | 3 | *0.1* | *0.1* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Freckled* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Greenblotched* | *1.3* | 3 | *1.1* | *0.9* | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 |
| *Greenspotted 40°10' to 42° N. latitude* | *9.3* | 2 | 8.5 | 7.7 | 7.0 | 6.4 | 5.7 | 5.1 | 4.4 | 3.7 |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | *5.1* | *4.2* | 3.5 | 2.9 | 2.3 | 1.8 | 1.4 | 1.0 |
| *Greenstriped* | *1,292.0* | 2 | *1,179.6* | *1,076.2* | 979.3 | 886.3 | 794.6 | 705.4 | 612.4 | 512.9 |
| *Halfbanded* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Harlequin* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Honeycomb* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Mexican* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pink* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pinkrose* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Puget Sound* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Pygmy* | 0.0 | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Redstripe* | 269.9 | 3 | 225.1 | 187.3 | 154.9 | 126.9 | 102.3 | 80.4 | 60.7 | 42.6 |
| *Rosethorn* | 12.9 | 3 | 10.8 | 9.0 | 7.4 | 6.1 | 4.9 | 3.8 | 2.9 | 2.0 |
| *Rosy* | 3.0 | 3 | 2.5 | 2.1 | 1.7 | 1.4 | 1.1 | 0.9 | 0.7 | 0.5 |
| *Silvergray* | 159.4 | 3 | 133.0 | 110.6 | 91.5 | 74.9 | 60.4 | 47.5 | 35.9 | 25.2 |
| *Speckled* | 0.2 | 3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| *Squarespot* | 0.2 | 3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| *Starry* | 0.0 | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Stripetail*** | **40.4** | **3** | **33.7** | **28.0** | **23.2** | **19.0** | **15.3** | **12.0** | **9.1** | **6.4** |
| *Swordspine* | 0.0 | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Tiger* | 1.0 | 3 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.2 |
| *Vermilion* | 9.7 | 3 | 8.1 | 6.7 | 5.6 | 4.6 | 3.7 | 2.9 | 2.2 | 1.5 |
| Minor Slope Rockfish North | 1,817 | | 1,691 | 1,574 | 1,465 | 1,363 | 1,262 | 1,163 | 1,059 | 944 |
| ***Aurora*** | **17.5** | **1** | **16.7** | **15.9** | **15.1** | **14.3** | **13.5** | **12.6** | **11.7** | **10.6** |
| *Bank* | 17.2 | 3 | 14.4 | 12.0 | 9.9 | 8.1 | 6.5 | 5.1 | 3.9 | 2.7 |
| *Blackgill* | 4.7 | 3 | 3.9 | 3.3 | 2.7 | 2.2 | 1.8 | 1.4 | 1.1 | 0.7 |
| *Redbanded* | 45.3 | 3 | 37.7 | 31.4 | 26.0 | 21.3 | 17.2 | 13.5 | 10.2 | 7.2 |
| ***Rougheye*** | **205.8** | **1** | **197** | **188** | **179** | **170** | **161** | **152** | **142** | **130** |
| ***Sharpchin*** | **297.6** | **2** | **271.7** | **247.9** | **225.6** | **204.2** | **183.0** | **162.5** | **141.1** | **118.1** |
| *Shortraker* | 18.7 | 3 | 15.6 | 13.0 | 10.7 | 8.8 | 7.1 | 5.6 | 4.2 | 3.0 |
| *Splitnose* | 1,018.2 | 1 | 973.4 | 929.6 | 885.8 | 843.0 | 798.2 | 752.4 | 701.5 | 641.4 |
| *Yellowmouth* | 192.4 | 3 | 160.5 | 133.6 | 110.5 | 90.4 | 72.9 | 57.3 | 43.3 | 30.4 |
| Minor Nearshore Rockfish South | 791 | | 692 | 607 | 532 | 464 | 403 | 346 | 292 | 238 |
| *Shallow Nearshore Species* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Black and yellow* | 27.5 | 3 | 23.0 | 19.1 | 15.8 | 12.9 | 10.4 | 8.2 | 6.2 | 4.4 |
| ***China*** | **NA** | **2** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| *Gopher (N of Pt. Conception)* | 144.0 | 1 | 137.7 | 131.5 | 125.3 | 119.2 | 112.9 | 106.4 | 99.2 | 90.7 |
| *Gopher (S of Pt. Conception)* | 25.6 | 3 | 21.4 | 17.8 | 14.7 | 12.0 | 9.7 | 7.6 | 5.8 | 4.0 |
| *Grass* | 59.6 | 3 | 49.7 | 41.4 | 34.2 | 28.0 | 22.6 | 17.8 | 13.4 | 9.4 |
| *Kelp* | 27.7 | 3 | 23.1 | 19.2 | 15.9 | 13.0 | 10.5 | 8.2 | 6.2 | 4.4 |
| *Deeper Nearshore Species* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| *Blue (assessed area)* | 190.3 | 2 | 173.8 | 158.5 | 144.3 | 130.6 | 117.0 | 103.9 | 90.2 | 75.6 |
| *Blue (S of 34°27’ N. latitude)* | 72.9 | 3 | 60.8 | 50.6 | 41.8 | 34.3 | 27.6 | 21.7 | 16.4 | 11.5 |
| ***Brown*** | **NA** | **2** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Calico* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Olive* | *224.6* | 3 | *187.4* | *155.9* | 128.9 | 105.6 | 85.1 | 66.9 | 50.5 | 35.5 |
| *Quillback* | *5.4* | 3 | *4.5* | *3.7* | 3.1 | 2.5 | 2.0 | 1.6 | 1.2 | 0.9 |
| *Treefish* | *13.2* | 3 | *11.0* | *9.2* | 7.6 | 6.2 | 5.0 | 3.9 | 3.0 | 2.1 |
| Minor Shelf Rockfish South | 1,915 | | 1,622 | 1,373 | 1,157 | 968 | 800 | 649 | 510 | 378 |
| *Bronzespotted* | *3.6* | 3 | *3.0* | *2.5* | 2.1 | 1.7 | 1.4 | 1.1 | 0.8 | 0.6 |
| *Chameleon* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Flag* | *23.4* | 3 | *19.5* | *16.3* | 13.4 | 11.0 | 8.9 | 7.0 | 5.3 | 3.7 |
| *Freckled* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Greenblotched* | *23.1* | 3 | *19.3* | *16.1* | 13.3 | 10.9 | 8.8 | 6.9 | 5.2 | 3.7 |
| *Greenspotted* | *78.4* | 2 | *71.6* | *65.3* | *59.5* | *53.8* | *48.2* | *42.8* | *37.2* | *31.1* |
| *Greenstriped* | *237.0* | 2 | *216.4* | *197.4* | 179.6 | 162.6 | 145.8 | 129.4 | 112.3 | 94.1 |
| *Halfbanded* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Harlequin* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Honeycomb* | *9.9* | 3 | *8.2* | *6.8* | 5.7 | 4.6 | 3.7 | 2.9 | 2.2 | 1.6 |
| *Mexican* | *5.1* | 3 | *4.2* | *3.5* | 2.9 | 2.4 | 1.9 | 1.5 | 1.1 | 0.8 |
| *Pink* | *2.5* | 3 | *2.1* | *1.8* | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.4 |
| *Pinkrose* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Pygmy* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Redstripe* | *0.5* | 3 | *0.4* | *0.3* | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| *Rosethorn* | *2.1* | 3 | *1.8* | *1.5* | 1.2 | 1.0 | 0.8 | 0.6 | 0.5 | 0.3 |
| *Rosy* | *44.5* | 3 | *37.1* | *30.9* | 25.5 | 20.9 | 16.9 | 13.3 | 10.0 | 7.0 |
| *Silvergray* | *0.5* | 3 | *0.4* | *0.4* | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 |
| *Speckled* | *39.4* | 3 | *32.8* | *27.3* | 22.6 | 18.5 | 14.9 | 11.7 | 8.9 | 6.2 |
| *Squarespot* | *11.1* | 3 | *9.2* | *7.7* | 6.4 | 5.2 | 4.2 | 3.3 | 2.5 | 1.8 |
| *Starry* | *62.6* | 3 | *52.2* | *43.4* | 35.9 | 29.4 | 23.7 | 18.6 | 14.1 | 9.9 |
| ***Stripetail*** | ***23.6*** | **3** | ***19.7*** | ***16.4*** | **13.6** | **11.1** | **9.0** | **7.0** | **5.3** | **3.7** |
| *Swordspine* | *14.2* | 3 | *11.9* | *9.9* | 8.2 | 6.7 | 5.4 | 4.2 | 3.2 | 2.2 |
| *Tiger* | *0.0* | 3 | *0.0* | *0.0* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Vermilion* | *269.3* | 3 | *224.6* | *186.9* | 154.6 | 126.6 | 102.1 | 80.2 | 60.6 | 42.5 |
| *Yellowtail* | *1,064.4* | 3 | *887.7* | *738.7* | 611.0 | 500.3 | 403.4 | 317.2 | 239.5 | 168.2 |
| Minor Slope Rockfish South | 807 | | 706 | 618 | 541 | 473 | 411 | 354 | 300 | 247 |
| ***Aurora*** | ***74.3*** | **1** | ***70.7*** | ***67.3*** | ***63.9*** | ***60.6*** | ***57.1*** | ***53.5*** | ***49.6*** | ***45.1*** |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Bank* | *503.2* | 3 | *419.7* | *349.2* | *288.8* | *236.5* | *190.7* | *150.0* | *113.2* | *79.5* |
| *Blackgill* | *140.0* | 1 | *133.8* | *127.8* | *121.8* | *115.9* | *109.8* | *103.5* | *96.5* | *88.2* |
| *Pacific ocean perch* | *0.0* | 3 | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| *Redbanded* | *10.4* | 3 | *8.7* | *7.2* | *6.0* | *4.9* | *3.9* | *3.1* | *2.3* | *1.6* |
| ***Rougheye*** | ***4.2*** | **1** | **4** | **4** | **4** | **3** | **3** | **3** | **3** | **3** |
| ***Sharpchin*** | ***74.4*** | **2** | ***67.9*** | ***62.0*** | ***56.4*** | ***51.0*** | ***45.8*** | ***40.6*** | ***35.3*** | ***29.5*** |
| *Shortraker* | *0.1* | 3 | *0.1* | *0.1* | *0.1* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| *Yellowmouth* | *0.8* | 3 | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.3* | *0.2* | *0.1* |
| Other Flatfish | 9,948 | | 8,633 | 7,496 | 6,494 | 5,595 | 4,775 | 4,021 | 3,299 | 2,590 |
| *Butter sole* | *4.6* | 3 | *3.9* | *3.2* | *2.7* | *2.2* | *1.8* | *1.4* | *1.0* | *0.7* |
| *Curlfin sole* | *8.2* | 3 | *6.9* | *5.7* | *4.7* | *3.9* | *3.1* | *2.5* | *1.9* | *1.3* |
| *Flathead sole* | *35.0* | 3 | *29.2* | *24.3* | *20.1* | *16.5* | *13.3* | *10.4* | *7.9* | *5.5* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | ***4,004.0*** | ***3,331.9*** | ***2,755.8*** | ***2,256.5*** | ***1,819.6*** | ***1,430.7*** | ***1,080.2*** | ***758.6*** |
| ***Rex sole*** | ***4,259.0*** | **2** | ***3,888.5*** | ***3,547.7*** | ***3,228.3*** | ***2,921.7*** | ***2,619.3*** | ***2,325.4*** | ***2,018.8*** | ***1,690.8*** |
| *Rock sole* | *66.7* | 3 | *55.6* | *46.3* | *38.3* | *31.3* | *25.3* | *19.9* | *15.0* | *10.5* |
| *Sand sole* | *773.2* | 3 | *644.8* | *536.6* | *443.8* | *363.4* | *293.0* | *230.4* | *174.0* | *122.2* |
| Other Fish | 6,355 | 0 | 5,498 | 4,758 | 4,108 | 3,527 | 2,999 | 2,515 | 2,053 | 1,602 |
| *Big skate* | *458.0* | 3 | *382.0* | *317.9* | *262.9* | *215.3* | *173.6* | *136.5* | *103.1* | *72.4* |
| *Cabezon (WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *California skate* | *86.0* | 3 | *71.7* | *59.7* | *49.4* | *40.4* | *32.6* | *25.6* | *19.4* | *13.6* |
| *Finescale codling* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Kelp greenling (CA)* | *118.9* | 3 | *99.2* | *82.5* | *68.2* | *55.9* | *45.1* | *35.4* | *26.8* | *18.8* |
| *Kelp greenling (OR & WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Leopard shark* | *167.1* | 3 | *139.4* | *116.0* | *95.9* | *78.5* | *63.3* | *49.8* | *37.6* | *26.4* |
| *Pacific grenadier* | *1,519.0* | 3 | *1,266.8* | *1,054.2* | *871.9* | *713.9* | *575.7* | *452.7* | *341.8* | *240.0* |
| *Ratfish* | *1,441.0* | 3 | *1,201.8* | *1,000.1* | *827.1* | *677.3* | *546.1* | *429.4* | *324.2* | *227.7* |
| *Soupfin shark* | *61.6* | 3 | *51.4* | *42.8* | *35.4* | *29.0* | *23.3* | *18.4* | *13.9* | *9.7* |
| *Spiny dogfish* | *2,503.3* | 2 | *2,285.5* | *2,085.2* | *1,897.5* | *1,717.2* | *1,539.5* | *1,366.8* | *1,186.5* | *993.8* |

a/ No ABC contribution for these stocks given the lack of an approved method for estimating the OFL.

# Management Strategy Evaluation for Rebuilding Revision Rules: A Proof of Concept

André E. Punt
School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195 USA

**Summary**
Rebuilding Revision Rules are decision rules which relate to how to change management actions in response to changes in the outcomes of Rebuilding Analyses. It is possible to develop many alternative Rebuilding Revision Rules (and they can be combined, with various components perhaps interacting in unexpected ways). This document outlines a management strategy evaluation which could be used to compare alternative Rebuilding Revision Rules. The document is primarily a "proof of concept" to show that it is possible to develop the MSE. However, illustrative results are shown for two example strategies.

## Introduction

Rebuilding Plans are required for stocks which are assessed to be below the Minimum Stock Size Threshold (MSST). Rebuilding Plans involve identifying a target year for recovery to the proxy for $B_{\mathrm{MSY}}$ (denoted $\mathrm{T_{TARGET}}$), and the adjusting fishing mortality (usually expressed as a Spawning Potential Ratio, SPR, for US west coast groundfish stocks) so that recovery occurs at or before $\mathrm{T_{TARGET}}$. $\mathrm{T_{TARGET}}$ is constrained to be less than $\mathrm{T_{MAX}}$, which is 10 years after the stock was declared overfished or one mean generation time plus the time to recover to the $B_{\mathrm{MSY}}$ proxy if there were no future catches (i.e. $\mathrm{T_{MIN}}$ plus one mean generation).

The biological information on which to select $\mathrm{T_{TARGET}}$ ($\mathrm{T_{MAX}}$ is a biological concept) relates to projections of rates of recovery to the proxy for $B_{\mathrm{MSY}}$ under different harvest strategies (usually levels of constant SPR, but perhaps also with a phase-in). The results of projections under different harvest strategies (and sometimes alternative states of nature) are referred to as a "Rebuilding Analysis".

Rebuilding Plans need to be reviewed every two years. For stocks with no new information, or for which no assessment is conducted, this may involve comparing the actual catches with those expected under the Rebuilding Plan. However, the information on a rebuilding stock does generally change over time. The changes can be "mild", such as the addition of new survey results and fishery length and age data, or "severe" such as a change to the assumed rate of natural mortality, the steepness of the stock recruitment relationship or the time-series of historical catches. Consequently, the results from projections will change even if management has followed the currently-adopted Rebuilding Plan[1]. Rebuilding Revision Rules involve (1) assessing adequacy of progress toward rebuilding and (2) altering Rebuilding Plans, given a change in stock status (Punt and Ralston, 2007).

There are, however, many possible Rebuilding Revision Rules, and it is not clear how they are likely to perform. Management Strategy Evaluation (MSE, Smith, 1994) involves using simulation testing to evaluate the performance of candidate management rules. In this context, management rules are the combination of the assessment method used to estimate stock status and productivity, and the control rules which translate these estimates into allowable catch levels (the "Rebuilding Revision Rules").

This document describes a MSE framework which could be used to evaluate alternative Rebuilding Revision Rules. As such, it provides a "proof of concept" to allow the Council

[1] Note that there will always be changes to projection outcomes because projections are conducted under the assumption that future recruitment will be randomly distributed about some average value. A new assessment will provide information on (recent) recruitments which would in the past have assumed to have been random.

and its advisory bodies to decide whether they wish to use MSE to compare alternative Rebuilding Rules. The document outlines a (simple) operating model, how assessments are conducted and two example Rebuilding Revision Rules. It also provides some example diagnostic plots and tables which could be used to quantify the performance of Rebuilding Revision Rules relative to Council goals and legal mandates.

**Methods**

*Overview*

The Management Strategy Evaluation involves three key components: (a) the operating model, which reflects the "truth" for the simulations, (b) the assessment method, and (c) the harvest control rules. An assessment is conducted every $4^{th}$ year, and the subsequent application of the harvest control rules lead to catch limits (which are assumed to be taken exactly) for the next four years.

*Operating model*

The operating model is an age- and sex-structured population dynamics model (Appendix A). The historical level of fishing effort is pre-specified while the catchability coefficient is selected so that the spawning biomass when assessments are first conducted is 10% of $B_0$. The data available for assessment purposes are the catches, a survey index of relative abundance, and fishery and survey age-composition data. The data on which the illustrative example is based are assumed to be highly informative. It is assumed that steepness is known exactly as is natural mortality and weight- and fecundity-at-age.

*Assessment method*

The assessment is based on Stock Synthesis 3 (Methot and Wetzel, 2013). The parameters which are estimated each time an assessment is conducted are $B_0$, the parameters which define logistic selectivity functions for the fishery and the survey, and the annual deviations about the stock-recruitment relationship.

*Harvest control rule*

Two harvest control rules are evaluated. The two harvest control rules: "50%-rule" and "flexible" have several features in common, as outlined below, but differ in terms of how they deal with cases in which a Rebuilding Plan is implemented and has not "failed". The harvest control rule for setting harvest specifications for year *y* (based on assessment with data up to year *y*-1) is:

A. If $S_y / S_0 \geq 0.4$, the stock is rebuilt so set catch limits to the ABCs. Stop (denoted Case X).
B. If $0.25 \leq S_y / S_0 < 0.4$ and the stock is not currently under a Rebuilding Plan, set the catch limits based on the 40-10 harvest control rule. Stop (denoted Case -X).
C. If $S_y / S_0 < 0.25$ and the stock is not currently under a Rebuilding Plan:
    a. Conduct a rebuilding analysis to determine $T_{MAX}$.
    b. Determine $T_{TARGET}$ so that there is a 0.6 probability of rebuilding to $0.4B_0$ by $T_{MAX}$.
    c. Set $SPR_{current}$ so that the probability of rebuilding by $T_{TARGET}$ is 0.5.
    d. Calculate the catch limits for the next four years based on $SPR_{current}$.
    e. Stop (denoted Case 0).

D. If $S_y / S_0$ < 0.4, the stock is currently under a Rebuilding Plan, and the year is beyond $T_{MAX}$, "Reboot", i.e. start a new Rebuilding Plan (reset $T_{MAX}$ and $T_{TARGET}$), but do not let SPR increase as a result of this. Stop (denoted Case 3).

E. If $S_y / S_0$ < 0.4, the stock is currently under a Rebuilding Plan, and the year is beyond $T_{TARGET}$ but not $T_{MAX}$:
   a. Set $T_{TARGET}$ equal to $T_{MAX}$ and try to find the SPR so that the probability of rebuilding to $0.4B_0$ is 0.5 by the new $T_{TARGET}$.
   b. If this SPR exists then set $SPR_{current}$ and compute catch limits for the next four years. Stop.
   c. If this SPR does not exist then "reboot", i.e. start a new Rebuilding Plan (reset $T_{MAX}$ and $T_{TARGET}$), but do not let SPR increase as a result of this. Stop.

F. If $S_y / S_0$ < 0.4, the stock is currently under a Rebuilding Plan and the year is not yet $T_{TARGET}$:
   a. Strategy "flexible"
      i. Project forward under $SPR_{current}$.
      ii. If the probability of rebuilding to $0.4B_0$ at least 0.4, set the catch limits for the next four years based on $SPR_{current}$. Stop (denoted Case 1).
      iii. If there is an SPR which corresponds to a 0.5 probability of rebuilding to $0.4B_0$ by $T_{MAX}$, set $SPR_{current}$ to this SPR, reset $T_{TARGET}$ to $T_{MAX}$, and compute catch limits for the next four years. Stop (denoted Case 2).
      iv. "Reboot", i.e. start a new Rebuilding Plan (reset $T_{MAX}$ and $T_{TARGET}$), but do not let SPR increase as a result of this. Stop.
   b. Strategy "50% rule"
      i. If there is an SPR which corresponds to a 0.5 probability of rebuilding to $0.4B_0$ by $T_{TARGET}$, set $SPR_{current}$ to this SPR, compute catch limits for the next four years. Stop (denoted Case 5).
      ii. If there is an SPR which corresponds to a 0.5 probability of rebuilding to $0.4B_0$ by $T_{MAX}$, set $SPR_{current}$ to this SPR, reset $T_{TARGET}$ to $T_{MAX}$, and compute catch limits for the next four years. Stop (denoted Case 2).
      iii. "Reboot", i.e. start a new Rebuilding Plan (reset $T_{MAX}$ and $T_{TARGET}$) but do not let SPR increase as a result of this. Stop.

*Performance metrics*

The performance metrics can be divided into those which are graphical and those which are numerical. An example graphical summary is provided and discussed below.

Punt and Ralston (2007) note that there are many statistics that could be used to summarize the performance of a management strategy. They focused on five principal management goals: (a) a high probability of the stock recovering by the $T_{MAX}$ selected when the Rebuilding Plan was originally developed[2], (b) high catches during rebuilding, (c) low inter-annual variation in catches, (d) stability in the Rebuilding Plan (i.e., minimizing changes to the value of $T_{MAX}$[2]), and (e) simplicity. Punt and Ralston (2007) noted that the first three of these five goals are typical of those commonly selected when conducting an MSE. The fourth goal is included because it measures the "administrative cost" of a management strategy; changing the SPR used to set the harvest guideline and changing harvest guidelines themselves is relatively straightforward administratively. In contrast, a reboot may require an amendment to the Fishery Management Plan. Punt and Ralston (2007) argue that the

[2] Given clarity in what is required in a Rebuilding Plan since Punt and Ralston (2007) was published, $T_{MAX}$ would need to be replaced by $T_{TARGET}$ if a metric along these lines was considered, and this is what was done for the example application.

importance of the goal of simplicity cannot be overstated. It is likely that the PFMC would select a simple set of Rebuilding Revision Rules over a more complicated set even if the performance of the more complicated set was marginally better than that of the simple set, purely because of the need for the public to know how decisions are made regarding the management of overfished stocks.

The (example / illustrative) performance measures used to quantify these five goals are:

1. The "rebuilding ratio," the ratio of the number of years before the stock was assessed to be rebuilt divided by the number of years that it was expected that rebuilding would take based on the original Rebuilding Plan, i.e., if the rebuilding ratio exceeds unity then rebuilding is perceived to have taken longer than originally expected.
2. A measure of the variability of the catches (abbreviation AAV), defined as:

$$AAV = 100 \frac{\sum_y \left| C_y - C_{y+1} \right|}{\sum_y C_y} \qquad (1)$$

   where $C_y$ is the catch during year $y$.
3. The average catch during the years when the resource was under a Rebuilding Plan.
4. The average catch during the first ten years of the rebuilding period.
5. The number of times it was necessary to "reboot".

Punt and Ralston (2007) argue that the rebuilding ratio should be based on the perception that the stock has rebuilt, rather than the stock having actually rebuilt. This is because this performance measure relates to what the decision makers would actually see. The performance measures should include both short- and long-term catches because the short-term catch reflects the likely immediate impact of the fishery.

**Results and Discussion**

*Illustrative results for single simulations*

Figures 1 and 2 explore the performance of the two candidate Rebuilding Revision Rules. The plots can be interpreted as follows

A. Upper Left Panel. This panel shows the true (i.e. operating model) time trajectory of spawning biomass relative to $B_0$ (solid line), along with the target biomass ($0.4B_0$) and the threshold which defines an overfished groundfish stock ($0.25B_0$). It also shows the estimates of spawning biomass relative to $B_0$ from each assessment[3]. For the simulation in Figure 1, spawning biomass is underestimated in the first assessment then overestimated for next eight assessments. In contrast, spawning biomass is underestimated for many years in the simulation in Figure 2. One consequence of the latter outcome is that the stock assessment does not detect that the stock has rebuilt for three assessment cycles after it actually rebuilds to $B_{\mathrm{MSY}}$. The bars at the top of this panel illustrate the changing nature of the Rebuilding Plan. The horizontal line ranges from when the stock was declared overfished to the current $\mathrm{T_{MAX}}$ (the open circle). $\mathrm{T_{TARGET}}$ is indicated by the closed circle. A "reboot" to the Rebuilding Plan is indicated by a change to the start of the horizontal line. The closed and open circles are the same for the fourth line in this panel in Figure 3; this reflects a case when $\mathrm{T_{TARGET}}$ was increased to $\mathrm{T_{MAX}}$ given it was found that rebuilding to $\mathrm{T_{TARGET}}$ could not occur with 50% probability (Case 2 above). There are periods in which there is no horizontal line in Figure 2 because the stock is assessed to have been rebuilt to $B_{\mathrm{MSY}}$ (so catches are based on the 40-10 rule).

[3] The assessment produces a time-series of estimates of biomass but the estimate for the last year in most critical to management so only this value is shown.

B. Upper Right Panel. This panel shows the time-trajectories of catches (the vertical dotted line indicates when the stock was first declared overfished). As expected, there can be major changes in catch every four or so years. The very low catches at the end of the projection period in Figure 1 reflect the situation where rebuilding can occur, but only if the fishery is effectively closed.
C. Lower Left Panel. This panel shows the SPR used to set the catch limit as a function of time. The symbols pertain to the case under consideration. All simulations start with a “0”, indicating the start of a Rebuilding Plan. A “1” (or a “5”) means that no major changes to the Rebuilding Plan were needed (the SPR was kept its current value (“1”; “flexible” strategy) or changed so that the probability of rebuilding was 0.5 (“5”; “50-rule” strategy)), whereas a “2” means that $T_{TARGET}$ was changed to $T_{MAX}$. A “3” in this panel indicates that a reboot took place.
D. Lower Right Panel. This panel shows the time-trajectory of the probability of rebuilding. As expected, this probability is (generally) 0.5 for the “50%-rule” strategy (Figure 1), but can be as low as 0.4 for the “flexible” strategy (Figure 2).

The results in Figures 1 and 2 are meant to be illustrative (the results for the two strategies are not even for the same simulations). However, they are meant to help the Council and its Advisory Bodies to better understand how the various components of a Rebuilding Revision Rule interact.

*Illustrative results for 100 simulations*

Figures 3 and 4 summarize the results of 100 simulations in terms of histograms of the five performance metrics outlined above. The ideal set of Rebuilding Revision Rules should have a rebuilding ratio of 100%, i.e. the stock rebuilt in the year it was predicted to rebuild in when the Rebuilding Plan was developed (or before this year, reflecting recovery “as soon as possible”), a low value for the AAR statistic, which measures the extent to which catches vary from one year to the next (a value for this statistic of 20%, means that catches change on average 20% from one to the next), and a value of zero for number of times it was necessary to reboot the Rebuilding Plan. The catches should be as high as possible (and preferably not vary much among simulations). It would also be expected that the average catch during the first ten years of the Rebuilding Plan would be less than those over the entire rebuilding period given the focus on harvest strategies with constant fishing mortality.

Less than 50% of simulations rebuilt to $B_{MSY}$ by the $T_{TARGET}$ selected when the Rebuilding Plan was developed for the “50% rule” strategy (Figure 3). The results for the ‘flexible” strategy suggest that rebuilding to $B_{MSY}$ occurs close to when it was expected to occur on average, but there is considerable uncertainty in this (Figure 4). In addition, ~75% of Rebuilding Plans had no “reboots”, but ~20% had one reboot and ~5% two reboots for the “flexible” strategy whereas only ~60% of Rebuilding Plans were not “rebooted” for the “50%-rule” strategy and three reboots occurred in one simulation. Catch variability was generally higher for the “50%-rule” strategy than for the “flexible” strategy (contrast the distributions for the AAV statistic in Figures 3 and 4).

*Next steps and overall discussion*

The framework outlined in this document represents an ideal situation which will over-estimate the performance of candidate Rebuilding Revision Rules. In particular, the stock assessment is structurally correct (no errors in pre-specified parameters such as steepness and *M*) while the data are high quality and available for all years. More realistic scenarios will have higher rates for the need for reboots, for example. However, these simulations provide a basis for estimating a baseline rate of, for example, reboots against which more sophisticated rebuilding revision rules can be compared.

There are three main next steps if the Council decides to pursue use of MSE to evaluate Rebuilding Revision Rules:

- Specification (or confirmation) of the performance metrics and plots. Performance metrics should be selected to capture performance relative to Council goals and objectives. The performance metrics and plots on which the analyses of this document were based were taken from Punt and Ralston (2007) and do not reflect Council (or Advisory Body) deliberations.
- Specification of additional Rebuilding Revision Rules. While it is not technically feasible to evaluate hundreds of Rebuilding Revision Rules (100 simulations for 80 years for one Rebuilding Revision Rule takes ~3-4 days on a fast desktop computer), more sets should be considered. Possible factors to consider in candidate Rebuilding Revision rules are: (a) not changing the SPR during the last xx years of the Rebuilding period, (b) only allowing the probability of rebuilding to lag behind 0.5 for one (or two) assessment cycles, etc. Martin Dorn has suggested that track should be kept of the projected year of rebuilding and "adequate progress towards rebuilding" defined as the projected time to rebuild to $B_{\mathrm{MSY}}$ under the current SPR ($T_{\mathrm{REBUILD}}$) being between 25% and 75% of (the current) $T_{\mathrm{TARGET}}$.
- Specification of operating models. The operating model of this document is unrealistic for several reasons, including that it assumes unrealistically good data, but also because the biological parameters are fairly unrealistic (relatively high *M* with very low steepness), having been chosen for illustrative purposes. The operating model does not include "black swan" events such as that a major change impacting the assessment (e.g., the pre-specified values assumed for steepness or *M* change). Such events are known to impact actual Rebuilding Plans and will be necessary to evaluate.

**Acknowledgements**

Chantel Wetzel (NWFSC, UW) and Martin Dorn (AFSC) are thanked for comments on an early draft of this document.

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Smith, A.D.M. 1994. Management strategy evaluation: The light on the hill. In: D.A. Hancock (ed.), Population dynamics for fisheries management. Australian Society for Fish Biology, Perth, Western Australia, pp. 249-253.

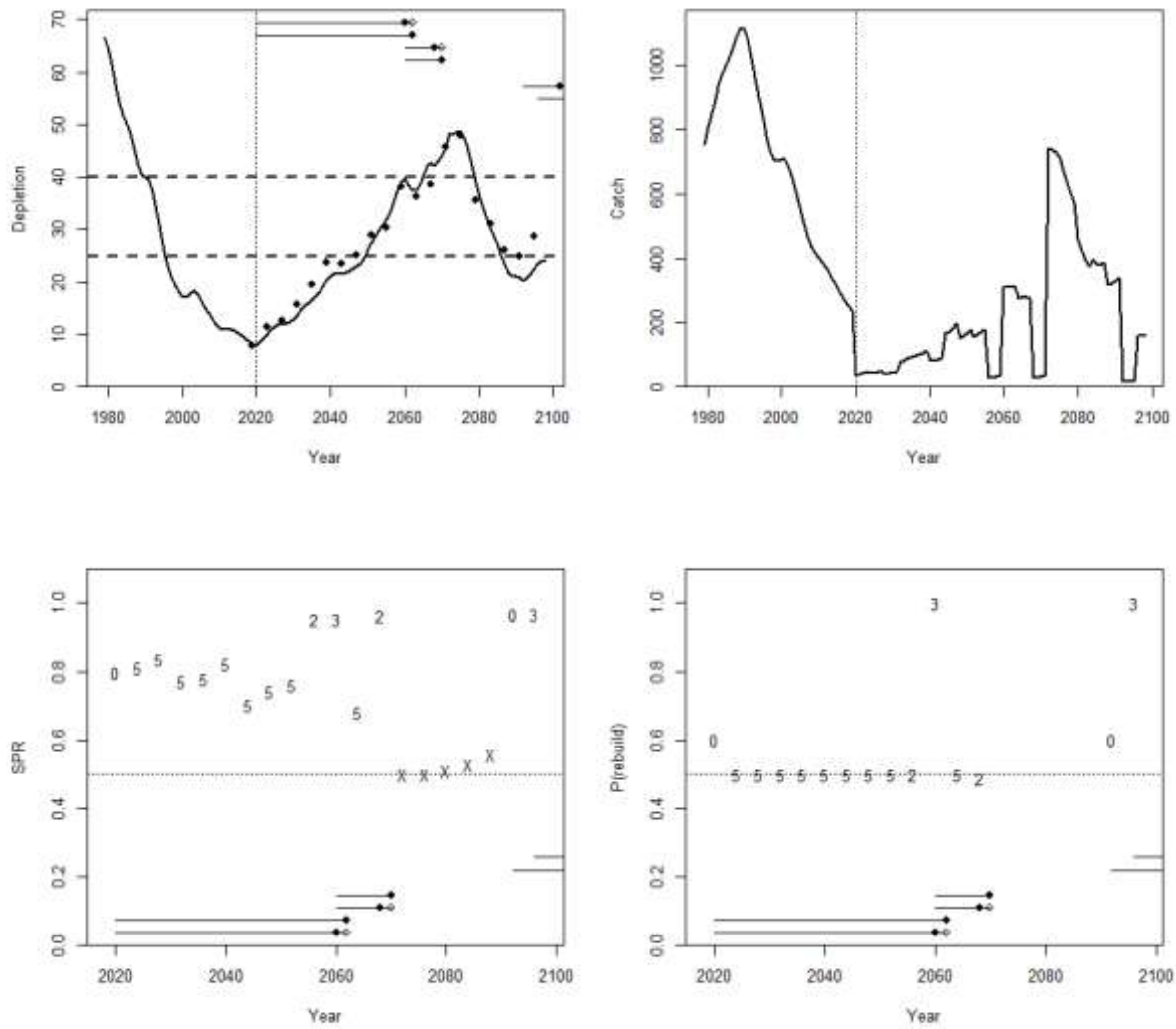


Figure 1. Plot showing overall performance for a single simulation. The Rebuilding Revision Rule is “50% rule” for this analysis. The numbers in the lower two panels indicate the outcomes of applying the Rebuilding Revision Rules every fourth year from 2020. The “3” in the lower panels indicates a year in which the Rebuilding Plan was “rebooted”.

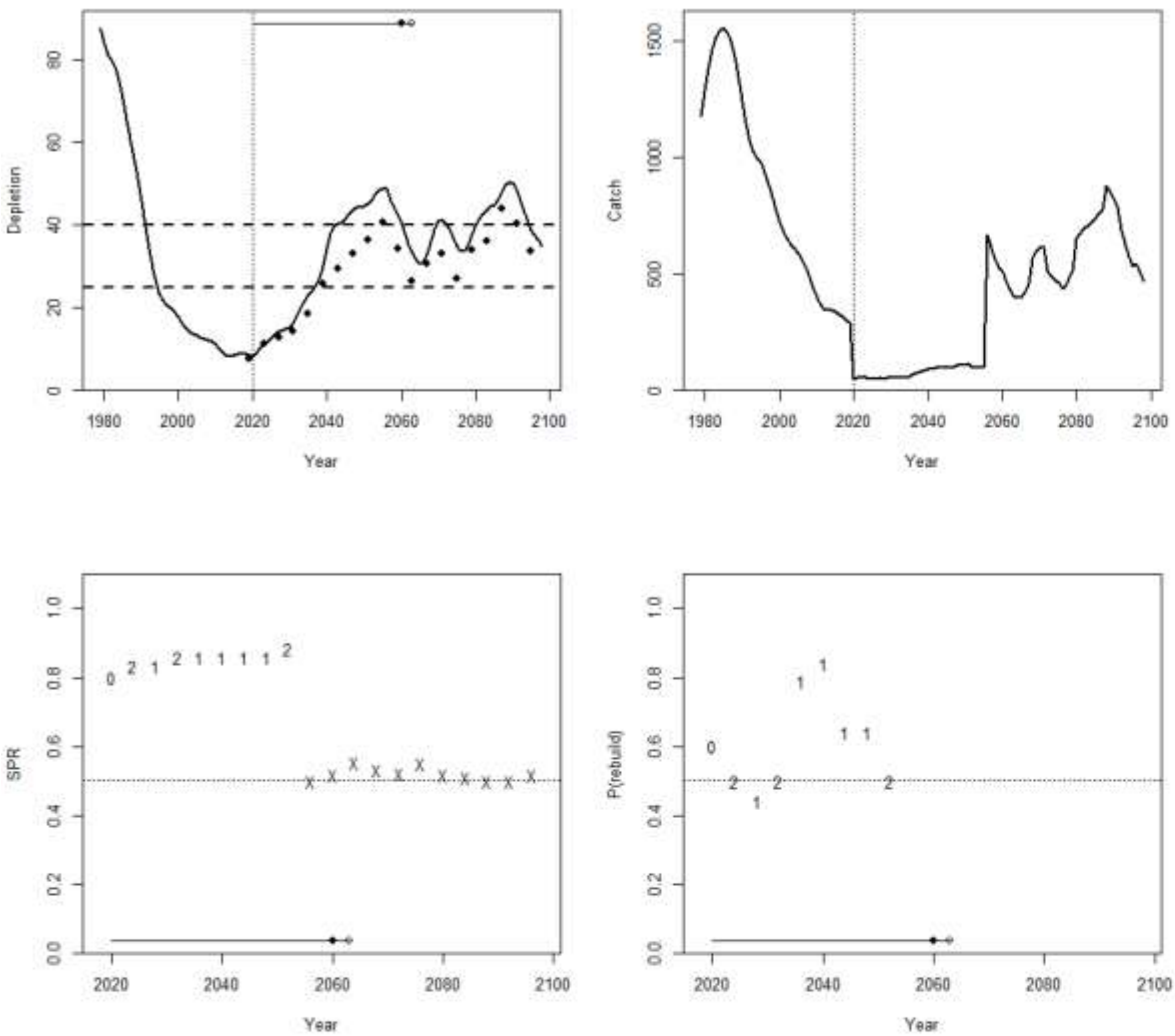


Figure 2. Plot showing overall performance for a single simulation. The Rebuilding Revision Rule is “flexible” for this analysis.

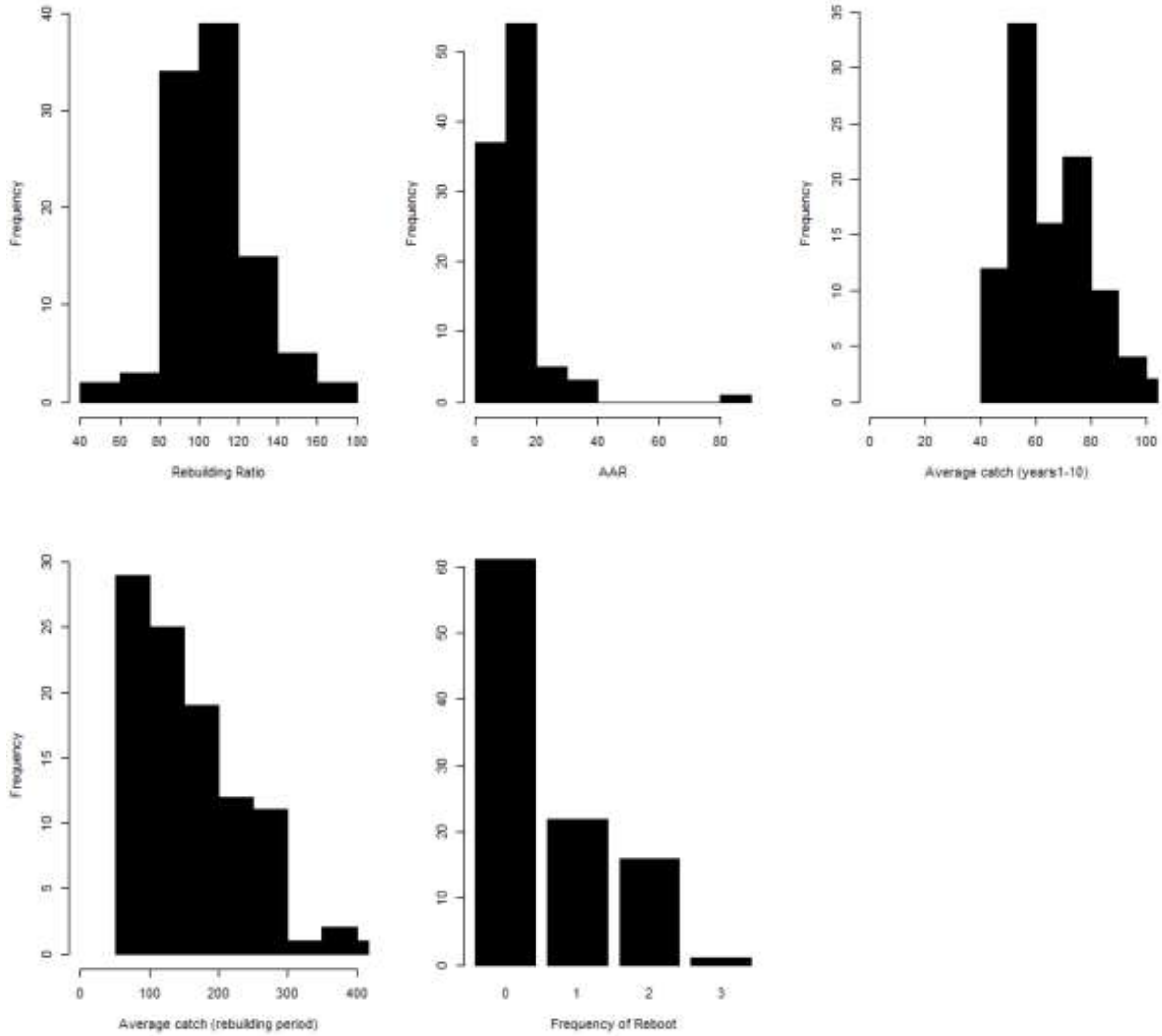


Figure 3. Histograms of performance metrics for the "50% rule" strategy based on 100 simulations.

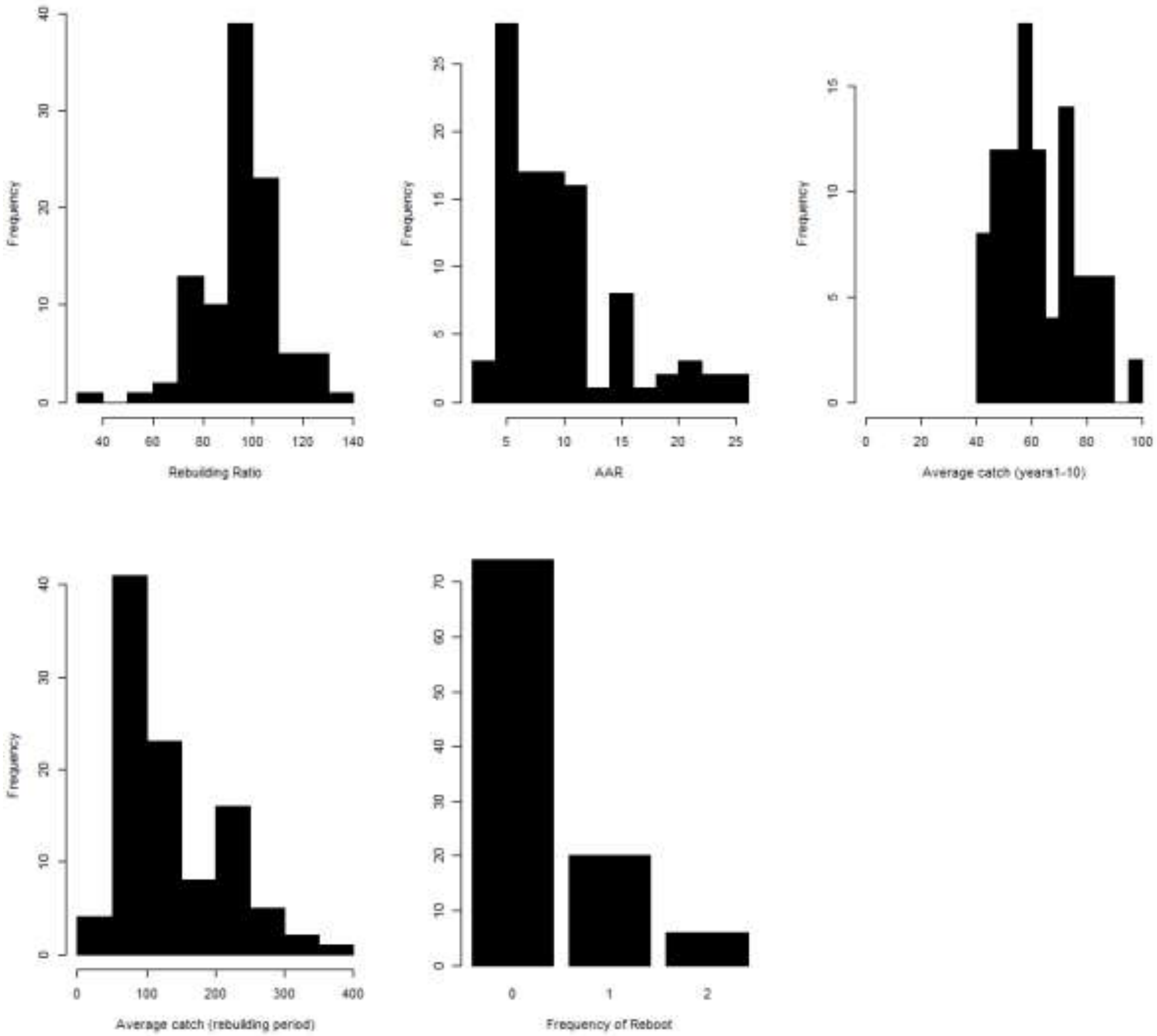


Figure 4. Histograms of performance metrics for the "flexible" strategy based on 100 simulations.

## Appendix A: The Operating Model
### Basic Dynamics
The dynamics of the simulated population are governed by the equation:

$$N^s_{y+1,a} = \begin{cases} 0.5\,R_y & \text{if } a = 0 \\ N^s_{y,a-1}\, e^{-Z^s_{y,a-1}} & \text{if } 1 \le a \le x-1 \\ N^s_{y,x-1}\, e^{-Z^s_{y,x-1}} + N^s_{y,x}\, e^{-Z^s_{y,x}} & \text{if } a = x \end{cases} \qquad \text{(A.1)}$$

where $N^s_{y,a}$ is the number of animals of sex *s* and age *a* at the start of year *y*, $Z^s_{y,a}$ is total mortality for animals of sex *s* and age *a* during year *y*:

$$Z^s_{y,a} = M^s + S_a F_y \qquad \text{(A.2)}$$

$M^s$ is the instantaneous rate of natural mortality for animals of sex *s*, $S_a$ is the selectivity on animals of age *a*, $F_y$ is the fully-selected fishing mortality, $R_y$ is the recruitment during year *y*, and *x* is the plus group age.

The annual recruitment is governed by a Beverton-Holt stock-recruitment relationship, parameterized in terms of steepness (*h*) and average unfished recruitment ($R_0$), i.e.:

$$R_y = \frac{4hR_0(B^S_y / B^S_0)}{(1-h)+(5h-1)(B^S_y / B^S_0)} e^{\varepsilon_y - \sigma^2_R/2} \qquad \text{(A.3)}$$

where $B^S_y$ is the spawning stock biomass at the start of year *y*:

$$B^S_y = \sum_{a=1}^{x} f_a\, w_a\, N^{\text{fem}}_{y,a} \qquad \text{(A.4)}$$

$f_a$ is the proportion of females which are mature at age *a*, and $w_a$ is the weight of an animal of age *a* at the start of the year.

The catch (in weight) during year *y*, $\tilde{C}_y$, is given by:

$$\tilde{C}_y = \sum_s \sum_{a=0}^{x} w_{a+1/2}\, C^s_{y,a} = \sum_s \sum_{a=0}^{x} w_{a+1/2}\, \tfrac{S_a F_y}{Z^s_{y,a}}\, N^s_{y,a}(1-e^{-Z^s_{y,a}}) \qquad \text{(A.5)}$$

where $w_{a+1/2}$ is the weight of animals of age *a* in the middle of the year.

The stock is assumed to be in an unfished state at the start of the first year with catches. The operating mortality is projected for 50 years. The time-series of effort, $E_y$, is given in Figure A.1. Fully-selected fishing mortality for these 50 years is given by $F_y = qE_y$ where the catchability coefficient *q* is selected so that the relative spawning at the start of year 51, $B^S_{51} / B^S_0$, equals a pre-specified value.

### Data generation
The data available for assessment purposes are the annual catches in weight (assumed to be known exactly), a survey index of biomass, and the age-composition of the fishery and survey catches. For the purposes of this example application, survey data are available for all years, and catch age-composition data are available for all years in which the catch is non-zero.

The survey index (and the expected survey age-compositions) is given by:

$$I_y = \sum_s \sum_{a=0}^{x} w_{a+1/2} \tilde{C}^s_{y,a} e^{\eta_y - \sigma_\eta^2/2} = \sum_s \sum_{a=0}^{x} w_{a+1/2} \tilde{S}_a N^s_{y,a} e^{-Z^s_{y,a}/2} e^{\eta_y - \sigma_\eta^2/2} \quad \text{(A.6)}$$

where $\tilde{S}_a$ is the survey selectivity at age $a$.

The survey age-compositions are assumed to be multinomially distributed about the true survey age-proportions, while the fishery age-compositions are assumed to be multinomially distributed about the true fishery age-compositions (Equation A.5).

**Table A.1. Values for the parameters of the operating model**

| Parameter | Values |
|---|---|
| **Biological Parameters** | |
| Natural mortality: females | 0.15yr$^{-1}$ |
| Natural mortality: males | 0.2yr$^{-1}$ |
| Fecundity-at-age | Figure A.2 |
| Weight-at-age | Figure A.2 |
| Selectivity-at-age | Figure A.2 |
| **Stock-recruitment relationship** | |
| Steepness, *h* | 0.4 |
| Extent of variation in recruitment, $\sigma_R$ | 0.6 |
| **Other** | |
| Number of age-classes | 20 |
| Initial depletion | 0.1 |
| **Data collection** | |
| Survey CV | 0.2 |
| Effective sample size for the survey age data | 100 |
| Effective sample size for the fishery age data | 100 |

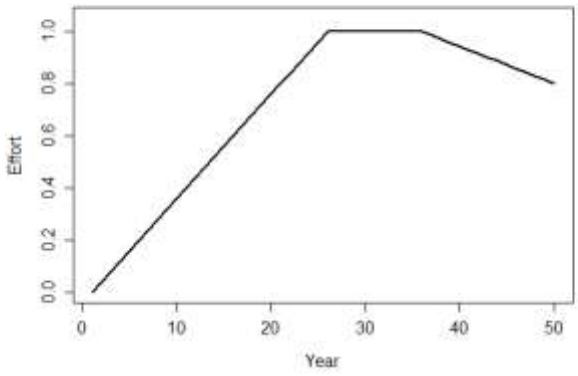


Figure A.1. Time-trajectory of effort.

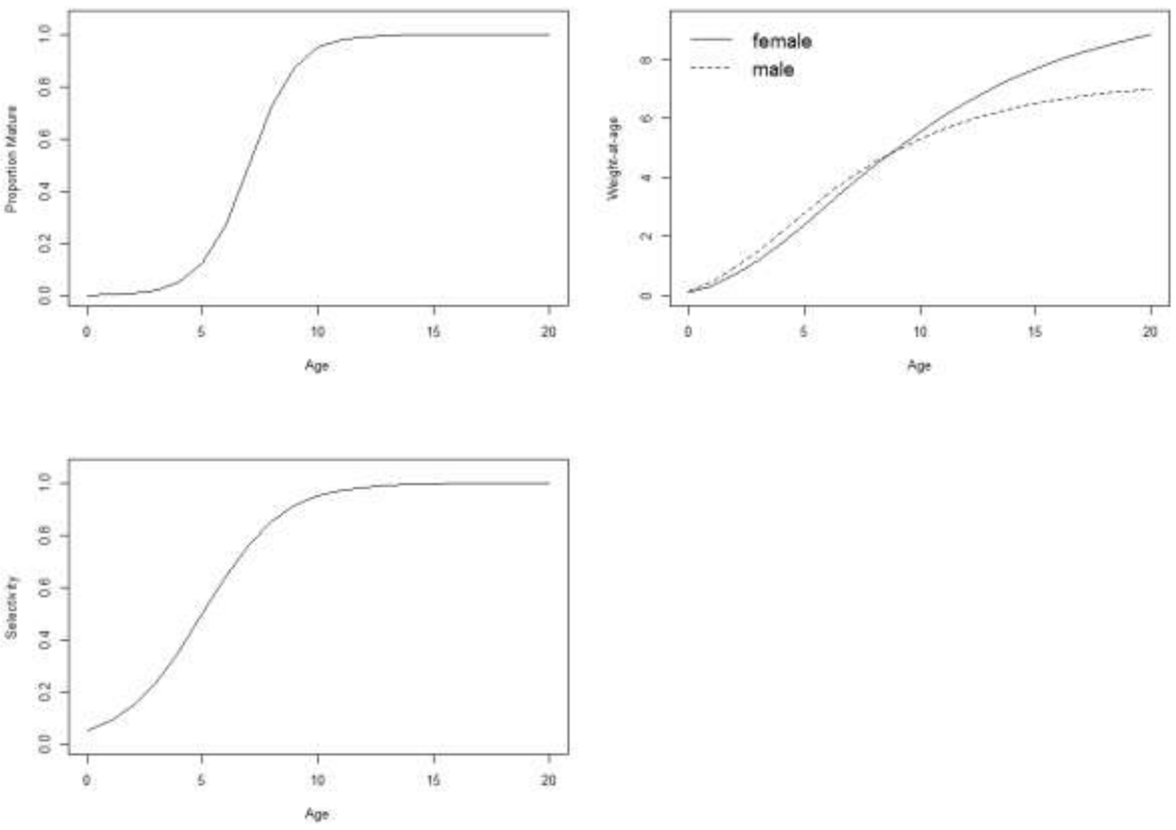


Figure A.2 Maturity, weight-at-age (mid-year), and selectivity as a function of age.

The following is an excerpt related to the biennial management cycle and activities for groundfish management (Schedule 1) from Council Operating Procedure 9. The original text can be found here http://tinyurl.com/lbu2q7v.

# COUNCIL OPERATING PROCEDURE

**Management and Activity Cycles**

9

Approved by Council: 07/10/85
Revised: 09/16/87, 04/06/95, 11/03/99, **03/11/05**

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## PURPOSE

To establish management and activity cycles conducted by the Pacific Fishery Management Council (Council), its advisory entities, staff for the groundfish, salmon, coastal pelagic species, halibut, and highly migratory species fisheries, and administrative matters.

## MANAGEMENT AND ACTIVITY CYCLES

Schedule 1 Biennial management cycle and activities related to groundfish management.

**SCHEDULE 1. Biennial management cycle and activities related to groundfish management.**

| Year | Month | Entity and Management Activity |
|---|---|---|
| Year 1 | September | To begin development of specifications for the next biennial management period (Years 3 and 4), the ***Groundfish Management Team (GMT) and Scientific and Statistical Committee (SSC)*** review and incorporate new impact assessment methodologies, including new observer data from January through December of the previous year, approve stock assessments completed in Year 1, and recommend appropriate harvest specifications.<br><br>***GMT and Groundfish Advisory Subpanel (GAP)*** meet to review current fishery status and develop inseason management recommendations, as necessary. GMT and GAP provide recommendations to inform Council action on harvest specifications and management measures for Years 3 and 4. |

| | | |
|---|---|---|
| | | ***Council*** adopts final modeling methodologies, stock assessments for the next biennial period (Years 3 and 4), final preferred overfishing limits (OFLs) and sigmas, as recommended by the SSC.[1] The Council will also adopt a range of P*/acceptable biological catches (ABCs), if applicable, including preliminary preferred values.<br><br>***Council*** will provide initial fishery management guidance, including a preliminary range of new management measures necessary to keep catch within the annual catch limits (ACL) or to address a habitat or protected resources concern. |
| | September | *SSC Groundfish Subcommittee* meets to review overfished species rebuilding analyses as well as any stock assessments approved for further review by the Council at the "mop-up" stock assessment review panel. |
| | October | *GMT* meets to review new stock assessments and rebuilding analyses. ***GMT*** drafts a recommended range of ACLs and preliminary management measures for consideration at the November Council meeting. |
| | November | ***GMT and GAP*** meet to review current fishery status and develop inseason management recommendations, as necessary.<br><br>***GMT and GAP*** provide recommendations to inform Council action on harvest specifications and management measures for Years 3 and 4.<br><br>***Council*** adopts rebuilding analyses and any assessments sent to the SSC Groundfish Subcommittee for review. ***Council*** adopts final preferred P*/ABCs; preliminary preferred non-overfished species ACLs, and, if necessary; a range of overfished species ACLs and preliminary preferred ACLs for overfished species.<br><br>***Council*** selects a range of 2-year allocations, final range of new management measures to keep catch within the ACL or to address a habitat or protected resources concern, and preliminary exempted fishing permit (EFP) applications for Years 3 and 4. |
| Year 2 | January | ***GMT*** meets to review and analyze Council actions relative to harvest specifications and management measures provided in Year 1, if necessary. |

[1] Council action could be postponed from September to November for any stock assessments recommended for further review by the SSC.

| | |
|---|---|
| March | ***GMT and GAP*** meet to review current fishery status and inseason management recommendations, as necessary.<br><br>***GMT*** and ***GAP*** provide recommendations to inform Council action on harvest specifications and management measures for Years 3 and 4.<br><br>***Council*** receives an informational briefing on selected results of the harvest specifications and management measures analysis. The ***Council*** may be asked to provide guidance or take action on emerging issues, as necessary. |
| April | ***GMT and GAP*** meet to review Pacific whiting harvest specifications and management measures as well as current fishery status and inseason management recommendations.<br><br>***GMT*** and ***GAP*** provide recommendations to inform Council action on harvest specifications and management measures for Years 3 and 4.<br><br>***Council*** recommends inseason management adjustments as necessary.<br><br>Consistent with the U.S./Canada agreement, the ***Council*** considers the harvest specifications recommended by the Joint Management Committee and confirms or recommends a lower U.S. TAC. The ***Council*** recommends set-asides and any adjustments to management measures for the Pacific Whiting fishery in Year 2.<br><br>***Council*** adopts preliminary management measures for public review and final harvest specifications for Years 3 and 4. |
| June | ***GMT and GAP*** meet to review current fishery status and inseason management recommendations, as necessary.<br><br>***GMT*** and ***GAP*** provide recommendations to inform Council action on harvest specifications and management measures for Years 3 and 4.<br><br>***Council*** recommends inseason management adjustments as necessary.<br><br>***Council*** adopts final EFP applications and management measures as well as any corrections to harvest specifications for implementation by NMFS for Years 3 and 4.<br><br>***Council*** recommends a prioritized list of new management measures to be analyzed outside of the harvest specifications and management |

| | | |
|---|---|---|
| | | measures process. |
| | July | Council staff and ***GMT*** complete analyses and NEPA documents, as necessary, for biennial management specifications and submit them to NOAA. |
| | September | ***GMT, GAP, and Council*** participate in inseason management activities and off-year activities, as appropriate. |
| | November | ***GMT, GAP, and Council*** participate in inseason management activities and off-year activities, as appropriate. |
| Year 3[1] | January | ***U.S. Department of Commerce*** implements harvest level specifications and management measures for next biennial management period (Years 3 and 4). |
| | March | ***GMT, GAP, and Council*** participate in inseason management activities and off-year activities, as appropriate. |
| | April | ***GMT and GAP*** meet to review Pacific whiting harvest specifications and management measures as well as current fishery status and inseason management recommendations, as necessary.<br><br>Consistent with the U.S./Canada agreement, the ***Council*** considers the harvest specifications recommended by the Joint Management Committee and confirms or recommends a lower U.S. TAC. The ***Council*** recommends set-asides and any adjustments to management measures for the Pacific Whiting fishery in Year 3. |
| | June and September | ***GMT, GAP, and Council*** participate in inseason management activities and off-year activities, as appropriate. |
| | November | Repeat management activities of November in Year 1 to begin development of next biennial cycle. |

[1] GMT generally meets in January, July, and October to review and discuss groundfish management issues, including stock assessments and STAR Panel reviews.

Agenda Item G.7.a
Attachment 4
September 2013

# NEW MANAGEMENT MEASURE PROCESS

The Council has committed to narrowing the scope of management measures for consideration during the biennial process. Eligible actions include adjusting existing management measures, including those designated as routine, to achieve but not exceed the annual catch limit (ACL). New management measures, which are those not previously analyzed and implemented in regulation, may be included for consideration during the biennial process if they necessary to keep catch within the ACL or address a habitat or protected resources concern. At June Council meetings in even years, the Council would decide which of the new management measures that did not meet the above-mentioned criteria would instead be considered in a subsequent, separate two-meeting process. The following document provides further clarification and examples of how management measures from the 2013-2014 process might be characterized under the new process (Table 1).

Adjustments to designated routine management measures would continue to be proposed in the new biennial process and through inseason action. Inseason adjustments may be announced by a single notification in the *Federal Register* if good cause exists under the Administrative Procedures Act to waive notice and comment, and if they have been designated as routine through the two-meeting process described in the Groundfish Fishery Management Plan (see Section 6.2). Most, but not all, trip, bag, and size limits, and area closures in the groundfish fishery have been designated routine.

Management measures available for use in the biennial process also include measures that have not been designated as routine. For example, establishing recreational harvest guidelines are available but are not designated as routine.

New measures are those that have not previously been analyzed or implemented in regulation. New management measures may be analyzed during the biennial process if they are necessary to keep catch within the ACL or address a habitat or protected resources concern. For example, a new Yelloweye Rockfish Conservation Area could be analyzed in the biennial process if it was needed to keep the mortality of yelloweye within the ACL.

**Table 1. Management Measure Examples:** Management measures from the 2013-2014 cycle categorized under the new process.

| **Measure** | **Category** | **Available in New Biennial Process** |
|---|---|---|
| Update coordinates defining RCAs to better approximate depth | Housekeeping to meet original intent | Yes |
| Catch accounting between limited entry and open access | Housekeeping to meet original a/ | Yes |
| Flexible management of ACL set-asides | New measure | No |
| Sorting requirements for aurora, shortraker, rougheye north of 40°10 N. latitude | Currently available measure | Yes |
| Blackgill management measures | | |
| a) Harvest guideline | a) Currently available measure | Yes |
| b) Sorting requirement | b) Currently available measure | Yes |
| c) Trip limit adjustments | c) Routine measure | Yes |
| Longnose skate management measures | | |
| a) RCA adjustments | a) Routine measure | Yes |
| b) Fixed gear trip limit adjustments | b) Routine measure | Yes |
| Remove or reduce the lingcod length limit | Routine measure | Yes |
| Modify the Amendment 21 widow rockfish within trawl allocations | New measure | No |
| Allow multiple gears on an IFQ trip | New measure | No |
| Modify trawl gear configurations – 4 seam net | New measure | No |
| Modify shorebased IFQ accumulation limits | New measure | No |

| **Measure** | **Category** | **Available in New Biennial Process** |
|---|---|---|
| Make issuance of shorebased IFQ carryover a routine measure | New measure | No |
| Recreational shelf rockfish retention in the CCA | Currently available measure | Yes |
| Remove the California recreational bocaccio size and fillet limit | Routine measure | Yes |

a/ Some housekeeping measures are complex and may require additional Council action to clarify intent. Complex housekeeping changes, while eligible under the new biennial process, may be more efficiently addressed through a separate two meeting process.

The following tables provide a range of 2015 and 2016 acceptable biological catches (ABCs) varied by the overfishing probability (P*). These tables **replace** Tables 4 and 5, respectively in Agenda Item G.7.a, Attachment 1. The revisions are based on Scientific and Statistical Committee (SSC) recommendations made under Agenda Item G.7.b, Supplemental SSC Report for overfishing limits (OFLs), stock categories, and estimated biomass variance (sigma) for groundfish stocks managed under the Pacific Coast Groundfish Fishery Management Plan (FMP).

Table 1. SSC-recommended stock categories and a range of alternative 2015 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **OVERFISHED STOCKS** | | | | | | | | | | |
| **BOCACCIO S. of 40°10' N. latitude** | **1,444** | **1** | **1,380** | **1,318** | **1,256** | **1,195** | **1,132** | **1,067** | **995** | **910** |
| CANARY | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| COWCOD S. of 40°10' N. latitude | NA | | NA | NA | NA | NA | NA | NA | NA | NA |
| ***COWCOD (Conception)*** | ***NA*** | ***2*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | *NA* | *3* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| **DARKBLOTCHED** | **588** | **1** | **562** | **537** | **512** | **487** | **461** | **435** | **405** | **370** |
| PACIFIC OCEAN PERCH | 842 | 1 | 805 | 769 | 733 | 697 | 660 | 622 | 580 | 530 |
| **PETRALE SOLE** | **2,946** | **1** | **2,816** | **2,690** | **2,563** | **2,439** | **2,310** | **2,177** | **2,030** | **1,856** |
| YELLOWEYE | 52 | 2 | 47 | 43 | 39 | 35 | 32 | 28 | 24 | 20 |
| **NON-OVERFISHED STOCKS** | | | | | | | | | | |
| Arrowtooth Flounder | 6,599 | 2 | 6,025 | 5,497 | 5,002 | 4,527 | 4,058 | 3,603 | 3,128 | 2,620 |
| Black Rockfish (OR-CA) | 1,176 | 1 | 1,124 | 1,074 | 1,023 | 974 | 922 | 869 | 810 | 741 |
| Black Rockfish (WA) | 421 | 1 | 402 | 384 | 366 | 349 | 330 | 311 | 290 | 265 |
| Cabezon (CA) | 161 | 1 | 154 | 147 | 140 | 133 | 126 | 119 | 111 | 101 |
| Cabezon (OR) | 49 | 1 | 47 | 45 | 43 | 41 | 38 | 36 | 34 | 31 |
| California scorpionfish | 119 | 1 | 114 | 109 | 104 | 99 | 93 | 88 | 82 | 75 |
| Chilipepper S. of 40°10' N. latitude | 1,703 | 1 | 1,628 | 1,555 | 1,482 | 1,410 | 1,335 | 1,259 | 1,173 | 1,073 |
| Dover Sole | 66,871 | 1 | 63,929 | 61,053 | 58,178 | 55,369 | 52,427 | 49,418 | 46,074 | 42,129 |
| **English Sole** | **12,092** | **2** | **11,040** | **10,073** | **9,166** | **8,295** | **7,437** | **6,602** | **5,732** | **4,801** |
| Lingcod N. of 40°10' N. latitude | 3,010 | 1 | 2,830 | 2,659 | 2,494 | 2,334 | 2,172 | 2,010 | 1,835 | 1,637 |
| Lingcod S. of 40°10' N. latitude | 1,205 | 2 | 1,100 | 1,004 | 913 | 827 | 741 | 658 | 571 | 478 |
| Longnose skate | 2,449 | 1 | 2,341 | 2,236 | 2,130 | 2,027 | 1,920 | 1,810 | 1,687 | 1,543 |
| **Longspine Thornyhead (coastwide)** | **4,405** | **2** | **4,022** | **3,669** | **3,339** | **3,022** | **2,709** | **2,405** | **2,088** | **1,749** |
| Pacific Cod | 3,200 | 3 | 2,669 | 2,221 | 1,837 | 1,504 | 1,213 | 954 | 720 | 506 |
| Sablefish (coastwide) | 7,857 | 1 | 7,511 | 7,173 | 6,836 | 6,506 | 6,160 | 5,806 | 5,413 | 4,950 |
| Shortbelly | 6,950 | 2 | 6,345 | 5,789 | 5,268 | 4,768 | 4,274 | 3,795 | 3,294 | 2,759 |
| **Shortspine Thornyhead (coastwide)** | **3,204** | **2** | **2,925** | **2,669** | **2,429** | **2,198** | **1,970** | **1,749** | **1,519** | **1,272** |
| Splitnose S. of 40°10' N. latitude | 1,794 | 1 | 1,715 | 1,638 | 1,561 | 1,485 | 1,406 | 1,326 | 1,236 | 1,130 |
| Starry Flounder | 1,841 | 2 | 1,681 | 1,534 | 1,395 | 1,263 | 1,132 | 1,005 | 873 | 731 |
| Widow | 4,137 | 1 | 3,929 | 3,729 | 3,532 | 3,337 | 3,138 | 2,930 | 2,705 | 2,446 |
| **Yellowtail N. of 40°10' N. latitude** | **12,281** | **2** | **11,213** | **10,230** | **9,309** | **8,425** | **7,553** | **6,705** | **5,821** | **4,876** |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **STOCK COMPLEXES** | | | | | | | | | | |
| Minor Nearshore Rockfish North | 68 | | 59 | 51 | 44 | 38 | 32 | 27 | 22 | 17 |
| *Black and yellow* | *0.014* | 3 | *0.011* | *0.009* | *0.008* | *0.006* | *0.005* | *0.004* | *0.003* | *0.002* |
| *Blue (CA)* | *27.4* | 2 | *25.0* | *22.9* | *20.8* | *18.8* | *16.9* | *15.0* | *13.0* | *10.9* |
| *Blue (OR & WA)* | *32.3* | 3 | *26.9* | *22.4* | *18.5* | *15.2* | *12.2* | *9.6* | *7.3* | *5.1* |
| ***Brown*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Calico* | - | 3 | - | - | - | - | - | - | - | - |
| ***China*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher* | - | 3 | - | - | - | - | - | - | - | - |
| *Grass* | *0.7* | 3 | *0.5* | *0.5* | *0.4* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* |
| *Kelp* | *0.009* | 3 | *0.008* | *0.006* | *0.005* | *0.004* | *0.003* | *0.003* | *0.002* | *0.001* |
| *Olive* | *0.3* | 3 | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* | *0.1* | *0.1* | *0.0* |
| *Quillback* | *7.4* | 3 | *6.2* | *5.1* | *4.2* | *3.5* | *2.8* | *2.2* | *1.7* | *1.2* |
| *Treefish* | *0.2* | 3 | *0.2* | *0.2* | *0.1* | *0.1* | *0.1* | *0.1* | *0.0* | *0.0* |
| Minor Shelf Rockfish North | 2,207 | | 1,943 | 1,711 | 1,505 | 1,316 | 1,141 | 978 | 818 | 657 |
| *Bronzespotted* | - | 3 | - | - | - | - | - | - | - | - |
| *Bocaccio* | *284.0* | 3 | *236.9* | *197.1* | *163.0* | *133.5* | *107.6* | *84.6* | *63.9* | *44.9* |
| *Chameleon* | - | 3 | - | - | - | - | - | - | - | - |
| *Chilipepper* | *128.2* | 3 | *106.9* | *88.9* | *73.6* | *60.2* | *48.6* | *38.2* | *28.8* | *20.3* |
| *Cowcod* | - | 3 | - | - | - | - | - | - | - | - |
| *Flag* | *0.07* | 3 | *0.06* | *0.05* | *0.04* | *0.03* | *0.03* | *0.02* | *0.02* | *0.01* |
| *Freckled* | - | 3 | - | - | - | - | - | - | - | - |
| *Greenblotched* | *1.3* | 3 | *1.1* | *0.9* | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.2* |
| *Greenspotted 40°10' to 42° N. latitude* | *9.3* | 2 | *8.5* | *7.7* | *7.0* | *6.4* | *5.7* | *5.1* | *4.4* | *3.7* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | *5.1* | *4.2* | *3.5* | *2.9* | *2.3* | *1.8* | *1.4* | *1.0* |
| *Greenstriped* | *1,281.9* | 2 | *1,170.3* | *1,067.8* | *971.7* | *879.4* | *788.3* | *699.9* | *607.6* | *508.9* |
| *Halfbanded* | - | 3 | - | - | - | - | - | - | - | - |
| *Harlequin* | - | 3 | - | - | - | - | - | - | - | - |
| *Honeycomb* | - | 3 | - | - | - | - | - | - | - | - |
| *Mexican* | - | 3 | - | - | - | - | - | - | - | - |
| *Pink* | *0.004* | 3 | *0.003* | *0.003* | *0.002* | *0.002* | *0.001* | *0.001* | *0.001* | *0.001* |
| *Pinkrose* | - | 3 | - | - | - | - | - | - | - | - |
| *Puget Sound* | - | 3 | - | - | - | - | - | - | - | - |
| *Pygmy* | - | 3 | - | - | - | - | - | - | - | - |
| *Redstripe* | *269.9* | 3 | *225.1* | *187.3* | *154.9* | *126.9* | *102.3* | *80.4* | *60.7* | *42.6* |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Rosethorn* | *12.9* | 3 | *10.8* | *9.0* | *7.4* | *6.1* | *4.9* | *3.8* | *2.9* | *2.0* |
| *Rosy* | *3.0* | 3 | *2.5* | *2.1* | *1.7* | *1.4* | *1.1* | *0.9* | *0.7* | *0.5* |
| *Silvergray* | *159.4* | 3 | *133.0* | *110.6* | *91.5* | *74.9* | *60.4* | *47.5* | *35.9* | *25.2* |
| *Speckled* | *0.17* | 3 | *0.14* | *0.12* | *0.10* | *0.08* | *0.06* | *0.05* | *0.04* | *0.03* |
| *Squarespot* | *0.17* | 3 | *0.14* | *0.12* | *0.10* | *0.08* | *0.07* | *0.05* | *0.04* | *0.03* |
| *Starry* | *0.00* | 3 | *0.003* | *0.003* | *0.002* | *0.002* | *0.001* | *0.001* | *0.001* | *0.001* |
| ***Stripetail*** | ***40.4*** | **3** | ***33.7*** | ***28.0*** | ***23.2*** | ***19.0*** | ***15.3*** | ***12.0*** | ***9.1*** | ***6.4*** |
| *Swordspine* | *0.0001* | 3 | *0.00008* | *0.00007* | *0.00006* | *0.00005* | *0.00004* | *0.00003* | *0.00002* | *0.00002* |
| *Tiger* | *1.0* | 3 | *0.8* | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.2* | *0.2* |
| *Vermilion* | *9.7* | 3 | *8.1* | *6.7* | *5.6* | *4.6* | *3.7* | *2.9* | *2.2* | *1.5* |
| Minor Slope Rockfish North | 1,804 | | 1,677 | 1,561 | 1,453 | 1,350 | 1,250 | 1,151 | 1,048 | 933 |
| ***Aurora*** | ***17.4*** | ***1*** | ***16.6*** | ***15.8*** | ***15.0*** | ***14.2*** | ***13.4*** | ***12.5*** | ***11.6*** | ***10.6*** |
| *Bank* | *17.2* | 3 | *14.4* | *12.0* | *9.9* | *8.1* | *6.5* | *5.1* | *3.9* | *2.7* |
| *Blackgill* | *4.7* | 3 | *3.9* | *3.3* | *2.7* | *2.2* | *1.8* | *1.4* | *1.1* | *0.7* |
| *Redbanded* | *45.3* | 3 | *37.7* | *31.4* | *26.0* | *21.3* | *17.2* | *13.5* | *10.2* | *7.2* |
| ***Rougheye*** | ***201.9*** | **1** | ***193*** | ***184*** | ***176*** | ***167*** | ***158*** | ***149*** | ***139*** | ***127*** |
| ***Sharpchin*** | ***305.6*** | ***2*** | ***279.0*** | ***254.6*** | ***231.6*** | ***209.6*** | ***187.9*** | ***166.9*** | ***144.9*** | ***121.3*** |
| *Shortraker* | *18.7* | 3 | *15.6* | *13.0* | *10.7* | *8.8* | *7.1* | *5.6* | *4.2* | *3.0* |
| *Splitnose* | *1,000.6* | 1 | *956.6* | *913.6* | *870.5* | *828.5* | *784.5* | *739.5* | *689.4* | *630.4* |
| *Yellowmouth* | *192.4* | 3 | *160.5* | *133.6* | *110.5* | *90.4* | *72.9* | *57.3* | *43.3* | *30.4* |
| Minor Nearshore Rockfish South | 793 | | 694 | 609 | 534 | 466 | 405 | 348 | 294 | 240 |
| *Shallow Nearshore Species* | *NA* | NA | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| *Black and yellow* | *28* | 3 | *23.0* | *19.1* | *15.8* | *12.9* | *10.4* | *8.2* | *6.2* | *4.4* |
| ***China*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher (N of Pt. Conception)* | *148* | 1 | *141.5* | *135.1* | *128.8* | *122.5* | *116.0* | *109.4* | *102.0* | *93.2* |
| *Gopher (S of Pt. Conception)* | *26* | 3 | *21.4* | *17.8* | *14.7* | *12.0* | *9.7* | *7.6* | *5.8* | *4.0* |
| *Grass* | *60* | 3 | *49.7* | *41.4* | *34.2* | *28.0* | *22.6* | *17.8* | *13.4* | *9.4* |
| *Kelp* | *28* | 3 | *23.1* | *19.2* | *15.9* | *13.0* | *10.5* | *8.2* | *6.2* | *4.4* |
| *Deeper Nearshore Species* | *NA* | NA | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| *Blue (assessed area)* | *189* | 2 | *172.2* | *157.1* | *142.9* | *129.4* | *116.0* | *103.0* | *89.4* | *74.9* |
| *Blue (S of 34 $^{o}$27' N. latitude)* | *73* | 3 | *60.8* | *50.6* | *41.8* | *34.3* | *27.6* | *21.7* | *16.4* | *11.5* |
| ***Brown*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Calico* | - | 3 | - | - | - | - | - | - | - | - |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Olive* | *225* | 3 | *187.4* | *155.9* | *128.9* | *105.6* | *85.1* | *66.9* | *50.5* | *35.5* |
| *Quillback* | *5* | 3 | *4.5* | *3.7* | *3.1* | *2.5* | *2.0* | *1.6* | *1.2* | *0.9* |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Treefish* | *13* | 3 | *11.0* | *9.2* | *7.6* | *6.2* | *5.0* | *3.9* | *3.0* | *2.1* |
| Minor Shelf Rockfish South | 1,914 | | 1,621 | 1,372 | 1,156 | 967 | 800 | 648 | 509 | 378 |
| *Bronzespotted* | *3.6* | 3 | *3.0* | *2.5* | *2.1* | *1.7* | *1.4* | *1.1* | *0.8* | *0.6* |
| *Chameleon* | - | 3 | - | - | - | - | - | - | - | - |
| *Flag* | *23.4* | 3 | *19.5* | *16.3* | *13.4* | *11.0* | *8.9* | *7.0* | *5.3* | *3.7* |
| *Freckled* | - | 3 | - | - | - | - | - | - | - | - |
| *Greenblotched* | *23.1* | 3 | *19.3* | *16.1* | *13.3* | *10.9* | *8.8* | *6.9* | *5.2* | *3.7* |
| *Greenspotted* | *79.0* | 2 | *72.1* | *65.8* | *59.9* | *54.2* | *48.6* | *43.1* | *37.4* | *31.4* |
| *Greenstriped* | *235.1* | 2 | *214.7* | *195.9* | *178.2* | *161.3* | *144.6* | *128.4* | *111.5* | *93.3* |
| *Halfbanded* | - | 3 | - | - | - | - | - | - | - | - |
| *Harlequin* | - | 3 | - | - | - | - | - | - | - | - |
| *Honeycomb* | *9.9* | 3 | *8.2* | *6.8* | *5.7* | *4.6* | *3.7* | *2.9* | *2.2* | *1.6* |
| *Mexican* | *5.1* | 3 | *4.2* | *3.5* | *2.9* | *2.4* | *1.9* | *1.5* | *1.1* | *0.8* |
| *Pink* | *2.5* | 3 | *2.1* | *1.8* | *1.5* | *1.2* | *1.0* | *0.8* | *0.6* | *0.4* |
| *Pinkrose* | - | 3 | - | - | - | - | - | - | - | - |
| *Pygmy* | - | 3 | - | - | - | - | - | - | - | - |
| *Redstripe* | *0.5* | 3 | *0.4* | *0.3* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* | *0.1* |
| *Rosethorn* | *2.1* | 3 | *1.8* | *1.5* | *1.2* | *1.0* | *0.8* | *0.6* | *0.5* | *0.3* |
| *Rosy* | *44.5* | 3 | *37.1* | *30.9* | *25.5* | *20.9* | *16.9* | *13.3* | *10.0* | *7.0* |
| *Silvergray* | *0.5* | 3 | *0.4* | *0.4* | *0.3* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* |
| *Speckled* | *39.4* | 3 | *32.8* | *27.3* | *22.6* | *18.5* | *14.9* | *11.7* | *8.9* | *6.2* |
| *Squarespot* | *11.1* | 3 | *9.2* | *7.7* | *6.4* | *5.2* | *4.2* | *3.3* | *2.5* | *1.8* |
| *Starry* | *62.6* | 3 | *52.2* | *43.4* | *35.9* | *29.4* | *23.7* | *18.6* | *14.1* | *9.9* |
| ***Stripetail*** | ***23.6*** | **3** | ***19.7*** | ***16.4*** | ***13.6*** | ***11.1*** | ***9.0*** | ***7.0*** | ***5.3*** | ***3.7*** |
| *Swordspine* | *14.2* | 3 | *11.9* | *9.9* | *8.2* | *6.7* | *5.4* | *4.2* | *3.2* | *2.2* |
| *Tiger* | *0.04* | 3 | *0.03* | *0.03* | *0.02* | *0.02* | *0.02* | *0.01* | *0.01* | *0.01* |
| *Vermilion* | *269.3* | 3 | *224.6* | *186.9* | *154.6* | *126.6* | *102.1* | *80.2* | *60.6* | *42.5* |
| *Yellowtail* | *1,064.4* | 3 | *887.7* | *738.7* | *611.0* | *500.3* | *403.4* | *317.2* | *239.5* | *168.2* |
| Minor Slope Rockfish South | 806 | | 699 | 606 | 525 | 452 | 387 | 326 | 269 | 214 |
| ***Aurora*** | ***74.3*** | **1** | ***70.7*** | ***67.3*** | ***63.9*** | ***60.6*** | ***57.1*** | ***53.5*** | ***49.6*** | ***45.1*** |
| *Bank* | *503.2* | 3 | *419.7* | *349.2* | *288.8* | *236.5* | *190.7* | *150.0* | *113.2* | *79.5* |
| *Blackgill* | *137.0* | 2 | *125.1* | *114.1* | *103.8* | *94.0* | *84.3* | *74.8* | *64.9* | *54.4* |
| *Pacific ocean perch* | - | 3 | - | - | - | - | - | - | - | - |
| *Redbanded* | *10.4* | 3 | *8.7* | *7.2* | *6.0* | *4.9* | *3.9* | *3.1* | *2.3* | *1.6* |
| ***Rougheye*** | ***4.1*** | **1** | ***3.9*** | ***3.8*** | ***3.6*** | ***3.4*** | ***3.2*** | ***3.0*** | ***2.8*** | ***2.6*** |
| ***Sharpchin*** | ***76.4*** | **2** | ***69.8*** | ***63.6*** | ***57.9*** | ***52.4*** | ***47.0*** | ***41.7*** | ***36.2*** | ***30.3*** |

| Stock | 2015 OFL | Category | Range of Alternative 2015 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **0.45** | **0.40** | **0.35** | **0.30** | **0.25** | **0.20** | **0.15** | **0.10** |
| *Shortraker* | *0.10* | 3 | *0.09* | *0.07* | *0.06* | *0.05* | *0.04* | *0.03* | *0.02* | *0.02* |
| *Yellowmouth* | *0.8* | 3 | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.3* | *0.2* | *0.1* |
| Other Flatfish | 11,298 | | 9,865 | 8,620 | 7,517 | 6,521 | 5,606 | 4,758 | 3,939 | 3,126 |
| *Butter sole* | *4.6* | 3 | *3.9* | *3.2* | *2.7* | *2.2* | *1.8* | *1.4* | *1.0* | *0.7* |
| *Curlfin sole* | *8.2* | 3 | *6.9* | *5.7* | *4.7* | *3.9* | *3.1* | *2.5* | *1.9* | *1.3* |
| *Flathead sole* | *35.0* | 3 | *29.2* | *24.3* | *20.1* | *16.5* | *13.3* | *10.4* | *7.9* | *5.5* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | ***4,004.0*** | ***3,331.9*** | ***2,755.8*** | ***2,256.5*** | ***1,819.6*** | ***1,430.7*** | ***1,080.2*** | ***758.6*** |
| ***Rex sole*** | ***5,609.0*** | **2** | ***5,121.0*** | ***4,672.3*** | ***4,251.6*** | ***3,847.8*** | ***3,449.5*** | ***3,062.5*** | ***2,658.7*** | ***2,226.8*** |
| *Rock sole* | *66.7* | 3 | *55.6* | *46.3* | *38.3* | *31.3* | *25.3* | *19.9* | *15.0* | *10.5* |
| *Sand sole* | *773.2* | 3 | *644.8* | *536.6* | *443.8* | *363.4* | *293.0* | *230.4* | *174.0* | *122.2* |
| Other Fish | 2,523 | | b/ | b/ | b/ | b/ | b/ | b/ | b/ | b/ |
| *Big skate* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Cabezon (WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *California skate* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Finescale codling* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Kelp greenling (CA)* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Kelp greenling (OR & WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Leopard shark* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Pacific grenadier* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Ratfish* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Soupfin shark* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Spiny dogfish* | *2,522.7* | 2 | *2,303.2* | *2,101.4* | *1,912.2* | *1,730.6* | *1,551.5* | *1,377.4* | *1,195.8* | *1,001.5* |

a/ No ABC contribution for these stocks given the lack of an approved method for estimating the OFL.

b/ No ABC recommended pending decisions on restructuring this complex.

Table 2. SSC-recommended stock categories and a range of alternative 2016 ABCs (mt) varied by the probability of overfishing (P*) for west coast groundfish stocks.

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **OVERFISHED STOCKS** | | | | | | | | | | |
| **BOCACCIO S. of 40$^0$10' N. latitude** | **1,351** | **1** | **1,291** | **1,233** | **1,175** | **1,118** | **1,059** | **998** | **931** | **851** |
| CANARY | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| COWCOD S. of 40$^0$10' N. latitude | NA | | NA | NA | NA | NA | NA | NA | NA | NA |
| ***COWCOD (Conception)*** | ***NA*** | ***2*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | *NA* | *3* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* | *NA* |
| **DARKBLOTCHED** | **595** | **1** | **569** | **543** | **518** | **493** | **466** | **440** | **410** | **375** |
| PACIFIC OCEAN PERCH | 850 | 1 | 813 | 776 | 740 | 704 | 666 | 628 | 586 | 536 |
| **PETRALE SOLE** | **3,044** | **1** | **2,910** | **2,779** | **2,648** | **2,520** | **2,386** | **2,250** | **2,097** | **1,918** |
| YELLOWEYE | 52 | 2 | 47 | 43 | 39 | 35 | 32 | 28 | 24 | 20 |
| **NON-OVERFISHED STOCKS** | | | | | | | | | | |
| Arrowtooth Flounder | 6,396 | 2 | 5,840 | 5,328 | 4,848 | 4,388 | 3,934 | 3,492 | 3,032 | 2,539 |
| Black Rockfish (OR-CA) | 1,183 | 1 | 1,131 | 1,080 | 1,029 | 980 | 927 | 874 | 815 | 745 |
| Black Rockfish (WA) | 423 | 1 | 404 | 386 | 368 | 350 | 332 | 313 | 291 | 266 |
| Cabezon (CA) | 158 | 1 | 151 | 144 | 137 | 131 | 124 | 117 | 109 | 100 |
| Cabezon (OR) | 49 | 1 | 47 | 45 | 43 | 41 | 38 | 36 | 34 | 31 |
| California scorpionfish | 117 | 1 | 111 | 106 | 101 | 97 | 91 | 86 | 80 | 73 |
| Chilipepper S. of 40$^0$10' N. latitude | 1,694 | 1 | 1,619 | 1,547 | 1,474 | 1,403 | 1,328 | 1,252 | 1,167 | 1,067 |
| Dover Sole | 59,221 | 1 | 56,615 | 54,069 | 51,522 | 49,035 | 46,429 | 43,764 | 40,803 | 37,309 |
| **English Sole** | **8,493** | **2** | **7,754** | **7,075** | **6,438** | **5,826** | **5,223** | **4,637** | **4,026** | **3,372** |
| Lingcod N. of 40º10' N. latitude | 2,891 | 1 | 2,719 | 2,555 | 2,398 | 2,245 | 2,089 | 1,934 | 1,766 | 1,577 |
| Lingcod S. of 40º10' N. latitude | 1,136 | 2 | 1,037 | 946 | 861 | 779 | 699 | 620 | 539 | 451 |
| Longnose skate | 2,405 | 1 | 2,299 | 2,196 | 2,092 | 1,991 | 1,885 | 1,777 | 1,657 | 1,515 |
| **Longspine Thornyhead (coastwide)** | **4,190** | **2** | **3,825** | **3,490** | **3,176** | **2,874** | **2,577** | **2,288** | **1,986** | **1,663** |
| Pacific Cod | 3,200 | 3 | 2,669 | 2,221 | 1,837 | 1,504 | 1,213 | 954 | 720 | 506 |
| Sablefish (coastwide) | 8,526 | 1 | 8,151 | 7,784 | 7,418 | 7,060 | 6,684 | 6,301 | 5,874 | 5,371 |
| Shortbelly | 6,950 | 2 | 6,345 | 5,789 | 5,268 | 4,768 | 4,274 | 3,795 | 3,294 | 2,759 |
| **Shortspine Thornyhead (coastwide)** | **3,168** | **2** | **2,892** | **2,639** | **2,401** | **2,173** | **1,948** | **1,730** | **1,502** | **1,258** |
| Splitnose S. of 40$^0$10' N. latitude | 1,826 | 1 | 1,746 | 1,667 | 1,589 | 1,512 | 1,432 | 1,349 | 1,258 | 1,150 |
| Starry Flounder | 1,847 | 2 | 1,686 | 1,539 | 1,400 | 1,267 | 1,136 | 1,008 | 875 | 733 |
| Widow | 3,990 | 1 | 3,790 | 3,596 | 3,407 | 3,218 | 3,026 | 2,826 | 2,609 | 2,359 |
| **Yellowtail N. of 40$^0$10' N. latitude** | **11,647** | **2** | **10,634** | **9,702** | **8,828** | **7,990** | **7,163** | **6,359** | **5,521** | **4,624** |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| | | | | | | | | | | |
| **STOCK COMPLEXES** | | | | | | | | | | |
| Minor Nearshore Rockfish North | 69 | | 59 | 51 | 44 | 38 | 33 | 27 | 22 | 17 |
| *Black and yellow* | *0.014* | 3 | *0.011* | *0.009* | *0.008* | *0.006* | *0.005* | *0.004* | *0.003* | *0.002* |
| *Blue (CA)* | *27.7* | 2 | *25.3* | *23.1* | *21.0* | *19.0* | *17.0* | *15.1* | *13.1* | *11.0* |
| *Blue (OR & WA)* | *32.3* | 3 | *26.9* | *22.4* | *18.5* | *15.2* | *12.2* | *9.6* | *7.3* | *5.1* |
| ***Brown*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Calico* | - | 3 | - | - | - | - | - | - | - | - |
| ***China*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| ***Copper*** | ***NA*** | **2** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** | ***NA*** |
| *Gopher* | - | 3 | - | - | - | - | - | - | - | - |
| *Grass* | *0.7* | 3 | *0.5* | *0.5* | *0.4* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* |
| *Kelp* | *0.009* | 3 | *0.008* | *0.006* | *0.005* | *0.004* | *0.003* | *0.003* | *0.002* | *0.001* |
| *Olive* | *0.32* | 3 | *0.26* | *0.22* | *0.18* | *0.15* | *0.12* | *0.09* | *0.07* | *0.05* |
| *Quillback* | *7.4* | 3 | *6.2* | *5.1* | *4.2* | *3.5* | *2.8* | *2.2* | *1.7* | *1.2* |
| *Treefish* | *0.22* | 3 | *0.18* | *0.15* | *0.12* | *0.10* | *0.08* | *0.06* | *0.05* | *0.03* |
| Minor Shelf Rockfish North | 2,217 | | 1,952 | 1,719 | 1,512 | 1,323 | 1,147 | 983 | 823 | 661 |
| *Bronzespotted* | - | 3 | - | - | - | - | - | - | - | - |
| *Bocaccio* | *284.0* | 3 | *236.9* | *197.1* | *163.0* | *133.5* | *107.6* | *84.6* | *63.9* | *44.9* |
| *Chameleon* | - | 3 | - | - | - | - | - | - | - | - |
| *Chilipepper* | *127.5* | 3 | *106.4* | *88.5* | *73.2* | *59.9* | *48.3* | *38.0* | *28.7* | *20.2* |
| *Cowcod* | - | 3 | - | - | - | - | - | - | - | - |
| *Flag* | *0.07* | 3 | *0.06* | *0.05* | *0.04* | *0.03* | *0.03* | *0.02* | *0.02* | *0.01* |
| *Freckled* | - | 3 | - | - | - | - | - | - | - | - |
| *Greenblotched* | *1.3* | 3 | *1.1* | *0.9* | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.2* |
| *Greenspotted 40°10' to 42° N. latitude* | *9.3* | 2 | *8.5* | *7.7* | *7.0* | *6.4* | *5.7* | *5.1* | *4.4* | *3.7* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | *5.1* | *4.2* | *3.5* | *2.9* | *2.3* | *1.8* | *1.4* | *1.0* |
| *Greenstriped* | *1,292.0* | 2 | *1,179.6* | *1,076.2* | *979.3* | *886.3* | *794.6* | *705.4* | *612.4* | *512.9* |
| *Halfbanded* | - | 3 | - | - | - | - | - | - | - | - |
| *Harlequin* | - | 3 | - | - | - | - | - | - | - | - |
| *Honeycomb* | - | 3 | - | - | - | - | - | - | - | - |
| *Mexican* | - | 3 | - | - | - | - | - | - | - | - |
| *Pink* | *0.004* | 3 | *0.003* | *0.003* | *0.002* | *0.002* | *0.001* | *0.001* | *0.001* | *0.001* |
| *Pinkrose* | - | 3 | - | - | - | - | - | - | - | - |
| *Puget Sound* | - | 3 | - | - | - | - | - | - | - | - |
| *Pygmy* | - | 3 | - | - | - | - | - | - | - | - |
| *Redstripe* | *269.9* | 3 | *225.1* | *187.3* | *154.9* | *126.9* | *102.3* | *80.4* | *60.7* | *42.6* |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| Rosethorn | 12.9 | 3 | 10.8 | 9.0 | 7.4 | 6.1 | 4.9 | 3.8 | 2.9 | 2.0 |
| Rosy | 3.0 | 3 | 2.5 | 2.1 | 1.7 | 1.4 | 1.1 | 0.9 | 0.7 | 0.5 |
| Silvergray | 159.4 | 3 | 133.0 | 110.6 | 91.5 | 74.9 | 60.4 | 47.5 | 35.9 | 25.2 |
| Speckled | 0.17 | 3 | 0.14 | 0.12 | 0.10 | 0.08 | 0.06 | 0.05 | 0.04 | 0.03 |
| Squarespot | 0.17 | 3 | 0.14 | 0.12 | 0.10 | 0.08 | 0.07 | 0.05 | 0.04 | 0.03 |
| Starry | 0.004 | 3 | 0.003 | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| **Stripetail** | **40.4** | **3** | **33.7** | **28.0** | **23.2** | **19.0** | **15.3** | **12.0** | **9.1** | **6.4** |
| Swordspine | 0.0 | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tiger | 1.0 | 3 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.2 |
| Vermilion | 9.7 | 3 | 8.1 | 6.7 | 5.6 | 4.6 | 3.7 | 2.9 | 2.2 | 1.5 |
| Minor Slope Rockfish North | 1,817 | | 1,691 | 1,574 | 1,465 | 1,363 | 1,262 | 1,163 | 1,059 | 944 |
| **Aurora** | **17.5** | **1** | **16.7** | **15.9** | **15.1** | **14.3** | **13.5** | **12.6** | **11.7** | **10.6** |
| Bank | 17.2 | 3 | 14.4 | 12.0 | 9.9 | 8.1 | 6.5 | 5.1 | 3.9 | 2.7 |
| Blackgill | 4.7 | 3 | 3.9 | 3.3 | 2.7 | 2.2 | 1.8 | 1.4 | 1.1 | 0.7 |
| Redbanded | 45.3 | 3 | 37.7 | 31.4 | 26.0 | 21.3 | 17.2 | 13.5 | 10.2 | 7.2 |
| **Rougheye** | **205.8** | **1** | **197** | **188** | **179** | **170** | **161** | **152** | **142** | **130** |
| **Sharpchin** | **297.6** | **2** | **271.7** | **247.9** | **225.6** | **204.2** | **183.0** | **162.5** | **141.1** | **118.1** |
| Shortraker | 18.7 | 3 | 15.6 | 13.0 | 10.7 | 8.8 | 7.1 | 5.6 | 4.2 | 3.0 |
| Splitnose | 1,018.2 | 1 | 973.4 | 929.6 | 885.8 | 843.0 | 798.2 | 752.4 | 701.5 | 641.4 |
| Yellowmouth | 192.4 | 3 | 160.5 | 133.6 | 110.5 | 90.4 | 72.9 | 57.3 | 43.3 | 30.4 |
| Minor Nearshore Rockfish South | 791 | | 692 | 607 | 532 | 464 | 403 | 346 | 292 | 238 |
| Shallow Nearshore Species | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Black and yellow | 27.5 | 3 | 23.0 | 19.1 | 15.8 | 12.9 | 10.4 | 8.2 | 6.2 | 4.4 |
| **China** | **NA** | **2** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| Gopher (N of Pt. Conception) | 144.0 | 1 | 137.7 | 131.5 | 125.3 | 119.2 | 112.9 | 106.4 | 99.2 | 90.7 |
| Gopher (S of Pt. Conception) | 25.6 | 3 | 21.4 | 17.8 | 14.7 | 12.0 | 9.7 | 7.6 | 5.8 | 4.0 |
| Grass | 59.6 | 3 | 49.7 | 41.4 | 34.2 | 28.0 | 22.6 | 17.8 | 13.4 | 9.4 |
| Kelp | 27.7 | 3 | 23.1 | 19.2 | 15.9 | 13.0 | 10.5 | 8.2 | 6.2 | 4.4 |
| Deeper Nearshore Species | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Blue (assessed area) | 190.3 | 2 | 173.8 | 158.5 | 144.3 | 130.6 | 117.0 | 103.9 | 90.2 | 75.6 |
| Blue (S of 34°27’ N. latitude) | 72.9 | 3 | 60.8 | 50.6 | 41.8 | 34.3 | 27.6 | 21.7 | 16.4 | 11.5 |
| **Brown** | **NA** | **2** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| Calico | - | 3 | - | - | - | - | - | - | - | - |
| **Copper** | **NA** | **2** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| Olive | 224.6 | 3 | 187.4 | 155.9 | 128.9 | 105.6 | 85.1 | 66.9 | 50.5 | 35.5 |
| Quillback | 5.4 | 3 | 4.5 | 3.7 | 3.1 | 2.5 | 2.0 | 1.6 | 1.2 | 0.9 |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Treefish* | *13.2* | 3 | *11.0* | *9.2* | *7.6* | *6.2* | *5.0* | *3.9* | *3.0* | *2.1* |
| Minor Shelf Rockfish South | 1,915 | | 1,622 | 1,373 | 1,157 | 968 | 800 | 649 | 510 | 378 |
| *Bronzespotted* | *3.6* | 3 | *3.0* | *2.5* | *2.1* | *1.7* | *1.4* | *1.1* | *0.8* | *0.6* |
| *Chameleon* | - | 3 | - | - | - | - | - | - | - | - |
| *Flag* | *23.4* | 3 | *19.5* | *16.3* | *13.4* | *11.0* | *8.9* | *7.0* | *5.3* | *3.7* |
| *Freckled* | - | 3 | - | - | - | - | - | - | - | - |
| *Greenblotched* | *23.1* | 3 | *19.3* | *16.1* | *13.3* | *10.9* | *8.8* | *6.9* | *5.2* | *3.7* |
| *Greenspotted* | *78.4* | 2 | *71.6* | *65.3* | *59.5* | *53.8* | *48.2* | *42.8* | *37.2* | *31.1* |
| *Greenstriped* | *237.0* | 2 | *216.4* | *197.4* | *179.6* | *162.6* | *145.8* | *129.4* | *112.3* | *94.1* |
| *Halfbanded* | - | 3 | - | - | - | - | - | - | - | - |
| *Harlequin* | - | 3 | - | - | - | - | - | - | - | - |
| *Honeycomb* | *9.9* | 3 | *8.2* | *6.8* | *5.7* | *4.6* | *3.7* | *2.9* | *2.2* | *1.6* |
| *Mexican* | *5.1* | 3 | *4.2* | *3.5* | *2.9* | *2.4* | *1.9* | *1.5* | *1.1* | *0.8* |
| *Pink* | *2.5* | 3 | *2.1* | *1.8* | *1.5* | *1.2* | *1.0* | *0.8* | *0.6* | *0.4* |
| *Pinkrose* | - | 3 | - | - | - | - | - | - | - | - |
| *Pygmy* | - | 3 | - | - | - | - | - | - | - | - |
| *Redstripe* | *0.5* | 3 | *0.4* | *0.3* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* | *0.1* |
| *Rosethorn* | *2.1* | 3 | *1.8* | *1.5* | *1.2* | *1.0* | *0.8* | *0.6* | *0.5* | *0.3* |
| *Rosy* | *44.5* | 3 | *37.1* | *30.9* | *25.5* | *20.9* | *16.9* | *13.3* | *10.0* | *7.0* |
| *Silvergray* | *0.5* | 3 | *0.4* | *0.4* | *0.3* | *0.3* | *0.2* | *0.2* | *0.1* | *0.1* |
| *Speckled* | *39.4* | 3 | *32.8* | *27.3* | *22.6* | *18.5* | *14.9* | *11.7* | *8.9* | *6.2* |
| *Squarespot* | *11.1* | 3 | *9.2* | *7.7* | *6.4* | *5.2* | *4.2* | *3.3* | *2.5* | *1.8* |
| *Starry* | *62.6* | 3 | *52.2* | *43.4* | *35.9* | *29.4* | *23.7* | *18.6* | *14.1* | *9.9* |
| ***Stripetail*** | ***23.6*** | **3** | ***19.7*** | ***16.4*** | ***13.6*** | ***11.1*** | ***9.0*** | ***7.0*** | ***5.3*** | ***3.7*** |
| *Swordspine* | *14.2* | 3 | *11.9* | *9.9* | *8.2* | *6.7* | *5.4* | *4.2* | *3.2* | *2.2* |
| *Tiger* | *0.04* | 3 | *0.03* | *0.03* | *0.02* | *0.02* | *0.02* | *0.01* | *0.01* | *0.01* |
| *Vermilion* | *269.3* | 3 | *224.6* | *186.9* | *154.6* | *126.6* | *102.1* | *80.2* | *60.6* | *42.5* |
| *Yellowtail* | *1,064.4* | 3 | *887.7* | *738.7* | *611.0* | *500.3* | *403.4* | *317.2* | *239.5* | *168.2* |
| Minor Slope Rockfish South | 807 | | 700 | 607 | 525 | 453 | 387 | 327 | 270 | 214 |
| ***Aurora*** | ***74.3*** | **1** | ***70.7*** | ***67.3*** | ***63.9*** | ***60.6*** | ***57.1*** | ***53.5*** | ***49.6*** | ***45.1*** |
| *Bank* | *503.2* | 3 | *419.7* | *349.2* | *288.8* | *236.5* | *190.7* | *150.0* | *113.2* | *79.5* |
| *Blackgill* | *140.0* | 2 | *127.8* | *116.6* | *106.1* | *96.0* | *86.1* | *76.4* | *66.4* | *55.6* |
| *Pacific ocean perch* | - | 3 | - | - | - | - | - | - | - | - |
| *Redbanded* | *10.4* | 3 | *8.7* | *7.2* | *6.0* | *4.9* | *3.9* | *3.1* | *2.3* | *1.6* |
| ***Rougheye*** | ***4.2*** | **1** | ***4*** | ***4*** | ***4*** | ***3*** | ***3*** | ***3*** | ***3*** | ***3*** |
| ***Sharpchin*** | ***74.4*** | **2** | ***67.9*** | ***62.0*** | ***56.4*** | ***51.0*** | ***45.8*** | ***40.6*** | ***35.3*** | ***29.5*** |

| Stock | 2016 OFL | Category | Range of Alternative 2016 ABCs Overfishing Probability (P*) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.20 | 0.15 | 0.10 |
| *Shortraker* | *0.10* | 3 | *0.09* | *0.07* | *0.06* | *0.05* | *0.04* | *0.03* | *0.02* | *0.02* |
| *Yellowmouth* | *0.8* | 3 | *0.7* | *0.6* | *0.5* | *0.4* | *0.3* | *0.3* | *0.2* | *0.1* |
| Other Flatfish | 9,948 | | 8,633 | 7,496 | 6,494 | 5,595 | 4,775 | 4,021 | 3,299 | 2,590 |
| *Butter sole* | *4.6* | 3 | *3.9* | *3.2* | *2.7* | *2.2* | *1.8* | *1.4* | *1.0* | *0.7* |
| *Curlfin sole* | *8.2* | 3 | *6.9* | *5.7* | *4.7* | *3.9* | *3.1* | *2.5* | *1.9* | *1.3* |
| *Flathead sole* | *35.0* | 3 | *29.2* | *24.3* | *20.1* | *16.5* | *13.3* | *10.4* | *7.9* | *5.5* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | ***4,004.0*** | ***3,331.9*** | ***2,755.8*** | ***2,256.5*** | ***1,819.6*** | ***1,430.7*** | ***1,080.2*** | ***758.6*** |
| ***Rex sole*** | ***4,259.0*** | **2** | ***3,888.5*** | ***3,547.7*** | ***3,228.3*** | ***2,921.7*** | ***2,619.3*** | ***2,325.4*** | ***2,018.8*** | ***1,690.8*** |
| *Rock sole* | *66.7* | 3 | *55.6* | *46.3* | *38.3* | *31.3* | *25.3* | *19.9* | *15.0* | *10.5* |
| *Sand sole* | *773.2* | 3 | *644.8* | *536.6* | *443.8* | *363.4* | *293.0* | *230.4* | *174.0* | *122.2* |
| Other Fish | 2,503 | 0 | b/ | b/ | b/ | b/ | b/ | b/ | b/ | b/ |
| *Big skate* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Cabezon (WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *California skate* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Finescale codling* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Kelp greenling (CA)* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Kelp greenling (OR & WA)* | *a/* | 3 | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* | *a/* |
| *Leopard shark* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Pacific grenadier* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Ratfish* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Soupfin shark* | *b/* | 3 | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* | *b/* |
| *Spiny dogfish* | *2,503.3* | 2 | *2,285.5* | *2,085.2* | *1,897.5* | *1,717.2* | *1,539.5* | *1,366.8* | *1,186.5* | *993.8* |

a/ No ABC contribution for these stocks given the lack of an approved method for estimating the OFL.
b/ No ABC recommended pending decisions on restructuring this complex.

Agenda Item G.7.b
SSC Groundfish Subcommittee Report
September 2013

SSC GROUNDFISH SUBCOMMITTEE STATEMENT REGARDING A CHANGE IN TARGET SPR RATE FOR WEST COAST ELASMOBRANCH SPECIES

## Background of the problem

The Pacific Fishery Management Council (the Council) uses biological reference points to determine whether a stock is in an overfished state, and whether overfishing is occurring. The former is determined from the estimated depletion level, which is the ratio of the reproductive output (number of eggs or embryos) in the fished condition, to the reproductive output in the unfished condition. The latter is determined by a fishing mortality rate ($F$), expressed based on spawning potential ratio (SPR). This ratio is the number of eggs (or another appropriate measure of reproductive output) produced by an average recruit over its lifetime when the stock is fished, divided by the same metric when the stock is unfished. The SPR is based on the principle that certain proportions of fish have to survive in order to spawn and replenish the stock at a sustainable level.

The spiny dogfish shark (*Squalus suckleyi*) is an elasmobranch fish species that inhabits waters of the North Pacific Ocean. In North America, spiny dogfish occur from the Gulf of Alaska to southern Baja California. The status of this species off the West Coast of the United States, in the area managed by the Council, was assessed for the first time in 2011 (Gertseva and Taylor 2011). The spiny dogfish assessment model estimated the reproductive output of the stock at the beginning of 2011 to be 63% of its unfished level, which is well above the MSY proxy reproductive output of 40% of the unfished condition of the stock.

The default proxy fishing mortality rate for spiny dogfish used by the Council has been $F_{SPR45\%}$. This value is not based on an analysis specific to spiny dogfish or other elasmobranchs, but rather on teleost species (whose life history is quite different), since information on elasmobranch species is generally limited.

The current spiny dogfish assessment model predicts that fishing at the current proxy rate of $F_{SPR45\%}$ will severely reduce the reproductive output of the stock over the long term, due to low productivity and other reproductive characteristics. The current assessment indicates that a rate no greater than $F_{SPR79\%}$ (higher SPR values equate to lower fishing mortality rates) would be required to maintain reproductive output near MSY proxy reproductive output.

The spiny dogfish Stock Assessment Review (STAR) Panel suggested that the Council's Scientific and Statistical Committee (SSC) consider the appropriateness of the current proxy fishing mortality rate for spiny dogfish. The SSC agreed that the Council's $F_{MSY}$ proxy of $F_{SPR45\%}$ may be too aggressive for spiny dogfish. The Council tasked the SSC to evaluate the current proxy and, if needed, propose a new target SPR value for spiny dogfish, as well as other elasmobranchs (sharks, skates, and rays) managed under the Groundfish Fishery Management Plan, since they share similar life history characteristics.

## The analysis

*Introduction*

The SSC has previous noted that proxy reference points should ideally be based on analysis and consideration of multiple species within a taxonomic group with similar life history characteristics, to avoid problems of high variability in estimates of SPR and MSY reference points within and between stock assessments, for any individual species (Haltuch et al. 2008). Exceptions to this would only be for stock assessments displaying a remarkable degree of consistency and certainty. Following the 2009 petrale sole assessment, the Council revised the reference points for flatfish, separately from other groundfish species. Then, the SSC rejected the notion of setting the target SPR rate based upon a single stock assessment and species[1], and revised the flatfish proxies only after undertaking a meta-analysis involving multiple species.[2]

Zhou et al. (2012) compiled information on fishing mortality reference points for more than 200 species and stocks worldwide that have been assessed with various methods, and conducted a meta-analysis to link fishing mortality-based reference points to natural mortality and other life history traits. Zhou et al. used Bayesian hierarchical errors-in-variables models to investigate the relationships and included the effect of taxonomic class and order.

To inform an appropriate target SPR rate for West Coast elasmobranch species managed by the Council, Dr. Martin Dorn conducted the following analysis using results reported in Zhou et al. (2012). The SSC Groundfish Subcommittee reviewed this analysis and formed its recommendation for the Council during a conference call that took place on August 16, 2013.

*Methods*

To obtain a target SPR value for elasmobranchs, the posterior distribution for $F_{\mathrm{MSY}}/M$ as reported for Chondrichthyes in the meta-analysis conducted by Zhou et al. (2012) was used. Chondrichthyes (with n=12) was used since the distributions at the lower taxonomic levels were considered unreliable, due to small sample sizes. Values of natural mortality used in Zhou et al. were highly uncertain; therefore the analysis used the mean-unbiased distribution of $F_{\mathrm{MSY}}/M$ ratio, in which measurement error in $M$ was taken into account. This distribution has a mean of 0.460 and standard deviation of 0.088 (Zhou et al. 2012). A large set of random draws was taken from the $F_{\mathrm{MSY}}/M$ posterior distribution. Normal and lognormal distributions for the sampled $F_{\mathrm{MSY}}/M$ ratio were explored. These two distributions did not differ substantially (Figure 1), and the results of the analysis were not sensitive to the assumed distribution. Therefore, the normal distribution was used for the target elasmobranch SPR analysis.

[1] PFMC Agenda Item E.6.c. Supplemental SSC Report, June 2009: "The SSC does not consider that a strong enough case has been made that the estimate of $B_{\mathrm{MSY}}$ is sufficiently reliable to be used for fisheries management… the SSC recommends that these analyses and model changes be reviewed by the SSC Groundfish Subcommittee at a short meeting during August. … The Groundfish Subcommittee may also consider whether a single proxy could be used for west coast flatfish stocks, since other assessed flatfish show the high productivity characteristics of petrale sole."

[2] PFMC Agenda Item E.2.c. Supplemental SSC Report, September 2009; SSC groundfish subcommittee Report on Petrale Sole: "The use of proxy estimates of $F_{\mathrm{MSY}}$ and $B_{\mathrm{MSY}}$ was adopted by the council due the inherent statistical difficulties in estimating these quantities in any single stock assessment and because of a well-developed scientific literature supporting the use of proxies."

The shark assessments used in the Zhou et al. meta-analysis were all based on aggregate biomass dynamics models and thus, values of $F_{\text{MSY}}$ reported by Zhou et al. would not necessarily be comparable to $F_{\text{MSY}}$ values produced by the age-structured models that were used in the spiny dogfish and longnose skate assessments, which are the only two West Coast elasmobranch species that have been assessed. To convert the Zhou et al. $F_{\text{MSY}}/M$ ratio to dogfish and longnose skate SPR rates, we used life history parameter vectors from the most recent (and only) dogfish and longnose skate assessments, and solved for SPR rates that produce an equilibrium (Catch/Mean exploitable biomass)/$M$ ratio, which is equal to the $F_{\text{MSY}}/M$ ratio from Zhou et al. It was assumed that Catch/Mean exploitable biomass approximates a production model fishing mortality, (i.e., $C = F\,\bar{B}, F = C/\bar{B}$). Since both catch and exploitable biomass can be expressed on a per recruit basis, the per recruit term cancels out, so that the developed relationship does not depend on the shape of the stock-recruit curve.

Life history vectors used included natural mortality at age, mid-year weight at age, reproductive output at age, selectivity at age, and fishery weight at age. All vectors were sex-specific. For spiny dogfish, where multiple fisheries were modeled in the assessment, a weighted average selectivity was used, with weights informed by the relative fishing mortality in each fishery. Fishery weights at age for spiny dogfish were also weighted averages. The resultant transfer functions for converting the Zhou et al. $F_{\text{MSY}}/M$ ratio to dogfish and longnose skate SPR rates are shown in Figure 2.

*Results*

For spiny dogfish, the mean SPR at $F_{\text{MSY}}$ is $F_{\text{SPR49\%}}$, at a full selection $F$ of 0.026 and a catch/biomass ratio of 2.9%. For longnose skate, the mean SPR at $F_{\text{MSY}}$ is calculated to be $F_{\text{SPR45\%}}$, at a full selection $F$ of 0.085, and a catch/biomass ratio of 9.0%. The distributions of longnose skate and spiny dogfish SPR obtained in the analysis are shown in Figure 3. An average mean SPR at $F_{\text{MSY}}$ across both distributions is $F_{\text{SPR47\%}}$.

The longnose skate assessment expresses reproductive output in spawning biomass (in common with most fish stocks), which may not accurately reflect elasmobranch reproductive biology; therefore it is reasonable to place more weight on the spiny dogfish result. Even in this case, $\text{F}_{\text{SPR50\%}}$ is the highest fishing mortality rate that does not exceed the $F_{\text{MSY}}$ value with 50% probability for either longnose skate or spiny dogfish (Table 1).

## SSC Groundfish Subcommittee Recommendations

The SSC's groundfish subcommittee continues to emphasize importance of using proxies as a general practice for management. It is usually very difficult to obtain reliable stock-specific estimates of $F_{\text{MSY}}$ and $B_{\text{MSY}}$ in any particular assessment (Haltuch et al. 2008). From a meta-analytical perspective, useful inference about management-related parameters can be drawn by comparative analysis of information drawn from studies of related species. Also, the use of proxies has a stabilizing influence on stock reference points, which is beneficial to the management process.

The SSC's groundfish subcommittee agrees that target elasmobranch SPR analysis (described above) represents the best available science and recommends that the Council adopt $F_{\text{SPR50\%}}$ as the default proxy fishing mortality rate for elasmobranch species in the West Coast of the United States, managed by the Council.

The subcommittee will continue to review existing information that is relevant to the target fishing mortality rate for elasmobranches, which may influence and/or supersede this recommendation, and if so, the recommended value will be refined in the future.

**References**

Gertseva, V. V., Taylor, I. G. 2011. Status of the spiny dogfish shark resource off the continental U.S. Pacific Coast in 2011. In Status of the Pacific Coast Groundfish Fishery through 2011, Stock Assessment and Fishery Evaluation: Stock Assessments, STAR Panel Reports, and Rebuilding Analyses. Pacific Fishery Management Council, Portland, Oregon.

Haltuch, M.A., Punt, A.E., Dorn, M.W. 2008. Simulation testing alternative estimators of unfished stock size. Fish. Res. 94: 290-303.

Zhou, S., Yin, S., Thorson, J., Smith, T., Fuller, M 2012. Linking fishing mortality reference points to life history traits: an empirical study. Can. J. Fish. Aquat. Sci. 69: 1292–1301.

**Table 1**. Probability of different $F$ values exceeding $F_{MSY}$ for spiny dogfish and longnose skate.

| | Spiny dogfish | Longnose skate |
|---|---|---|
| Pr($F_{35\%}$>$F_{MSY}$) | 0.997 | 0.969 |
| Pr($F_{40\%}$> $F_{MSY}$) | 0.950 | 0.801 |
| Pr($F_{45\%}$> $F_{MSY}$) | 0.731 | 0.474 |
| Pr($F_{50\%}$> $F_{MSY}$) | 0.386 | 0.193 |
| Pr($F_{55\%}$> $F_{MSY}$) | 0.164 | 0.061 |
| Pr($F_{60\%}$> $F_{MSY}$) | 0.048 | 0.017 |

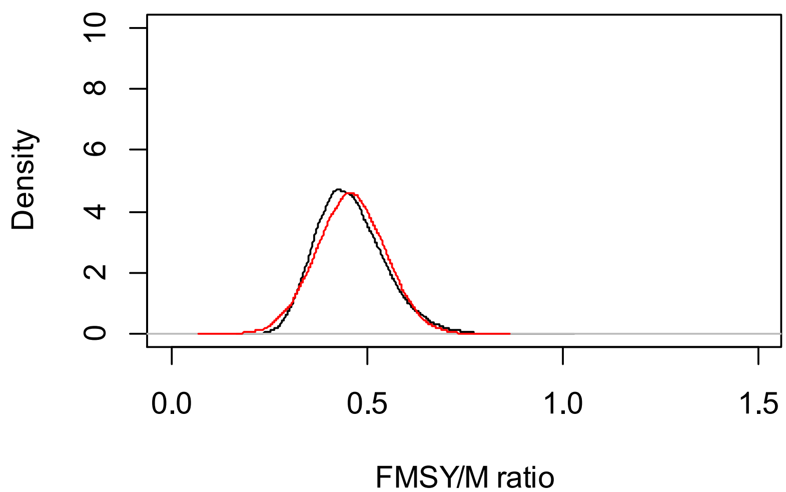


**Figure 1**. Comparison of normal and lognormal distributions for $F_{MSY}/M$ developed based on results in Zhou et al. (2012). The curve on the right (red) is the normal distribution and the curve on the left (black) is the lognormal distribution. A normal distribution for $F_{MSY}/M$ was assumed for the analysis.

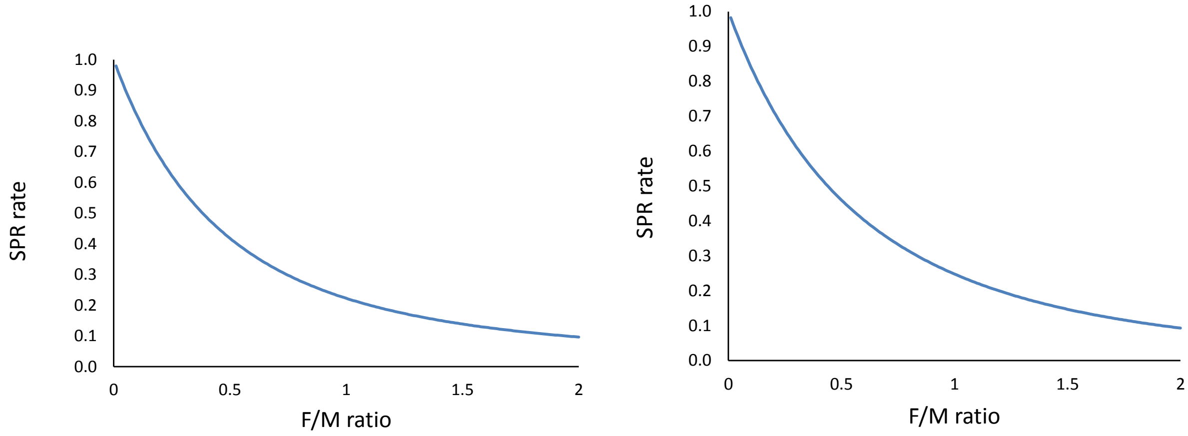


**Figure 2**. Transfer functions converting $F_{\mathrm{MSY}}/M$ to SPR for longnose skate (left panel) and spiny dogfish (right panel).

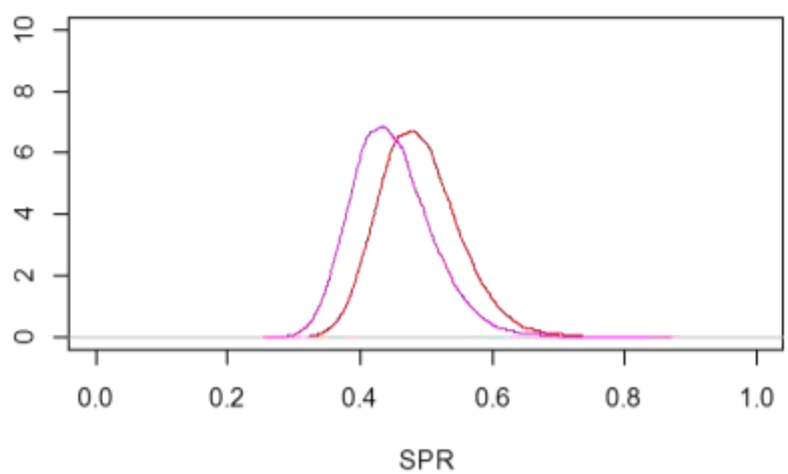


**Figure 3**. Distributions of spiny dogfish and longnose skate SPR obtained in the analysis. The curve on the right (red) represents spiny dogfish SPR distribution and the curve on the left (pink) represents longnose skate SPR distribution.

# CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE REPORT ON INITIAL ACTIONS FOR SETTING 2015-2016 GROUNDFISH FISHERIES

The California Department of Fish and Wildlife (CDFW) developed a draft range of management measures for the 2015-16 commercial and recreational fisheries. CDFW is considering the following possible changes to existing management measures based on the results of new assessments and/or rebuilding analyses.

## Commercial

CDFW is considering changes to commercial nearshore trip limits to keep catches within allowable harvest limits. CDFW is also considering removing the commercial gear restriction on flatfish to reduce regulatory complexity and align commercial and recreational regulations.

## Recreational

CDFW is considering changes to recreational regulations to keep catches within allowable harvest limits. The changes may include, but are not limited to, time/area management measures, bag limits, depth restrictions, and season structures.

## Other

CDFW is also considering changes to Rockfish Conservation Area lines in the San Diego area to more closely align way points with actual depth contours.

PFMC
09/14/13

# GROUNDFISH ADVISORY SUBPANEL REPORT ON INITIAL ACTIONS FOR SETTING 2015-16 GROUNDFISH FISHERIES

The Groundfish Advisory Subpanel (GAP) received a presentation from Mr. John DeVore and Ms. Kelly Ames on groundfish harvest specifications and management measures for the 2015-16 management cycle.

## Overfishing Limits and Acceptable Biological Catches

The only comment the GAP has on proposed overfishing limits (OFLs) and acceptable biological catches (ABCs) is that we would suggest the Council select a P* range of .25 to .45 for ABCs for all species for analysis. This would provide the greatest flexibility for all users to consider reasonable ABC and ACL alternatives at future meetings.

## Management Measures

The GAP worked from the table in Attachment 1 of the GMT statement when we discussed management measures. We appreciate the whole slate of potential measures and offer comments on three in particular:

*4) Bag limit, season structures, depth restrictions:* The GAP appreciates the inclusion of this for all three states, as the GAP requests a season extension of January and February for the southern California sport fishery.

*9) Year-round retention of lingcod by fixed-gear fisheries:* This would allow fishermen to keep only incidental catch for some fishermen and likely would not create a target fishery, especially if the number of pounds of lingcod allowed to be kept remained at limited levels.

*10) Allow crab pots to be fished by groundfish vessels:* The GAP understands this measure relates to derelict gear recovery in Oregon and suggests the term “fished” be changed to “retrieved” to avoid confusion. This way it is clear that if, for example, a trawl vessel hauls up a derelict crab pot in the net, the trawler can bring that crab pot to shore and not be required to leave it in the ocean. We also understand that subsequent discussions with enforcement consultants may make this issue inconsequential.

PFMC
09/15/13

# GROUNDFISH MANAGEMENT TEAM REPORT ON INITIAL ACTIONS FOR SETTING 2015-2016 AND BEYOND GROUNDFISH FISHERIES

The Groundfish Management Team (GMT) reviewed the items in the briefing book under this agenda item, participated in joint discussions with the Groundfish Advisory Subpanel (GAP) and Scientific and Statistical Committee (SSC), and provides the following comments.

**Proposed Overfishing Limits and Potential Acceptable Biological Catches for 2015 and 2016 Groundfish Fisheries**

The GMT reviewed the tables in Attachment 1 under this agenda item. Since recommending the overfishing limits (OFLs) is the purview of the SSC, the GMT does not have comments on the values in the table. We do note that the Minor Nearshore Rockfish North and Minor Nearshore Rockfish South complexes in Table 1 have "NA" as the OFL for brown, China, and copper rockfishes. The complex totals in the table do not include any value for those species with NAs. Therefore, when the OFLs for brown, China, and copper rockfishes are recommended by the SSC, the complex totals will need to be adjusted.

**Management Strategy Evaluation for Rebuilding Revision Rules**

The GMT received an overview from Dr. Andre´ Punt on his proof of concept paper on a management strategy evaluation for rebuilding revision rules (Attachment 2) and had a joint discussion with the SSC. Based on the discussion with the SSC, the GMT believes this concept is worth pursuing. Dr. Punt has requested input from the GMT on the range of scenarios to be considered in the analysis and intends to dedicate time at our October meeting to this topic. It is our understanding that Dr. Punt may wish to participate in that October discussion. The GMT welcomes his input and will continue to work with Dr. Punt and the SSC on this issue.

**Revisions to Council Operating Procedure 9**

The GMT reviewed a revised version of Council Operating Procedure 9 (COP 9) in the June Briefing Book at the June Council meeting. However, we did not have time to fully flesh out our thoughts and recommendations. Since the June meeting, the GMT has had the opportunity to further review and discuss the version of COP 9 in the September Briefing Book (Agenda Item G.7.a, Attachment 3) and provide the following additional thoughts.

In June, the GMT expressed concern with the portion of the COP that is being proposed as criteria for determining whether management measures should be considered in the biennial harvest specification and management measures analysis or analyzed in a separate process considered by the Council at the June meeting in even years. In June, the COP 9 language said eligible new management measures were only those needed to address conservation concerns. The GMT thinks the revised COP 9 criteria in the September briefing book (Agenda Item G.7.a, Attachment 3) which states "Council will provide initial fishery management guidance, including a preliminary range of new management measures necessary to keep catch within the annual catch limits (ACL) or address a habitat or protected resource concern" is an improvement.

The Council may wish to fashion these criteria more as strict rules, or more as a flexible standard. The latter would involve the Council having more direct consideration of how a particular item fits within the analysis, timing, workload, etc. Such discussions might take more time, and it can be difficult to apply standards consistently and fairly. A stricter rule, on the other hand, could be more quickly and consistently applied, with the downside that it might be overly restrictive in certain cases.

If the Council wishes to go with a stricter set of criteria, we recommend there be some discussion of what the criteria would be. For instance, it was unclear to some of us why habitat issues would be included. Some habitat issues might require extensive analysis. As it is now, the proposed criteria imply that by law or some policy that certain issues receive priority. The Council may want to discuss these criteria.

If the Council wishes to go with a more flexible approach, then additional language might be added to this section to allow the Council to have additional discussion on what management measures could be analyzed in the biennial process on a case by case basis. Some items may be better evaluated within the suite of alternatives in the biennial analysis but might not fit into the proposed criteria. The Council could consider adding more flexible language such as, "the Council may include other management measures if the timing or information presented in the harvest specifications would improve the efficiency of the analysis, implementation, or otherwise aid the Council's consideration." As it is now, one major limitation on what could be included comes from the scope of what has been previously and adequately analyzed in the Tier 1 Environmental Impact Statement (EIS) or elsewhere. And like now, consideration of additional analysis workload would be a major consideration in deciding whether to include a specific management measure in the analysis.

If the Council decides to adopt the proposed language in COP9, the Council may wish to consider the language "... keeping catch within the ACL..." and whether it might be better to revise the language to "... keeping catch within a specification." The term, specification, is defined in groundfish regulations (50 CFR 660.10) and includes annual catch targets, fishery harvest guidelines (ACL less tribal, research, groundfish mortality from non-groundfish fisheries, and EFPs), allocations, area apportionments, harvest guidelines (e.g., recreational HG for overfished species), etc. New management measures may be needed to keep catch within these specifications, which are broader than simply ACLs, and should be included for analysis during the harvest specification and management measures process.

The GMT also discussed the idea of incorporating the process for the methodology review of groundfish models that are used in the harvest specification and management measure process into COP 9. The Council is currently scheduled to develop a groundfish methodology review process, similar to what is specified in COP 15 for salmon, at the March 2014 meeting (see Agenda Item H.5.a, Attachment 1 Year at a Glance Schedule). During the model review process for the upcoming 2015-16 biennial process many of the model developers and the SSC reviewers expressed some confusion with the model review process and need for a more defined process. The GMT thinks a separate COP outlining a groundfish methodology review process is a good idea that would address these issues.

COP 9 specifies that the Council will select a range of two-year allocations in November of Year One. Receiving the preliminary Tribal set-aside estimates at this time is needed to establish those allocations and conduct analyses. In the past the Tribes have then provided their final estimate in June of Year Two. At the June Council meeting, the Tribes proposed to continue with this process (Agenda Item F.7.b, Supplemental Tribal Comment, June 2013). The GMT supports the Tribal proposal since it has worked well in recent biennial cycles. The COP could be revised to include the timelines for Tribal estimates of catch for the upcoming biennium.

**New Management Measures for 2015-2016**

The Council has committed to narrowing the scope of management measures for consideration during the biennial processes. As discussed above under COP 9, management measures that are considered "routine", currently available, or that are necessary to keep impacts within the ACL or address habitat or protected resource concerns are within the limited scope. Trip limits, bag limits, size limits for most species, seasons, and area closures are considered routine or currently available. Any measure that does not meet that criteria or has not been previously analyzed will be considered "new" and will be considered in a separate process beginning in June 2014 (June of even years).

At this meeting, the Council is scheduled to adopt a preliminary list of new management measures for consideration during this biennial process. It is a Council policy decision as to which management measures are "in" or "out" of the biennial process. To help the Council prioritize the list of management measures and determine which are "in" and which are "out", Attachment 1 contains the management measures the GMT has been informed of, so far, and our attempt to determine if they are eligible for the biennial process or should be postponed until the new process beginning in June of 2014. At the October meeting, the GMT will schedule time to review proposed management measures and evaluate the analysis that will be needed. We will provide the Council with more information at the November meeting.

**SPR Harvest Rate for West Coast Elasmobranch Species**

The GMT reviewed the SSC groundfish subcommittee report on the target spawning potential ratio (SPR) for west coast elasmobranch species. The new SPR of $F_{SPR50\%}$ will produce a spiny dogfish overfishing level (OFL) for 2015 of 2,523 mt, which is 86 percent of the OFL (2,921 mt) under the previous SPR of $F_{SPR45\%}$. Under the new SPR, using the status quo p-star (P*) of 0.30, the resulting ABC would be 1,731 mt. For some context, the 2014 ABC will be 2,024 mt, while the total mortality from all sectors was approximately 1,200 mt in 2010 and 1,662 mt in 2011 from the West Coast Groundfish Observer Program (WCGOP) groundfish mortality reports (Bellman et al, 2011 and Bellman et al, 2012). At this time, since the Council has not provided a range of harvest specifications (e.g., P* and ABCs), it is uncertain whether there is a need to explore adjustments to existing management measures (e.g., trip limits) or create new management measures (e.g., allocations, shorebased IFQ, etc).

**References**

Bellman, M.A., A.W. Al-Humaidhi, J. Jannot, J. Majewski. 2011. Estimated discard and catch of groundfish species in the 2010 U.S. west coast fisheries. West Coast Groundfish Observer Program. National Marine Fisheries Service, NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112.

Bellman, M.AA., A.W. Al-Humaidhi, J. Jannot, J. Majewski. 2012. Estimated discard and catch of groundfish species in the 2011 UU.S. west coast fisheries. West Coast Groundfish Observer Program.. National Marine Fisheries Service, NWFSC, 27225 Montlake Blvd E., Seattle, WA 98112.

Attachment 1. Table of proposed management measures that the GMT was informed of in time for this statement.

| No. | Proposed By | Sector | Measure | Part of 15-16 Biennial Analysis | "New" June 2014 Process | Comment |
|---|---|---|---|---|---|---|
| 1 | GMT | All | Update coordinates defining RCAs to better approximate depth | X | | Housekeeping |
| 2 | GMT | Fixed gear | Increase fixed gear trip limits for selected species (e.g., lingcod, slope rockfish, etc.) | X | | Trip limit adjustment. |
| 3 | GMT | Shorebased Trawl | Depending on harvest specifications and allocations for certain species, IFQ may need to be issued (e.g., dogfish) | X | | If IFQ are needed to keep catch within the ACL, it's eligible. However, given workload associated with initial allocations (esp. with a discarded species), it might be best to be done in a separate 2-3 mtg process with implementation for Jan 1, 2015. |
| 4 | CDFW/ ODFW/ WDFW | Recreational | Bag limit, season structures, depth restrictions | X | | Routine adjustments |
| 5 | ODFW/ WDFW | OR/WA recreational | Retention of bottomfish (or lingcod or flatfish) in the recreational all-depth halibut fishery | X | | Bag limit change |
| 6 | CDFW | Nearshore | Consider making the deeper nearshore rf trip limits the same for south 40°10' - i.e. remove the split at 34°27'. This applies for periods 1 and 3. | X | | Trip limit adjustment |
| 7 | ODFW | OR recreational | Recreational management line at 50 fm | X | | Area closure change |
| 8 | ODFW | OR recreational | Consider adjustments to YRCAs | X | | RCA adjustment |
| 9 | ODFW | Fixed gear | Year-around retention of lingcod by commercial fixed gear fisheries | X | | Open season adjustment |

| No. | Proposed By | Sector | Measure | Part of 15-16 Biennial Analysis | "New" June 2014 Process | Comment |
|---|---|---|---|---|---|---|
| 10 | ODFW | Commercial | Allow crab pots to be fished by groundfish vessels | | **X** | Allow vessels to participate in the Dungeness crab fishery or retrieve derelict gear while they have groundfish and/or groundfish gear onboard the vessel. Exempt crab gear from this regulation. |
| 11 | WDFW | WA recreational | Consider new yelloweye YRCAs | **X** | | New RCA |
| 12 | WDFW | WA recreational | Modify depth restrictions | **X** | | Seasonal depth restriction adjustment |
| 13 | WDFW | WA recreational | Modify or eliminate boundaries of lingcod closure areas | **X** | | Area adjustment |
| 14 | Public | Fixed gear | Increase allocation of canary rockfish for directed OA in CA | **X** | | Allocation |
| 15 | Public | Fixed gear | Increase allocation of yelloweye rockfish for directed OA in CA | **X** | | Allocation |
| 16 | Public | Nearshore | Add a management line at Año Nuevo (37°07' N lat.) for a possible discrete area from 34°27 ' to 37° 07' for increased management option for Port San Luis and Morro Bay commercial nearshore fishermen to attain a higher percentage of the ACL of nearshore finfish species | | **X** | New management line, to attain more of the ACL |
| 17 | Public | Nearshore | Increase the bi-monthly trip limit to 1,000 pounds of shallow nearshore rockfish in periods 1, 3-6 for commercial nearshore fishermen in the area from 34°27' to 37°07' N lat. | **X** | | Trip limit adjustment |

| No. | Proposed By | Sector | Measure | Part of 15-16 Biennial Analysis | "New" June 2014 Process | Comment |
|---|---|---|---|---|---|---|
| 18 | Public | Nearshore | Increase the bi-monthly trip limit to 1,000 pounds of deeper nearshore rockfish in period 1, 3-6 for commercial nearshore fishermen in the area from 34° 27' to 37° 07' N lat. | **X** | | Trip limit adjustment |
| 19 | Public | Nearshore | Change season dates for lingcod: Allow for lingcod retention in the LE and OA fixed gear fisheries Dec, Jan, and Feb in OR and CA | **X** | | Season date adjustment |
| 20 | Public | Fixed gear | For commercial directed open access groundfish consider allowing fishing from 0 to 40 fathoms | **X** | | Area closure change |
| 21 | Public ~~a/~~ | Recreational | Retention of canary rockfish in the recreational fishery | **X** | | Bag limit change |
| 22 | Public ~~a/~~ | Recreational | Recreational long-leader gear outside of 40 fm | | **X** | New gear/fishery--appears to be on its own separate process, though it has been delayed from Nov 13 to Mar 14. On list as a reminder |

# GROUNDFISH MANAGEMENT TEAM REPORT ON THE SSC ECONOMICS AND GROUNDFISH SUBCOMMITTEES' REPORT ON DATA AND MODELS TO BE USED IN THE SOCIOECONOMIC ANALYSIS FOR THE 2015-16 GROUNDFISH BIENNIAL SPECIFICATIONS PROCESS

During the 2012-13 time frame, the Scientific and Statistical Committee (SSC) Economics and Groundfish Subcommittee reviewed data and models to be used by the Groundfish Management Team (GMT) for their analysis of 2015-16 Harvest Specification and Management Measures (2015-16 SPEX). This 2015-16 SPEX analysis will include a long term Tier 1 analysis. At the June 2013 Pacific Fishery Management Council (PFMC) meeting, the SSC submitted a report which included summaries and recommendations from those reviews (Agenda Item F.7.b, Supplemental SSC Report, June 2013). The following overarching requests were made in the report:

- Provide more data and model documentation, focusing on specific areas suggested in their report;
- Ensure that this documentation be made publically available on the PFMC website or other location;
- Provide the SSC a time frame for when specific model recommendations and updates would be addressed by the GMT;
- Provide a GMT liaison for each model; and
- Allow time for the SSC to review the socioeconomic analysis that will be included in the 2015-16 SPEX analysis.

The SSC report also recommended that review of the current GMT Trawl Bycatch Model was a "high priority". This model may be part of the 2015-16 SPEX analysis. Reviews of the Northwest Fisheries Science Center's (NWFSC) voluntary cost-earnings, angler expenditures, and charter operator surveys were considered "lower priority". The data collected from these surveys will underlie some of the socioeconomic analysis to be included in the 2015-16 SPEX document (2015-16 Environment Impact Statement or EIS).

The SSC report concluded the GMT models reviewed in the 2012-13 time frame represented the best available science and were appropriate for use in the 2015-16 SPEX analysis. Also note that the Landings Distribution Model was reviewed in September 2011 and was also recommended as appropriate for use. The SSC report also pointed to specific areas where models could be updated or improved but did not necessarily suggest that these items had to be completed for the 2015-16 SPEX. Instead, they suggested that continued work and dialogue regarding these updates be planned in the near future, for example, in the "off-years" (i.e., even numbered years when stock assessments are not being reviewed).

In August, a subgroup of the GMT discussed these recommendations and comments (typically highlighted in bold typeface in the SSC report), and identified the following:

- items that would be addressed in time for the 2015-16 SPEX analysis; and
- items that require more time for analysis and/or discussion (i.e., after the 2015-16 SPEX analysis is complete.

Of note, the full GMT has not had an opportunity to discuss the SSC's specific model recommendations and how they might help improve the socioeconomic analysis included in each SPEX analysis. Our understanding is that reviewing and improving the socioeconomic analysis was the initial intent of these reviews. Some on the GMT may have different views on such things as priorities for what should be reviewed next and what model updates to work on. We would like an opportunity to discuss any differences in views with the SSC. Moreover, competing workload has meant that the full team has not had the opportunity to participate in each of the model reviews or discuss the bigger picture with the SSC regarding further direction of the reviews by the Economics and Groundfish Subcommittees. Those on the team contributing to this report support the SSC's recommendation for continued dialogue between the two advisory bodies on these issues.

***Oregon Recreational Model***

Patrick Mirick from the Oregon Department of Fish and Wildlife (ODFW) presented this model in March 2012. Lynn Mattes (ODFW) is the GMT liaison to the SSC and Mr. Mirick for this model.

*To be completed for the 2015-16 SPEX analysis*

- Explore whether the distribution of effort by depth bin varies by port. If so, effort projections should be done at the port level.
- Apply a "smoothing or interpolating model" to the angler catch data that is used to populate a multiplier table that underlies the model's prediction of bag limit changes.
- Changes to the regression line for projecting harvest and discard mortality in the halibut fishery.

*Further discussion and future analysis*

- Development of variance estimates for harvest and discard mortalities was considered "highest priority" for this model. This recommendation echoed one also made by the Marine Recreational Information Program (MRIP) during their review of this model

(Breidt et al. 2010). To realize this recommendation, the ODFW's Oregon Recreational Boat Survey (ORBS) sampling program would need to provide these estimates. It is our understanding that ORBS is working on this but a specific timeline is not currently available.

- Related to the "Issues for future reviews" in this model's summary report, the GMT would like to note that reconciling the port complex level economic impacts resulting from IO-PAC and the port or community level economic impacts conducted by state agencies (e.g., pp. B97-B101, Appendix B, 2013-14 FEIS) is an issue for further discussion. We would like to continue a dialogue with the SSC about how to interpret these reported impacts.
- Also see "Oregon, Washington and California Recreational Model" section below.

***Washington Recreational Model***

Heather Reed from the Washington Department of Fish and Wildlife (WDFW) presented this model in September 2012 and is the GMT liaison to the SSC and WDFW for this model.

*To be completed for the 2015-16 SPEX analysis*

Complete a retrospective analysis of how effort projections compare with post-season effort estimates. However, the GMT notes that this model does not predict changes in effort when the differences between alternative management measures are very small.

*Further discussion and future analysis*

See "Oregon, Washington and California Recreational Model" section below.

***California Recreational Model (CA RecFISH)***

John Budrick from the California Department of Fish and Wildlife (CDFW) presented this model in September 2012 and is the GMT liaison to the SSC and CDFW for this model.

*To be completed for the 2015-16 SPEX analysis*

Validate the current model assumptions related to how effort responds to depth closures and time of year. "This validation could be extended to more broadly examine how the proportion of effort varies by time (month) and depth, using recent historical data." At minimum, a qualitative analysis of these model assumptions will be completed for the 2015-16 SPEX.

*Further discussion and future analysis*

- Regarding the retrospective analysis of catch provided by CDFW at this model's review: "redefine the stratification of areas so that they correspond to the areas used in the Spex process and focus the analysis on effort rather than catch." This will be considered after the 2015-16 SPEX.

- A diagnostic recommended for this model: the coefficients of variation (CVs) "could be carried through the model to show measures of uncertainty in the final output." The GMT agrees that this would be valuable. However, similar to the OR Recreational Model, these estimates will need to be calculated by partners outside the GMT: CA's sampling program, the California Recreational Fishing Survey (CRFS). As was the case for ODFW, the MRIP review of the CA RecFISH model provided a similar recommendation (Breidt et al. 2011). Our understanding is that a specific timeline from CRFS is not currently available.
- One diagnostic recommended for this model included a summary statistics of "the number of correct predictions (with "correct" defined within a given bound)." The GMT would like further discussion with the SSC about how this "correct" definition is to be applied.
- Also see "Oregon, Washington and California Recreational Model" section below.

***Oregon, Washington, and California Recreational Model Reviews***

The SSC Subcommittee's report on the OR Recreational Model review pointed to three sets of questions that should be answered for future reviews ("Issues for future reviews"). Though these questions are found only in the OR Recreational Model summary, some on the GMT agreed that they apply to all three state recreational models.

- The first set of questions, which will be discussed in the 2015-16 SPEX analysis, are questions related to the kind of data or model estimates that the state fishery agencies provide for the IO-PAC model and the process for "moving" this data into IO-PAC.
- The second set of questions is related to how RecFIN estimates groundfish landings and effort for each state, and whether these estimates differ from the data inputted into IO-PAC. This item will require collaboration with RecFIN and the NWFSC. Though a specific timeline is unclear, this is an item that requires more time for discussion and may be addressed after the 2015-16 SPEX analysis is complete.
- The third question in the SSC report asked how projection methods used by the GMT differ from the IO-PAC model's estimation methods. This item will require collaboration from the NWFSC. It is currently unclear when this item can be addressed but it may be included for further discussion following the 2015-16 SPEX process.

Additional recommendations were mentioned specifically in the WA Recreational Model summary that some on the GMT recognized as applicable to all three state recreational models:

- A retrospective analysis of changes in fishing effort over time will be completed for the 2015-16 SPEX. This has already been completed for the OR Recreational Model.
- Develop models that predict the effect of "fishery-related drivers on angler effort" (e.g., area/depth restrictions) to "more accurately consider the economic impacts of management alternatives." This item will require more time, discussion, and possibly additional expertise from outside the team. This item may be addressed after the 2015-16 SPEX analysis is complete.

***Non-nearshore Impact Projection Model***

Corey Niles (WDFW) presented this model in March 2013. Mr. Niles and Dan Erickson (ODFW) are the GMT liaisons to the SSC and the West Coast Groundfish Observer Program (WCGOP) for this model. The WCGOP updates this model for the GMT and collects the data underlying this model. Any model updates must be completed by WCGOP and a timeline for addressing recommendations in the SSC report is currently unclear. Also, some GMT members (e.g., NMFS, ODFW) but not all (e.g., CDFW, WDFW) currently have confidentiality agreements with WCGOP that allows access to the datasets used in this model. To the extent that the GMT can address some of the SSC recommendations, this is noted below.

*To be completed for the 2015-16 SPEX analysis*

- Develop a measure of variability to be included with the projection estimates. Dr. Jason Cope (NWFSC) has developed a method of estimating coefficients of variation for the bycatch estimates of overfished species. This method is currently being reviewed by the WCGOP; the SSC noted that it too would like an opportunity to review this method. The WCGOP will provide these estimates to the GMT prior to the November 2013 PFMC meeting.

*Further discussion and future analysis*

- Conduct data analysis to determine whether there is a trend in the data and to better understand inter-annual variation in the data. The time frame for completing this is currently unknown and will require collaboration with WCGOP to address this item.
- Explore "possible highgrading of the catch" as a possible source of error, and more generally, the possibility of using "total catch" of sablefish instead of "retained catch" as the denominator in the bycatch ratios. If it is possible to do so, this change might simplify the model by removing the sablefish discard as a variable in the model. However, it may not be possible to do this given how WCGOP collects data and estimates catch. In addition, making this change will not eliminate uncertainty caused by annual variations in discard amounts. Those on the GMT with current confidentiality agreements with WCGOP can begin to address this item after the 2015-16 SPEX analysis is complete and will need to collaborate with the WCGOP as well.

***Nearshore Impact Projection Model***

Dan Erickson (ODFW) presented this model in March 2013. Mr. Erickson and Bob Leos (CDFW) are the GMT liaisons to the SSC and the West Coast Groundfish Observer Program (WCGOP) for this model. As is the case with the Non-nearshore Impact Projection Model, the WCGOP assists the GMT with the development and maintenance of this model. That is, WCGOP collects and provides bycatch and effort data, and the GMT provides landings data as well as recreational discard-mortality data by depth strata. Any model updates must be completed in collaboration with WCGOP.

The timeline for addressing these recommendations in the SSC report is currently unclear. As mentioned previously, some GMT members (e.g., NMFS, ODFW) but not all (e.g., CDFW, WDFW) currently have confidentiality agreements with WCGOP that allows access to the datasets used in this model. To the extent that the GMT can address some of the SSC recommendations, this is noted below.

*To be completed for the 2015-16 SPEX analysis*

- Define risk tolerance in this model by identifying "explicit buffers (e.g., one standard deviation for projected annual landings) that are sufficiently wide to avoid exceeding allocations for overfished species." A range of buffers will be analyzed for Council consideration in November.
- Develop a measure of variability to be included with the projection estimates. Dr. Jason Cope (NWFSC) has developed a method of estimating coefficients of variation for the bycatch estimates of overfished species. This method is currently being reviewed by the WCGOP; the SSC noted that it too would like an opportunity to review this method. The WCGOP will provide these estimates to the GMT prior to the November 2013 PFMC meeting.

*Further discussion and future analysis*

- Evaluate the representativeness of nearshore vessels included in the WCGOP data. Those members of the GMT with access to the WCGOP data will begin to address this item after the 2015-16 SPEX analysis is complete.
- A comment was made in the SSC report about evaluating trends in this model while noting that small sample sizes and outliers may make interpretation of trends difficult. We would like further discussion with the SSC about how to move forward with this recommendation. That is, how small is a "small sample", how should years be weighted, how many years to include, etc.
- Related to the above, the SSC report noted that "[s]mall samples of nearshore vessels in the WCGOP have hampered the GMT's ability to evaluate and improve the performance

of the Nearshore Model. Lack of access to WCGOP data is also an issue for CDFW." We would like further discussion with the SSC on this item, e.g., how small is too small when it comes to sample sizes used for this model?

- The SSC report mentioned that "changes in overfished species catch ratios is complicated by the fact that the denominator includes a mix of species that are differentially priced in the market and whose availability to the fishery is affected by depth restrictions that change over time." We would like further discussion with the SSC on how to move forward with this comment. For example, the GMT could choose a few frequently caught species (e.g., black rockfish, north of 40°10') to include in the denominator but we are uncertain whether this is sufficient or desirable.
- The SSC commented that "[i]ncreasing the number of area strata may allow management to be more finely tuned in terms of protecting overfished stocks while reducing negative community effects. However, finer stratification may also suggest that the model can do more than it actually can, given the sample size constraints." The GMT provided ratios and sample sizes for two additional area strata in the model presentation and documentation presented in March 2013. We would like further discussion with the SSC on how to move forward with this recommendation and whether this comment was specific to an area (e.g., south of 34°27'). As previously mentioned, the GMT would need to collaborate with the WCGOP if changes in the model structure (i.e., changes in area stratification) are recommended.
- The model relies on Oregon gear compositions from 2004-06 to characterize both the Oregon and California fisheries (i.e., longline and pot use versus "recreational-like" gear use). The SSC noted that this "may be problematic" but the "CDFW lacks the data needed to make similar calculation on their own." Though the GMT can update the estimates derived from the ODFW logbook data to the three most recent years, for example, we would like further discussion with the SSC on whether this approach is sufficient for responding to this item. The GMT could also explore how the WCGOP data might inform estimates of proportions of gear types used by area and depth strata.
- The model assumes that mortality at depths greater than 20 fathoms is 100%, which contradicts the recreational mortality-depth matrix. Though not specifically noted in the SSC Subcommittee's report, we will explore this assumption further and collaborate with WCGOP to determine whether a model adjustment should be made.

***Rebuilding analysis and discussion***

A joint GMT and SSC discussion occurred in April 2012 regarding the upcoming rebuilding analysis that Dr. Andre Punt is currently completing. Dr. Punt will present his updated rebuilding analysis at the September 2013 PFMC meeting. The models reviewed by the SSC Subcommittees and discussed in this report all play a part in the analysis of alternative rebuilding plans. The GMT recognizes a need to look at how well these models and rebuilding analyses are able to compare and contrast rebuilding alternatives relative to the "needs of the fishing community," a factor that the Council considers when setting and revising rebuilding plans. That is, what weight should be given to short-term needs relative to long-term conservation benefits? Corey Niles is the GMT liaison to the SSC for this ongoing rebuilding discussion.

*To be completed for the 2015-16 SPEX analysis*

- The GMT will be exploring rebuilding analyses scenarios that will look at the effect of implementation error (i.e., actual catch differing from what was planned for) and add prediction/confidence intervals to rebuilding forecasts.
- The GMT will be interested in continuing discussing with the SSC, and it's relevant Subcommittees, the issue of long-term trade-offs in rebuilding and how they might be explored with the rebuilding analyses forecasts and the Management Strategy Evaluation.
- The GMT will be discussing, with the SSC, how adequate progress in rebuilding can be better evaluated and how the Council can best avoid the "chasing of noise" when responding to updated stock assessments and rebuilding forecasts.

*After the 2015-16 SPEX analysis*

- The GMT agrees with the SSC's recommendation to continue dialogue on the rebuilding analysis in off-years. It is an ongoing discussion that the GMT would like to remain engaged in.

In addition, the GMT notes that there may be some connection between the rebuilding analysis and the Tier 1 analysis that is part of the 2015-16 SPEX analysis.

***Other data and models contributing to the 2015-16 SPEX analysis***

*Landings Distribution Model (LDM)*

This model was presented by Ed Waters (PFMC contractor) in September 2012 to provide the SSC with an overview of the model to help them better understand the connection between the GMT's landings and effort projection models and the NWFSC' IO-PAC model (a regional economic impact model) reviewed in 2012-13 time frame. Dr. Kit Dahl (Council staff) serves as the liaison to the SSC, GMT, and Mr. Waters for this model. The LDM was reviewed in September 2011 and the results of that review were provided in the November 2011 Briefing Book (Draft September 2011 SSC Minutes, November 2011). The SSC report recommended that the 2015-16 SPEX socioeconomic analysis include information regarding the predictive performance of the LDM projections by port area and sector. The SSC report also requested documentation of how effort and landings projections are distributed among ports. The GMT notes that the LDM is documented in Appendix A of the 2013-14 FEIS. We would like further discussion with the SSC to determine whether this existing information is sufficient for addressing this recommendation.

Council staff and the GMT have been in contact with Mr. Waters regarding the SSC's recommendations but a time frame for responding to them is not available at this time. Further discussion about these recommendations will occur with Mr. Waters at the GMT's October working meeting (9/30 – 10/4, location to be decided).

*IO-PAC and the Economic Data Collection Program (EDC)*
The IO-PAC model was presented by Jerry Leonard (Northwest Fisheries Science Center or NWFSC) and the EDC Program was presented by Dr. Todd Lee (NWFSC) and Erin Steiner (NWFSC). Dr. Kit Dahl (Council staff) serves as the liaison to the SSC, GMT, and the NWFSC staff for this model. Council staff and the GMT have not yet had an opportunity to discuss with the NWFSC staff regarding the SSC's recommendations and their time frame for responding to them. Council staff and the GMT are currently discussing different options for continuing related dialogue with the NWFSC.

As mentioned previously in the OR Recreational Model section above, the GMT would like further discussion with the SSC on interpreting the port complex level economic impacts generated by the IO-PAC model relative to the community or port level economic impacts generated by state agencies (e.g., ODFW).

***References***

Breidt, J. and J. Opsomer. 2010. "Consultant's Report: Review of Ocean Recreational Boat Survey." Available at:
http://www.countmyfish.noaa.gov/projects/downloads/MRIP_ORBS_Review_Report_Final.pdf

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# SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON INITIAL ACTIONS FOR SETTING 2015-2016 GROUNDFISH FISHERIES

The Scientific and Statistical Committee (SSC) reviewed and discussed a number of topics relating to Agenda Item G.7 "Initial Actions for Setting 2015-2016 Groundfish Fisheries", including 1) the proposed 2015-16 overfishing limits (OFLs), stock categories, and sigma values for stocks and stock complexes (Agenda Item G.7.a, Attachment 1), 2) a new proxy $F_{MSY}$ spawning potential ratio for elasmobranchs (Agenda Item G.7.b, SSC Groundfish Subcommittee Statement Regarding a Change in Target SPR Rate for West Coast Elasmobranch Species), 3) Dr. André Punt's briefing paper on Management Strategy Evaluation for Rebuilding Revision Rules: A Proof of Concept (Agenda Item G.7.a, Attachment 2), and 4) the GMT's response to the SSC Economics Subcommittee report on data and models to be used in the socioeconomic analysis for the 2015-16 groundfish biennial specifications process (Agenda Item G.7.b, Supplemental GMT Report). Mr. John DeVore was available to answer questions and contributed to the discussions.

## 2015-16 Overfishing Limits, Stock Categories, and Sigma Values

The SSC reviewed the draft table of OFLs for 2015-16 and with the assistance of Mr. DeVore developed a revised table (attached) that includes changes to some of the OFL values (e.g., the revised OFL for bocaccio rockfish is from the 2013 assessment rather than the 2011 rebuilding analysis), category assignments (e.g., longspine and shortspine thornyhead are now category 2 stocks) and corrections to some subcategory designations. Information was unavailable for several stocks pending further analyses (e.g., a rebuilding analysis for cowcod and revised data-moderate assessment results for China rockfish). The information for the Other Fish stock complex will be completed following the Council's decision on restructuring this stock complex. The table shows "NA" values for canary rockfish pending a review of the 2011 rebuilding analysis, which may have had a mis-specification. With regard to buffers for scientific uncertainty, the SSC recommends calculating values for the percentage reductions in OFLs based on the information presented in Table 3 of Agenda Item G.7.a, Attachment 1, but notes that the column of values for shortspine thornyhead does not apply because the SSC has determined that this stock should be treated as a category 2 stock.

The SSC notes that several of the stocks listed in the OFL table are from assessments that are now rather dated (e.g., gopher rockfish was last assessed in 2005). Because catch projections become increasingly uncertain as the length of the projection period increases, the buffer for scientific uncertainty should also increase. During the coming year the SSC will consider different approaches for revising OFL buffers for increasing scientific uncertainty through time, which will affect harvest specifications for 2017 and beyond.

The SSC recommends the OFL values and category designations indicated in the attached table. Values that are unavailable (NA) will be provided in a revised table at the November Council meeting.

Proxy $F_{MSY}$ Spawning Potential Ratio for Elasmobranchs

The SSC reviewed the Groundfish Subcommittee's report on a new proxy $F_{MSY}$ spawning potential ratio for elasmobranchs and received a presentation from Dr. Martin Dorn, who conducted the analysis that informed the Subcommittee report. The SSC concurs with the Subcommittee's recommendation that the Council adopt $F_{SPR50\%}$ as the default proxy fishing mortality rate for elasmobranch species managed by the Council. However, to inform management decisions for 2017 and beyond the SSC may recommend further revision to the default SPR for elasmobranchs based on an analysis of the maximum rate of population increase implied by the number of pups per female, which is constraining in elasmobranch species compared to rockfish or other species that produce large numbers of offspring per female.

The SSC was not presented with any information to justify changing the $B_{MSY}$ proxy from the current proxy of $B_{40\%}$.

Management Strategy Evaluation for Rebuilding Revision Rules

The SSC received a presentation from Dr. André Punt on the software that he has developed for conducting a management strategy evaluation (MSE) of possible rules for revising rebuilding plans (e.g., whether, when, and by how much to change the target SPR). The software is designed to measure how different revision rules for rebuilding plans are impacted by uncertainty in assessments and other sources of noise, and how the rules influence relative performance in terms of catch, variability in catch, and the frequency of false declarations that a stock has rebuilt. This tool will provide useful guidance to the Council, but designing an appropriate set of simulation runs will require consultation with Council staff and advisory bodies and careful planning of a simulation experiment to evaluate a limited set of revision rules. The SSC notes that the Council currently has only one stock (cowcod) for which a new rebuilding analysis will be conducted. The SSC recommends that the process for developing revision rules for rebuilding plans be separated from the development of Amendment 24 and the 2015-16 biennial management specification process. Dr. Punt will collaborate with the GMT to further develop the analysis and will provide a summary to the Council in November.

GMT response to the SSC Economics Subcommittee report

In 2012-2013, the SSC Economics and Groundfish Subcommittees reviewed data and models used in the socioeconomic analysis for the groundfish specifications process. The report by the Groundfish Management Team (Agenda Item G.7, GMT Report) discusses how the GMT intends to incorporate some of the SSC recommendations into the 2015-16 specifications analysis, and also notes other issues raised by SSC that would require longer-term work and consultation with the SSC and various staff at NMFS and state agencies. The SSC recommends a 1-2 day meeting of the GMT and the SSC Economics Subcommittee in 2014 to address some of these longer-term issues. Priority issues to be addressed at the meeting and the materials to be prepared in advance of the meeting would be identified in consultation with the GMT.

Table 1. 2014 OFLs (mt) and SSC-recommended 2015 and 2016 OFLs (mt) for west coast groundfish stocks (overfished stocks in CAPS; stocks with new assessments in **bold**; component stocks in status quo stock complexes in *italics*).

| Stock | 2014 OFL | Category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|
| | | | | |
| **OVERFISHED STOCKS** | | | | |
| **BOCACCIO S. of 40$^{0}$10’ N. latitude** | **881** | **1** | **1,444** | **1,351** |
| CANARY | 741 | 1 | NA | NA |
| COWCOD S. of 40$^{0}$10’ N. latitude | 12 | | **NA** | **NA** |
| ***COWCOD (Conception)*** | **7** | **2** | ***NA*** | ***NA*** |
| *COWCOD (Monterey)* | 5 | 3 | ***NA*** | ***NA*** |
| **DARKBLOTCHED** | **553** | **1** | **588** | **595** |
| PACIFIC OCEAN PERCH | 838 | 1 | 842 | 850 |
| **PETRALE SOLE** | **2,774** | **1** | **2,946** | **3,044** |
| YELLOWEYE | 51 | 2 | 52 | 52 |
| **NON-OVERFISHED STOCKS** | | | | |
| Arrowtooth Flounder | 6,912 | 2 | 6,599 | 6,396 |
| Black Rockfish (OR-CA) | 1,166 | 1 | 1,176 | 1,183 |
| Black Rockfish (WA) | 428 | 1 | 421 | 423 |
| Cabezon (CA) | 165 | 1 | 161 | 158 |
| Cabezon (OR) | 49 | 1 | 49 | 49 |
| California scorpionfish | 122 | 1 | 119 | 117 |
| Chilipepper S. of 40$^{0}$10’ N. latitude | 1,722 | 1 | 1,703 | 1,694 |
| Dover Sole | 77,774 | 1 | 66,871 | 59,221 |
| **English Sole** | **5,906** | **2** | **12,092** | **8,493** |
| Lingcod N. of 40º10’ N. latitude | 3,162 | 1 | 3,010 | 2,891 |
| Lingcod S. of 40º10’ N. latitude | 1,276 | 2 | 1,205 | 1,136 |
| Longnose skate | 2,816 | 1 | 2,449 | 2,405 |
| **Longspine Thornyhead (coastwide)** | **3,304** | **2** | **5,007** | **4,763** |
| Pacific Cod | 3,200 | 3 | 3,200 | 3,200 |
| Sablefish (coastwide) | 7,158 | 1 | 7,857 | 8,526 |
| Shortbelly | 6,950 | 2 | 6,950 | 6,950 |
| **Shortspine Thornyhead (coastwide)** | 2,310 | **2** | **3,203** | **3,169** |
| Splitnose S. of 40$^{0}$10’ N. latitude | 1,747 | 1 | 1,794 | 1,826 |
| Starry Flounder | 1,834 | 2 | 1,841 | 1,847 |
| Widow | 4,435 | 1 | 4,137 | 3,990 |
| **Yellowtail N. of 40$^{0}$10’ N. latitude** | **4,584** | **2** | **12,281** | **11,647** |
| **STOCK COMPLEXES** | | | | |
| Minor Nearshore Rockfish North | 110 | | NA | NA |
| *Black and yellow* | *0.01* | 3 | *0.01* | *0.01* |
| *Blue (CA)* | *27.4* | 2 | *27.4* | *27.7* |
| *Blue (OR & WA)* | *32.3* | 3 | *32.3* | *32.3* |
| ***Brown*** | ***5.5*** | **2** | ***NA*** | ***NA*** |
| *Calico* | - | 3 | - | - |
| ***China*** | ***9.8*** | **2** | ***NA*** | ***NA*** |
| ***Copper*** | ***26.0*** | **2** | ***NA*** | ***NA*** |
| *Gopher* | - | 3 | - | - |
| *Grass* | *0.7* | 3 | *0.7* | *0.7* |
| *Kelp* | *0.01* | 3 | *0.01* | *0.01* |
| *Olive* | *0.3* | 3 | *0.3* | *0.3* |
| *Quillback* | *7.4* | 3 | *7.4* | *7.4* |
| *Treefish* | *0.2* | 3 | *0.2* | *0.2* |
| Minor Shelf Rockfish North | 2,195 | | 2,207 | 2,217 |

| Stock | 2014 OFL | Category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|
| *Bronzespotted* | - | 3 | - | - |
| *Bocaccio* | *284.0* | 3 | *284.0* | *284.0* |
| *Chameleon* | - | 3 | - | - |
| *Chilipepper* | *129.6* | 3 | *128.2* | *127.5* |
| *Cowcod* | - | 3 | - | - |
| *Flag* | *0.1* | 3 | *0.1* | *0.1* |
| *Freckled* | - | 3 | - | - |
| *Greenblotched* | *1.3* | 3 | *1.3* | *1.3* |
| *Greenspotted 40°10' to 42° N. latitude* | *9.4* | 2 | *9.3* | *9.3* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *6.1* | 3 | *6.1* | *6.1* |
| *Greenstriped* | *1,268.3* | 2 | *1,281.9* | *1,292.0* |
| *Halfbanded* | - | 3 | - | - |
| *Harlequin* | - | 3 | - | - |
| *Honeycomb* | - | 3 | - | - |
| *Mexican* | - | 3 | - | - |
| *Pink* | *0.004* | 3 | *0.004* | *0.004* |
| *Pinkrose* | - | 3 | - | - |
| *Puget Sound* | - | 3 | - | - |
| *Pygmy* | - | 3 | - | - |
| *Redstripe* | *269.9* | 3 | *269.9* | *269.9* |
| *Rosethorn* | *12.9* | 3 | *12.9* | *12.9* |
| *Rosy* | *3.0* | 3 | *3.0* | *3.0* |
| *Silvergray* | *159.4* | 3 | *159.4* | *159.4* |
| *Speckled* | *0.2* | 3 | *0.2* | *0.2* |
| *Squarespot* | *0.2* | 3 | *0.2* | *0.2* |
| *Starry* | *0.004* | 3 | *0.004* | *0.004* |
| ***Stripetail*** | ***40.4*** | **3** | ***40.4*** | ***40.4*** |
| *Swordspine* | *0.0001* | 3 | *0.0001* | *0.0001* |
| *Tiger* | *1.0* | 3 | *1.0* | *1.0* |
| *Vermilion* | *9.7* | 3 | *9.7* | *9.7* |
| Minor Slope Rockfish North | 1,553 | | 1,804 | 1,817 |
| ***Aurora*** | ***15.4*** | **1** | ***17.4*** | ***17.5*** |
| *Bank* | *17.2* | 3 | *17.2* | *17.2* |
| *Blackgill* | *4.7* | 3 | *4.7* | *4.7* |
| *Redbanded* | *45.3* | 3 | *45.3* | *45.3* |
| ***Rougheye*** | ***71.1*** | **1** | ***201.9*** | ***205.8*** |
| ***Sharpchin*** | ***214.5*** | **2** | ***305.6*** | ***297.6*** |
| *Shortraker* | *18.7* | 3 | *18.7* | *18.7* |
| *Splitnose* | *974.1* | 1 | *1,000.6* | *1,018.2* |
| *Yellowmouth* | *192.4* | 3 | *192.4* | *192.4* |
| Minor Nearshore Rockfish South | 1,160 | | NA | NA |
| *Shallow Nearshore Species* | NA | NA | NA | NA |
| *Black and yellow* | *27.5* | 3 | *27.5* | *27.5* |
| ***China*** | ***16.6*** | **2** | ***NA*** | ***NA*** |
| *Gopher (N of Pt. Conception)* | *153.0* | 1 | *148.0* | *144.0* |
| *Gopher (S of Pt. Conception)* | *25.6* | 3 | *25.6* | *25.6* |
| *Grass* | *59.6* | 3 | *59.6* | *59.6* |
| *Kelp* | *27.7* | 3 | *27.7* | *27.7* |
| *Deeper Nearshore Species* | NA | NA | NA | NA |
| *Blue (assessed area)* | *187.8* | 2 | *188.6* | *190.3* |
| *Blue (S of 34°27' N. latitude)* | *72.9* | 3 | *72.9* | *72.9* |
| ***Brown*** | ***204.6*** | **2** | ***NA*** | ***NA*** |

| Stock | 2014 OFL | Category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|
| *Calico* | - | 3 | - | - |
| ***Copper*** | ***141.5*** | **2** | ***NA*** | ***NA*** |
| *Olive* | *224.6* | 3 | *224.6* | *224.6* |
| *Quillback* | *5.4* | 3 | *5.4* | *5.4* |
| *Treefish* | *13.2* | 3 | *13.2* | *13.2* |
| Minor Shelf Rockfish South | 1,912.9 | | 1,914.1 | 1,915.4 |
| *Bronzespotted* | *3.6* | 3 | *3.6* | *3.6* |
| *Chameleon* | - | 3 | - | - |
| *Flag* | *23.4* | 3 | *23.4* | *23.4* |
| *Freckled* | - | 3 | - | - |
| *Greenblotched* | *23.1* | 3 | *23.1* | *23.1* |
| *Greenspotted* | *80.3* | 2 | *79.0* | *78.4* |
| *Greenstriped* | *232.7* | 2 | *235.1* | *237.0* |
| *Halfbanded* | - | 3 | - | - |
| *Harlequin* | - | 3 | - | - |
| *Honeycomb* | *9.9* | 3 | *9.9* | *9.9* |
| *Mexican* | *5.1* | 3 | *5.1* | *5.1* |
| *Pink* | *2.5* | 3 | *2.5* | *2.5* |
| *Pinkrose* | - | 3 | - | - |
| *Pygmy* | - | 3 | - | - |
| *Redstripe* | *0.5* | 3 | *0.5* | *0.5* |
| *Rosethorn* | *2.1* | 3 | *2.1* | *2.1* |
| *Rosy* | *44.5* | 3 | *44.5* | *44.5* |
| *Silvergray* | *0.5* | 3 | *0.5* | *0.5* |
| *Speckled* | *39.4* | 3 | *39.4* | *39.4* |
| *Squarespot* | *11.1* | 3 | *11.1* | *11.1* |
| *Starry* | *62.6* | 3 | *62.6* | *62.6* |
| ***Stripetail*** | ***23.6*** | **3** | ***23.6*** | ***23.6*** |
| *Swordspine* | *14.2* | 3 | *14.2* | *14.2* |
| *Tiger* | *0.04* | 3 | *0.04* | *0.04* |
| *Vermilion* | *269.3* | 3 | *269.3* | *269.3* |
| *Yellowtail* | *1,064.4* | 3 | *1,064.4* | *1,064.4* |
| Minor Slope Rockfish South | 685 | | 806 | 807 |
| ***Aurora*** | ***26.1*** | **1** | ***74.3*** | ***74.3*** |
| *Bank* | *503.2* | 3 | *503.2* | *503.2* |
| *Blackgill* | *134.0* | 2 | *137.0* | *140.0* |
| *Pacific ocean perch* | - | 3 | - | - |
| *Redbanded* | *10.4* | 3 | *10.4* | *10.4* |
| ***Rougheye*** | ***0.4*** | **1** | ***4.1*** | ***4.2*** |
| ***Sharpchin*** | ***9.8*** | **2** | ***76.4*** | ***74.4*** |
| *Shortraker* | *0.1* | 3 | *0.1* | *0.1* |
| *Yellowmouth* | *0.8* | 3 | *0.8* | *0.8* |
| Other Flatfish | 10,060 | | 11,298 | 9,948 |
| *Butter sole* | *4.6* | 3 | *4.6* | *4.6* |
| *Curlfin sole* | *8.2* | 3 | *8.2* | *8.2* |
| *Flathead sole* | *35.0* | 3 | *35.0* | *35.0* |
| ***Pacific sanddab*** | ***4,801.0*** | **3** | ***4,801.0*** | ***4,801.0*** |
| ***Rex sole*** | ***4,371.5*** | **2** | ***5,609.0*** | ***4,259.0*** |
| *Rock sole* | *66.7* | 3 | *66.7* | *66.7* |
| *Sand sole* | *773.2* | 3 | *773.2* | *773.2* |
| Other Fish a/ | 6,802 | 3 | NA | NA |
| *Big skate* | *458.0* | 3 | *c/* | *c/* |

| Stock | 2014 OFL | Category | 2015 OFL | 2016 OFL |
|---|---|---|---|---|
| *Cabezon (WA)* | *b/* | 3 | *b/* | *b/* |
| *California skate* | *86.0* | 3 | *c/* | *c/* |
| *Finescale codling* | *b/* | 3 | *b/* | *b/* |
| *Kelp greenling (CA)* | *118.9* | 3 | *c/* | *c/* |
| *Kelp greenling (OR & WA)* | *b/* | 3 | *b/* | *b/* |
| *Leopard shark* | *167.1* | 3 | *c/* | *c/* |
| *Pacific grenadier* | *1,519.0* | 3 | *c/* | *c/* |
| *Ratfish* | *1,441.0* | 3 | *c/* | *c/* |
| *Soupfin shark* | *61.6* | 3 | *c/* | *c/* |
| *Spiny dogfish* | *2,950.0* | 2 | *2,522.7* | *2,503.3* |

a/ Values for these specifications are the sum of known contributions of component stocks.

b/ No OFL contribution for these stocks given the lack of an approved method.

c/ No OFL recommended pending decisions on restructuring this complex.

Table 2. The basis for SSC-recommended 2015 and 2016 OFLs for West Coast groundfish stocks.

| Stock | Comments |
|---|---|
| | |
| **OVERFISHED STOCKS** | |
| **BOCACCIO S. of 40$^0$10' N. latitude** | **Projected using a 50% SPR from the 2013 update stock assessment with a 6% reduction to subtract the portion of the assessed stock north of 40°10' N. lat.** |
| CANARY | OFL projections not yet available pending a review of the 2011 rebuilding analysis, which may have had a mis-specification |
| COWCOD S. of 40$^0$10' N. latitude | Sum of Conception and Monterey OFLs. |
| ***COWCOD (Conception)*** | **Projected using a 50% SPR from the 2013 stock assessment.** |
| *COWCOD (Monterey)* | Not yet available. Revised DB-SRA estimate. |
| **DARKBLOTCHED** | **Projected using a 50% SPR from the 2013 stock assessment** |
| PACIFIC OCEAN PERCH | Projected using a 50% SPR from the 2011 rebuilding analysis |
| **PETRALE SOLE** | **Projected using a 30% SPR from the 2013 stock assessment** |
| YELLOWEYE | Projected using a 50% SPR from the 2011rebuilding analysis |
| **NON-OVERFISHED STOCKS** | |
| Arrowtooth Flounder | Projected using a 30% SPR from the 2007 full assessment. |
| Black Rockfish (OR-CA) | Projected using a 50% SPR from the 2007 full assessment with the addition of 3% of the northern OFL to account for the portion of the stock estimated between Cape Falcon and the Columbia River. |
| Black Rockfish (WA) | Projected using a 50% SPR from the 2007 full assessment with a 3% reduction to account for the portion of the stock estimated between Cape Falcon and the Columbia River. |
| Cabezon (CA) | Projected using a 45% SPR from the 2009 full assessment. |
| Cabezon (OR) | Projected using a 45% SPR from the 2009 full assessment. |
| California scorpionfish | Projected using a 45% SPR from the 2005 full assessment. |
| Chilipepper S. of 40$^0$10' N. latitude | Projected using a 50% SPR from the 2007 full assessment. The portion of the coastwide stock south of 40°10' N. lat. (93%) is based on average historical landings. |
| Dover Sole | Projected using a 30% SPR from the 2011 full assessment. |
| **English Sole** | **Projected using a 30% SPR from the 2013 data-moderate assessment.** |
| Lingcod N. of 40º10' N. latitude | Projected using a 45% SPR from the 2009 full assessment with 48% of the OFL S. of 42º N. latitude added to account for line shift. |
| Lingcod S. of 40º10' N. latitude | Projected using a 45% SPR from the 2009 full assessment with 48% of the OFL S. of 42º N. latitude subtracted to account for line shift. |
| Longnose skate | Projected using a 50% SPR from the 2007 full assessment. 2015 and 2016 OFLs projected using the status quo 45% SPR rate are 2,745 and 2,686 mt, respectively. |
| **Longspine Thornyhead (coastwide)** | **Projected using a 50% SPR from the 2013 full assessment.** |
| Pacific Cod | Status quo OFL. |
| Sablefish (coastwide) | Projected using a 45% SPR from the 2011 full assessment. |
| Shortbelly | MSY estimated from 2007 assessment. |
| **Shortspine Thornyhead (coastwide)** | **Projected using a 50% SPR from the 2013 full assessment.** |

| Stock | Comments |
|---|---|
| Splitnose S. of $40^{0}$10' N. latitude | Projected using a 50% SPR from the 2009 full assessment. The portion of the coastwide stock south of 40°10' N. lat. (64.2%) is based on average historical (1916-2008) landings. |
| Starry Flounder | Projected using a 30% SPR from the 2005 full assessment. |
| Widow | Projected using a 50% SPR from the 2011 full assessment. |
| **Yellowtail N. of $40^{0}$10' N. latitude** | **Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| **STOCK COMPLEXES** | |
| Minor Nearshore Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| *Black and yellow* | *DB-SRA estimate.* |
| *Blue (CA)* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the assessed stock in CA north of 40°10' N. lat. (12.7%) is based on average historical landings.* |
| *Blue (OR & WA)* | *DCAC estimate.* |
| ***Brown*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Calico* | *No harvest contribution (3a stock). Max. landings <2 mt, 1928-2008; mainly a discard species* |
| ***China*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| ***Copper*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Gopher* | *No harvest contribution (3a stock).* |
| *Grass* | *DB-SRA estimate.* |
| *Kelp* | *DB-SRA estimate.* |
| *Olive* | *DB-SRA estimate.* |
| *Quillback* | *DB-SRA estimate.* |
| *Treefish* | *DB-SRA estimate.* |
| Minor Shelf Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| *Bronzespotted* | *No harvest contribution in the north (3a stock)* |
| *Bocaccio* | *DB-SRA estimate.* |
| *Chameleon* | *No harvest contribution (3a stock).* |
| *Chilipepper* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the coastwide stock north of 40°10' N. lat. (7%) is based on average historical landings.* |
| *Cowcod* | *No harvest contribution (3a stock).* |
| *Flag* | *DB-SRA estimate.* |
| *Freckled* | *No harvest contribution (3a stock).* |
| *Greenblotched* | *DB-SRA estimate.* |
| *Greenspotted 40°10' to 42° N. latitude* | *Projection using a 50% SPR from the full 2011 assessment. The portion of the assessed area north of 40°10' N lat. (22.2% of OFL from northern California model) based on average historical catch.* |
| *Greenspotted N. of 42 N. latitude (OR & WA)* | *DCAC estimate* |
| *Greenstriped* | *Projected using a 50% SPR from the full 2009 assessment. The portion of the coastwide stock north of 40°10' N. lat. (84.5%) is based on the mean of the 2003-2008 swept area biomass estimates from the NMFS trawl survey.* |

| Stock | Comments |
|---|---|
| *Halfbanded* | *No harvest contribution (3a stock). Max. landings <2 mt, 1928-2008; mainly a discard species* |
| *Harlequin* | *DB-SRA estimate.* |
| *Honeycomb* | *No harvest contribution in the north (3a stock)* |
| *Mexican* | *No harvest contribution in the north (3a stock)* |
| *Pink* | *DB-SRA estimate.* |
| *Pinkrose* | *DB-SRA estimate.* |
| *Puget Sound* | *No harvest contribution (3a stock).* |
| *Pygmy* | *No harvest contribution (3a stock).* |
| *Redstripe* | *DB-SRA estimate.* |
| *Rosethorn* | *DB-SRA estimate.* |
| *Rosy* | *DB-SRA estimate.* |
| *Silvergray* | *DB-SRA estimate.* |
| *Speckled* | *DB-SRA estimate.* |
| *Squarespot* | *DB-SRA estimate.* |
| *Starry* | *DB-SRA estimate.* |
| ***Stripetail*** | ***DB-SRA estimate. Only status determined from 2013 data-moderate assessment, so presumed to remain a cat. 3 stock.*** |
| *Swordspine* | *DB-SRA estimate.* |
| *Tiger* | *DB-SRA estimate.* |
| *Vermilion* | *DB-SRA estimate.* |
| Minor Slope Rockfish North | Sum of OFL contributions of component stocks in the complex. |
| ***Aurora*** | ***Projected using a 50% SPR from the 2013 full assessment. The portion of the coastwide stock north of 40º10' N lat. (19%) is based on average survey biomass.*** |
| *Bank* | *DB-SRA estimate.* |
| *Blackgill* | *DCAC estimate.* |
| *Redbanded* | *DB-SRA estimate.* |
| ***Rougheye*** | ***Projected using a 50% SPR from the 2013 full assessment. The coastwide OFLs are apportioned north (98%) and south (2%) based on average landings during 1985-2012.*** |
| ***Sharpchin*** | ***Coastwide OFLs projected using a 50% SPR from the 2013 data-moderate assessment. OFLs are apportioned north and south of 40º10' N lat. (80%N, 20% S) based on average swept area biomass estimates from the triennial survey.*** |
| *Shortraker* | *DB-SRA estimate.* |
| *Splitnose* | *Projected using a 50% SPR from the 2009 full assessment. The portion of the coastwide stock north of 40°10' N. lat. (35.8%) is based on average historical (1916-2008) landings.* |
| *Yellowmouth* | *DB-SRA estimate.* |
| Minor Nearshore Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| *Shallow Nearshore Species* | |

| Stock | Comments |
|---|---|
| *Black and yellow* | *DB-SRA estimate.* |
| ***China*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Gopher (N of Pt. Conception)* | *Projected using a 50% SPR from the 2005 full assessment.* |
| *Gopher (S of Pt. Conception)* | *DCAC estimate.* |
| *Grass* | *DB-SRA estimate.* |
| *Kelp* | *DB-SRA estimate.* |
| *Deeper Nearshore Species* | |
| *Blue (assessed area)* | *Projected using a 50% SPR from the 2007 full assessment. The portion of the assessed stock in CA south of 40°10' N. lat. (87.3%) is based on average historical landings.* |
| *Blue (S of 34 °27' N. latitude)* | *DCAC estimate.* |
| ***Brown*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Calico* | *No harvest contribution (3a stock). Max. landings <2 mt, 1928-2008; mainly a discard species* |
| ***Copper*** | **Not yet available. Projected using a 50% SPR from the 2013 data-moderate assessment.** |
| *Olive* | *DB-SRA estimate.* |
| *Quillback* | *DB-SRA estimate.* |
| *Treefish* | *DB-SRA estimate.* |
| Minor Shelf Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| *Bronzespotted* | *DB-SRA estimate.* |
| *Chameleon* | *No harvest contribution (3a stock).* |
| *Flag* | *DB-SRA estimate.* |
| *Freckled* | *No harvest contribution (3a stock).* |
| *Greenblotched* | *DB-SRA estimate.* |
| *Greenspotted* | *Projection using a 50% SPR from the full 2011 assessment. The portion of the assessed area south of 40°10' N lat. (77.8% of OFL from northern California model from average historical catch + the OFL from the southern California model)* |
| *Greenstriped* | *Projected using a 50% SPR from the full 2009 assessment. The portion of the coastwide stock south of 40°10' N. lat. (15.5%) is based on the mean of the 2003-2008 swept area biomass estimates from the NMFS trawl survey.* |
| *Halfbanded* | *No harvest contribution (3a stock).* |
| *Harlequin* | *DB-SRA estimate.* |
| *Honeycomb* | *DB-SRA estimate.* |
| *Mexican* | *DB-SRA estimate.* |
| *Pink* | *DB-SRA estimate.* |
| *Pinkrose* | *DB-SRA estimate.* |
| *Pygmy* | *No harvest contribution (3a stock).* |
| *Redstripe* | *DB-SRA estimate.* |
| *Rosethorn* | *DB-SRA estimate.* |

| Stock | Comments |
|---|---|
| *Rosy* | *DB-SRA estimate.* |
| *Silvergray* | *DB-SRA estimate.* |
| *Speckled* | *DB-SRA estimate.* |
| *Squarespot* | *DB-SRA estimate.* |
| *Starry* | *DB-SRA estimate.* |
| ***Stripetail*** | ***DB-SRA estimate. Only status determined from 2013 data-moderate assessment, so presumed to remain a cat. 3 stock.*** |
| *Swordspine* | *DB-SRA estimate.* |
| *Tiger* | *DB-SRA estimate.* |
| *Vermilion* | *DB-SRA estimate.* |
| *Yellowtail* | *DB-SRA estimate.* |
| Minor Slope Rockfish South | Sum of OFL contributions of component stocks in the complex. |
| ***Aurora*** | ***Projected using a 50% SPR from the 2013 full assessment. The portion of the coastwide stock south of 40º10' N lat. (81%) is based on average survey biomass.*** |
| *Bank* | *DB-SRA estimate.* |
| *Blackgill* | *Projected using a 50% SPR from the 2011 full assessment.* |
| *Pacific ocean perch* | *No harvest contribution (3a stock).* |
| *Redbanded* | *DB-SRA estimate.* |
| ***Rougheye*** | ***Projected using a 50% SPR from the 2013 full assessment. The coastwide OFLs are apportioned north (98%) and south (2%) based on average landings during 1985-2012.*** |
| ***Sharpchin*** | ***Coastwide OFLs projected using a 50% SPR from the 2013 data-moderate assessment. OFLs are apportioned north and south of 40º10' N lat. (80%N, 20% S) based on average swept area biomass estimates from the triennial survey.*** |
| *Shortraker* | *DB-SRA estimate.* |
| *Yellowmouth* | *DB-SRA estimate.* |
| Other Flatfish | Sum of OFL contributions of component stocks in the complex. |
| *Butter sole* | *Based on the average catch during 1994-1998 + a 60% discard rate estimated from the EDCP study.* |
| *Curlfin sole* | *Based on the average catch during 1994-1998 + a 60% discard rate estimated from the EDCP study.* |
| *Flathead sole* | *Max. catch = 35 mt in 2005* |
| ***Pacific sanddab*** | ***DB-SRA estimate. Only status determined from 2013 full assessment, so presumed to remain a cat. 3 stock.*** |
| ***Rex sole*** | ***Projected using a 50% SPR from the 2013 data-moderate assessment.*** |
| *Rock sole* | *DB-SRA estimate.* |
| *Sand sole* | *DB-SRA estimate.* |
| Other Fish a/ | No analytical basis for the status quo OFL. |
| *Big skate* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Cabezon (WA)* | |

| Stock | Comments |
|---|---|
| *California skate* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Finescale codling* | |
| *Kelp greenling (CA)* | *DB-SRA estimate.* |
| *Kelp greenling (OR & WA)* | |
| *Leopard shark* | *DB-SRA estimate.* |
| *Pacific grenadier* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Ratfish* | *Derived from survey biomass and MSY harvest rate estimates* |
| *Soupfin shark* | *DCAC estimate.* |
| *Spiny dogfish* | *Projected using a 50% SPR from the 2011 full assessment. 2015 and 2016 OFLs projected using the status quo 45% SPR rate are 2,921 and 2,893 mt, respectively.* |

PFMC
09/14/13

Ms. Chair Loman, Mr.Vice Chair Pollard :

My name Bill James. I am speaking to you today representing myself and Port San Luis Commercial Fishermen's Association fishing out of Port San Luis (Avila) which is located on the Central California coast 13 miles south of Morro Bay.

Port San Luis together with Morro Bay are the two top producing Nearshore "Live Fish" ports on the west coast. The live fish markets and live fish restaurants of San Francisco and the surrounding bay area and also the Los Angeles and surrounding area depend on our almost year round deliveries of premium nearshore live fish.

This year and the last few years the Commercial Nearshore Fishermen in California have been landing only about 50 percent of their ACL (optimum yield). Favorable conditions of the last few years have allowed most Nearshore and Shelf Finfish species to increase in abundance.

To catch a higher percentage of the ACL of Nearshore and Shelf finfish species myself and PSLCFA request the Council include for analysis for "Setting Fisheries in 2015-2016" the following items:

1). A increase in allocation of Canary Rockfish for Directed Open Access in California.

2). A increase in allocation of Yelloweye Rockfish for Directed Open Access in California.

3) Adding a management line at Ano Nuevo, 37:07N latitude for a possible discrete area from 34:27 to 37:07 for increased management options for Port San Luis and Morro Bay Commercial Nearshore Fishermen to attain a higher percentage of the ACL of Nearshore Finfish species.

4) Increase the bi-monthly trip limit to 1000 lbs.of Shallow Nearshore Rockfish in periods 1, 3-6 for Commercial Nearshore fishermen in the area from 34:27 to 37:07N latitude.

5) Increase the bi-monthly trip limit to 1000 lbs.of Deeper Nearshore Rockfish in period 1, 3-6 for Commercial Nearshore fishermen in the area from 34:27 to 37:07N latitude.

6).Open Lingcod in Dec, Jan, and Feb to align with California Commercial Nearshore fishery open periods.

7). For Commercial Directed Open Access Groundfish consider allowing fishing from 0 to 40 fathoms.

I want to thank the Council on behalf of myself and Port San Luis Commercial Fishermen's Association for allowing us to submit these requests for the September Council meeting in Boise, Idaho. I wish I could attend.

Sincerely, Bill James

# Background

- March 2013:  Council voted to narrow the scope of management measures
  - General criterion was routine and conservation measures stay in biennial specifications process
  - Other new measures move to June even years
- New Management Measures:  those measures not previously analyzed or implemented in regulation

# Proposed COP 9 Criteria
## Agenda Item G.7.a, Attachment 3 pg 2

***Council*** adopts final modeling methodologies, stock assessments for the next biennial period (Years 3 and 4), final preferred overfishing limits (OFLs) and sigmas, as recommended by the SSC.[1] The Council will also adopt a range of P*/acceptable biological catches (ABCs), if applicable, including preliminary preferred values.

***Council*** will provide initial fishery management guidance, including a preliminary range of new management measures necessary to keep catch within the annual catch limits (ACL) or to address a habitat or protected resources concern.

| | |
|---|---|
| September | *SSC Groundfish Subcommittee* meets to review overfished species rebuilding analyses as well as any stock assessments approved for further review by the Council at the "mop-up" stock assessment review panel. |
| October | *GMT* meets to review new stock assessments and rebuilding analyses. ***GMT*** drafts a recommended range of ACLs and preliminary management measures for consideration at the November Council meeting. |

# Recommended Modifications

***Council*** will provide initial fishery management guidance, including a preliminary range of new management measures necessary to keep catch within ~~the annual catch limits (ACL)~~ or to address a habitat or protected resources concern.

***Council*** will provide initial fishery management guidance, including a preliminary range of new management measures necessary to keep catch within a specification or to address a habitat or protected resources concern.

# Recommended COP 9 Modifications

- The Council may include other management measures if the timing or information presented in the harvest specifications would improve the efficiency of the analysis, implementation, or otherwise aid the Council's consideration (GMT Report 2, page 2)

# Council Action

3. Review and discuss proposed revisions to Council Operating Procedure 9 based on Council action taken thus far under Amendment 24.

4. Adopt a prioritized range of new management measures for preliminary analysis.

# Proposed New Measures

a) Shorebased IFQ, depending on harvest specifications (GMT report)

b) Consider new YRCA in WA (GMT report)

c) Lingcod daily trip limit associated with the lingcod season date removal (Public comment)

# CONSIDER STOCK COMPLEX AGGREGATIONS

The 2006 reauthorization of the Magnuson-Stevens Act (MSA) included a mandate to end overfishing. The revised National Standard 1 (NS1) guidelines of 2009 recommended a framework for accomplishing the MSA mandate, including criteria for managing stocks in a complex to reduce the risk of overfishing. Stock complex means a group of stocks that are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impact of management actions on the stocks is similar. The framework recommended in the revised NS1 guidelines was incorporated in the groundfish fishery management plan (FMP) under Amendment 23, which was implemented in 2011.

The Council considered strawman stock complex alternatives for six species groups (nearshore rockfish, shelf rockfish, slope rockfish, flatfish, cartilaginous fish, and roundfish) at the June 2013 meeting. The Council decided to replace these alternatives with those provided by the Groundfish Management Team (GMT), and tasked the GMT to develop additional alternatives using the criteria they provided in their supplemental June report. Further, the Council prioritized analysis of the alternatives for slope rockfish, shelf rockfish, cartilaginous fishes, and roundfish species groups. Alternatives for restructuring the Other Flatfish complex were given a lower priority, and alternatives for the nearshore rockfish complexes were considered but eliminated from further detailed analysis.

The alternatives and analyses developed by the GMT are presented in Agenda Item G.8.b, GMT Reports 1-3 and in Supplemental GMT Report 4. These analyses consider the question of stocks in the groundfish fishery and tradeoffs of alternatives designed to meet the objectives outlined in the FMP and NS1 guidelines. These tradeoffs concern the efficacy of retaining status quo complexes versus establishing additional complexes versus a restructuring of complexes that would necessitate reallocating harvestable yields of some of these species to fishing sectors (i.e., revisiting some Amendment 21 allocations).

The Council task at this meeting is to adopt preliminary preferred alternatives for each species group for public review, so as to enable a decision on final preferred alternatives for stock complexes at the November meeting. It will be critically important to decide final preferred alternatives for stock complexes in November to facilitate a more focused analysis of harvest specifications for 2015 and beyond. If the Council is unable to reach a final decision on stock complexes in November, it will be far less disruptive to the Council groundfish management decision-making process to defer decisions until the 2017-2018 specifications process than to defer a final decision to next year.

The Council should consider the GMT reports, Scientific and Statistical Committee advice on the analyses presented in these reports, as well as the recommendations of the Groundfish Advisory Subpanel and public before taking action on this item.

**Council Action:**

**Adopt preliminary preferred alternatives for restructuring stock complexes for public review.**

Reference Materials:

1. Agenda Item G.8.b, GMT Report 1: Groundfish Management Team Report on Additional Methods that May Be Used to Evaluate Alternatives for Stock Complex Reorganization.
2. Agenda Item G.8.b, GMT Report 2: Groundfish Management Team Report on the Classification of Stocks in the Groundfish Fishery Management Plan.
3. Agenda Item G.8.b, GMT Report 3: Groundfish Management Team Report on Port Sampling Surveys.
4. Agenda Item G.8.b, Supplemental GMT Report 4: Groundfish Management Team Report on Considerations for Restructuring West Coast Groundfish Stock Complexes: Analyses and Recommendations for Slope Rockfish, Shelf Rockfish, Other Flatfish, and Other Fish Complexes.

Agenda Order:

a. Agenda Item Overview John DeVore
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Consider Analysis of Stock Complex Aggregations Alternatives

PFMC
08/22/13

# GROUNDFISH MANAGEMENT TEAM REPORT ON ADDITIONAL METHODS THAT MAY BE USED TO EVALUATE ALTERNATIVES FOR STOCK COMPLEX REORGANIZATION

## Overview

The Groundfish Management Team (GMT) presented descriptions of methods intended for evaluation of alternatives for stock complex reorganization at the June 2013 Pacific Fishery Management Council (PFMC) Meeting under Agenda Item F.8.b, GMT Report, June 2013. That report suggested that the new methods were meant to supplement, not replace, other methods and analyses shown in an April Council Report (i.e., Agenda Item D.3.a, Attachment 1, April 2013). Methods provided in that April report, as well as those described in a June Council Report (i.e., Agenda Item F.8.a, Attachment 1, June 2013) were considered and applied by the GMT during the June meeting to evaluate alternatives to reconfigure the slope rockfish and "other fish" complexes (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013).

Some of the primary methods used by the GMT for the June 2013 analysis were described in detail under Agenda Item F.8.b, GMT Report, June 2013. Those methods were:

- Spatial Analysis (haul/set level, or 25 fathom x 1$^{o}$ lat. blocks, depending on data source)
- Species Co-occurrence Tables (haul/set level)
- C-scores Derived from the Co-occurrence Tables (haul/set level)
- Cluster Analysis (haul/set level)
- Description of a Survey developed by the GMT to acquire information from Port Biologists and State Fishery Managers

The Scientific and Statistical Committee (SSC) provided comment on these methods under Agenda Item F.8.b, Supplemental SSC Report, June 2013. Their guidance included:

- Analyses should be made using only catch-based (e.g., observer) data
- Cluster analysis should not be used to identify co-occurrence
- Co-occurrence tables should be based on probability of co-occurrence (as was done in June) as well as catch weight or catch per unit of effort (CPUE)

In addition, the SSC reiterated its recommendation from the April meeting that metrics should include the ratio of total cumulative catch to total cumulative overfishing limit (OFL) "and the mean difference between total catch and total component OFL" (Agenda Item F.8.b, Supplemental SSC Report, June 2013).

The purpose of this document is to provide a summary of methods that the GMT plans to apply for evaluation of alternatives for stock complex reorganization. Those methods already presented and reviewed by the SSC will only briefly be mentioned herein (see above). Only new methods for which the GMT seeks SSC review will be described in detail.

**Previous or Updated Analyses and Methods (SSC reviewed)**

Methods and analyses that the SSC had previously reviewed and recommended for use to evaluate stock complex reorganization can be found at ftp://ftp.pcouncil.org/pub/Stock_Complex_Materials/. These methods include spatial analysis, C-scores, and tables of co-occurrence, and were fully described under Agenda Item F.8.b, GMT Report, June 2013. Figures and tables will be uploaded to this FTP site prior to publication of the September 2013 briefing book; these analyses will be based on West Coast Groundfish Observer Program (WCGOP) data (groundfish trawl and non-trawl), CPUE metrics (i.e., spatial analysis), or encounters ( i.e., C-scores and tables of co-occurrence). The GMT plans to upload tables of co-occurrence based on catch levels or CPUE just prior to or at the September Council meeting. All analyses will be completed for species within the current:

- Slope rockfish complex
- Shelf rockfish complex
- "Other fish" complex
- "Other flatfish" complex

**Additional Analyses for SSC Review**

The GMT intends to provide analyses and recommendations for restructuring stock complexes at this September Council meeting. Although most analyses and data sets used by the GMT have been reviewed by the SSC (see above), three analyses remain for SSC review. Those are provided or referenced in this section. The GMT notes that although the underlying data (e.g., WCGOP) or underlying methods such a Productivity and Susceptibility Analysis (Cope et al., 2011) have been reviewed by the SSC, our application of those sources for evaluation of stock complexes has not been reviewed.

*Application of PSA Scores*

The Productivity and Susceptibility Analysis (PSA) will be applied by the GMT to (a) identify species that are "in the fishery" and (b) provide an independent estimate species susceptibility to overfishing (especially those that have no status determination criteria). The GMT provided a separate report in the briefing book on PSA scores and its application for identifying species that are "in the fishery" (Groundfish Management Team Report on the Classification of Stocks in the Groundfish Fishery Management Plan; Agenda Item G.8.b, GMT Report 2, September 2013). It is expected that the SSC will provide comments on that report, where Susceptibility (S) scores were re-weighted to eliminate the contribution of management-related attributes (e.g., rockfish conservation areas; RCAs). We note that for the purpose of evaluating alternatives for stock complex reconfiguration, the GMT intends to use original PSA scores shown by Cope et al. (2011) with the exception of individual species adjustments shown in Agenda Item G.8.b, GMT Report 2, September 2013 for longspine thornyhead and dusky rockfish. More detailed discussions on interpretation of PSA scores can be found in the GMT "in the fishery" document (Agenda Item G.8.b, GMT Report 2, September 2013).

*Port Sampling Surveys*

The GMT provided a report in the briefing book that describes results of state groundfish sampling surveys (Groundfish Management Team Report on Port Sampling Surveys; Agenda Item G.8.b, GMT Report 3, September 2013). Surveys developed by the GMT were taken by state sampling program managers and supervisors, and by state agency port biologists and samplers during June, 2013. The intent of these surveys was to evaluate potential impacts of stock complex reorganization to state groundfish sampling programs.

*Risk Analysis*

Tables 1-4 were developed to evaluate the risk of overfishing. Although some of this information had already been applied for the preliminary analyses shown in Agenda Item F.8.b, Supplemental GMT Report 2, June 2013, the information has been updated and additional metrics have been developed.

Species shown in Tables 1-4 are provided only as an example of our intended process. Complete tables will be developed for the September Council meeting that will include **all species** which are currently members of slope rockfish, shelf rockfish, other fish, and other flatfish complexes. Species or species groups that are not currently in the FMP may be added to this analysis, depending on results shown by the GMT's "in the fishery" analysis (Agenda Item G.8.b, GMT Report 2, September 2013).

Annual Catch Apportioned By Management Area: Catch estimates from 2004-2011 were compiled for the commercial, Tribal, recreational and research sectors (Table 1). Estimates from 2004-2010 were the result of a summation of mortality data provided from WCGOP for commercial sectors, recreational data provided by Washington and Oregon state sampling programs, recreational data taken from the Recreational Fisheries Information Network (RecFIN) by California, and research catch provided by the National Marine Fisheries Service (NMFS) Northwest Region. For 2011, estimates for each species were taken directly from the 2011 total mortality report for all sources of mortality (Bellman et al., 2012). For our initial analysis, rockfish complexes were stratified by management area (i.e., north and south of 40°10′ N latitude).

A detailed description of sources of commercial and recreational catch estimates were provided in our "in the fishery" analysis (see Agenda Item G.8.b, GMT Report 2, September 2013). Note that data were filtered for the "in the fishery" analysis. Data filtering was not performed for this risk analysis.

The example in Table 1 shows catch by recreational, commercial, Tribal, and research sectors for three species from the minor slope rockfish complex (north). Recent (2009-2011) and longer-term averages (2004-2011) are also provided.

**Table 1. Estimated annual catch for aurora, bank, and blackgill rockfishes (north of 40°10´ N latitude) from 2004 through 2011. Mean catches for 2009-2011 and for 2004-2011 are shown for comparison. Data were obtained from WCGOP (commercial and Tribal catch), NMFS Northwest Region (research catch), and state GMT representatives (recreational catch).**

**Minor Slope Rockfish North (subgroup)**

| | Catch (mt) by Year or Range of Years | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Component Stock** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **Mean 2009-2011** | **Mean 2004-2011** |
| Aurora (north) | 30.1 | 12.1 | 14.0 | 34.4 | 37.4 | 52.2 | 36.6 | 20.7 | 36.5 | 29.7 |
| Bank (north) | 3.6 | 1.4 | 1.1 | 2.0 | 1.3 | 1.0 | 0.5 | 0.7 | 0.8 | 1.4 |
| Blackgill (north) | 6.4 | 3.8 | 5.1 | 7.0 | 9.7 | 6.4 | 12.3 | 4.6 | 7.8 | 6.9 |

Metrics to Evaluate Risk of Overfishing: Various metrics may be used to evaluate the risk of overfishing. Metrics that the GMT may use to evaluate this risk are shown in Table 2 for aurora, bank, and blackgill rockfishes (north of 40°10´ N latitude). These species are provided as examples only. The full suite of species being considered for complex reorganization will be included in the risk analysis that will be presented at the September Council meeting.

The PSA vulnerability scores and associated "vulnerability" to being overfished (= PSA relative value) are shown in Table 2. Cope et al. (2011) assigned ranks to these scores as follows: Major concern ($V \geq 2.2$), High concern ($2.0 \leq V < 2.2$), Medium concern ($1.8 \leq V < 2.0$), and Low concern ($V < 1.8$). For the examples shown in Table 2, all vulnerabilities would be ranked as High. Note that in one case, the PSA vulnerability score was very close to Medium. The GMT does not plan to create additional levels of vulnerability. However, the actual PSA vulnerability score should be acknowledged for those "borderline" cases.

The GMT understands that other metrics may be more suitable than PSA for evaluating the risk of overfishing. It may be better to emphasize those metrics recommended by the SSC to evaluate this risk, such as the ratio of annual catch relative to the OFL (see below). The GMT will provide more comment on the use of PSA analysis for evaluating risk of overfishing at the September Council meeting.

Catch as a percent of the component Allowable Biological Catch (ABC) and as a percent of the component OFL is shown for catches over three periods: 2011, 2009-2011, and 2004-2011. In all cases, the average annual catch was divided by the 2013 component OFL or the 2013 component ABC. The most recent component OFL or component ABC was selected as the denominator to emulate the most recent stock status.

The percent of years that catch may have exceeded the 2013 component ABC or 2013 component OFL is shown for 2004-2011. We provide catch for a period of 8 years. For aurora rockfish north of 40°10´ N latitude, Table 2 shows that the component OFL was exceeded 75 percent of the time from 2004-2011. In other words, the 2013 component OFL for aurora rockfish (north) would have been exceeded in 6 out of 8 years.

The GMT points out that aurora rockfish and other stocks have been recently assessed and the resulting OFL and ABC values should replace those used in the analysis described above, which is based on OFLs derived from data-poor methods. Comparisons with new projected OFLs for species such as aurora rockfish will be completed at the September meeting and included in the GMTs supplemental statement. The most current projected OFLs should be evaluated before concern is expressed regarding "apparent overages" based on data-poor methods since our understanding of stock status, the stocks overfishing limit, and potential overfishing will be supplanted by new assessment results.

The last column of Table 2 represents the percent contribution of this management area OFL (i.e., north or south) to the coastwide OFL. At the June Council meeting, the SSC and the GMT discussed the significance of this proportion when considering a management response (see Agenda Item F.8.b, Supplemental SSC Report, June 2013 and Agenda Item F.8.b, Supplemental GMT Report 2, June 2013). In this example, the contribution of the OFL for aurora rockfish (north) represents 37 percent of the coastwide OFL. The OFL for bank rockfish (north) and blackgill rockfish (north) account for only 3 percent of the coastwide OFL for both species. Given that the regional OFL reflects the relative expected biomass in region, if a very low proportion of the total biomass resides in the region in question, the Council may want to weigh whether an overage poses a risk to the health and productivity of the stock as a whole when considering taking management action to address an overage (i.e. blackgill rockfish).

Shaded cells in the table represent metrics that may suggest high risk of overfishing. However, since the management lines may not be of biological importance, and many of these component OFLs are shown north and south of 40°10′ N latitude (i.e., for rockfish complexes), the GMT will also provide coastwide risk analyses for all species that contain "shaded" cells within one or more management areas (i.e., north or south of 40°10' N latitude). Examples of our planned coastwide-risk analysis are shown in Table 3 and Table 4.

**Table 2. Metrics that may be used to evaluate the risk of overfishing for aurora, bank, and blackgill rockfishes (north of 40°10′ N latitude. Metrics include (1) PSA score and PSA relative value (Cope et al., 2011), (2) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (3) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (4) percent contribution of the management-unit OFL (i.e., north or south of 40°10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

**Minor Slope Rockfish North (subgroup)**

| Species | PSA Score | PSA Relative Value | 2013 OFL | 2013 ABC | Catch as Percent of ABC 2011 | Catch as Percent of ABC 2009-2011 | Catch as Percent of ABC 2004-2011 | Percent of Years Over ABC 2004-2011 | Catch as Percent of OFL 2011 | Catch as Percent of OFL 2009-2011 | Catch as Percent of OFL 2004-2011 | Percent of Years Over OFL 2004-2011 | Percent Contribution to the Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurora (north) | 2.1 | High | 15.4 | 12.8 | 161% | 285% | 232% | 88% | 134% | 237% | 193% | 75% | 37% |
| Bank (north) | 2.02 | High | 17.2 | 14.4 | 5% | 5% | 10% | 0% | 4% | 4% | 8% | 0% | 3% |
| Blackgill (north) | 2.08 | High | 4.7 | 3.9 | 119% | 199% | 177% | 88% | 99% | 165% | 147% | 75% | 3% |

Table 3 provides catch estimates only for aurora and blackgill rockfishes (coastwide). Bank rockfish would be dropped from further analysis of risk because annual catch from 2004-2011 never exceeded the 2013 OFL or 2013 ABC (north or south of 40°10' N latitude). Hence, our full analysis will only provide coastwide catch tables for those species that "seemed" at risk at either north or south of 40°10' N latitude to evaluate whether the combined coastwide OFL has also been exceeded.

Note that for bank rockfish, the PSA analysis suggests a high risk of overfishing, whereas our ratio analysis (i.e., catch:OFL) suggests that under current management, it is at low risk of overfishing. The appropriate use or weighting procedure of these metrics to evaluate risk of overfishing will be discussed extensively by the GMT prior to making recommendations.

**Table 3. Estimated annual catch for aurora, bank, and blackgill rockfishes (coastwide) from 2004 through 2011. Mean catches for 2009-2011 and for 2004-2011 are shown for comparison. Data were obtained from WCGOP (commercial and Tribal catch), NMFS Northwest Region (research catch), and state GMT representatives (recreational catch).**

**Coastwide Catch (mt)**

| Stock | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| Aurora (coastwide) | 83.6 | 53.8 | 59.2 | 64.0 | 48.7 | 68.3 | 41.1 | 27.2 |
| Blackgill (coastwide) | 159.4 | 92.2 | 100.5 | 55.2 | 84.3 | 142.3 | 164.8 | 154.9 |

Metrics that may be used to evaluate the risk of overfishing will be provided on a coast wide level for those species that seemed at risk of overfishing within one or both management areas. An example of this is provided in Table 4. Descriptions of the column headers are the same as shown for Table 2 (see above).

**Table 4. Metrics that may be used to evaluate the risk of overfishing for aurora, bank, and blackgill rockfishes (north of 40°10' N latitude). Metrics include (1) PSA score and PSA relative value (Cope et al., 2011). (2) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (3) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (4) percent contribution of the management-unit OFL (i.e., north or south of 40° 10' N latitude) to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

**Metrics to Evaluate Risk of Overfishing (Coastwide)**

| Species | PSA Score | PSA Relative Value | 2013 OFL | 2013 ABC | Catch as Percent of ABC 2011 | Catch as Percent ABC 2009-2011 | Catch as Percent of ABC 2004-2011 | Percent of Years Over ABC 2004-2011 | Catch as Percent of OFL 2011 | Catch as Percent of OFL 2009-2011 | Catch as Percent of OFL 2004-2011 | Percent of Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurora (coastwide) | 2.1 | High | 41.5 | 34.5 | 80% | 132% | 162% | 88% | 67% | 110% | 134% | 75% |
| Blackgill (coastwide) | 2.08 | High | 134.7 | 122.6 | 126% | 126% | 97% | 50% | 115% | 114% | 88% | 50% |

One metric that the SSC requested but not yet provided is "the mean difference between total catch and the total OFL". This metric will be provided prior to or at the September Council meeting.

**Summary**

In this report, the GMT provided some new approaches or analyses for (a) evaluating species that should be "in or out" of the fishery (Agenda Item G.8.b, GMT Report 2, September 2013), (b) assessing costs of stock complex reorganization at the state level through surveys provided to state managers and state port biologists (Agenda Item G.8.b, GMT Report 2, September 2013), and (c) evaluating the risk of overfishing (this document). The GMT plans to present these analyses to the SSC at the Council meeting and expects feedback and recommendations from the SSC on the three reports. We will incorporate the SSCs recommendations when developing final GMT analyses for the September Council meeting.

**References**


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# GROUNDFISH MANAGEMENT TEAM REPORT ON THE CLASSIFICATION OF STOCKS IN THE GROUNDFISH FISHERY MANAGEMENT PLAN

This report follows the Groundfish Management Team's (GMT) suggested approach for evaluating the classification of stocks in the Fishery Management Plan (FMP) (i.e., the "in the fishery" issue). The approach described here is the same as recommended by the GMT in past biennial cycles, which the GMT most comprehensively described in September 2011.[1]

This year the FMP classification issue has been presented to the Council as part of the larger evaluation of the stock complexes. And much of the information presented there has been included here. In this report, we pull that information out and present it in a different context so that the Council may give the "in the fishery" issue more focused consideration.

Following the structure of the National Standard 1 Guidelines, the "in the fishery" classification is a threshold question in which the Council considers which species are in need of conservation and management with annual catch limits (ACLs). The organization of the stock complexes is a separate question about how to best manage and account for the catch of stocks that are determined to have such a need.

This report intends to provide the basic data on catch and stock vulnerability that the GMT has suggested the Council look to when recommending how to classify stocks in the FMP. No recommendations are made on how specific stocks should be classified. The team will provide further analysis and may offer specific recommendations and alternatives in a supplemental statement after opportunity for full team discussion and public input at the September meeting.

*General Overview of the "In the Fishery" Classification*

The Council has undertaken the "in the fishery" evaluation with its other three FMPs and did so partially with Amendment 23 to the Groundfish FMP. We therefore only briefly remind the Council of the main factors for consideration. The National Standard 1 Guidelines (the "Guidelines") recommendations of the classification of stocks can be found at 50 C.F.R. § 600.310(d).[2] In brief, the Guidelines recommend that the Council consider which stocks encountered during fishing activities covered by the FMP should be classified as "in the fishery," as Ecosystem Component (EC) species, or left out of the FMP altogether.

[1] September 2011 Briefing Book, Agenda Item G.5.a, Attachment 5: *Report of GMT Subgroup and Council Staff on Analysis of Stock Vulnerability and Configuration of Stock Complexes.*

[2] The Guidelines can also be found with explanation of the rationale behind them in the notice announcing the final publication of the last revisions to the Guidelines: 74 Federal Register 3178 (Friday, January 16, 2009).

As a reminder, the National Marine Fisheries Service (NMFS) suggested the "in the fishery" classification framework in response to the question about which stocks encountered in a fishery needed status determination criteria (SDC) and ACLs. One view put forth was that every stock encountered should have an ACL. When crafting the final Guidelines, NMFS rejected that view and instead recommended that ACLs be focused on stocks where the risk of overfishing or overfished status is of concern. Following this line of reasoning, the Guidelines recommend that the FMP's "in the fishery" classification be used for: (1) target stocks; and, (2) non-target stocks that are retained for personal use or commercial sale generally or more than just occasionally.

The Groundfish FMP's target stocks are well-known, as are the non-target stocks that are retained and landed. So the main stocks for attention here are those non-target stocks that are mostly discarded at sea and those stocks in the FMP now that are caught rarely if at all.

The team has discussed how well the degree to which a non-target stock is retained might serve as an indicator of the need for conservation and management. Some have questioned the usefulness of focusing on the difference between "occasional" and "general" retention of non-target stocks and think that the degree of discard should be at most a secondary factor in the Council's consideration. The line between "occasionally" and "generally" could be tough to draw. And more importantly, that line might not be the right one to focus on: a non-target stock that most everyone discards in a multispecies fishery could be driven to low abundance if it is frequently caught with valuable target stocks.[3]

A more direct approach to evaluating non-target stocks is suggested by Section (d)(5) of the Guidelines. This section lists criteria for which non-target stocks could be designated as EC species. The two key factors are that EC species should:

- "[n]ot be determined to be subject to overfishing, approaching overfished, or overfished;" or
- "[n]ot be likely to become subject to overfishing or overfished, according to the best available information, in the absence of conservation and management measure."

The implication is that stocks that do not meet these criteria should be designated as "in the fishery."

The question to evaluate for each stock is therefore whether, in the absence of conservation and management, the stock would face a likely risk of overfishing or being reduced to overfished status. This risk can be weighed directly to the extent that stocks have assessments that determine fishing mortality and population status relative to Overfishing Limits (OFLs) and the Minimum Stock Size Threshold (MSST). The GMT's approach, described below, is intended to

[3] Spiny dogfish provides an example. People may differ on whether dogfish are retained "in general" in many fishery sectors. Some have targeted dogfish but the great majority of catch is now non-target and discarded. Despite the high discard, dogfish catch has approached the stock's OFL in recent years.

help the Council weigh the likelihood of overfishing or overfished for stocks without this information.

*The General Approach*

The GMT has suggested that the Council use two main indicators to compare the conservation and management need of stocks encountered by the groundfish fisheries: (1) total catch, and; (2) the vulnerability scores produced from the Productivity and Susceptibility Analysis (PSA) recommended by NMFS.[4] As just discussed, the risk of overfishing or overfished status cannot be directly evaluated for many stocks. For such stocks, catch and PSA Scores allow for a comparison and evaluation of relative need for conservation and management. The logic is that stocks facing similar levels of catch and similar PSA scores should be treated similarly as "in the fishery," as EC species, or determined to be not in need of conservation and management and left out or removed from the FMP altogether.[5]

Neither catch nor PSA scores are perfect metrics. There may be other reasons to explain where what looks like inconsistent treatment between stocks based on catch and PSA scores could be otherwise reasonable.

*The Catch Dataset*

Commercial catch estimates for the years 2002 to 2011 were compiled and provided to the GMT by West Coast Groundfish Observer Program (WGCOP) staff. This dataset includes catch estimates from the sectors monitored by WCGOP, the shoreside whiting sector, and those at sea sectors, tribal and non-tribal, monitored by the Alaska Fisheries Science Center's (AFSC) observer program.[6] The WCGOP monitored sectors include fisheries managed through other FMPs or the states that catch groundfish incidentally (e.g. the California Halibut fishery).

The three states also provided recreational catch estimates for ocean trips in the years, 2004-2011.[7] To use a common timeframe between the commercial and recreational data and to reflect recent conditions in the fisheries, we display catch estimates for the years 2007-2011. The recreational catch data also includes catch from trips where groundfish are caught incidentally or at least secondarily to other target stocks.

Research catch has not been added to the dataset. The NMFS Bottom Trawl Survey would be the largest source of catch for most species. However, we do not suspect adding it would change the

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[4] *See* NMFS's website on Assessing Vulnerability (http://www.nmfs.noaa.gov/msa2007/vulnerability.htm).

[5] NMFS' letter disapproving the Council's recommendation to remove dusky rockfish and dwarf red rockfish from the FMP as part of Amendment 23 provides additional guidance: http://www.pcouncil.org/wp-content/uploads/am_16-5_and_23_dec_letter.pdf

[6] Prior to the start of the individual fishing quota (IFQ) program, WCGOP did not observe the shoreside whiting sector. It was instead a maximized retention fishery where all fish were to be landed except in limited circumstances.

[7] The year 2004 was chosen for the recreational fisheries because of the change in California's catch estimation methodology and because there is also a chance in how data is available from RecFIN pre- and post- 2004.

overall picture because research catch should occur in close proportion to what is seen in the commercial catch.

*Filters Applied to the Catch Data*

There are over 430 non-FMP species and species categories reported in the combined commercial and recreational datasets and not currently managed within the FMP. To narrow in on those potentially facing a risk of overfishing from the FMP's commercial and recreational sectors, we removed several stocks from consideration:

- Species managed under other FMPs (e.g. blue shark) or by the states (e.g. hagfish, California sheephead).[8]
- Species caught predominately in the nearshore and state waters. This includes the surfperches, sea basses, sea chubs, croakers, smelts, many sculpins, and a few species of skates and rays. We applied this filter based on the Council's guidance to focus on stocks found in federal waters.[9]
- Species caught by recreational fisheries likely targeting pelagic species (e.g. Pacific barracuda). These species are found in the recreational data but are mostly likely caught in trips that are not targeting groundfish.
- Invertebrates, including crustaceans and cephalopods.

The GMT can alter these filters if the team has misunderstood the Council's past guidance or if the Council sees reason to look at catches of stocks that have been filtered out. The stocks filtered out based on these criteria and that would have been otherwise displayed based on the average catch criteria discussed below are listed in Table 4 and Table 5.

After removing these species from the dataset, we cast the net broadly for the remaining stocks by reporting any stock with an average annual catch of 1 metric ton or more, rounded to the nearest ton, over the 2007-2011 time period (Table 1). For FMP stocks, we chose an overlapping range and display stocks and stock categories with an average annual catch of 150 mt and less (Table 2).

In addition to average catch, Table 1 reports the percentage of catch coming from the FMP's sectors and the percentage of the total catch that was retained in commercial and recreational fisheries over 2007 to 2011. We considered filtering out species where more than 20 percent of the catch came from non-FMP sectors that catch groundfish incidentally. The reason is that the Council is focused on the risk of overfishing from the sectors managed under the Groundfish FMP. Yet the 20 percent level was arbitrary and it turned out that there are only few species

[8] The Guidelines do make recommendations for how to consider stocks that may span FMPs and those caught in state and federal waters (*see* § 600.310(d)(7) and (e)(5)(iii) of the Guidelines).
[9] The GMT will have to consider certain species like Kelp Greenling and Cabezon, which are in the FMP now but would have been excluded on these grounds if they had not been.

where this threshold would have mattered. Instead of applying the filter we display all stocks with the average catch of at least 1 metric ton and flag those where more than 80 percent of the catch has come from non-FMP sectors.

Slender sole is one that the GMT and others had flagged in earlier reports as a candidate for inclusion in the FMP. Until now we had failed to notice that ~85 percent of the catch comes in Pink Shrimp Trawl fishery. Whether this matters or not in the weighing of the species' relative need for conservation and management should be a point of discussion for the team at the September meeting.

Many stocks in Table 1 are related species or reported as unidentified as species (i.e. "unid."). Figure 1 displays the combined catch of the species and species categories for cat sharks, eelpouts, non-FMP grenadiers, and slickheads. The Council may wish to consider such species groups together. The Guidelines provide guidance on organizing stocks together in complexes, even for stocks designated as EC Species.

The commercial and recreational datasets used here are the best available information and greatly improved over what has been available. At the same time, it should be recognized that catch cannot be monitored perfectly. With the commercial data, we are relying mostly on the discard estimates of WCGOP observers for information on the non-FMP stocks. The focus of observers is on discards. WCGOP then uses fish ticket data to account for the retained and landed catch. Because many if not all of these non-FMP species are not marketed and have not been given much management attention, landings data would not be expected to as reliable as for FMP stocks. The datasets may therefore underestimate both total catch and the percentage retained for some stocks.

To elaborate, landings may not be reported in a way that allows identification to species or even species group. For example, Washington does not require eelpouts to be reported as such but it is known that they are landed together with bottom trawl caught groundfish. And when landed, they would be reported under a miscellaneous category that, unlike the groundfish market categories, would not be sampled for later enumeration/expansion to species. Notes made on a couple recent fish tickets illustrate the issue (Figure 2). However, we would not expect the extent of any such underestimation to be large. These species are likely landed only in small amounts, mixed in with other species and too difficult to sort out at sea. In addition, we would expect that large volumes of miscellaneous fish would be noticed and noted.

*The Data – PSA Scores*

The Productivity and Susceptibility Analysis and its use in this FMP has been explained in several reports including a publication authored by members of the GMT (Cope et al. 2011).[10] As a brief summary, the method involves gauging the biological productivity of stocks based on a set of life history attributes that can be scored high, medium, or low based on set criteria for each attribute. The contribution of each attribute to the overall Productivity score ("P-score") can be given higher or lower weight, including zero weight, depending on the scorers' judgment about which are most relevant. For example, and as explained in earlier materials, the weights given to the attributes for rockfish were different from those used to score the sharks, skates, and rays.

A second set of attributes is used to gauge a stock's susceptibility to the fisheries, also scored as high, medium, or low based on set criteria. The attributes and criteria contributing to the Susceptibility score ("S-score") are given in the Appendix. In short, they focus on the overlap of a stock's distribution with that of fishing activities, a species' relative selectivity/catchability, and the desirability of the species in the commercial and recreational fisheries.

The PSA Vulnerability Score for a stock is then a function of its P-score and S-score. PSA vulnerability can be displayed graphically, as in Figure 3 and Figure 4. With the P-score plotted on an x-axis running in reverse from 3 to 1, and the S-score plotted along a y-axis running from 1 to 3, the Vulnerability Score is the distance from the graph's origin at x = 3, y = 1.

For this analysis, we reviewed and made a few changes to the PSA scores that we have presented to the Council in earlier cycles, in the Cope et al. (2011) paper, and in the stock complex analysis materials presented this year. These changes include:

- Revising the S-score for Longspine Thornyhead. We had previously given it the lowest possible value of 1.0. After reviewing the scores for this analysis, we decided the susceptibility attributes had not been scored consistently to other stocks. In turn, we made some revisions to the S-score for Shortspine Thornyhead.[11]
- We gave S-scores of 1 to dusky rockfish and dwarf red rockfish instead of zeroes. Giving them S-scores of zero had the effect of increasing their overall PSA score above what a 1 would produce.[12] S-scores of 1 for these species is also somewhat inconsistent with how

[10] *See* Section 4.1.1.2 of the Environmental Impact Statement produced for the 2013-14 Harvest Specifications; J. M. Cope et al. (2011). *An Approach to Defining Stock Complexes for U.S. West Coast Groundfishes Using Vulnerabilities and Ecological Distributions*. North American Journal of Fisheries Management 31(4):589-604.

[11] Longspine was given an S-Score of 1 before mainly because the stock's distribution goes deeper than the fishery operates. Considering the information presented in the assessment being considered at this meeting, it does not seem plausible that more than 75 percent of the stock is found in these unfished depths.

[12] The formula for PSA Vulnerability is $\sqrt{}(\text{P-Score} - 3)^2 + (\text{S-score} - 1)^2$, so an S-score of 1 zeroes out its contribution to the overall score whereas an S-score of zero would add a 1.

other stocks have been scored.[13] Another approach would be to remove these stocks from the PSA altogether. The consensus of the GMT and Council staff has been that the overlap of these stocks with the fisheries is minimal if not zero. As Table 2 shows, however, there are several species with only trace amounts of catch.

- We re-weighted all the S-score attributes to eliminate the contribution of management-related-attributes because the Guidelines suggest considering the risk of overfishing in "the absence of conservation and management."[14] This re-weighting resulted in small changes in the S-scores for some stocks but in no change for most. The weighting of each attribute is shown in the Appendix ( Table 6 and Table 7).
- We scored two new species/categories—eelpouts and ragfish—using the PSA because of their catch relative to the other stocks we have scored. We scored eelpouts in aggregate because the great majority of catch is not identified to species. The Appendix (Table 8 and Table 9) provides some general information about these stocks and how they were scored in the PSA. The full GMT has not had occasion to review the scores for these new stocks and so they might be revised after they are reviewed. Other non-FMP stocks had already been scored with the PSA. Because of time constraints, we only scored additional non-FMP stocks with an average annual catch of more than 10 mt.[15]

One factor that we could not easily adjust was the effect of the Rockfish Conservation Area (RCA) and other closed areas on the S-scores. These areas were held in mind when scoring the overlap attributes. Closed areas are thought to reduce the overlap of the fisheries with several stocks and so removing the RCA and other areas for an "absence of conservation and management" scenario would increase the S-scores of these stocks. However, re-scoring the overlap attributes with a "no RCA" scenario in mind would have been very time consuming. As an alternative, the GMT will look for sensitivity to the RCA on a stock by stock basis when making more detailed recommendations to the Council.

The PSA scores for species focused on in this analysis are shown in Table 3. The scores and input files used to score all stocks are available upon request to the GMT.[16]

Cope et al. (2011), of which many GMT members were co-authors, concluded that PSA vulnerability of less than 1.8 suggested low concern of an overfishing risk. As Figure 3 and Figure 4 show, there is also a natural break below a PSA vulnerability of 1.5. Non-target stocks

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[13] To elaborate, the stocks would get high scores of 3's for the discard mortality attribute and this would increase their scores above 1.

[14] This re-weighting has also has the advantage of scoring every stock on the same set of attributes and weights. It also eliminates the possible circularity resulting from using "management strategy" as an attribute. This attribute would increase the S-scores of non-FMP stocks just on the basis that they are not currently managed.

[15] We could have scored file tail cat shark but concluded after reviewing the stock's life history that brown cat shark's PSA score could be used a proxy.

[16] The input files are viewable using the NOAA Fisheries Toolbox PSA tool: http://nft.nefsc.noaa.gov/PSA.html.

around these vulnerabilities could be considered for EC species designation or removal from the FMP.

The PSA tool has been used in various places to advance ecosystem based fisheries management.[17] It provides a high level assessment of risks that helps focus and set priorities for future, more rigorous attention. Its advantage here is that it provides a structured and consistent method for comparing the relative vulnerability of stocks. The scores, however, should be recognized as based on best professional judgment in many cases, especially with the susceptibility attributes. For instance, we do not have good quantitative measures of the range and density of species or of the intensity and fishing locations of all fisheries sectors. The Productivity scores could be considered "data poor" as well because of the lack of basic life history research for many stocks.

Indeed, this cycle is producing assessment results that have shown less of overfishing risk than PSA scores would suggest (e.g. Aurora Rockfish). In close cases, the GMT and others may want to give further scrutiny to scores for individual stocks.

Lastly, the PSA scores should be recognized as ordinal in nature. The decimal intervals between two scores indicate a judgment about the relative vulnerability of two stocks. Yet a PSA vulnerability of 2.4 is not necessarily "twice as vulnerable" as stock with a score of 1.2.

*Discussion*

The Figures and Tables presented here are intended to provide consistent and as objective as possible metrics for comparing the relative conservation and management need of stocks caught in the groundfish fisheries. As is seen here and has been pointed out before, there is a seeming inconsistency now in that some unmanaged stocks have higher catch levels and higher PSA ranked vulnerability than some stocks listed as FMP species. This fact should not be surprising because it is only in the last management cycle that we began to receive information on the catch of non-FMP stocks. The FMP's existing list of species was likely based mostly on landed species and on species with life history traits that make them vulnerable to overfishing, mainly the rockfishes.

To address this inconsistency the Council is considering three main alternatives for non-target stocks where the risk of overfishing is questionable: (i) designation as "in the fishery," (ii) designation as EC species, or (iii) removing/leaving them out of the FMP.  This report focusing on the first step of creating the list of stocks where that risk should be looked at closely.

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[17] *See e.g.,* A.D.M. Smith et al. (2007). *Scientific tools to support the practical implementation of ecosystem-based fisheries management.* ICES J. Mar. Sci. 64(4): 633-639 (http://icesjms.oxfordjournals.org/content/64/4/633.full).

**Table 1.** Non-FMP species with average annual catches of at least 1 metric ton (rounded to nearest ton) over the period 2007-2011. Species with less than 20 percent of the catch coming from the FMP's recreational and commercial sectors are shaded. Several other species were excluded based on other factors, as explained in the text.

| | Avg. catch (mt) | | | | | Avg. catch (mt) | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Species** | **FMP Sectors** | **All Sectors** | **% FMP** | **Retained %** | **Species** | **FMP Sectors** | **All Sectors** | **% FMP** | **Retained %** |
| 1. Skate Unid. | 725 | 741 | 97.8% | 95.8% | 25. Hornyhead Turbot | 0 | 4 | 5.5% | 55.6% |
| 2. Giant Grenadier | 170 | 170 | 100.0% | 0.0% | 26. Longnose Cat Shark | 3 | 3 | 100.0% | 0.0% |
| 3. Slender Sole | 21 | 149 | 14.4% | 0.0% | 27. Aleutian Skate | 3 | 3 | 100.0% | 0.0% |
| 4. Grenadier Unid. | 135 | 135 | 99.9% | 93.8% | 28. Bigfin Eelpout | 2 | 3 | 75.5% | 0.0% |
| 5. Shark Unid. | 114 | 116 | 97.8% | 7.2% | 29. Twoline Eelpout | 3 | 3 | 100.0% | 0.0% |
| 6. Brown Cat Shark | 90 | 90 | 99.8% | 12.6% | 30. Eel Unid. | 0 | 2 | 7.7% | 100.0% |
| 7. Bat Ray | 26 | 75 | 35.5% | 34.3% | 31. Thornback Skate | 1 | 2 | 33.6% | 32.4% |
| 8. Bering/sandpaper skate | 70 | 70 | 99.9% | 0.1% | 32. Threadfin Slickhead | 1 | 1 | 100.0% | 0.0% |
| 9. Black/Roughtail Skate | 44 | 44 | 100.0% | 0.1% | 33. Gray Smoothhound Shark | 1 | 1 | 100.0% | 87.7% |
| 10. Ragfish | 43 | 43 | 100.0% | 51.2% | 34. Pacific Dogfish Shark | 1 | 1 | 100.0% | 0.0% |
| 11. Eelpout Unid. | 33 | 43 | 76.4% | 0.1% | 35. Duckbill Barracudina | 1 | 1 | 100.0% | 75.5% |
| 12. Deepsea Sole | 32 | 32 | 99.4% | 2.5% | 36. Cat Unid. Shark | 1 | 1 | 100.0% | 0.0% |
| 13. California Slickhead | 28 | 28 | 100.0% | 0.0% | 37. Salmon Shark | 1 | 1 | 100.0% | 0.0% |
| 14. Sanddab Unid. | 21 | 22 | 96.7% | 84.0% | 38. Longspine Combfish | 0 | 1 | 20.5% | 0.0% |
| 15. Shovelnose Guitarfish | 19 | 22 | 87.0% | 80.0% | 39. Starry Skate | 0 | 1 | 46.8% | 0.0% |
| 16. Pacific Angel Shark | 0 | 13 | 0.2% | 78.7% | 40. Tubeshoulder Unid. | 1 | 1 | 99.9% | 3.7% |
| 17. Pacific Electric Ray | 1 | 11 | 12.2% | 0.0% | 41. Deepsea Skate | 1 | 1 | 100.0% | 0.0% |
| 18. Filetail Cat Shark | 11 | 11 | 100.0% | 0.0% | 42. Slickhead Unid. | 1 | 1 | 100.0% | 0.0% |
| 19. Pacific Sleeper Shark | 8 | 8 | 100.0% | 2.3% | 43. Swell Shark | 0 | 1 | 5.8% | 0.0% |
| 20. Brown Smoothhound Shark | 2 | 7 | 26.5% | 13.7% | 44. Fantail Sole | 0 | 1 | 0.0% | 18.3% |
| 21. King of the Salmon | 6 | 6 | 100.0% | 44.6% | 45. Pacific Black Dogfish | 1 | 1 | 100.0% | 0.0% |
| 22. Snailfish Unid. | 5 | 5 | 99.2% | 0.3% | 46. Longnose Lancetfish | 1 | 1 | 100.0% | 64.8% |
| 23. Walleye Pollock | 4 | 4 | 100.0% | 96.2% | 47. Sixgill Shark | 0 | 1 | 75.6% | 0.0% |
| 24. California Grenadier | 4 | 4 | 100.0% | 0.0% | | | | | |

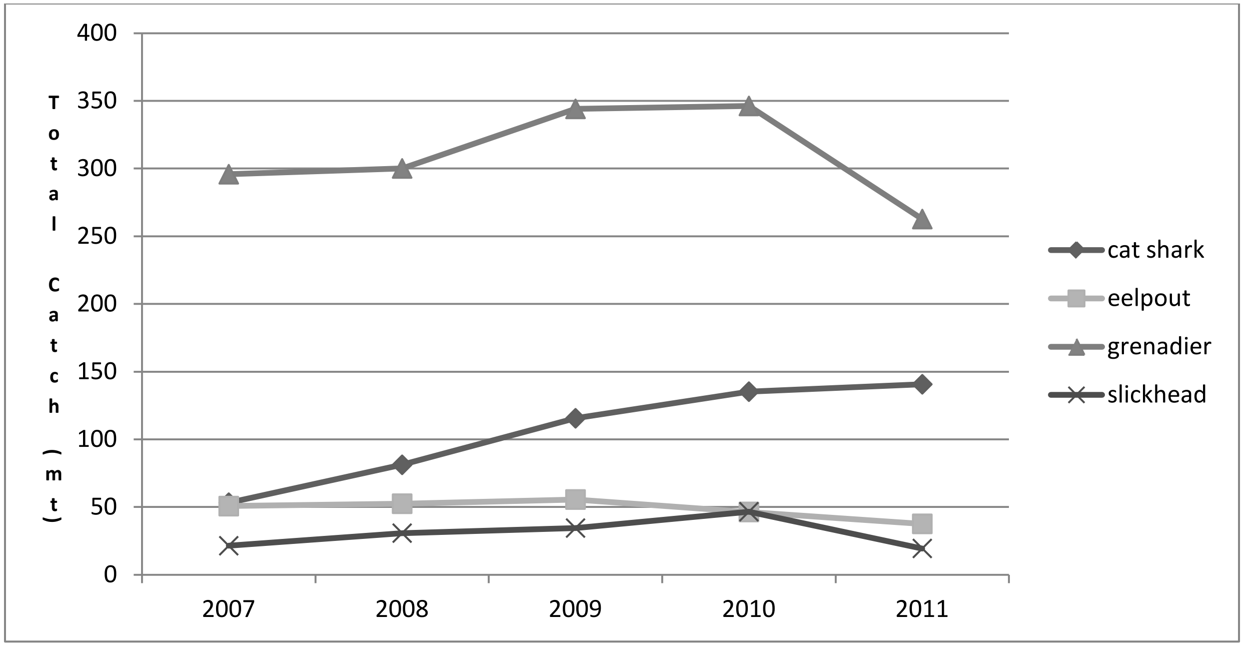


**Figure 1.** Annual catches of combines species and species categories for cat sharks, eelpouts, non-FMP grenadiers, and slickheads.

Notes: 2 lbs of Misc is Eelpout, 1 lb of Misc is Ratfish, 1 lb of Misc is Starfish,8 lbs of Shelf is Rosethorn, 104 lbs of Slope is Rougheye, 490 lbs of Slope is Splitnose, 14 lbs of Slope is Redbanded, 16 lbs of Slope is Aurora, 2384 lbs of Slope is Blackgil, 13 lbs of Skate is Sandpaper Skate, 2 lbs of Sole is Deep Sea Sole, 13 lbs of Sole is Slender Sole

Notes: 629 lbs of Slope is Splitnose,16 lbs of Misc is Garbage according to the observer, 3 lbs of Shelf is Rosethorn, 174 lbs of Slope is Rougheye, 74 lbs of Slope is Shortraker, 18 lbsa of Slope is Redbanded, 19 lbs of Slope is Shortraker, 3 lbs of Shark is Cat Shark, 1 lb of Misc is Snailfish, 13 lbs of Misc is Ratfish, 10 lbs of Misc is Eelpout, 2 lbs of Misc is Grenadere, 5 lbs of Skate is Sandpaper

**Figure 2.** Two notes from Washington fish tickets illustrating how non-FMP species are landed under miscellaneous categories that are not enumerated to species. Such notes are not required or entered into the state's landings databases.

**Table 2**. Catch statistics for FMP stocks with an average annual catch less than 150 mt over 2007 to 2011. Catch is reported to the nearest metric ton (i.e., 0 mt includes catches less than 0.5 mt). The percentage of catch retained combines recreational and commercial catch and will not reflect differences between discarding practices in the two.

| | catch (mt) | | | | catch (mt) | | | | catch (mt) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **avg.** | **max** | **retain. %** | **Species** | **avg.** | **max** | **retain. %** | **Species** | **avg.** | **max** | **retain. %** |
| *1.* Spotted Ratfish | 146 | 228 | 0.2% | *26.* Grass Rockfish | 19 | 23 | 99.4% | *51.* Rosethorn Rockfish | 4 | 5 | 23.4% |
| *2.* Pacific Ocean Perch Rockfish | 135 | 179 | 68.9% | *27.* Starry Flounder | 17 | 24 | 79.6% | *52.* Yellowmouth Rockfish | 4 | 10 | 53.6% |
| *3.* Pacific Grenadier | 131 | 212 | 0.0% | *28.* Greenstriped Rockfish | 15 | 25 | 29.2% | *53.* Redstripe Rockfish | 4 | 11 | 89.1% |
| *4.* Blackgill Rockfish | 120 | 164 | 95.8% | *29.* Quillback Rockfish | 15 | 20 | 96.6% | *54.* Squarespot Rockfish | 3 | 6 | 94.0% |
| *5.* Blue Rockfish | 120 | 192 | 91.8% | *30.* Greenspotted Rockfish | 15 | 19 | 95.1% | *55.* Tiger Rockfish | 1 | 1 | 96.3% |
| *6.* Cabezon | 101 | 128 | 98.4% | *31.* California Skate | 14 | 18 | 0.6% | *56.* Butter Sole | 1 | 2 | 8.1% |
| *7.* Big Skate | 95 | 170 | 1.7% | *32.* Finescale codling/Pacific Flatnose | 13 | 19 | 0.0% | *57.* Nearshore Rockfish Unid. | 1 | 3 | 100.0% |
| *8.* Brown Rockfish | 90 | 116 | 97.8% | *33.* Stripetail Rockfish | 12 | 15 | 0.7% | *58.* Halfbanded Rockfish | 1 | 2 | 61.2% |
| *9.* Gopher Rockfish | 85 | 120 | 96.7% | *34.* Slope Rockfish Unid. | 12 | 21 | 100.0% | *59.* Greenblotched Rockfish | 1 | 1 | 98.8% |
| *10.* California Scorpionfish | 76 | 104 | 90.2% | *35.* Silvergray Rockfish | 11 | 44 | 17.5% | *60.* Blackspotted Rockfish | 1 | 1 | 100.0% |
| *11.* Bocaccio Rockfish | 73 | 115 | 77.8% | *36.* Shortraker/Rougheye Unid. | 10 | 34 | 0.3% | *61.* Cowcod Rockfish | 1 | 1 | 17.3% |
| *12.* Copper Rockfish | 69 | 80 | 94.4% | *37.* Yelloweye Rockfish | 9 | 12 | 13.6% | *62.* Calico Rockfish | 1 | 2 | 17.5% |
| *13.* Aurora Rockfish | 50 | 68 | 51.0% | *38.* Treefish Rockfish | 8 | 14 | 94.0% | *63.* Mexican Rockfish | 0 | 0 | 100.0% |
| *14.* Sand Sole | 49 | 85 | 94.5% | *39.* Kelp Rockfish | 8 | 18 | 96.4% | *64.* Chameleon Rockfish | 0 | 0 | 99.4% |
| *15.* Bank Rockfish | 47 | 93 | 99.7% | *40.* Soupfin Shark* | 8 | 18 | 91.9% | *65.* Pinkrose Rockfish | 0 | 0 | 100.0% |
| *16.* Kelp Greenling | 43 | 56 | 97.1% | *41.* Sharpchin Rockfish | 8 | 12 | 15.0% | *66.* Pygmy Rockfish | 0 | 0 | 0.3% |
| *17.* Canary Rockfish | 42 | 52 | 36.4% | *42.* Shelf Rockfish Unid. | 7 | 21 | 100.0% | *67.* Bronzespotted Rockfish | 0 | 0 | 78.2% |
| *18.* Redbanded Rockfish | 36 | 40 | 76.9% | *43.* Flag Rockfish | 7 | 9 | 92.0% | *68.* Swordspine Rockfish | 0 | 0 | 40.2% |
| *19.* Leopard Shark | 35 | 38 | 81.4% | *44.* Rock Sole | 6 | 8 | 80.8% | *69.* Freckled Rockfish | 0 | 0 | 100.0% |
| *20.* Shortraker Rockfish | 32 | 35 | 69.7% | *45.* Shortbelly Rockfish | 6 | 11 | 2.9% | *70.* Spotted Rockfish Unid. | 0 | 0 | 0.0% |
| *21.* China Rockfish | 32 | 35 | 92.1% | *46.* Rosy Rockfish | 6 | 7 | 83.3% | *71.* Dusky Rockfish | 0 | 0 | 0.0% |
| *22.* Olive Rockfish | 32 | 54 | 94.2% | *47.* Flathead Sole | 6 | 11 | 36.2% | *72.* Harlequin Rockfish | 0 | 0 | 43.0% |
| *23.* Rockfish Unid. | 29 | 69 | 7.7% | *48.* Speckled Rockfish | 5 | 8 | 94.7% | *73.* Pink Rockfish | 0 | 0 | 100.0% |
| *24.* Starry Rockfish | 24 | 30 | 91.1% | *49.* Honeycomb Rockfish | 5 | 10 | 85.2% | *74.* Dwarf Red Rockfish | 0 | 0 | #N/A |
| *25.* Black And Yellow Rockfish | 23 | 32 | 99.0% | *50.* Curlfin Sole/Turbot | 5 | 10 | 17.9% | | | | |

*Note: Only 15.6% of the catch of Soupfin Shark comes in the FMP's commercial and recreational sectors. The remainder is taken in the California Halibut and other non-FMP sectors.

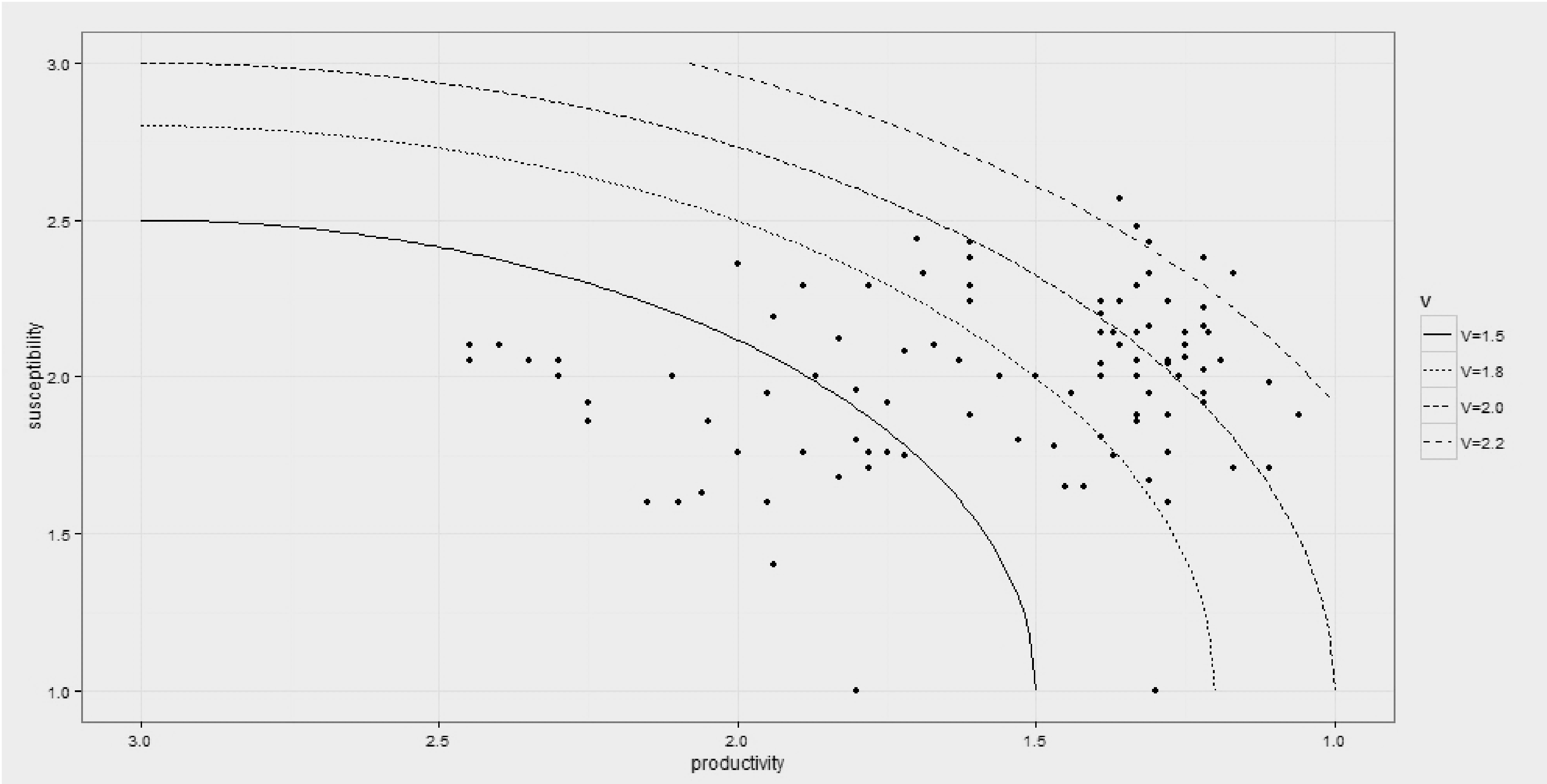


**Figure 3.** PSA scores for all stocks scored with isoclines delineating scores of 1.5, 1.8, 2.0, and 2.2 (moving from bottom to top).

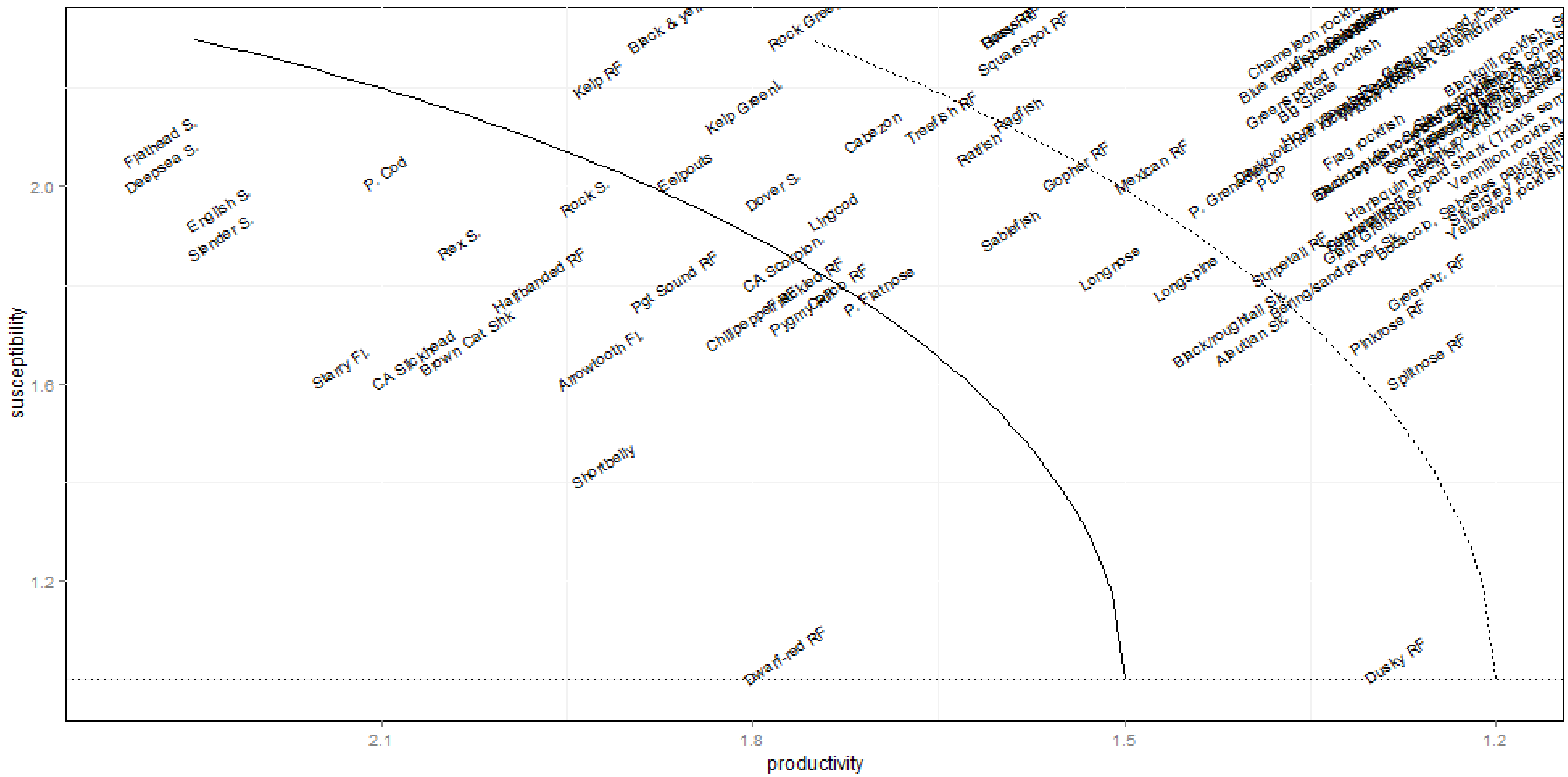


**Figure 4.** Same as previous Figure but zoomed and labeled to highlight the stocks falling near PSA vulnerabilities of 1.5 and 1.8. Labels are jittered to reduce overlap. Specific PSA scores for these stocks are listed in the table below.

**Table 3.** FMP and Non-FMP stocks with PSA Vulnerability scores of 1.90 and lower.

| Stock | P-score | S-score | Vulnerability | Stock | P-score | S-score | Vulnerability |
|---|---|---|---|---|---|---|---|
| 1. Grass rockfish | 1.61 | 2.29 | 1.89 | 30. Kelp rockfish | 1.94 | 2.19 | 1.59 |
| 2. Rosy Rockfish | 1.61 | 2.29 | 1.89 | 31. Lingcod | 1.75 | 1.92 | 1.55 |
| 3. Greenstriped rockfish | 1.28 | 1.76 | 1.88 | 32. Dover Sole | 1.80 | 1.96 | 1.54 |
| 4. Shortspine thornyhead | 1.33 | 1.88 | 1.88 | 33. Eelpouts spp. | 1.87 | 2.00 | 1.51 |
| 5. Yellowtail rockfish | 1.33 | 1.88 | 1.88 | 34. Finescale codling | 1.72 | 1.75 | 1.48 |
| 6. Giant grenadier | 1.33 | 1.86 | 1.87 | 35. Calico rockfish | 1.75 | 1.76 | 1.46 |
| 7. Olive rockfish | 1.69 | 2.33 | 1.87 | 36. Freckled rockfish | 1.78 | 1.76 | 1.44 |
| 8. Squarespot rockfish | 1.61 | 2.24 | 1.86 | 37. Pygmy rockfish | 1.78 | 1.71 | 1.42 |
| 9. Pacific grenadier | 1.44 | 1.95 | 1.82 | 38. Rock sole | 1.95 | 1.95 | 1.42 |
| 10. Pinkrose rockfish | 1.31 | 1.67 | 1.82 | 39. California scorpionfish | 1.80 | 1.80 | 1.40 |
| 11. Splitnose rockfish | 1.28 | 1.60 | 1.82 | 40. Chilipepper | 1.83 | 1.68 | 1.35 |
| 12. Bering/sandpaper skate | 1.37 | 1.75 | 1.80 | 41. Puget Sound rockfish | 1.89 | 1.76 | 1.35 |
| 13. Mexican rockfish | 1.50 | 2.00 | 1.80 | 42. Pacifc cod | 2.11 | 2.00 | 1.34 |
| 14. Ragfish | 1.60 | 2.12 | 1.80 | 43. Rex sole | 2.05 | 1.86 | 1.28 |
| 15. Stripetail rockfish | 1.39 | 1.81 | 1.80 | 44. Flathead sole | 2.30 | 2.05 | 1.26 |
| 16. Rock greenling | 1.78 | 2.29 | 1.77 | 45. Halfbanded rockfish | 2.00 | 1.76 | 1.26 |
| 17. Gopher rockfish | 1.56 | 2.00 | 1.76 | 46. Pacific sanddab | 2.40 | 2.10 | 1.25 |
| 18. Treefish rockfish | 1.67 | 2.10 | 1.73 | 47. Curlfin Sole | 2.45 | 2.10 | 1.23 |
| 19. Ratfish | 1.63 | 2.05 | 1.72 | 48. Sand sole | 2.35 | 2.05 | 1.23 |
| 20. Aleutian skate | 1.42 | 1.65 | 1.71 | 49. Deepsea sole | 2.30 | 2.00 | 1.22 |
| 21. Longspine Thornyhead | 1.47 | 1.78 | 1.71 | 50. Arrowtooth Flounder | 1.95 | 1.60 | 1.21 |
| 22. Black-and-yellow rockfish | 1.89 | 2.29 | 1.70 | 51. Dwarf-red rockfish | 1.80 | 1.00 | 1.20 |
| 23. Dusky rockfish | 1.30 | 1.00 | 1.70 | 52. English Sole | 2.25 | 1.92 | 1.19 |
| 24. Pacific whiting | 2.00 | 2.36 | 1.69 | 53. Butter Sole | 2.45 | 2.05 | 1.18 |
| 25. Black/roughtail skate | 1.45 | 1.65 | 1.68 | 54. Brown cat shark | 2.06 | 1.63 | 1.14 |
| 26. Cabezon | 1.72 | 2.08 | 1.68 | 55. Slender sole | 2.25 | 1.86 | 1.14 |
| 27. Longnose skate | 1.53 | 1.80 | 1.68 | 56. Shortbelly rockfish | 1.94 | 1.40 | 1.13 |
| 28. Sablefish | 1.61 | 1.88 | 1.64 | 57. California slickhead | 2.10 | 1.60 | 1.10 |
| 29. Kelp greenling | 1.83 | 2.12 | 1.62 | 58. Starry flounder | 2.15 | 1.60 | 1.04 |

## Appendix – Supplemental Tables

**Table 4.** Invertebrate species and species categories excluded from the analysis. Only species with an average catch greater than 1 mt across all sectors in the dataset are displayed.

| Average Catch (mt) 2007-2011 | | | | | |
|---|---|---|---|---|---|
| **Crustaceons** | **FMP Sectors** | **All Sectors** | **Cephalopods** | **FMP Sectors** | **All Sectors** |
| 1. Dungeness Crab | 1,693 | 22,331 | 1. Humboldt Squid | 1,596 | 1,596 |
| 2. Pink Shrimp | 0 | 18,132 | 2. Squid Unid | 443 | 490 |
| 3. Red Rock Crab | 21 | 597 | 3. Octopus Unid | 10 | 13 |
| 4. Shrimp Unid. | 1 | 409 | **Mollusks and Other Invertebrates** | **FMP Sectors** | **All Sectors** |
| 5. Tanneri Tanner Crab | 405 | 405 | 1. Red Sea Urchin | 0 | 5,343 |
| 6. California Spiny Lobster | 6 | 325 | 2. Sea Cucumber Unid. | 3 | 305 |
| 7. Spotted Prawn | 5 | 168 | 3. Razor Clam | 0 | 113 |
| 8. Ridgeback Prawn | 0 | 157 | 4. Jellyfish Unid. | 2 | 89 |
| 9. Bait Shrimp Unid. | 0 | 118 | 5. Basket Cockle | 0 | 77 |
| 10. Crab Unid. | 2 | 38 | 6. Mollusks Unid. | 4 | 73 |
| 11. Tanner Crab Unid. | 36 | 36 | 7. Urchin Unid. | 7 | 9 |
| 12. Ghost Shrimp | 0 | 21 | 8. Butter Clam | 0 | 8 |
| 13. Sheep Crab | 0 | 4 | 9. Gaper Clam | 0 | 5 |
| 14. Graceful Crab | 0 | 3 | 10. Sea Urchin Unid. | 0 | 2 |
| 15. Brown Box Crab | 2 | 2 | 11. Bivalves Unid. | 1 | 1 |
| 16. Armored Box Crab | 1 | 2 | 12. Manila Clam | 0 | 1 |
| 17. Yellow Rock Crab | 0 | 1 | 13. Echinoderm Unid. | 0 | 1 |
| 18. Scarlet King Crab | 1 | 1 | | | |
| 19. Pacific Rock Crab | 1 | 1 | | | |
| 20. Mud Shrimp | 0 | 1 | | | |

**Table 5.** Non-FMP species in the catch dataset that were excluded from the analysis because they are managed under another FMP or state or international management or expected to be found mainly in state and nearshore waters. Only species with an average catch greater than 1 mt across all sectors in the dataset are displayed. Species are sorted by the average annual catch across all sectors, in descending order.

| Average Catch (mt), 2007-2011 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | FMP Sectors | All Sectors | Species | FMP Sectors | All Sectors | Species | FMP Sectors | All Sectors |
| 1. Market Squid | 2 | 86,620 | 26. Thresher Shark | 56 | 56 | 52. Shortfin Mako Shark | 6 | 6 |
| 2. Pacific Sardine | 39 | 78,636 | 27. White Seabass | 55 | 55 | 53. Sargo | 6 | 6 |
| 3. Albacore Tuna | 283 | 11,712 | 28. Striped Bass | 54 | 54 | 54. Pink (Humpback) Salmon | 5 | 6 |
| 4. Northern Anchovy | 2 | 6,541 | 29. Blue Shark | 47 | 49 | 55. Whitebait Smelt | 0 | 6 |
| 5. Pacific Mackerel | 1 | 3,580 | 30. White Croaker | 21 | 48 | 56. Bigeye Tuna | 0 | 6 |
| 6. Hagfish Unid.. | 1 | 1,776 | 31. Yellowfin Tuna | 25 | 48 | 57. White Sturgeon | 5 | 5 |
| 7. King (Chinook) Salmon | 471 | 1,043 | 32. Yellowtail (Amberjack) | 40 | 46 | 58. Striped Seaperch | 5 | 5 |
| 8. Pacific Bonito | 71 | 728 | 33. American Shad | 22 | 40 | 59. Bigeye Thresher Shark | 0 | 4 |
| 9. Pacific Herring | 11 | 727 | 34. Red (Sockeye) Salmon | 30 | 30 | 60. Blacksmith | 4 | 4 |
| 10. Pacific Halibut | 583 | 701 | 35. Bonito (Shortfin Mako) Shark | 1 | 29 | 61. California Corbina | 4 | 4 |
| 11. Swordfish | 0 | 469 | 36. Spotfin Croaker | 25 | 25 | 62. Shiner Surfperch | 3 | 3 |
| 12. Silver (Coho) Salmon | 411 | 459 | 37. Yellowfin Croaker | 21 | 21 | 63. Rubberlip Surfperch | 3 | 3 |
| 13. California Halibut | 192 | 393 | 38. Ocean Whitefish | 19 | 19 | 64. Giant Sea Bass | 0 | 3 |
| 14. Jack Mackerel | 29 | 314 | 39. Black Surfperch | 19 | 19 | 65. Dog (Chum) Salmon | 3 | 3 |
| 15. White Sea Bass | 0 | 247 | 40. Eulachon | 0 | 13 | 66. Skipjack Tuna | 1 | 2 |
| 16. Chub (Pacific) Mackerel | 240 | 240 | 41. Redtail Surfperch | 12 | 12 | 67. Poacher Unid. | 0 | 2 |
| 17. Pacific Barracuda | 143 | 173 | 42. Opaleye | 12 | 12 | 68. California Lizardfish | 2 | 2 |
| 18. Smelt Unid. | 0 | 157 | 43. Mackerel Unid. | 1 | 11 | 69. Monkeyface Prickleback | 2 | 2 |
| 19. Common Thresher Shark | 1 | 126 | 44. Surf Smelt | 10 | 10 | 70. Pacific Hagfish | 0 | 1 |
| 20. Barred Sand Bass | 115 | 116 | 45. Halfmoon | 10 | 10 | 71. White Seaperch | 1 | 1 |
| 21. Bluefin Tuna | 0 | 116 | 46. Walleye Surfperch | 9 | 9 | 72. Green Sturgeon | 0 | 1 |
| 22. Kelp Bass | 97 | 97 | 47. Surfperch Unid. | 0 | 8 | 73. Dorado | 0 | 1 |
| 23. Jack Smelt | 78 | 78 | 48. Spotted Sandbass | 8 | 8 | 74. Wolf-eel | 1 | 1 |
| 24. California Sheephead | 76 | 77 | 49. Top Smelt | 8 | 8 | 75. Pacific Staghorn Sculpin | 1 | 1 |
| 25. Bat Ray | 26 | 75 | 50. Queenfish | 7 | 7 | 76. Silver Surfperch | 1 | 1 |
| 26. Barred Surfperch | 61 | 61 | 51. Sculpin Unid. | 4 | 6 | 77. Pile Surfperch | 1 | 1 |

**Table 6.** List of the PSA productivity attributes with bin definitions and score weightings for different species groups and those with and without Council-approved assessments. Default weights for all attributes are 2.

| | Bins | | | Weight (0 - 4) | | | |
|---|---|---|---|---|---|---|---|
| **Productivity Attributes** | High (3) | Moderate (2) | Low (1) | Elasmobranchs | Flatfish | Rockfishes & other fishes | non-FMP |
| r | >0.5 | 0.5-0.16 | <0.16 | 2 | 2 | 2 | Different weights used depending on available information |
| Maximum Age | < 10 years | 10 - 30 years | > 30 years | 2 | 2 | 2 | |
| Maximum Size | < 60 cm | 60-150 cm | > 150 cm | 1 | 2 | 1 | |
| von Bertalanffy Growth Coefficient (k) | > 0.25 | 0.15-0.25 | < 0.15 | 2 | 2 | 2 | |
| Estimated Natural Mortality | > 0.40 | 0.20-0.40 | < 0.20 | 2 | 2 | 2 | |
| Measured Fecundity | > 10e4 | 10e2-10e3 | < 10e2 | 2 | 2 | 1 | |
| Breeding Strategy | 0 | between 1 and 3 | ≥4 | 2 | 2 | 2 | |
| Recruitment Pattern | highly frequent recruitment success (> 8 per decade) | moderately frequent recruitment success (>1 & <8 per decade) | infrequent recruitment success (< 1 per decade) | 2 | 2 | 2 | |
| Age at Maturity | < 2 years | 2-4 years | > 4 years | 2 | 2 | 2 | |
| Mean Trophic Level | <2.5 | 2.5-3.5 | >3.5 | 2 | 2 | 2 | |

**Table 7.** List of the PSA fishery susceptibility attributes and score weightings for all species scored in this analysis. As explained in the text, the management related attributes were given zero weight.

| **Susceptibility Attributes** | Low (1) | Moderate (2) | High (3) | Weight (0-4) |
|---|---|---|---|---|
| *Management Strategy* | Proactive management; sort requirements; individual specification; discard monitoring; biological data; representative fishery-independent indices | Reactive management; decent catch records; some assessment data; weak spatial knowledge; weakly informed indices | High catch uncertainty; low assessment data; no sorting; inadequate discard monitoring; low confidence in control rule | 0 |
| *Areal Overlap* | < 25% of stock occurs in the area fished | Between 25% and 50% of the stock occurs in the area fished | > 50% of stock occurs in the area fished | 2 |
| *Geographic Concentration* | stock is distributed in > 50% of its total range | stock is distributed in 25% to 50% of its total range | stock is distributed in < 25% of its total range | 2 |
| *Vertical Overlap* | < 25% of stock occurs in the depths fished | Between 25% and 50% of the stock occurs in the depths fished | > 50% of stock occurs in the depths fished | 2 |
| *F relative to M* | <0.5 | 0.5 - 1.0 | >1 | 0 |
| *Relative Spawning Biomass* | B is > 40% of B0 (or maximum observed from time series of biomass estimates) | B is between 25% and 40% of B0 (or maximum observed from time series of biomass estimates) | B is < 25% of B0 (or maximum observed from time series of biomass estimates) | 0 |
| *Seasonal Migrations* | Seasonal migrations decrease overlap with the fishery | Seasonal migrations do not substantially affect the overlap with the fishery | Seasonal migrations increase overlap with the fishery | 2 |
| *Schooling/Aggregation and Other Behavioral Responses* | Behavioral responses decrease the catchability of the gear | Behavioral responses do not substantially affect the catchability of the gear | Behavioral responses (e.g. schooling) increase the catchability of the gear | 2 |
| *Morphology Affecting Capture* | Species shows low selectivity to the fishing gear. | Species shows moderate selectivity to the fishing gear. | Species shows high selectivity to the fishing gear. | 2 |
| *Survival After Capture and Release* | Survival probability > 67% | 33% < survival probability < 67% | Survival probability < 33% | 2 |
| *Desirability/Value of the Fishery* | stock is not highly valued or desired by the fishery | stock is moderately valued or desired by the fishery | stock is highly valued or desired by the fishery | 2 |
| *Fishery Impact to EFH or Habitat in General for Non-targets* | Adverse effects absent, minimal or temporary | Adverse effects more than minimal or temporary but are mitigated | Adverse effects more than minimal or temporary and are not mitigated | 0 |

| *Productivity Attribute* | *Score* | *Weight* | *Reasons* |
|---|---|---|---|
| r | 2 | 2 | FishBase estimats a minimum population doubling time of 4.5-14 years for Blackbelly and Bigfin (doubling time ≈ Ln 2 / r) |
| Maximum Age | 2 | 2 | Love (2011) reports a Bigfin 7-8 years old at 75 percent of max size. |
| Maximum Size | 3 | 1 | Fishbase Bigfin, Wattled |
| von Bertalanffy Growth Coefficient (k) | 1.5 | 2 | Love (2011) reports k = 0.13 for Fish Doctor, FishBase has k= 0.31 for Blackbelly |
| Estimated Natural Mortality | 2 | 0 | no data |
| Measured Fecundity | 1.5 | 1 | Love (2001) reports some species with less than 100 eggs and others with 1000s of eggs. Ferry Graham et al. (2007) lab work reports less than 100 eggs and questions higher estimates. |
| Breeding Strategy | 2 | 2 | Nests and some egg guarding, long hatching times (Love 2011 and Ferry Graham et al. 2007) |
| Recruitment Pattern | 2 | 0 | no data |
| Age at Maturity | 2 | 2 | Love (2011) reports Blackbelly Eelpout mature at 2-3 years. |
| Mean Trophic Level | 1.5 | 2 | FishBase estimates for Bigfin, Blackbelly, Twoline (3.3-3.6). |

**Table 8.** PSA scoring, attribute weights, and reasoning for Eelpouts (Family Zoarcidae).

| *Productivity Attribute* | *Score* | *Weight* | *Reasons* |
|---|---|---|---|
| *r* | 2 | 2 | FishBase estimats a minimum population doubling time of 4.5-14 years for Blackbelly and Bigfin (doubling time ≈ Ln 2 / r) |
| *Maximum Age* | 2 | 2 | Love (2011) reports a Bigfin 7-8 years old at 75 percent of max size. |
| *Maximum Size* | 3 | 1 | Fishbase Bigfin, Wattled, others don't get bigger than 60 cm. |
| *von Bertalanffy Growth Coefficient (k)* | 1.5 | 2 | Love (2011) reports k = 0.13 for Fish Doctor, FishBase has k= 0.31 for Blackbelly |
| *Estimated Natural Mortality* | -- | 0 | no data |
| *Measured Fecundity* | 1.5 | 1 | Love (2001) reports some species with less than 100 eggs and others with 1000s of eggs. Ferry Graham et al. (2007) lab work reports less than 100 eggs and questions higher estimates. |
| *Breeding Strategy* | 2 | 2 | Nests and guarding, long hatching times, some birth live young (Love 2011 and Ferry Graham et al. 2007) |
| *Recruitment Pattern* | -- | 0 | no data |
| *Age at Maturity* | 2 | 2 | Love (2011) reports Blackbelly Eelpout mature at 2-3 years. |
| *Mean Trophic Level* | 1.5 | 2 | FishBase estimates for Bigfin, Blackbelly, Twoline (3.3-3.6). |

| *Susceptibility Attributes* | *Score* | *Weight* | *Reasons* |
|---|---|---|---|
| *Management Strategy* | -- | 0 | not scored in this analysis |
| *Areal Overlap* | 3 | 2 | Focusing just on CA Current area, their range has high overlap with fisheries |
| *Geographic Concentration* | 2 | 2 | Appear to be evenly distributed in trawl survey area, un-trawlable habitats unknown. |
| *Vertical Overlap* | 3 | 2 | They're found in trawlable habitats and depths. |
| *F relative to M* | -- | 0 | not scored in this analysis |
| *Relative Spawning Biomass* | -- | 0 | not scored in this analysis |
| *Seasonal Migrations* | 2 | 2 | no suggestion of migrations or movements that would change overlap. |
| *Schooling/Aggregation and Other Behavioral Responses* | 2 | 2 | Unknown. Many species burrow, which would suggest reduced exposure, yet they could be attracted to trawl activity (e.g. stirred up prey). |
| *Morphology Affecting Capture* | 2 | 2 | Nothing stands out as affecting their catchability either way except small size. |
| *Survival After Capture and Release* | 2 | 2 | Unknown. Moderate score seems reasonable assumption. |
| *Desirability/Value of the Fishery* | 1 | 2 | Not marketed. |
| *Fishery Impact to EFH or Habitat in General for Non-targets* | -- | 0 | not scored in this analysis |

**Main References Consulted**


Bradburn, M.J., A.A. Keller, and B.H. Horness. 2011. The 2003 to 2008 U.S. West Coast bottom trawl surveys of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, length, and age composition. NOAA Tech. Memo. NMFS-NWFSC-114.

Ferry-Graham, Lara A., Jeffrey C. Drazen, and Veronica Franklin. 2007. Laboratory observations of reproduction in the deep-water zoarcids Lycodes cortezianus and Lycodapus mandibularis (Teleostei: Zoarcidae)." Pacific science 61(1): 129-139.

**Table 9.** PSA scoring, attribute weights, and reasoning for the ragfish (*Icosteus aenigmaticus*).

| *Productivity Attribute* | *Score* | *Weight* | *Reasons* |
|---|---|---|---|
| *r* | 2 | 2 | FishBase estimate of population doubling time is 4.5 - 14 years corresponding to an r of 0.15-0.05 (doubling time ≈ Ln 2 / r) |
| *Maximum Age* | -- | 0 | Allen (2001) reports they are difficult to age. |
| *Maximum Size* | 1 | 1 | FishBase (Fitch and Lavenberg 1968) and Allen (2001) report max size 200 cm |
| *von Bertalanffy Growth Coefficient (k)* | 1 | 1 | FishBase (Fitch and Lavenberg 1968) reports k = 0.13 |
| *Estimated Natural Mortality* | -- | 0 | no data. |
| *Measured Fecundity* | 3 | 2 | Allen (2001) reports fecundity of 144,000-552,000 eggs. |
| *Breeding Strategy* | 1 | 2 | Allen (2001):eggs in icthyoplankton |
| *Recruitment Pattern* | -- | 0 | no data |
| *Age at Maturity* | -- | 0 | No age data. |
| *Mean Trophic Level* | 1 | 2 | FishBase estimates TL of 4.5; Allen (2001) notes shortspine in stomach of one speciman. |

| *Susceptibility Attributes* | *Score* | *Weight* | *Reasons* |
|---|---|---|---|
| *Management Strategy* | -- | 0 | not scored in this analysis |
| *Areal Overlap* | 2.5 | 2 | They are found out to 600 fm in the NWFSC Trawl Survey yet are rarely seen. Allen(2001) reports use of canyons and shelf. |
| *Geographic Concentration* | 1.5 | 2 | Best guess is an even, sparse distribution throughout the range yet Allen (2001) note some clustering of where specimens were taken. |
| *Vertical Overlap* | 3 | 2 | Caught in bottom trawl and midwater whiting - suggests high overlap. |
| *F relative to M* | -- | 0 | not scored in this analysis |
| *Relative Spawning Biomass* | -- | 0 | not scored in this analysis |
| *Seasonal Migrations* | 2 | 2 | They may move onto the shelf to spawn yet overlap probably not affected.. |
| *Schooling/Aggregation and Other Behavioral Responses* | 2 | 2 | Sparse in the NWFSC Trawl survey (2003-08) so schooling, if any, would be off the bottom or in non-trawlable habitats. |
| *Morphology Affecting Capture* | 2 | 2 | They get pretty large so modeate selectivity and Allen (2001) reports specimens taken by multiple gears. |
| *Survival After Capture and Release* | 3 | 2 | No data, score of 2 assumed. |
| *Desirability/Value of the Fishery* | 1 | 2 | Not marketed. |
| *Fishery Impact to EFH or Habitat in General for Non-targets* | -- | 0 | not scored in this analysis |

**Main References Consulted**


Allen, G. H. (2001). The Ragfish, *Icosteus aenigmaticus* Lockington, 1880: A Synthesis of Historical and Recent Records From the North Pacific Ocean and the Bering Sea. Marine Fisheries Review, 63(4): 1-31.

Bradburn, M.J., A.A. Keller, and B.H. Horness. 2011. The 2003 to 2008 U.S. West Coast bottom trawl surveys of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, length, and age composition. NOAA Tech. Memo. NMFS-NWFSC-114.

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# GROUNDFISH MANAGEMENT TEAM REPORT ON PORT SAMPLING SURVEYS

In April 2013, the Groundfish Management Team (GMT) discussed the possibility of collecting information that might help inform decisions related to restructuring existing groundfish stock complexes (Agenda Item D.3.b, Supplemental GMT Report, April 2013). Changes to existing stock complexes could result in additional sorting requirements. Sorting requirements allow for better tracking of individual stocks that may be of concern to fisheries managers and improves the quality of data available for management of these stocks. Prior to the June 2013 meeting, a subgroup of the GMT designed and implemented two surveys: one intended for state sampling program managers and supervisors, and a second for state agency port biologists and samplers (including seasonal samplers, where applicable).

The primary purpose of both web-based surveys was to provide the GMT and the Pacific Fishery Management Council (PFMC) with information to aid discussions about whether and how to change existing groundfish stock complexes. Information of interest to the GMT included how often individual stocks within existing stock complexes were encountered, what tools were used to distinguish these individual stocks, and perceived impacts to state sampling programs, fishing activities, and processing operations. These areas of interest have been mentioned in previous GMT statements (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013; Agenda Item D.3.b, Supplemental GMT Report, April 2013) and in Appendix C of the 2013-14 Final Environmental Impact Statement for the Pacific Coast Groundfish Fishery (pp. C-45 – C-46, FEIS 2012). The Oregon Department of Fish and Wildlife (ODFW) submitted a state report in June that discussed potential impacts to ODFW's sampling program and Oregon fisheries with greater specificity (Agenda Item F.8.b, ODFW Report, June 2013). Collecting information that provides greater specificity to the GMT's current understanding was a goal of both surveys.

An overview of each survey and summarized results are provided below. Both survey instruments are included as part of this report: Appendix A is the program manager/supervisor survey and Appendix B is the port biologist/samplers survey and Appendix B.

## Program manager and supervisor survey

A reoccurring discussion related to changing existing stock complexes is focused on the types and magnitude of impacts to state agencies, fishing operations, and processing plants (see Agenda Item D.3.b, Supplemental GMT Report, April 2013 for an example). As is the case with inferring which groundfish species may be difficult to distinguish (see "Port biologist and samplers survey" section below), many on the GMT, Council staff, and others could speculate about potential impacts or "costs" associated with changes to existing complexes. For example, increasing the number of market categories may increase the sampling burden on port samplers. The team thought it worthwhile to survey those whose jobs are to balance existing sampling program resources with state sampling goals, existing stock complexes, and market categories: state sampling program managers and supervisors. These employees could also have some insight into potential impacts to fishing and processing operations since identifying and surveying this population was not feasible at the time. Changes to sorting requirements are expected to have a larger impact on state port sampling programs, fishing operations, and processing facilities (p. C-45, FEIS 2012). No impact was expected for federal observers and "minimal to moderate" impact was expected for catch monitors and enforcement (p. C-45, FEIS 2012). A survey was designed by a subgroup of the GMT using Google Forms™; a web link to that survey was sent to state sampling program managers and supervisors between 6/10 – 6/11/13. The survey was open for one week, closing on 6/17/13. All five program managers and supervisors were invited to participate; all five responded.

The survey comprised of eight questions (see Appendix A). These questions and corresponding results are described below.

*Current port sampling coverage*

Question 1 in this survey sought to gain information about the ability of state sampling programs to have groundfish sampling coverage across their state given the current funding levels available. Responses to this question may provide information about baseline or current levels of coverage, before possible changes to stock complexes.

Consistent between all three states was that sampling coverage was greater at fishing ports with more fishing activity; similarly, fewer species composition samples are taken at fishing ports with lower levels of groundfish fishing activity. This response, in addition to others mentioned by respondents that may also be applicable coastwide, are listed below as reasons why sampling coverage may be lower at some port locations:

- Ports with the highest volume of fish landed are more likely to have more sampling resources spent there.
- Likewise, ports with fewer groundfish fishery participants, less processing capacity, and smaller volumes of landed catch have proportionally fewer samples taken from them.
- However, some port sampling program resources are spent in ports with lower volumes of groundfish landings in order to sample different fishing strategies and areas in these lower volume ports. Otherwise, it was mentioned that these fishing strategies and areas would not be represented. Lower volume ports that support nearshore fisheries and the different gears that are used (trawl, longline, pot, or hook-and-line) were noted as an example.
- Sampling coverage may depend on the season or the year. For example, non-hake groundfish trips may have less sampling coverage during hake season due to sampling program resource limitations.
- Ports with more trawl-caught groundfish landings have more sampling coverage.
- Travel distance to ports due to the actual distance and/or traffic conditions were cited as influencing sampling coverage in some ports.
- An existing shortage of port biologists due to limited funding for more positions was mentioned as a factor determining the number of composition samples taken.

- The presence of "mobile dealers" was also mentioned as a reason why fewer samples might be taken from a particular port. When fish are offloaded, it is often transferred directly to trucks or vans, leaving little or no time for taking composition samples. The ability to take samples is also dependent on voluntary cooperation from fishermen or dealers.

*Possible challenges to state port sampling programs*

Questions 2 and 3 provided program managers and supervisors an opportunity to reflect on how increasing market categories might impact state port sampling programs. Question 2 provided respondents with nine possible response categories (including an "Other" category) that the GMT suggested as possible impacts. Question 2 asked respondents the following:

> In June, the PFMC will decide on preliminary alternatives for reorganizing the slope rockfish and "other fish" stock complexes. **In general**, how might your port sampling program be affected if the reorganized stock complexes increases the number of market categories? *Please check all that apply. This list may not be complete; please tell us more in the following question.*

Nine response categories were provided for this question. These response categories and the number of respondents who agreed with that category, are listed in Table 1 below.

Table 1. Increasing market categories and how state port sampling programs may be affected.

| **Potential impacts to state sampling programs** | **Number of respondents** |
|---|---|
| Achieving our state's groundfish sampling goals may become more difficult. | 4 |
| Prior to sampling landings, port biologists and other sampling personnel will spend more time waiting for groundfish landings to be sorted. | 4 |
| A greater number of groundfish samples will need to be taken if the number of market categories increases. | 4 |
| A greater number of groundfish samples taken by port biologists or other port samplers will likely contain higher levels of contamination (i.e., more misidentified fish in each sample) | 3 |
| Each groundfish species composition sample may take more time to process due to higher levels of misidentified species | 4 |
| Each groundfish species composition sample may take more time to process due to an increased number of market categories. | 3 |
| Existing fish ticket or landing receipt books and/or data management software and programs will have to be updated. | 5 |
| Additional training of state agency staff, fishing operations personnel, and/or fish processing employees will be necessary. | 5 |
| Other – please tell us more in the next question | 2 |

All five program managers/supervisors agreed that the following impacts may occur if the number of market categories were to increase:

- Existing fish ticket or landing receipt books and/or data management software and programs will have to be updated.
- Additional training of state agency staff, fishing operations personnel, and/or fish processing employees will be necessary.

Respondents who indicated “Other” in the above question were given an opportunity to describe in more detail what other impact might result from changing market categories (Q3). Possible changes in the level of accuracy of data collected by port biologists and samplers was a theme of one of the comments:

> “Because there may be more 'gaps' in sampling due to the increase in market categories, there will likely be more 'borrowing' sample information from one port to another or from the same port from another time period. This may result in less accurate data, rather than the more accurate data that was expected by reorganizing the stock complexes.”

Another respondent mentioned the challenges relative to current funding levels for state sampling programs and how this will also affect sampling coverage and editing landing receipts (in addition to the possibility of new market categories):

> “We were cut significantly on our funding this year. If that happens again we are looking at loosing 1.5 PYs.[1] We will not be able to sample as much as we have in the past and I doubt we will be able to cover new market categories. Port Biologists also edit landing receipts. It will take more time to edit (properly code) if there are new/more market categories. The QSM system… will have to be rewritten to handle the new market categories.”

A detailed description of similar challenges and other challenges that may affect the Oregon Department of Fish and Wildlife (ODFW) is available in an ODFW report under this agenda item in the June 2013 Briefing Book (Agenda Item F.8.b, ODFW Report).

*Possible challenges to fishing operations and processing plants*

Questions 4 and 5 provided respondents an opportunity to reflect on how increasing market categories might impact fishing operations and processing plants. Question 4 provided respondents with seven possible response categories (including an “Other” category) that the GMT suggested as possible impacts. Question 4 asked respondents the following:

> What challenges do you think **fishing operations and/or processing plants** might face if reorganized stock complexes increases the number of market categories? *Please check all that apply. This list may not be complete; please tell us more in the following question.*

[1] This respondent mentioned “PYs” but what this was an abbreviation for was unclear. Considering the comment as a whole, we interpreted this acronym as referring to port biologist and sampling staff.

Seven response categories were provided for this question. These response categories and the number of respondents who agreed with that category, are listed in Table 2 below.

Table 2. Increasing market categories and how fishing and processing activities may be affected.

| **Potential impacts to fishing operations and/or processing plants** | **Number of respondents** |
|---|---|
| Having to increase the number of bins needed for sorting more market categories | 4 |
| Finding space for additional bins is going to be a challenge (i.e., on a vessel, in a plant) | 4 |
| Fishing operations and/or processing plants will be need to train new or existing employees to accurately sort these market categories | 5 |
| Fishermen, plant workers, etc. will spend more time sorting groundfish landings if the number of market categories increases | 5 |
| Additional fishermen, plant workers, etc. may need to be hired to help sort groundfish landings | 2 |
| The quality of groundfish products may change due to landings spending more time on ice before plants can process them, misidentified species, etc. | 0 |
| Other – please tell us more in the next question | 3 |

All five program managers/supervisors agreed that the following impacts were likely to occur if the number of market categories were to increase:

- Fishing operations and/or processing plants will be need to train new or existing employees to accurately sort these market categories
- Fishermen, plant workers, etc. will spend more time sorting groundfish landings if the number of market categories increases

Respondents who indicated "Other" in the above question were asked to provide more information in an open-ended question (Q5) following the one above. In addition to the response categories listed in the question, one respondent suggested that the "frustration level" of plant managers and workers might increase if they are asked to re-sort species that are difficult to differentiate. Similarly, another respondent stated that state sampling staff often ask processing personnel to re-sort when contamination levels (that is, when the proportion of misidentified fish) are too high. What is "too high" is a judgment call made by the port sampler[2] and depends on factors such as species, market category, and landing volume. Asking processing personnel to re-sort requires "extra time for both [port biologists] and processing personnel" and stops everyone's "work flow to educate plant personnel" and re-sort.

Also regarding time, one respondent further stated that "species with similar appearances that are difficult to distinguish from each other will require more additional time than those that are relatively easy to identify." This comment suggests that if species that are difficult to differentiate are now required to be differentiated, the time to do so would increase.

[2] This was mentioned for Oregon and Washington samplers. This protocol to ask fishermen and processing personnel to re-sort landings was not mentioned as a practice in California.

One respondent commented on impacts to fish buyers. That is, that the "quality of fish" may not decline as much as might be anticipated because fish buyers will maintain quality by using more ice or making other changes during the offloading process. However, this may cost fish buyers more time and money. From this comment, it could be surmised that this higher cost may be passed on to someone along the supply chain.

One respondent commented about the potential need for the GMT or others to talk to fishing operations and processing plants directly: "I can't speak to the potential need to hire extra plant workers, or a degradation in quality due to more time needed for sorting prior to processing. Please don't interpret my lack of checks in those boxes to mean I don't think they will occur (although if I had to guess, I'd guess they would not be significant issues... but this guess is coming from someone who has never worked in a fish plant)."

*Other information collected*

Three general questions were asked in this final section: how long these individuals had been working for the state agency in their current capacity (Q6; range of 4 to 21 years); where they have been employed as a port biologist, other port sampler, or program management involved with groundfish (Q7; each had experience in one of the following states: CA, OR, and WA; no one had experience in AK or two or more states); and whether they have been employed as a fishermen, plant monitor, or dock or plant worker where they handled or sorted groundfish (Q8; one had been employed in CA doing this).

One final opportunity was provided at the end of the survey to comment on the contents of the survey (Q9). One respondent took that opportunity to write: "Increasing the number of market samples by reorganizing the species complexes does not necessarily increase the accuracy of determining the percentage of a given species from a complex when the species are difficult to tell apart on the sorting belt."

**Port biologist and sampler survey**

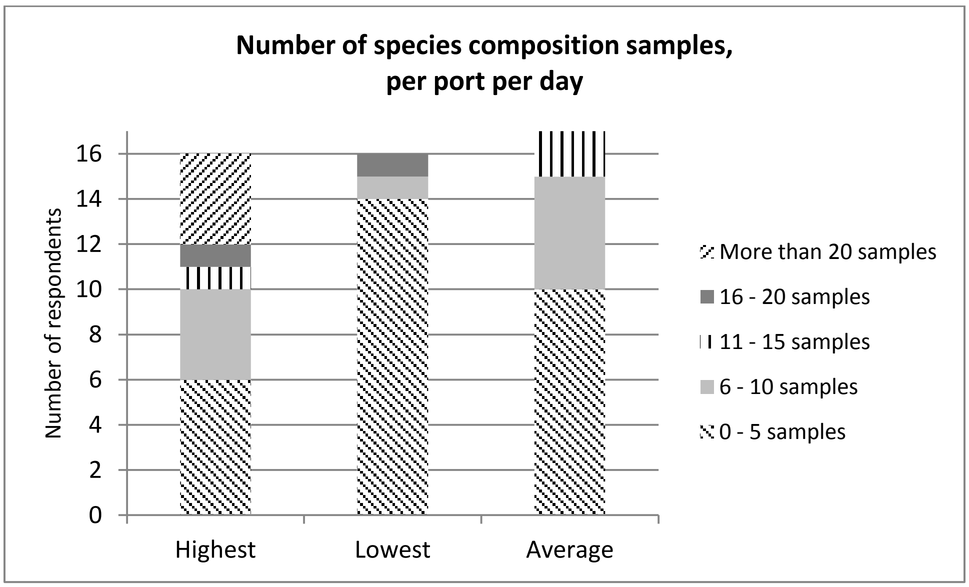
One of the main reasons for organizing stocks into a complex is when individual stocks are "difficult for fishermen, observers, plant monitors, port biologists, and others to distinguish" (Agenda Item D.3.b, Supplemental GMT Report, April 2013). Though many on the GMT, Council staff, and others could speculate which species might be difficult to distinguish (for example, aurora rockfish from splitnose rockfish), the team thought it was worthwhile to survey those whose jobs require positive identification of species within complexes and market categories: port biologists and samplers. Though federal observers and catch monitors are recognized as having similar training and expertise in groundfish identification, only state port biologists and samplers were surveyed at that time. It is assumed that information collected from port biologists and samplers would be similar to their federal observer and catch monitor counterparts. A survey was designed by a subgroup of the GMT using Google Forms™; a web link to that survey was sent to state program managers and supervisors between 6/10 – 6/11/13 to be forwarded to their staff. The survey was open for one week, closing on 6/17/13. All 21 state agency port biologists and samplers were invited to participate; 17 responded.

The survey consisted of 28 questions (see Appendix B). Due to the high number of questions and survey length, the survey was split into two parts. This allowed respondents to complete each part at different times, if needed. Of the groundfish stock complexes currently in the Pacific Coast Groundfish Fishery Management Plan, the PFMC prioritized the slope rockfish and "other fish" complexes for possible restructuring in time for the 2015-16 biennial groundfish management cycle (PFMC Decision Summary Document, June 2013). Stocks included in the "other fish" complex are cartilaginous species and various roundfishes. Other flatfish and shelf rockfish complexes were given lower priority for restructuring at this time. Nearshore rockfish complexes were dropped from further consideration during this cycle.

*General port sampling questions*

The following results are from questions related to: the number of groundfish species composition samples taken at any given port location on an average day (Q1); amount of time it takes to process species composition samples given three levels of contamination (i.e., proportion of misidentified species; Q2); number of market categories encountered in a given port location (Q3); amount of time spent waiting for catch to be offloaded prior to starting their species composition sampling protocol (Q4); and how often do port biologists and samplers work with fishermen, dock workers, or plant workers to accurately identify groundfish species (Q5).

Figure 1. Number of species composition samples processed, per port per day (Q1)



Question 2 asked respondents to estimate how much time they spend processing groundfish species composition samples with different levels of contamination ranging from less than 10% to greater than 25%. Table 3 displays the time estimates from 10 of the 17 respondents:

Table 3. Number of respondents and their estimated time to process species composition samples, given different levels of contamination.

| | Estimated time to process species composition samples | | | | | | |
|---|---|---|---|---|---|---|---|
| % contamination | *< 10 min* | *10 – 20* | *21 - 30* | *31 - 45* | *46 - 60* | *61 – 90* | *> 90 min* |
| < 10% | 4[1] | 3 | 2 | | | | 1[2] |
| 10 – 25% | 3[1] | 2 | 3[3] | 1 | | | 1[2] |
| > 25% | | 3[4] | 1 | 3 | 1 | 1 | 1[2] |

[1]One respondent added the caveat that this was true if the task was sampling "50 lb of rockfish".
[2]One respondent noted a range of 5 – 100 minutes, which varied based on a number of factors such as volume of landings, species landed, etc.
[3]One respondent noted a range of 30 – 90 minutes, which was variable based on a number of factor (see table note 2 and the discussion that follows this table).
[4]One respondent noted that this was true for "50 lb of rockfish". For "5,000 lb of rockfish," 30 – 180 minutes was noted as the time needed to process landings.

Several of these 10 respondents, as well as the other seven, mentioned multiple reasons why this question was difficult to answer. That is, the time needed to process species composition samples was not only based on the proportion of contamination but also many other factors including:

- The fishery or the boat itself. One respondent noted that their responses referred only to "… the shoreside hake fishery." Another respondent noted that "[t]he amount of time to complete the sample varies greatly not just from boat to boat, but also from offload to offload of the same boat."
- Volume of catch. Many port biologists and samplers mentioned this to be a factor when estimating the time needed to process species composition samples. One respondent noted that "… the new IFQ [program] limits the amount of fish to be sorted [and] varies greatly from trip to trip. If there is a total of 50 pounds of rockfish landed with less than 10% contamination, I am only looking at maybe 2-5 min to sort out contamination. 10-25% [contamination] may take me 5-10 min, greater than 25% really isn't going to take much longer. Ok, now make that off-load 5,000 pounds and it's going to take maybe half an hour to three hours."
- Depends on the species, complex, and/or size of individual fish. Several respondents mentioned this to be a factor. Comments included:
    - For less than 10% contaminated, a composition sample may take "approximately 5 min for most species. [However] slope [composition samples] usually take the longest at around 15 min because it requires more species sorting. If contamination is low, it doesn't add much time to the process in the field or in the write up."

- "The greatest species contamination I have experienced would be long/short [spine] thornyheads. If the contamination was greater than 25%, processing time would be significant. If the contamination occurred with larger species of fish such as roundfish, slope, nearshore, shelf, etc. [then the] process time would be insignificant. If contamination occurred with smaller flatfish species, such as rex [sole], sanddabs, etc. [then] time would be a factor."
- "The time required… greatly depends on which species is being sampled. For something like blue rockfish contamination of black rockfish landings, species comp[osition] sampling is very quick since its immediately apparent what species each fish is. It might only take a couple extra minutes to do such a sample if there were greater than 25% contamination. [However f]or something like shortspine thornyhead contamination of longspine thornyhead [landings], it takes much longer since each fish must be examined for a positive ID. In this example, 10%, 10-25%, and greater than 25% would all take the same amount of time, since you are looking at every fish regardless. In another example, you could consider splitnose and aurora . Again, both species are fairly readily identifiable and a sample could be quickly sorted much like with blacks and blues. Contamination [level] might add a couple extra minutes of time."
- "These questions show that the author is (completely) unfamiliar with the process... the time that [it] takes [to sample] depends on the category, boat, dock crew, type of fish, conditions, etc..."

- <u>Depends on the number or variety of species present</u>. One respondent wrote that "[t]his time estimate is dependent on the number of species present. Following our project protocol for species composition, it would take less than 5 minutes if composed of two species (e.g., longspine vs. shortspine thornyhead). If composed of four to five species (e.g., slope rockfish), it would take 8-10 minutes."
- <u>Depends on whether the species are familiar</u>. One respondent wrote that sampling "… times would greatly depend on [whether] they were common species that I see often and on a regular basis. If they were it wouldn't take me much longer to sort each one of these contamination percentages. However, if there are species that I don't see often or would need to be keyed out, then it would take me longer and that is represented in my above estimated times. These are just estimates, each situation is different and it is hard to quantify."
- <u>Greater than 25% contaminated</u> requires a change in their sampling process. One respondent wrote that "if it's really contaminated, I would start pulling all the different species out and put them in separate baskets according to species." Doing this would add time to the time needed to process samples.
- Several respondents noted that <u>high levels of species contamination is rare.</u> One respondent mentioned that "… nearly all of my samples come in without contamination. All my groundfish samples are of such low total quantities that regardless of species

composition, the most time it would take me is approximately 15 minutes per sample." Other respondents mentioned that:

  - "It is very unusual to see… [10-25%] contamination. If it is just one species of contamination it might add on a few minutes in the field plus a few more minutes [for] processing papers."
  - "I've only seen [>25% contamination]… a couple times in the past decade. Usually, [this is due to] someone new sorting the fish and it's a matter of fish ID education. In the past, I've notified the person in charge of sorting to the problem and they have made the new worker(s) resort the species correctly. This has been effective."
  - "Normally I do not see a species contamination level greater than 10%."

- Whether landings must be re-sorted influences how long it takes to sample. One respondent wrote that "[t]his [question] is difficult to answer as currently structured due to my sampling protocol as follows: When [there is] a tote consisting of >10% contamination, I stop doing the composition [sampling] and inform the dock foreman of the contamination and ask for a re-sort. This ensures that the fish ticket will portray the best accurate weights for individual species or species complexes. I will, however, resume sampling a contaminated tote if the dock foreman refuses to do a re-sort on this tote. In this case it will typically take an hour to process highly contaminated totes of fish (>10%)."
- Talking or working with those who sort landings (i.e., fishing and processing industry) may add time to their sampling protocol. One respondent noted that if the contamination level was less than 10%, they would not mention this to the processing crew. However, a contamination level of 10-25% would require some "casual talk about ID to workers and crew" and greater than 25% contamination would require "extra cluster sampling, lots of talk with crew and workers about ID, and possible resort[ing of landings]."
- Related to the above, sample processing time depends on the experience level of fishing and processing personnel. Some comments included:
  - "[Time to process samples m]ostly depends on the plant crew and how fast the fish is coming off the boat. If there are 1 or 2 novices on the [processing] line and the fish are coming off here and there, it can take up to 30 mins or more to go over the different species… In [it is] an IFQ landing and there is a dock monitor, some [will] with help and spend time with the crew and some will not. If [the dock monitor] helps, I may not have to spend any time with the crew on the line."
  - "There is quite a large turn-around with people sorting fish for the [processing] plants. Therefore, we are frequently working with new sorters and fish ID."
  - "The real problem with these sorting scenarios is not with trained sampling biologists. The problem is with industry. The average deckhand or dockworker will have a tough time identifying aurora versus splitnose [rockfishes]. Not only will [new] sorting requirement[s] add significantly to offload times… the sorting

will not be accurate anyway. There has been a black/blue rockfish sorting requirement for many years, yet contamination is still routinely found in landings since many buyers just don't notice the difference between species..."

Relative to this last comment, one respondent mentioned that they themself are not always able to identify a species while sampling. In these cases when a species cannot be "… 100% identified in the field… [it is] thoroughly photographed and then keyed later that day."

In addition, potential differences in the sampling protocols between states were discernible from many comments made by respondents relative to Q2. Port biologists and samplers mentioned the following differences:

- Whether they were taking biological samples. There may be some slight differences between states relative to whether biological samples (e.g., for age, size, gender) are always taken in tandem with species composition samples.
    - For Washington, their protocol for processing a species composition sample was described in two steps (WDFW, personal communication, 5/16/13). First, a "quick check" is made to assess the level of contamination in that sample. If it is greater than 10%, the fishermen/dock worker/processing personnel are asked to re-sort those landings. Once the level of contamination is "low enough", the port biologist/sampler will re-sample and assess the species composition of those samples. Biological sampling was described as somewhat separate from this process. Thus in the survey, we asked respondents to consider only species composition sampling when responding to our questionnaire.
    - However, a comment made by one respondent from Oregon seemed to suggest that separating the species composition sampling process from the biological sampling process was not so clear cut, at least for our ODFW respondents: "… you asked us to please exclude 'biological sampling' [and it] is largely the point of being there – our methods used to collect biological samples yield the species comp[osition]s… Occasionally when pressed for time we might collect a species comp only…"
    - For California, one respondent stated that "[e]very sample we collect is a species composition sample." Thus framing the survey questions by asking respondents to consider only species composition sampling (versus biological sampling) protocols may have not made as much sense to our CDFW respondents.

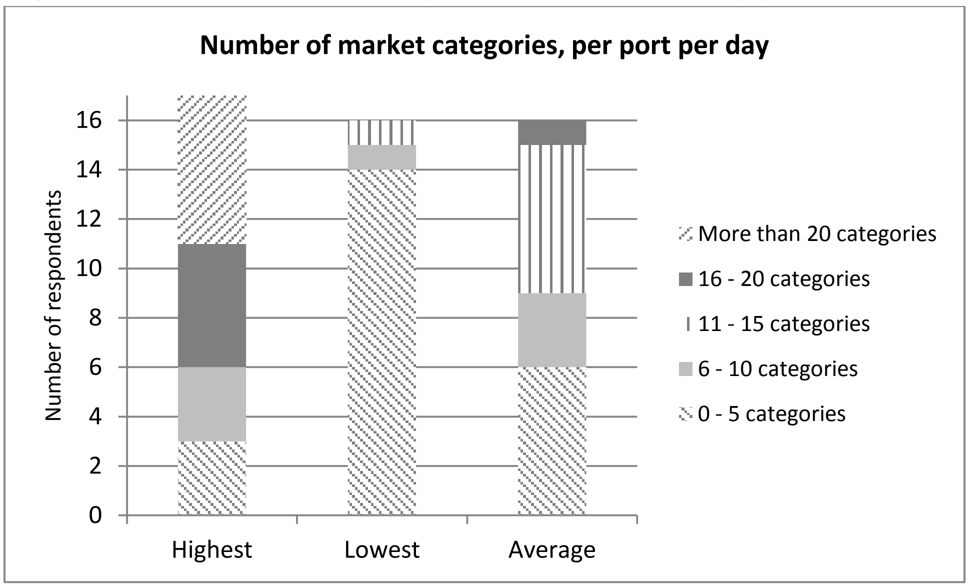
- Whether fishing and processing personnel were asked to re-sort landings.
    - In Washington and Oregon, port biologists and samplers may ask fishing and processing personnel to re-sort landed catch if the contamination level is too high. What is "too high" in Oregon is up to the discretion of that port biologist/sampler. However in Washington, port biologists/samplers typically ask that landings be

resorted when species composition samples contain contamination levels greater than 10%.

- In California, port biologists/samplers do not ask fishing or processing personnel to re-sort, regardless of contamination level. However, if the contamination level is consistently high at a particular location, the state's sampling program manager may be notified and discussions with fishing/processing personnel may occur.

Question 3 asked respondents how many market categories (highest, average, and lowest,) they might encounter at any given port location in a day. We acknowledge that many different factors such as port location, what is marketable at that location, and species distribution along the coast will influence an individual's response to this question. The intent was to learn, roughly, the range of market categories port biologists and samplers might encounter during the course of their species composition sampling work day.

Figure 2. Number of market categories encountered at any given port location (Q3)

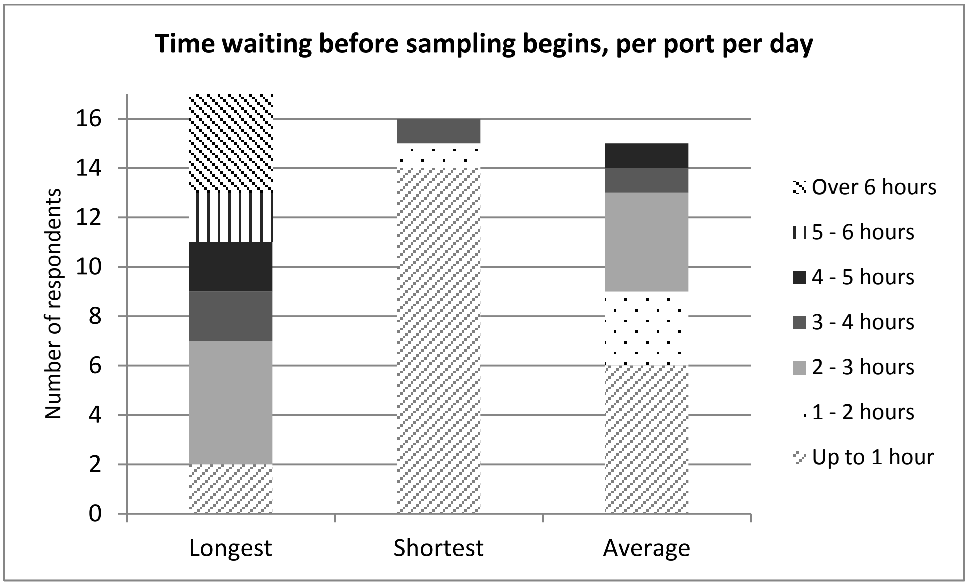



Some respondents commented directly about market categories. Regarding chondrichthyes (elasmobranchs and other cartilaginous fishes), one respondent noted that there are "too many categories and there is not enough room, physically, for all the totes and baskets – [there is] only so much space on the docks." Another respondent stated that the number of market categories is "not too much of a burden on me – I was going to identify that fish to [the] species level and collect biologicals on it anyway, regardless of what category it is in."

Regarding who is responsible for sorting landed catch, "[i]t's the boat crews and plant crews who are legally responsible to sort the catch into the categories prior to first weighing." That is, the role of a port biologist/sampler is to sample landed catch and note the proportion of catch not sorted to the correct market category. Market category can refer to a specific species (e.g., black rockfish) or category of species (e.g., red rockfishes), depending on the state, which species are marketable, and which species have sorting requirements (federal or state regulations). In addition, market categories are periodically updated and have increased over time (e.g., Agenda Item F.8.b, ODFW Report, June 2013).

Question 4 asked respondents how much time (longest, average, and shortest, waiting times) they spent waiting for catch to be offloaded prior to starting their species composition sampling protocol. The intent of this question was to learn how much waiting time is part of a port biologist/sampler's job. The time spent waiting is time not spent on composition sampling.

Figure 3. Time spent waiting before groundfish species composition sampling begins (Q4)



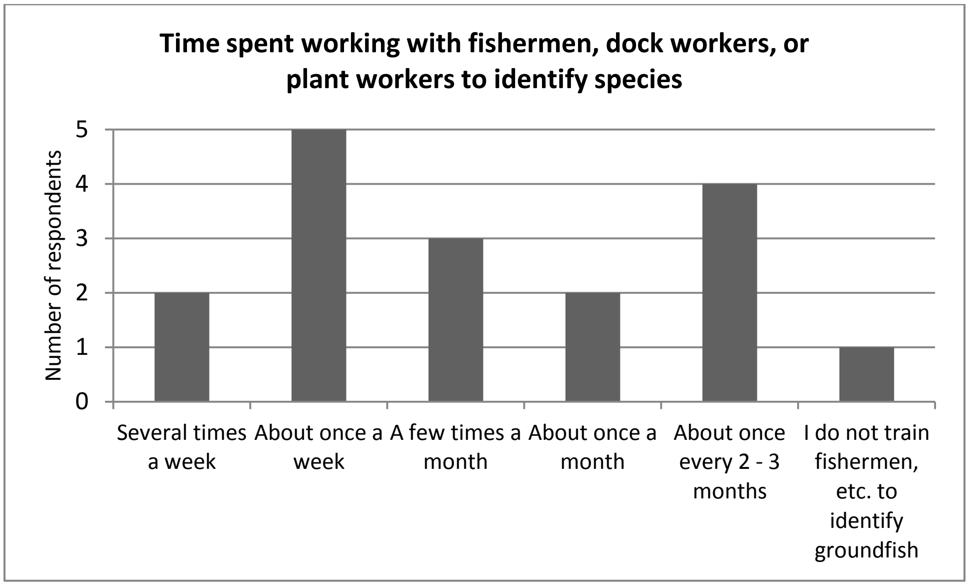

One respondent commented directly about their time spent waiting at the docks. Regarding slope rockfish sampling, this individual noted that "if there is any sorting by size dockside, the time frame for sampling is longer and usually restricted to [the] time period directly after completion of offload so th[at] all sort[ed] size groups can be sampled." So in addition to the number of market categories a port biologist/sampler may have to sample, if those market categories have been further sorted for size, the port biologist/sampler will also have to subsample those different sizes. Species within a market category might be sorted by size due to requests made by buyers.

Also regarding size of individual fish, one respondent wrote: "Since trawl went ITQ, our sampling efforts [with] regards to man power and time have changed [with] regards to species composition sampling. If the processor is sorting any rockfish complex by size prior to weighing, we typically have to wait much longer to get access to all sort groups (usually [at the] conclusion of [the] offload)… with a shorter time window to complete [processing of] the sample/"

It was also noted that in California, port biologists/samplers try to take their samples during the off-loading process but only after the fish totes have been weighed (CDFW, personal communication, 8/21/13). Therefore, the exact wording of Q4 may not have made sense to respondents in all situations they encounter.

Question 5 asked port biologist/samplers how much time they spent (within the last 12 months) working with fishermen, dock workers, or plant workers to accurately identify groundfish species. The intent of this question was to learn how frequently their job entailed working with and/or training fishing and processing personnel to correctly identify species that may be difficult to differentiate.

Figure 4. Time spent working with fishermen, dock workers, or plant workers to identify groundfish species (Q5)




One respondent mentioned that this question was “hard to answer or put a time to… [due to] the [number of] different fisheries, plants, crews, and categories. All require some time with novices, or even someone that hasn't been on the line in several months.” Another respondent wrote that “the amount of time spent training people on species ID and sorting / reporting requirements is entirely variable on the situation - ranges from 20+hrs [per] week to 20+ hrs [per] year. [I]t is important when its necessary and about every 2-3 years we have [a] total turnover in dock crews at a plant or new dealers opening with new crews. Then we have to be there all the time. Once they know what they're doing, our time spent goes way down. Reduced landings can make it difficult for plants to keep knowledgeable crews working, [i.e., ] not enough work hours [are available], then we get a 'new' crew more often.”

Overarching written comments from port biologists for this section:

- “In all cases, regardless of species groups, any ID that cannot be made quickly often has more to do with what fisheries are regularly seen in a given port, rather than any true difference in how difficult the ID is. If a given sampler is used to seeing a broad range of nearshore rockfish for example, all IDs will be made quickly by visual means. However, since most of the shelf is closed and most fisheries do not land any of these rockfish, a sampler may need to consult a key when first exposed to these species.”
- “Port Biologists and samplers are trained in fish ID, so even if a key is consulted, species ID will be pretty quick in most cases.”

- “I'm frankly a little puzzled why the GMT would spend so much time on this when Port Bio initial feedback stressed the difficulty for industry, not our programs.  Many dock workers and deckhands will have significant problems with many of these species if they are required to sort further.”
- “There are still significant problems with sorting, even for market categories that were split out many years ago. The implementation of catch monitors has done nothing to change that (most catch monitors don't even touch a single fish during an offload, let alone determine contamination levels).”
- “Adding further layers of market categories is a great feel-good thing for fisheries managers, but it will essentially increase the amount of inaccurate data that managers are basing decisions on...”

*Frequency of species encounters*

Question 15 asked respondents to tell us how often they encountered species found within each of the six species categories. Their responses are summarized in the following tables (Tables 4 through 9).

Table 4. Frequency of encounter: slope rockfishes.

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Aurora | 12 | 3 | 1 | 1 | 17 |
| Bank | 3 | 4 | 7 | 3 | 17 |
| Blackgill | 8 | 7 | 2 | 0 | 17 |
| Darkblotched | 11 | 4 | 1 | 1 | 17 |
| Longspine thornyhead | 13 | 2 | 2 | 0 | 17 |
| Pacific ocean perch | 7 | 4 | 4 | 2 | 17 |
| Redbanded | 10 | 4 | 2 | 1 | 17 |
| Rougheye | 12 | 0 | 2 | 3 | 17 |
| Sharpchin | 1 | 6 | 7 | 3 | 17 |
| Shortraker | 5 | 4 | 5 | 3 | 17 |
| Shortspine thornyhead | 15 | 1 | 1 | 0 | 17 |
| Splitnose | 13 | 2 | 1 | 1 | 17 |
| Yellowmouth | 0 | 3 | 10 | 4 | 17 |

Table 5. Frequency of encounter: flatfishes

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Arrowtooth flounder | 13 | 2 | 1 | 1 | 17 |
| Butter sole | 0 | 2 | 6 | 9 | 17 |
| Curlfin sole | 0 | 3 | 4 | 10 | 17 |
| Deep sea sole | 5 | 4 | 3 | 4 | 16 |
| Dover sole | 15 | 1 | 1 | 0 | 17 |
| English sole | 12 | 3 | 2 | 0 | 17 |
| Flathead sole | 2 | 5 | 3 | 6 | 16 |
| Pacific sanddab | 3 | 7 | 5 | 2 | 17 |
| Petrale sole | 12 | 3 | 1 | 1 | 17 |
| Rex sole | 13 | 2 | 1 | 1 | 17 |
| Rock sole | 1 | 5 | 5 | 6 | 17 |
| Sand sole | 2 | 4 | 4 | 7 | 17 |
| Slender sole | 5 | 1 | 6 | 5 | 17 |
| Starry flounder | 0 | 6 | 4 | 7 | 17 |

Table 6. Frequency of encounter: elasmobranches and other fishes (chondrichthyes)

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Aleutian skate | 0 | 4 | 4 | 9 | 17 |
| Bering/sandpaper skate | 2 | 6 | 3 | 5 | 16 |
| Big skate | 6 | 7 | 3 | 1 | 17 |
| Black/roughtail skate | 1 | 3 | 6 | 7 | 17 |
| Brown catshark | 4 | 3 | 5 | 5 | 17 |
| California skate | 0 | 2 | 8 | 7 | 17 |
| Longnose skate | 14 | 3 | 0 | 0 | 17 |
| All other skates | 0 | 3 | 5 | 9 | 17 |
| Ratfish | 3 | 6 | 6 | 2 | 17 |
| Leopard shark | 0 | 1 | 1 | 14 | 16 |
| Soupfin shark | 0 | 0 | 10 | 7 | 17 |
| Spiny dogfish | 8 | 6 | 1 | 2 | 17 |

Table 7. Frequency of encounter: roundfishes

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Cabezon | 7 | 4 | 2 | 4 | 17 |
| California scorpionfish | 0 | 1 | 0 | 16 | 17 |
| California slickhead | 1 | 4 | 1 | 11 | 17 |
| Finescale codling | 0 | 0 | 3 | 14 | 17 |
| Lingcod | 14 | 3 | 0 | 0 | 17 |
| Pacific cod | 5 | 4 | 3 | 5 | 17 |
| Pacific whiting | 8 | 3 | 2 | 4 | 17 |
| Sablefish | 16 | 1 | 0 | 0 | 17 |
| Giant grenadier | 0 | 8 | 3 | 6 | 17 |
| Pacific grenadier | 5 | 6 | 4 | 2 | 17 |
| All other grenadiers | 0 | 2 | 6 | 9 | 17 |
| Kelp greenling | 5 | 4 | 1 | 7 | 17 |
| All other greenlings | 0 | 2 | 5 | 10 | 17 |

Table 8. Frequency of encounter: nearshore rockfishes

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Black | 8 | 2 | 3 | 4 | 17 |
| Black and yellow | 2 | 5 | 2 | 8 | 17 |
| Blue | 7 | 3 | 2 | 5 | 17 |
| Brown | 1 | 5 | 5 | 6 | 17 |
| Calico | 0 | 0 | 1 | 16 | 17 |
| China | 3 | 6 | 2 | 6 | 17 |
| Copper | 4 | 4 | 5 | 4 | 17 |
| Gopher | 5 | 2 | 3 | 7 | 17 |
| Grass | 2 | 4 | 3 | 8 | 17 |
| Honeycomb | 0 | 0 | 2 | 15 | 17 |
| Kelp | 0 | 2 | 3 | 12 | 17 |
| Olive | 0 | 3 | 6 | 7 | 16 |
| Quillback | 2 | 4 | 6 | 5 | 17 |
| Treefish | 1 | 1 | 1 | 14 | 17 |

Table 9. Frequency of encounter: shelf rockfishes

| | Always or often | Sometimes | Rarely | Never | Total |
|---|---|---|---|---|---|
| Bank | 3 | 6 | 6 | 2 | 17 |
| Bocaccio | 5 | 9 | 3 | 0 | 17 |
| Bronzespotted | 0 | 1 | 4 | 12 | 17 |
| Canary | 6 | 6 | 3 | 1 | 16 |
| Chameleon | 0 | 0 | 1 | 16 | 17 |
| Chilipepper | 3 | 7 | 4 | 3 | 17 |
| Cowcod | 1 | 1 | 7 | 8 | 17 |
| Dusky | 0 | 0 | 3 | 14 | 17 |
| Dwarf red | 0 | 0 | 1 | 16 | 17 |
| Flag | 0 | 0 | 5 | 12 | 17 |
| Freckled | 0 | 0 | 1 | 16 | 17 |
| Greenblotched | 0 | 3 | 4 | 10 | 17 |
| Greenspotted | 1 | 5 | 5 | 5 | 16 |
| Greenstriped | 4 | 10 | 3 | 0 | 17 |
| Halfbanded | 0 | 0 | 4 | 13 | 17 |
| Harlequin | 0 | 0 | 2 | 15 | 17 |
| Longspine thornyhead | 13 | 1 | 3 | 0 | 17 |
| Mexican | 0 | 0 | 2 | 15 | 17 |
| Pink | 0 | 1 | 3 | 13 | 17 |
| Pinkrose | 0 | 0 | 2 | 15 | 17 |
| Puget Sound | 0 | 0 | 2 | 15 | 17 |
| Pygmy | 0 | 0 | 3 | 14 | 17 |
| Redstripe | 2 | 5 | 5 | 4 | 16 |
| Rosethorn | 4 | 6 | 3 | 4 | 17 |
| Rosy | 1 | 1 | 5 | 10 | 17 |
| Shortbelly | 0 | 3 | 6 | 8 | 17 |
| Shortspine thornyhead | 15 | 0 | 2 | 0 | 17 |
| Silvergray | 3 | 7 | 2 | 5 | 17 |
| Speckled | 0 | 0 | 1 | 16 | 17 |
| Squarespot | 0 | 0 | 2 | 15 | 17 |
| Starry | 0 | 1 | 5 | 11 | 17 |
| Stripetail | 1 | 6 | 4 | 6 | 17 |
| Swordspine | 0 | 0 | 1 | 16 | 17 |
| Tiger | 2 | 3 | 6 | 6 | 17 |
| Vermilion | 4 | 3 | 7 | 3 | 17 |
| Widow | 9 | 6 | 1 | 1 | 17 |
| Yelloweye | 1 | 5 | 7 | 4 | 17 |
| Yellowtail | 9 | 5 | 1 | 2 | 17 |

Overarching written comments from port biologists for this section:

- Encounter rates with species and/or market categories is based on their level of exposure to various fisheries and/or ports:
  - “All my answers are primarily related to the shoreside hake fishery.”
  - “Some species I only see in the ‘trash’ bin, for example grenadiers or hake. Most of what I see landed in my port is usually in pretty pure market categories. I don't have access to all fish being landed or may miss some while sampling, so my answers are generalized for what I have seen [and are] not necessarily [true] for all the landings in this port.”
  - “For all questions involving how often I encountered individual species, I only reflected what I've seen during the past five years. Prior to that time, I did see such species as curlfin sole, butter sole and at a time when I used to have regular beach-trawl landings. These flatfish species, as some other rockfish species, will not be encountered in waters where my current vessels fish due to depth and area fished.”
- Levels of contamination :
  - “Longspine thornyhead may occur in ALL trawled market categories (including flatfishes and roundfishes). Usually, this is the result of net-fed fish not being removed from [the] buccal/gill cavity. On occasion (1 in 10 landings), I have seen a significant number (~5%) of longspine stuck in sablefish. At present, this is not accounted for in our program protocol and [the] market category [is] reported as ‘clean’.”
- The impact of additional sorting requirements:
  - “I just want to reiterate that additional sorting requirements are not an issue for the fisheries/biology [port biologist/sampler] community. The issue is with industry. Some of the proposed sorting requirements will cause a lot of confusion among dock workers and deckhands. The end result may be continued poor sorting, even years later. Some effort should be made to gather industry feedback, especially with regard to some of the proposed slope rockfish sorting requirements.”
  - “My biggest concern with adding more species (or species complexes)… is in regards to collecting enough samples for each strata. We shoot for a quarterly 25% comp sampling rate per species (or complex) by total pounds landed for port, gear, condition, and PMFC area. As it is now, we struggle to make that goal when considering area because our port covers so many PMFC areas. I believe that add[ing] more comps will likely cause us to miss a strata if PMFC areas are still included. Currently, borrowing rules (which are less than perfect) go into effect when this occurs.” (More information about ODFW’s borrowing rules is available in Agenda Item F.8.b, ODFW Report, June 2013.)

*Tools used to identify species*

In Part II of this survey, port biologists and samplers were asked which tool they used to identify species within each category. The five categories of "tools" were: (1) quick visual/external look; (2) closer visual/internal look, etc.; (3) quick tactile/skin texture, etc.; (4) closer tactile, headspine count, etc.; and (5) identification key. The intent of this question was to learn "how far" they had to go to identify a particular species. For example, all respondents indicated that longnose skate could be identified with a "Quick visual: external look". In contrast, 12 out of 17 respondents indicated that they would have to pull out their "Identification key" to correctly identify an Aleutian skate.

However, one respondent indicated that the five categories of "tools" may not be mutually exclusive as we intended, stating that the "[s]urvey was a bit unclear as to the cut-off point on when 'quick visual' becomes 'quick tacti[le].'" This individual cited three examples:

1. The anal fin of a chilipepper is sometimes quickly viewed but it may be necessary to "abduct spines to note length," necessitating a "quick tactile".
2. Differentiating an aurora rockfish from a splitnose rockfish may require viewing its "nose" that "requires abducting dentary." Thus, is this a quick visual or tactile identification?
3. For small shortspine thornyheads, "if you only execute tactile on occasion (1 in 25) [that requires] spreading [its] pectoral fin [to look] for [a] white checkered pigment pattern, or lifting [its] operculum to view medial surface pigment," which tool should be indicated for this species?

The following tables (Tables 10 through 15) indicate species in each category (slope rockfish, flatfishes, chondrichthyes, roundfishes, nearshore rockfish, shelf rockfish) relative to the five categories of identification tools.

Table 10. Tools to identify species: slope rockfishes (Q16)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Aurora | 13 | 2 | 0 | 1 | 1 |
| Bank | 10 | 1 | 1 | 1 | 4 |
| Blackgill | 10 | 7 | 0 | 0 | 0 |
| Darkblotched | 16 | 1 | | | |
| Longspine thornyhead | 16 | 1 | | | |
| Pacific ocean perch | 13 | 2 | | | 2 |
| Redbanded | 14 | 3 | | | |
| Rougheye | 6 | 2 | 7 | 1 | 1 |
| Sharpchin | 8 | 3 | 0 | 4 | 2 |
| Shortraker | 5 | 5 | 3 | 3 | 1 |
| Shortspine thornyhead | 16 | 1 | | | |
| Splitnose | 14 | 2 | | | |
| Yellowmouth | 6 | 4 | 1 | 2 | 4 |

Table 11. Tools to identify species: flatfishes (Q18)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Arrowtooth flounder | 15 | 1 | | | 1 |
| Butter sole | 1 | 4 | 3 | 1 | 8 |
| Curlfin sole | 6 | 1 | 2 | | 8 |
| Deep sea sole | 12 | | 1 | 1 | 3 |
| Dover sole | 17 | | | | |
| English sole | 17 | | | | |
| Flathead sole | 7 | 2 | 2 | 2 | 4 |
| Pacific sanddab | 13 | 1 | 1 | | 2 |
| Petrale sole | 16 | 1 | | | |
| Rex sole | 17 | | | | |
| Rock sole | 6 | 5 | 2 | 2 | 2 |
| Sand sole | 7 | 4 | 2 | 1 | 3 |
| Slender sole | 10 | 1 | | 3 | 3 |
| Starry flounder | 16 | | | | 1 |

Table 12. Tools to identify species: chondrichthyes (elasmobranchs and other cartilaginous fishes, Q20)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Aleutian skate | 2 | 2 | | 1 | 12 |
| Bering/sandpaper skate | 5 | 1 | 4 | 3 | 4 |
| Big skate | 14 | 2 | | | 1 |
| Black/roughtail skate | 6 | 2 | | | 9 |
| Brown catshark | 12 | 1 | | | 4 |
| California skate | 2 | 3 | | 3 | 9 |
| Longnose skate | 17 | | | | |
| All other skates | | 2 | | 1 | 13 |
| Ratfish | 13 | 1 | | | 2 |
| Leopard shark | 10 | 2 | | | 4 |
| Soupfin shark | 7 | 3 | | | 7 |
| Spiny dogfish | 16 | | | | 1 |

Table 13. Tools to identify species: roundfishes (Q22)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Cabezon | 17 | | | | |
| California scorpionfish | 5 | 3 | | | 9 |
| California slickhead | 6 | 1 | 1 | | 9 |
| Finescale codling | 2 | 3 | | | 11 |
| Lingcod | 17 | | | | |
| Pacific cod | 12 | 2 | | | 3 |
| Pacific whiting | 13 | 1 | | 1 | 2 |
| Sablefish | 17 | | | | |
| Giant grenadier | 7 | 3 | 1 | | 6 |
| Pacific grenadier | 11 | 1 | | 1 | 4 |
| All other grenadiers | 2 | 1 | | 1 | 13 |
| Kelp greenling | 17 | | | | |
| All other greenlings | 7 | 4 | | 1 | 5 |

Table 14. Tools to identify species: nearshore rockfishes (Q24)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Black | 17 | | | | |
| Black and yellow | 9 | 2 | | | 6 |
| Blue | 17 | | | | |
| Brown | 9 | 3 | | | 5 |
| Calico | 3 | 1 | 1 | 1 | 11 |
| China | 17 | | | | |
| Copper | 13 | 2 | | | 1 |
| Gopher | 8 | 3 | | | 6 |
| Grass | 7 | 4 | | | 6 |
| Honeycomb | 3 | 1 | | 2 | 11 |
| Kelp | 5 | 2 | | | 10 |
| Olive | 6 | 3 | | | 8 |
| Quillback | 16 | 1 | | | |
| Treefish | 9 | 1 | | | 7 |

Table 15. Tools to identify species: shelf rockfishes (Q26)

| | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Bank | 10 | 2 | 1 | | 4 |
| Bocaccio | 16 | | 1 | | |
| Bronzespotted | 3 | 3 | | 1 | 10 |
| Canary | 16 | 1 | | | |
| Chameleon | 1 | 2 | | 2 | 12 |
| Chilipepper | 11 | 2 | | 1 | 3 |
| Cowcod | 9 | 5 | | | 3 |
| Dusky | 2 | 4 | | | 11 |
| Dwarf red | 1 | 2 | | | 14 |
| Flag | 6 | 2 | 1 | 3 | 5 |
| Freckled | 1 | 2 | 1 | 1 | 12 |
| Greenblotched | 2 | 4 | 2 | 2 | 7 |
| Greenspotted | 6 | 3 | 2 | 1 | 5 |
| Greenstriped | 16 | 1 | | | |
| Halfbanded | 3 | 3 | | 3 | 7 |
| Harlequin | 1 | 2 | 1 | 1 | 12 |
| Longspine thornyhead | 17 | | | | |
| Mexican | 1 | 2 | 1 | 1 | 12 |
| Pink | | 4 | | | 13 |
| Pinkrose | | 3 | | 1 | 13 |
| Puget Sound | | 2 | 2 | | 13 |
| Pygmy | | 3 | 2 | | 12 |
| Redstripe | 11 | 3 | | 2 | 1 |
| Rosethorn | 12 | 1 | 1 | 1 | 2 |
| Rosy | 4 | 4 | 1 | 1 | 7 |
| Shortbelly | 5 | 5 | | 1 | 6 |
| Shortspine thornyhead | 17 | | | | |
| Silvergray | 11 | | 2 | 1 | 3 |
| Speckled | 2 | 3 | | 1 | 11 |
| Squarespot | 2 | 3 | | | 12 |
| Starry | 5 | 3 | | | 9 |
| Stripetail | 8 | 2 | 1 | | 6 |
| Swordspine | 2 | 2 | 1 | 1 | 11 |
| Tiger | 15 | 1 | | 1 | |
| Vermilion | 14 | 1 | 1 | | 1 |
| Widow | 16 | 1 | | | |
| Yelloweye | 14 | | 1 | 1 | 1 |
| Yellowtail | 15 | 1 | | | 1 |

*Differentiating between similar looking species*

Immediately following questions about tools used to identify species, port biologists and samplers were asked to list any species they might mistake with another species. That is, they were asked to write-in any species that would require them to take a more careful look to positively differentiate it from a similar looking species (e.g., small-sized rougheye rockfish may look similar to small-sized shortraker rockfish). There were six open-ended questions of this type (Q17, Q19, Q21, Q23, Q25, Q27), one for each species category (slope, flatfishes, chondrichthyes, roundfishes, nearshore, shelf). The following tabulates the responses.

Among the slope rockfishes, Table 16 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Slope rockfish species not noted by respondents as possibly mistaken for others were: longspine thornyhead, redbanded rockfish, and shortspine thornyhead.

Table 16. Slope rockfishes (first column) and species mentioned by port biologists/samplers as similar in appearance (Species A - D). The number of respondents who indicated a species is noted in parentheses. (Q17)

| | Species A | Species B | Species C | Species D |
|---|---|---|---|---|
| Aurora[2] | Sharpchin[2] (1) | Splitnose[2] (3) | -- | -- |
| Bank[2, 4] | Widow (1) | -- | -- | -- |
| Blackgill | Rougheye (1) | -- | -- | -- |
| Darkblotched | Sharpchin (1) | -- | -- | -- |
| POP | Sharpchin (1) | -- | -- | -- |
| Rougheye[2] | Blackgill[2] (1) | POP[2] (1) | Shortraker[2] (4) | Blackspotted[1, 3] (3) |
| Sharpchin[2] | Darkblotched[2] (1) | POP[2, 6] (4) | Yellowmouth[2] (1) | Stripetail[1, 2, 5] (2) |
| Shortraker[2, 7] | Redbanded[2] (1) | Rougheye[2, 7] (3) | Cowcod[1] (1) | -- |
| Splitnose | Aurora (1) | -- | -- | -- |
| Yellowmouth[2] | POP[2] (2) | Rougheye (1) | Shortraker (1) | -- |
| Chilipepper[1] | POP (1) | -- | -- | -- |

[1]This species or group is not part of the current slope rockfish stock complex.
[2]Juvenile or smaller-sized fish were noted as more difficult to identify.
[3]One respondent wrote, "dark spotted" in relation to rougheye. We interpreted this as blackspotted.
[4] This species or group was mention by itself. We interpreted this to mean that it was generally difficult to identify. Also, one respondent stated that "Milton Love['s] book is wrong on head spine count."
[5]One respondent noted that small stripetail look similar to sharpchin when "stripes on [the] tail [are] not prominent."
[6]One respondent noted that a "washed out sharpchin – not showing the '>' mark on [the] gill plate" looked similar to Pacific Ocean perch.
[7]One respondent mentioned that shortraker and rougheye were commonly misidentified by those who sort groundfish. This individual also asked the question, "how short do the rakers have to be for it to be a shortraker?"

Among the flatfishes, Table 17 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Flatfish species not noted by respondents as possibly mistaken for others were: arrowtooth flounder, curlfin sole, deep sea sole, Dover sole, rex sole, slender sole, and starry flounder.

Table 17. Flatfishes (first column) and species mentioned by port biologists/samplers as similar in appearance (Species A - D). The number of respondents who indicated a species is noted in parentheses. (Q19)

| | Species A | Species B | Species C | Species D |
|---|---|---|---|---|
| Butter sole[3] | Curlfin sole(1) | Flathead sole (1) | Rock sole(1) | Sand sole(2) |
| English sole | Flathead sole (1) | Forkline sole[1] (1) | -- | -- |
| Flathead sole[3] | Petrale sole(2) | -- | -- | -- |
| Pacific sanddab[3] | All other sanddabs[1, 3] (1) | -- | -- | -- |
| Petrale sole[2, 3] | Flathead sole[2] (3) | -- | -- | -- |
| Rock sole[3] | Butter sole (1) | Curlfin sole (1) | Sand sole (1) | |
| Sand sole[3] | Rock sole (1) | -- | -- | -- |

[1]This species or group is not part of the current "other flatfish" stock complex.

[2]Juvenile or smaller-sized fish were noted as more difficult to identify.

[3]Species or group mentioned as uncommon or rare.

Among the chondrichthyes (elasmobranchs and other cartilaginous fishes), Table 18 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Chondrichthyes species not noted by respondents as possibly mistaken for others were: Bering/sandpaper skate, big skate, black/roughtail skate, brown catshark, California skate, longnose skate, ratfish, leopard shark, soupfin shark, and spiny dogfish.

Table 18. Chondrichthyes (elasmobranchs and other cartilaginous fishes, first column) and species mentioned by port biologists/samplers as similar in appearance (Species A - B). The number of respondents who indicated a species is noted in parentheses. (Q21)

| | Species A | Species B |
|---|---|---|
| Aleutian skate | Longnose skate (1) | -- |
| All other skates[1] | California skate (1) [1] | Soupfin shark (1) [1] |

[1] One respondent listed these species in a format that left their response open to interpretation. Their response could be interpreted as skates and soupfin sharks are difficult to differentiate – an assertion that some on the GMT think is unlikely – or could be interpreted as "all other skates" and California skates are difficult to differentiate from one another, and soupfin sharks are difficult to differentiate from other sharks.

Among the roundfishes, Table 19 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Roundfish species not noted by respondents as possibly mistaken for others were: cabezon, California slickhead, finescale codling, lingcod, Pacific whiting, sablefish, giant grenadier, "All other grenadiers," kelp greenling, and "All other greenlings." Of these, Pacific whiting, giant grenadier, and "all other grenadiers" were noted by respondents as uncommon or rare.

Table 19. Roundfishes (first column) and species mentioned by port biologists/samplers as similar in appearance (Species A - B). The number of respondents who indicated a species is noted in parentheses. (Q23)

| | Species A | Species B |
|---|---|---|
| California scorpionfish[2] | Cabezon[2] (1) | |
| Pacific cod[3] | Pacific whiting (1) | Pollock[1] (1) |
| Pacific grenadier[3] | Giant grenadier (1) | |

[1]This species or group is not part of the current "other fish" stock complex.

[2]Juvenile or smaller-sized fish were noted as more difficult to identify.

[3]Species or group mentioned as uncommon or rare.

Among the nearshore rockfishes, Table 20 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Nearshore rockfish species not noted by respondents as possibly mistaken for others were: brown, calico, china, gopher, grass, kelp, quillback, treefish.

Table 20. Nearshore rockfishes (first column) and species mentioned by port biologists/samplers as similar in appearance (Species A). The number of respondents who indicated a species is noted in parentheses. (Q25)

| | Species A |
|---|---|
| Black | Blue (1) |
| Black and yellow | Gopher (1) |
| Blue[3] | Black[3] (2) |
| Copper[2] | Brown (1) |
| Honeycomb | Freckled[1] (1) |
| Olive | Yellowtail[1] (2) |

[1]This species or group is not part of the current nearshore rockfish stock complex.

[2]One respondent mentioned that copper rockfishes were more difficult to identify in El Nino years.

[3]One respondent noted that blue and black rockfishes were "commonly mixed up".

Among the shelf rockfishes, Table 21 shows species that were noted by respondents as ones which could potentially be mistaken for another species. Shelf rockfish species not noted by respondents as possibly mistaken for others were: bocaccio, bronzespotted, canary, chameleon, dwarf red, flag, greenspotted, greenstriped, harlequin, longspine thornyhead, Mexican, pink, Puget Sound, pygmy, shortbelly, speckled, squarespot, starry, swordspine, tiger, vermilion, and widow. One respondent listed pink, Puget Sound, and pygmy rockfishes alone without noting a corresponding species each might be mistaken for. This was interpreted to mean that these species were generally difficult to identify.

Table 21. Shelf rockfishes (first column) and species mentioned by port biologists/samplers as similar in appearance (Species A - C). The number of respondents who indicated a species is noted in parentheses. (Q27)

| | Species A | Species B | Species C |
|---|---|---|---|
| Bank[2] | Rougheye[2] (1) | -- | -- |
| Chilipepper[2] | Redstripe[2] (1) | -- | -- |
| Cowcod | Rougheye (1) | Shortraker[7] (1) | -- |
| Dusky | Bank (1) | -- | -- |
| Freckled | Speckled (1) | Honeycomb (1) | -- |
| Greenblotched[4] | Greenspotted (1) | Greenstriped (1) | -- |
| Halfbanded | Stripetail (1) | -- | -- |
| Pinkrose[3] | Rosethorn (1) | Rosy (1) | Swordspine (1) |
| Redstripe[2] | Chilipepper[2] (1) | -- | -- |
| Rosethorn | Pink(1) | Pinkrose[6] (1) | Rosy (1) |
| Rosy[8] | Bronzespotted (1) | Pinkrose (1) | Rosethorn (2) |
| Shortspine thornyhead[2] | Longspine thornyhead[2] (1) | -- | -- |
| Silvergray | Bocaccio (1) | -- | -- |
| Stripetail | Sharpchin (1) | -- | -- |
| Yelloweye[5] | Vermilion (1) | Rougheye (1) | -- |
| Yellowtail | Olive (1) | -- | -- |
| Sharpchin[1, 2] | Stripetail (1) | POP[2] (1) | -- |

[1]This species or group is not part of the current shelf rockfish stock complex.

[2]Juvenile or smaller-sized fish were noted as more difficult to identify.

[3]Species or group mentioned as uncommon or rare.

[4]This species or group was mention by itself. We interpreted this to mean that it was generally difficult to identify.

[5]One respondent noted that adult yelloweye rockfish which were "washed out without the obvious yellow color in [the] eye" might be mistaken for vermilion or rougheye rockfishes.

[6]One respondent mentioned that pinkrose rockfish was not common in "northern coastal waters" but could be mistaken for rosethorn rockfish.

[7]One respondent mentioned that some "people call shortrakers 'cowcods'."

[8]One respondent wrote "rose" rockfish as a species mistaken for rosethorn, pinkrose, and bronzespotted rockfishes. We interpreted "rose" as rosy rockfish.

In many instances, respondents left Questions 17, 19, 21, 23, 25, and 27 blank. Initially, we interpreted this as that port biologist/sampler did not have any difficulty differentiating between species in that particular species category. However, when we considered some of the comments made in response to these questions, and considered other open-ended questions that provided opportunities to share their thoughts (i.e., Q15, Q28), we could infer the following about these individuals:

- Respondents who left these questions blank do not have concerns about mistaking one species for another (due to years of experience or overall confidence in their abilities); or

- Respondent who left these questions blank have little or no experience with species within that category (due to lack of years of experience or lack of exposure to those species at particular port locations, despite many years of experience). These individuals were therefore unable to tell us other species that they might mistake it for.

For respondents who answered these questions (i.e., wrote in species and their similar looking counterparts), we could infer the following:

- These individuals encountered these species enough times to be aware of their similarities and distinguishing (but perhaps subtle) differences.

The experience level of a port biologist/sampler likely factors into how they responded to questions about similar looking species. Experience level can be defined in a number of different ways:

1) How many years they have worked as a port biologist/sampler;
2) Which state they have worked or currently work in;
3) Which ports they have worked or currently work in;
4) The variety of species they have been exposed to;
5) The number of times they have been exposed to various species; and
6) The number of times they have been exposed to different sizes of each species (smaller-sized/juvenile fish vs. larger-sized/adult fish).

Points 4, 5, and 6 may be influenced by where they have worked or work (i.e., geographic location), and/or which species and sizes are marketable at the port(s) they have worked or currently work in.

Some of these points were echoed by port biologists/samplers in their responses to the open-ended questions (Q15, Q17, Q19, Q21, Q23, Q25, Q27, and Q28). Other factors that may influence whether similar looking species are mistaken for each other are listed below. These factors were derived from written comments made by respondents.

- The size of individual fish that are landed can influence how easy or hard it is to identify. Species where size was a factor in mistaking one species for another were flagged with a "[2]" (table note) in Tables 16 through 21. For example, aurora and splitnose rockfishes were noted as species mistaken for one another (Table 16).

- The volume of landed catch can make a difference in terms of the ability of fishermen, dock workers, or plant workers to accurately sort their catch. This catch is then sampled by a port biologist/sampler for accuracy. One respondent wrote, that "thousands of pounds of [an] Aurora/Splitnose mix [particularly the small ones] … would take the sorting belt crew all day to sort through – with questionable results" (comment relative to slope rockfishes).
- Rare or uncommonly seen species were also noted as more difficult to differentiate from others and some respondents mentioned that an identification key was necessary to accurately identify them. Whether a species was rare or uncommon could be influenced by geographic location (e.g., port), season (e.g., summer), or oceanographic conditions (e.g., El Nino). Respondents wrote:
  - "A lot of these species I don't see on a regular basis or at all, so it was hard to say what I could potentially mistake them for. The ones I do see regularly I no longer think it possible to mistake. However, there are always those few that pop up and I need to use my identification key" (general comment; not specific to a species category).
  - "A lot of these species I probably won't see or sample, so it is difficult to accurately report sampling concerns [about] them" (general comment; not specific to a species category).
  - "Rosethorn [can be mistaken for] pinkrose that oddly shows up in the northern coastal waters" (comment relative to shelf rockfishes).
  - "Flathead… being uncommon here, are often pitched in with the petrale" (comment relative to flatfishes).
  - "Rock/butter/sand/curlfin – the ever more rare beach trawler delivering these seldom seen, or seasonally seen [flatfishes] usually have to explain species [identification] to the dock crew, which is likely a new crew since last summer or have forgotten which ones are what. Currently each [species] are their own category" (comment relative to flatfishes).
  - "Besides all the flatfish I see on regular basis[,] I would need to key out all others to make sure which… species [each] was[.] [T]herefore, they all could be mistaken for each other until further examination" (comment relative to flatfishes).
  - "With [the exception of longnose skate, big skate, and spiny dogfish], I would need further identification of [every] other species. So at this point I wouldn't be able to tell you what I would be concerned with mistaking" (comment relative to chondrichthyes).
  - "I don't see grenadier enough to know which ones I would mistake, same with Pacific cod and whiting" (comment relative to roundfishes).
  - "Note: I would use an ID key for most of the species I never see" (comment relative to nearshore rockfishes).
  - "Coppers are so variable – [they] get squirrely to [identify in] [E]l [N]ińo years" (comment relative to nearshore rockfishes).
- Quality of the fish after it has been landed may influence whether a species is mistaken for another:
  - "Adult washed out yelloweye without the obvious yellow color in [the] eye [may be mistaken for] vermilion [or] rougheye" (comment relative to shelf rockfishes).

- “[Identifying species is] not as bad now that the shelf [rockfishes] are more hook caught. [W]hen they [were] all trawled [un]til the scales were all gone... good luck. [Also], less commonly seen = more difficult” (comments relative to shelf rockfishes).

- Type of gear used to catch fish makes a difference. As was mentioned in the previous comment, hook caught shelf rockfishes, for example, are easier to identify than trawl caught shelf rockfishes.
- Whether a port biologist/sampler or fishermen/plant/dock worker was identifying species may be a factor. In a comment above, a respondent noted that certain flatfishes (rock, butter, sand, and curlfin soles) can be difficult to distinguish because they are rare or seasonal, and a new crew of dock workers (relative to the previous summer) may be sorting landings. Other comments included:
    - “Shortraker [and rougheye] are commonly switched – [misidentified] – how short do the rakers have to be for it to be a shortraker?” (comment relative to slope rockfishes)
    - “I am not concerned about [identifying] any of these species. I am concerned about industry [identifying] some of these species” (comment relative to slope rockfishes).
    - “Blue rockfish and black rockfish are commonly mixed up – although I don't believe that I have a problem identifying them” (comment relative to nearshore rockfishes).
- The diversity of species within a category may influence whether individual fish are identified accurately. Relative to shelf rockfishes, one respondent seemed to suggest that remembering “just the names themselves...” was a challenge, due to the diversity of species in this category.

*Other information collected*

The following general information was collected about each respondent. Information about years of experience in their current position was collected. However, for two respondents who had port biologist/sampler experience in states other than the one they are currently employed in, their experience in other states may have been included in their response. Figure 5 and Table 22 show the range of experience report by respondents.

Figure 5. Number of years as a port biologist or sampler in their current position (Q12).

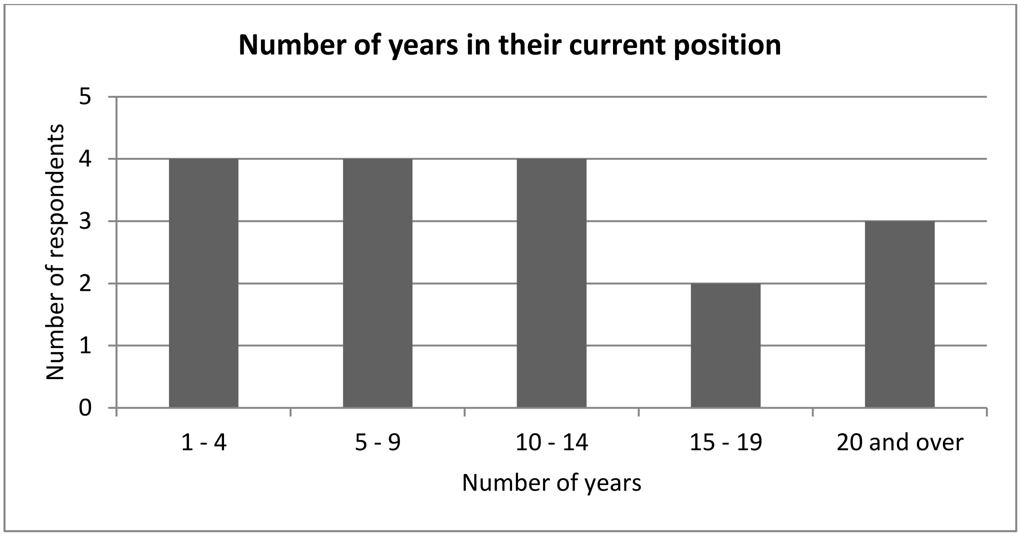



Table 22. Experience as a port sampler: average number of years in their current position only, range of experience in their current position, experience in other states where Pacific Coast groundfish are landed, and experience as a fishermen, plant monitor, dock or plant worker.

| | Number of respondents | Average number of years[1] | Range of experience | Experience in a state other than current? | Experience as a fishermen, etc.?[3] |
|---|---|---|---|---|---|
| WA | 5 | 13.8 years | 4 – 25 years | Yes = 0 | Yes = 2 |
| OR | 6 | 14.5 years | 8 – 35 years | Yes = 2[2] | Yes = 2 |
| CA | 6 | 7.3 years | 1 – 20 years | Yes = 0 | Yes = 4 |

[1]Refers to the average number of years as a port biologist/sampler in their *current position* only. However, it was discovered that some respondents may have included other related work experience.
[2]One respondent worked as a port biologist/sampler in OR and AK. The other worked in OR, CA, and AK.
[3]One respondent from ODFW had experience in OR and CA. All other respondents who answered, “Yes” to this question had experience in their respective state only.

## Pacific Coast Groundfish Fishery
## Species Composition Sampling – Program Managers

Currently, the Pacific Fishery Management Council (PFMC) is discussing possible changes to the composition of stock complexes in the Pacific Coast groundfish fishery. Changes to existing ***groundfish*** stock complexes may result in changes to sorting requirements that may affect the work of port biologists, other port samplers, groundfish observers, plant monitors, fishermen, and others who must sort, identify, or sample landed catch. Specifically, changes to the slope rockfish and "other fish" (i.e., other flatfish, other roundfish, and other elasmobranchs) complexes are being given priority for consideration at this time. The PFMC may recommend changes to the other stock complexes as well.

To engage those whose work may be most affected by these changes, the following survey has been developed by the Groundfish Management Team (GMT), an advisory body of the PFMC.

This survey is an initial attempt to collect general information about possible challenges that state port sampling programs may face if current stock complexes and associated market categories and sorting requirements are changed.

Participation in this survey is voluntary but is greatly appreciated. Results from this survey will be considered by the GMT in their analyses of existing and proposed stock complex configurations. All results from this survey will be confidential and will be reported in summary form so that the identity of each respondent will not be linked to their response.

This survey is comprised of **8 questions** that should take approximately <u>15 – 20 minutes</u> to complete. Thank you for your participation.

**Groundfish species composition sampling – NOT biological sampling (age, sex, and length)**

Q1 Availability of resources (time and personnel) often dictates the ability of sampling programs to have a presence at every port location in a given year. Keeping these resource constraints in mind: **a)** in which **groundfish port location(s)** does your program have the fewest number of groundfish species composition samples taken in a given year; and **b) why** are there fewer samples taken at these groundfish ports?

*Please list the groundfish port locations (or port complexes, if applicable) and why fewer samples are taken.*

*[Space for them to type]*

**Challenges to your state's sampling program**

Q2 In June, the PFMC will decide on preliminary alternatives for reorganizing the slope rockfish and "other fish" stock complexes. **In general**, how might your port sampling program be affected if the reorganized stock complexes increases the number of market categories? *Please check all that apply. This list may not be complete; please tell us more in the following question.*

- ❑ Achieving our state's groundfish sampling goals may become more difficult.
- ❑ Prior to sampling landings, port biologists and other sampling personnel will spend more time waiting for groundfish landings to be sorted.
- ❑ A greater number of groundfish samples will need to be taken if the number of market categories increases.
- ❑ A greater number of groundfish samples taken by port biologists or other port samplers will likely contain higher levels of contamination (i.e., more misidentified fish in each sample)
- ❑ Each groundfish species composition sample may take more time to process due to higher levels of misidentified species
- ❑ Each groundfish species composition sample may take more time to process due to an increased number of market categories.
- ❑ Existing fish ticket or landing receipt books and/or data management software and programs will have to be updated.
- ❑ Additional training of state agency staff, fishing operations personnel, and/or fish processing employees will be necessary.
- ❑ Other – please tell us more in the next question

Q3 If you indicated "Other" in the previous question or have other thoughts you'd like to share, please tell us more here:

*[Space for them to respond]*

**Challenges to fishing operations and/or processing plants**

Q4 What challenges do you think **fishing operations and/or processing plants** might face if reorganized stock complexes increases the number of market categories? *Please check all that apply. This list may not be complete; please tell us more in the following question.*

- ❑ Having to increase the number of bins needed for sorting more market categories
- ❑ Finding space for additional bins is going to be a challenge (i.e., on a vessel, in a plant)
- ❑ Fishing operations and/or processing plants will be need to train new or existing employees to accurately sort these market categories
- ❑ Fishermen, plant workers, etc. will spend more time sorting groundfish landings if the number of market categories increases
- ❑ Additional fishermen, plant workers, etc. may need to be hired to help sort groundfish landings
- ❑ The quality of groundfish products may change due to landings spending more time on ice before plants can process them, misidentified species, etc.
- ❑ Other – please tell us more in the next question

Q5 If you indicated “Other” in the previous question or have other thoughts you’d like to share, please tell us more here:

*[Space for them to respond]*

**Final questions**

Q6 **Approximately how long** have you worked for your state agency in your current capacity? *Please indicate the number of years.*

*[Space for them to fill in]*

Q7 In which states have you been employed as a port biologist, other port sampler, or program manager where you were involved with **groundfish**? *Please check all that apply, including the location of your current job.*

- ❑ Washington
- ❑ Oregon
- ❑ California
- ❑ Alaska

Q8 Have you ever worked as a fisherman, plant monitor, dock or plant worker, or other profession where you **handled and/or sorted groundfish**? *Please check all that apply.*

- ❑ Yes, in Washington
- ❑ Yes, in Oregon
- ❑ Yes, in California
- ❑ Yes, in Alaska
- ❑ No

**Thank you for your participation!**

**If you have any additional comments you would like to share, please provide them here:**

*[Space for them to fill in]*

**If you have any questions about this survey, please contact one of the following GMT representatives:**


| | | |
|---|---|---|
| Bob Leos, CDFW | 831-649-2889 | rleos@dfg.ca.gov |
| Dan Erickson, ODFW | 541-961-2053 | daniel.l.erickson@state.or.us |
| Corey Niles, WDFW | 360-249-1223 | corey.niles@dfw.wa.gov |

**Pacific Coast Groundfish Fishery – Part I**
**Species Composition Sampling – Port Biologists and Other Port Samplers**

Currently, the Pacific Fishery Management Council (PFMC) is discussing possible changes to the composition of stock complexes in the Pacific Coast groundfish fishery. Changes to existing ***groundfish*** stock complexes may result in changes to sorting requirements that may affect the work of port biologists, other port samplers, groundfish observers, plant monitors, fishermen, and others who must sort, identify, or sample landed catch. Specifically, changes to the slope rockfish and "other fish" (i.e., other flatfish, other roundfish, and other elasmobranchs) complexes are being given priority for consideration at this time. The PFMC may recommend changes to the other stock complexes as well.

To engage those whose work may be most affected by these changes, the following survey has been developed by the Groundfish Management Team (GMT), an advisory body of the PFMC.

This survey is intended to collect information about **groundfish species composition sampling**: which species are most difficult to differentiate, how difficult is it to differentiate these species, which life stages are particularly troublesome, etc. We are **not** collecting information about biological sampling protocols at this time.

Participation in this survey is voluntary but is greatly appreciated. Results from this survey will be considered by the GMT in their analyses of existing and proposed stock complex configurations. All results from this survey will be confidential and will be reported in summary form so that the identity of each respondent will not be linked to their response.

This survey is comprised of two parts: Part I and Part II. Part I consists of 15 questions and may take approximately 20 – 30 minutes to complete. Each part can be completed at different times. Thank you for your participation.

**Please enter your unique identification number below:**

*[Space to write-in]*

**Groundfish species composition sampling – NOT biological sampling (age, sex, and length)**

Q1 In any given port location on an average day, **how many species composition samples for groundfish** do you have time to check for sorting accuracy and species proportions? *Please include both "quick checks" for species contamination level and sampling for proportion by species, and exclude biological sampling (age, sex, and length). The number of samples may vary by port location and circumstance; please estimate as best you can.*

| Per port per day | 0 – 5 samples | 6 – 10 | 11 – 15 | 16 – 20 | More than 20 |
|---|---|---|---|---|---|
| Highest number of species comp samples | ❑ | ❑ | ❑ | ❑ | ❑ |
| Lowest number of species comp samples | ❑ | ❑ | ❑ | ❑ | ❑ |
| Average number of species comp samples | ❑ | ❑ | ❑ | ❑ | ❑ |

Q2 Please tell us approximately **how long** it could it take to process groundfish species composition samples given the following <u>levels of contamination</u>: **a) less than 10%, b) 10-25%, and c) greater than 25%**. *Species contamination refers to the proportion of a sample that includes species that have been misidentified. In the space below, please tell us about your process of dealing with each level of contamination, and the time it takes to process each for groundfish species proportions. Please exclude biological sampling (age, sex, and length).*

*[Space for write-in]*

Q3 Please tell us approximately **how many market categories for groundfish** you encounter in a given port location. *This may vary by port location and circumstance; please estimate as best you can and consider only the last 12 months*.

| **Per port per day** | **0 – 5 categorie s** | **6 – 10** | **11 – 15** | **16 – 20** | **More than 20** |
|---|---|---|---|---|---|
| Highest number of categories | ❑ | ❑ | ❑ | ❑ | ❑ |
| Lowest number of categories | ❑ | ❑ | ❑ | ❑ | ❑ |
| Average number of categories | ❑ | ❑ | ❑ | ❑ | ❑ |

Q4 Please tell us approximately **how much time you spend waiting** before starting your groundfish species composition sampling protocol at a given port location. *Please consider the time you spend waiting from the beginning to the end of an offload. This may vary by port location and circumstance; please estimate as best you can and consider only the last 12 months.*

| **Per port per day** | **Up to 1 hour** | **1 to 2** | **2 to 3** | **3 to 4** | **4 to 5** | **5 to 6** | **Over 6 hours** |
|---|---|---|---|---|---|---|---|
| Longest waiting time | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| Shortest waiting time | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |
| Average waiting time | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ | ❑ |

Q5 **How often do you spend time working with** new or existing fishermen, dock workers, or plant workers to accurately identify groundfish species? *Please estimate how often you spend time working with those who sort landings within the last 12 months.*

❑ Several times a week
❑ About once a week
❑ A few times a month
❑ About once a month
❑ About once every 2-3 months
❑ I do not train fishermen, dock workers, or plant workers to accurately identify groundfish.

The following questions are focused on different groundfish stock complexes that may be modified by the PFMC. These complexes include the following categories: slope rockfishes, other flatfishes, elasmobranchs and other fishes, roundfishes, nearshore rockfishes, and shelf rockfishes. We are interested in learning how often you encounter the species within these categories.

## Groundfish species – frequency of encounter

Q6 How often do you see the following **slope rockfishes**? *Please check one box for each species.*

| Slope rockfishes | Always or often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Aurora | ❑ | ❑ | ❑ | ❑ |
| Bank | ❑ | ❑ | ❑ | ❑ |
| Blackgill | ❑ | ❑ | ❑ | ❑ |
| Darkblotched | ❑ | ❑ | ❑ | ❑ |
| Longspine thornyhead | ❑ | ❑ | ❑ | ❑ |
| Pacific Ocean Perch | ❑ | ❑ | ❑ | ❑ |
| Redbanded | ❑ | ❑ | ❑ | ❑ |
| Rougheye | ❑ | ❑ | ❑ | ❑ |
| Sharpchin | ❑ | ❑ | ❑ | ❑ |
| Shortraker | ❑ | ❑ | ❑ | ❑ |
| Shortspine thornyhead | ❑ | ❑ | ❑ | ❑ |
| Splitnose | ❑ | ❑ | ❑ | ❑ |
| Yellowmouth | ❑ | ❑ | ❑ | ❑ |

Q7 How often do you see the following **flatfishes**? *Please check one box for each species.*

| Flatfishes | Always or often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Arrowtooth flounder | ❑ | ❑ | ❑ | ❑ |
| Butter sole | ❑ | ❑ | ❑ | ❑ |
| Curlfin sole | ❑ | ❑ | ❑ | ❑ |
| Deep sea sole | ❑ | ❑ | ❑ | ❑ |
| Dover sole | ❑ | ❑ | ❑ | ❑ |
| English sole | ❑ | ❑ | ❑ | ❑ |
| Flathead sole | ❑ | ❑ | ❑ | ❑ |
| Pacific sanddab | ❑ | ❑ | ❑ | ❑ |
| Petrale sole | ❑ | ❑ | ❑ | ❑ |
| Rex sole | ❑ | ❑ | ❑ | ❑ |
| Rock sole | ❑ | ❑ | ❑ | ❑ |
| Sand sole | ❑ | ❑ | ❑ | ❑ |
| Slender sole | ❑ | ❑ | ❑ | ❑ |
| Starry flounder | ❑ | ❑ | ❑ | ❑ |

Q8 How often do you see the following **elasmobranchs and other fishes**? *Please check one box for each species.*

| Elasmobranchs and others | Always or often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Aleutian skate | ❑ | ❑ | ❑ | ❑ |
| Bering/sandpaper skate | ❑ | ❑ | ❑ | ❑ |
| Big skate | ❑ | ❑ | ❑ | ❑ |
| Black/roughtail skate | ❑ | ❑ | ❑ | ❑ |
| Brown catshark | ❑ | ❑ | ❑ | ❑ |
| California skate | ❑ | ❑ | ❑ | ❑ |
| Longnose skate | ❑ | ❑ | ❑ | ❑ |
| All other skates | ❑ | ❑ | ❑ | ❑ |
| Ratfish | ❑ | ❑ | ❑ | ❑ |
| Leopard shark | | | | |
| Soupfin shark | ❑ | ❑ | ❑ | ❑ |
| Spiny dogfish | ❑ | ❑ | ❑ | ❑ |

Q9 How often do you see the following **roundfishes**? *Please check one box for each species.*

| Roundfish | Always or often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Cabezon | ❑ | ❑ | ❑ | ❑ |
| California scorpionfish | ❑ | ❑ | ❑ | ❑ |
| California slickhead | ❑ | ❑ | ❑ | ❑ |
| Finescale codling | ❑ | ❑ | ❑ | ❑ |
| Lingcod | ❑ | ❑ | ❑ | ❑ |
| Pacific cod | ❑ | ❑ | ❑ | ❑ |
| Pacific whiting | ❑ | ❑ | ❑ | ❑ |
| Sablefish | ❑ | ❑ | ❑ | ❑ |
| Giant grenadier | ❑ | ❑ | ❑ | ❑ |
| Pacific grenadier | ❑ | ❑ | ❑ | ❑ |
| All other grenadiers | ❑ | ❑ | ❑ | ❑ |
| Kelp greenling | ❑ | ❑ | ❑ | ❑ |
| All other greenlings | ❑ | ❑ | ❑ | ❑ |

Q10 How often do you see the following **nearshore rockfishes**? *Please check one box for each species.*

| Nearshore rockfishes | Always or often | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Black | ❑ | ❑ | ❑ | ❑ |
| Black and yellow | ❑ | ❑ | ❑ | ❑ |
| Blue | ❑ | ❑ | ❑ | ❑ |
| Brown | ❑ | ❑ | ❑ | ❑ |
| Calico | ❑ | ❑ | ❑ | ❑ |
| China | ❑ | ❑ | ❑ | ❑ |
| Copper | ❑ | ❑ | ❑ | ❑ |
| Gopher | ❑ | ❑ | ❑ | ❑ |
| Grass | ❑ | ❑ | ❑ | ❑ |
| Honeycomb | ❑ | ❑ | ❑ | ❑ |
| Kelp | ❑ | ❑ | ❑ | ❑ |
| Olive | ❑ | ❑ | ❑ | ❑ |
| Quillback | ❑ | ❑ | ❑ | ❑ |
| Treefish | ❑ | ❑ | ❑ | ❑ |

Q11 How often do you see the following **shelf rockfishes**? *Please check one box for each species.*

| Shelf rockfishes | Always or often | Sometim es | Rarely | Never |
|---|---|---|---|---|
| Bank | ❑ | ❑ | ❑ | ❑ |
| Bocaccio | ❑ | ❑ | ❑ | ❑ |
| Bronzespotted | ❑ | ❑ | ❑ | ❑ |
| Canary | ❑ | ❑ | ❑ | ❑ |
| Chameleon | ❑ | ❑ | ❑ | ❑ |
| Chilipepper | ❑ | ❑ | ❑ | ❑ |
| Cowcod | ❑ | ❑ | ❑ | ❑ |
| Dusky | ❑ | ❑ | ❑ | ❑ |
| Dwarf red | ❑ | ❑ | ❑ | ❑ |
| Flag | ❑ | ❑ | ❑ | ❑ |
| Freckled | ❑ | ❑ | ❑ | ❑ |
| Greenblotched | ❑ | ❑ | ❑ | ❑ |
| Greenspotted | ❑ | ❑ | ❑ | ❑ |
| Greenstriped | ❑ | ❑ | ❑ | ❑ |
| Halfbanded | ❑ | ❑ | ❑ | ❑ |
| Harlequin | ❑ | ❑ | ❑ | ❑ |
| Longspine thornyhead | ❑ | ❑ | ❑ | ❑ |
| Mexican | ❑ | ❑ | ❑ | ❑ |
| Pink | ❑ | ❑ | ❑ | ❑ |
| Pinkrose | ❑ | ❑ | ❑ | ❑ |
| Puget Sound | ❑ | ❑ | ❑ | ❑ |
| Pygmy | ❑ | ❑ | ❑ | ❑ |
| Redstripe | ❑ | ❑ | ❑ | ❑ |
| Rosethorn | ❑ | ❑ | ❑ | ❑ |
| Rosy | ❑ | ❑ | ❑ | ❑ |
| Shortbelly | ❑ | ❑ | ❑ | ❑ |
| Shortspine thornyhead | ❑ | ❑ | ❑ | ❑ |
| Silvergray | ❑ | ❑ | ❑ | ❑ |
| Speckled | ❑ | ❑ | ❑ | ❑ |
| Squarespot | ❑ | ❑ | ❑ | ❑ |
| Starry | ❑ | ❑ | ❑ | ❑ |
| Stripetail | ❑ | ❑ | ❑ | ❑ |

| | | | | |
|---|---|---|---|---|
| Swordspine | ❑ | ❑ | ❑ | ❑ |
| Tiger | ❑ | ❑ | ❑ | ❑ |
| Vermilion | ❑ | ❑ | ❑ | ❑ |
| Widow | ❑ | ❑ | ❑ | ❑ |
| Yelloweye | ❑ | ❑ | ❑ | ❑ |
| Yellowtail | ❑ | ❑ | ❑ | ❑ |

**Final questions**

Q12 Approximately **how long** have you worked for your state agency in your current capacity? *Please indicate the number of years.*

*[Space for write-in]*

Q13 In which states have you been employed as a port biologist, other port sampler, or program manager, where you were involved with **groundfish**? *Please check all that apply, including the location of your current job.*

❑ Washington
❑ Oregon
❑ California
❑ Alaska

Q14 Have you ever worked as a fisherman, plant monitor, dock or plant worker, or other profession where you **handled and/or sorted groundfish**? *Please check all that apply.*

❑ Yes, in Washington
❑ Yes, in Oregon
❑ Yes, in California
❑ Yes, in Alaska
❑ No, this is my first gig

Q15 Do you have any additional comments you would like to share?

*[Space for write-in]*

**Thank you for participating!**

**If you have any questions about this survey, please contact one of the following GMT representatives:**

Bob Leos, CDFW 831-649-2889 rleos@dfg.ca.gov
Dan Erickson, ODFW 541-961-2053 daniel.l.erickson@state.or.us
Corey Niles, WDFW 360-249-1223 corey.niles@dfw.wa.gov

**Pacific Coast Groundfish Fishery – Part II**
**Species Composition Sampling – Port Biologists and Other Port Samplers**

Currently, the Pacific Fishery Management Council (PFMC) is discussing possible changes to the composition of stock complexes in the Pacific Coast groundfish fishery. Changes to existing ***groundfish*** stock complexes may result in changes to sorting requirements that may affect the work of port biologists, other port samplers, groundfish observers, plant monitors, fishermen, and others who must sort, identify, or sample landed catch. Specifically, changes to the slope rockfish and "other fish" (i.e., other flatfish, other roundfish, and other elasmobranchs) complexes are being given priority for consideration at this time. The PFMC may recommend changes to the other stock complexes as well.

To engage those whose work may be most affected by these changes, the following survey has been developed by the Groundfish Management Team (GMT), an advisory body of the PFMC.

This survey is intended to collect information about **groundfish species composition sampling**: which species are most difficult to differentiate, how difficult is it to differentiate these species, which life stages are particularly troublesome, etc. We are **not** collecting information about biological sampling protocols at this time.

Participation in this survey is voluntary but is greatly appreciated. Results from this survey will be considered by the GMT in their analyses of existing and proposed stock complex configurations. All results from this survey will be confidential and will be reported in summary form so that the identity of each respondent will not be linked to their response.

This survey is comprised of two parts: Part I and Part II. Part II consists of 13 questions and may take approximately 20 – 30 minutes to complete. Each part can be completed at different times. Thank you for your participation.

**Please enter your unique identification number below:**

*[Space to write-in]*

## Identifying groundfish species

The following questions will ask you about tools and/or references you may use to identify individual groundfish species.

### Slope rockfishes

Q16 How far do you have to go to identify the following species? *Please check one for each species.*

| Slope rockfishes | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Aurora | ❑ | ❑ | ❑ | ❑ | ❑ |
| Bank | ❑ | ❑ | ❑ | ❑ | ❑ |
| Blackgill | ❑ | ❑ | ❑ | ❑ | ❑ |
| Darkblotched | ❑ | ❑ | ❑ | ❑ | ❑ |
| Longspine thornyhead | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pacific Ocean Perch | ❑ | ❑ | ❑ | ❑ | ❑ |
| Redbanded | ❑ | ❑ | ❑ | ❑ | ❑ |
| Rougheye | ❑ | ❑ | ❑ | ❑ | ❑ |
| Sharpchin | ❑ | ❑ | ❑ | ❑ | ❑ |
| Shortraker | ❑ | ❑ | ❑ | ❑ | ❑ |
| Shortspine thornyhead | ❑ | ❑ | ❑ | ❑ | ❑ |
| Splitnose | ❑ | ❑ | ❑ | ❑ | ❑ |
| Yellowmouth | ❑ | ❑ | ❑ | ❑ | ❑ |

Q17 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Flatfishes**

Q18 How far do you have to go to identify the following species? *Please check one for each species.*

| Flatfishes | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Arrowtooth flounder | ❑ | ❑ | ❑ | ❑ | ❑ |
| Butter sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Curlfin sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Deep sea sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Dover sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| English sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Flathead sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pacific sanddab | ❑ | ❑ | ❑ | ❑ | ❑ |
| Petrale sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Rex sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Rock sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Sand sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Slender sole | ❑ | ❑ | ❑ | ❑ | ❑ |
| Starry flounder | ❑ | ❑ | ❑ | ❑ | ❑ |

Q19 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Elasmobranchs and other fishes**

Q20 How far do you have to go to identify the following species? *Please check one for each species.*

| Elasmobranchs and others | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Aleutian skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| Bering/sandpaper skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| Big skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| Black/roughtail skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| Brown catshark | ❑ | ❑ | ❑ | ❑ | ❑ |
| California skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| Longnose skate | ❑ | ❑ | ❑ | ❑ | ❑ |
| All other skates | ❑ | ❑ | ❑ | ❑ | ❑ |
| Ratfish | ❑ | ❑ | ❑ | ❑ | ❑ |
| Leopard shark | ❑ | ❑ | ❑ | ❑ | ❑ |
| Soupfin shark | ❑ | ❑ | ❑ | ❑ | ❑ |
| Spiny dogfish | ❑ | ❑ | ❑ | ❑ | ❑ |

Q21 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Roundfishes**

Q22 How far do you have to go to identify the following species? *Please check one for each species.*

| Roundfish | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Cabezon | ❑ | ❑ | ❑ | ❑ | ❑ |
| California scorpionfish | ❑ | ❑ | ❑ | ❑ | ❑ |
| California slickhead | ❑ | ❑ | ❑ | ❑ | ❑ |
| Finescale codling | ❑ | ❑ | ❑ | ❑ | ❑ |
| Lingcod | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pacific cod | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pacific whiting | ❑ | ❑ | ❑ | ❑ | ❑ |
| Sablefish | ❑ | ❑ | ❑ | ❑ | ❑ |
| Giant grenadier | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pacific grenadier | ❑ | ❑ | ❑ | ❑ | ❑ |
| All other grenadiers | ❑ | ❑ | ❑ | ❑ | ❑ |
| Kelp greenling | ❑ | ❑ | ❑ | ❑ | ❑ |
| All other greenlings | ❑ | ❑ | ❑ | ❑ | ❑ |

Q23 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Nearshore rockfishes**

Q24 How far do you have to go to identify the following species? *Please check one for each species.*

| Nearshore rockfishes | Quick visual: external look | Closer visual: internal look, etc. | Quick tactile: skin texture, etc. | Closer tactile: headspine count, etc. | Identification key |
|---|---|---|---|---|---|
| Black | ❑ | ❑ | ❑ | ❑ | ❑ |
| Black and yellow | ❑ | ❑ | ❑ | ❑ | ❑ |
| Blue | ❑ | ❑ | ❑ | ❑ | ❑ |
| Brown | ❑ | ❑ | ❑ | ❑ | ❑ |
| Calico | ❑ | ❑ | ❑ | ❑ | ❑ |
| China | ❑ | ❑ | ❑ | ❑ | ❑ |
| Copper | ❑ | ❑ | ❑ | ❑ | ❑ |
| Gopher | ❑ | ❑ | ❑ | ❑ | ❑ |
| Grass | ❑ | ❑ | ❑ | ❑ | ❑ |
| Honeycomb | ❑ | ❑ | ❑ | ❑ | ❑ |
| Kelp | ❑ | ❑ | ❑ | ❑ | ❑ |
| Olive | ❑ | ❑ | ❑ | ❑ | ❑ |
| Quillback | ❑ | ❑ | ❑ | ❑ | ❑ |
| Treefish | ❑ | ❑ | ❑ | ❑ | ❑ |

Q25 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Shelf rockfishes**

Q26 How far do you have to go to identify the following species? *Please check one for each species.*

| **Shelf rockfishes** | **Quick visual: external look** | **Closer visual: internal look, etc.** | **Quick tactile: skin texture, etc.** | **Closer tactile: headspine count, etc.** | **Identification key** |
|---|---|---|---|---|---|
| Bank | ❑ | ❑ | ❑ | ❑ | ❑ |
| Bocaccio | ❑ | ❑ | ❑ | ❑ | ❑ |
| Bronzespotted | ❑ | ❑ | ❑ | ❑ | ❑ |
| Canary | ❑ | ❑ | ❑ | ❑ | ❑ |
| Chameleon | ❑ | ❑ | ❑ | ❑ | ❑ |
| Chilipepper | ❑ | ❑ | ❑ | ❑ | ❑ |
| Cowcod | ❑ | ❑ | ❑ | ❑ | ❑ |
| Dusky | ❑ | ❑ | ❑ | ❑ | ❑ |
| Dwarf red | ❑ | ❑ | ❑ | ❑ | ❑ |
| Flag | ❑ | ❑ | ❑ | ❑ | ❑ |
| Freckled | ❑ | ❑ | ❑ | ❑ | ❑ |
| Greenblotched | ❑ | ❑ | ❑ | ❑ | ❑ |
| Greenspotted | ❑ | ❑ | ❑ | ❑ | ❑ |
| Greenstriped | ❑ | ❑ | ❑ | ❑ | ❑ |
| Halfbanded | ❑ | ❑ | ❑ | ❑ | ❑ |
| Harlequin | ❑ | ❑ | ❑ | ❑ | ❑ |
| Longspine thornyhead | ❑ | ❑ | ❑ | ❑ | ❑ |

| | | | | | |
|---|---|---|---|---|---|
| Mexican | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pink | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pinkrose | ❑ | ❑ | ❑ | ❑ | ❑ |
| Puget Sound | ❑ | ❑ | ❑ | ❑ | ❑ |
| Pygmy | ❑ | ❑ | ❑ | ❑ | ❑ |
| Redstripe | ❑ | ❑ | ❑ | ❑ | ❑ |
| Rosethorn | ❑ | ❑ | ❑ | ❑ | ❑ |
| Rosy | ❑ | ❑ | ❑ | ❑ | ❑ |
| Shortbelly | ❑ | ❑ | ❑ | ❑ | ❑ |
| Shortspine thornyhead | ❑ | ❑ | ❑ | ❑ | ❑ |
| Silvergray | ❑ | ❑ | ❑ | ❑ | ❑ |
| Speckled | ❑ | ❑ | ❑ | ❑ | ❑ |
| Squarespot | ❑ | ❑ | ❑ | ❑ | ❑ |
| Starry | ❑ | ❑ | ❑ | ❑ | ❑ |
| Stripetail | ❑ | ❑ | ❑ | ❑ | ❑ |
| Swordspine | ❑ | ❑ | ❑ | ❑ | ❑ |
| Tiger | ❑ | ❑ | ❑ | ❑ | ❑ |
| Vermilion | ❑ | ❑ | ❑ | ❑ | ❑ |
| Widow | ❑ | ❑ | ❑ | ❑ | ❑ |
| Yelloweye | ❑ | ❑ | ❑ | ❑ | ❑ |
| Yellowtail | ❑ | ❑ | ❑ | ❑ | ❑ |

Q27 The GMT would also like to collect your views on which species you are concerned about mistaking with one another. For each species listed above, please list all other species you might mistake it for when sampling. If you do not have such a concern for a particular species, then you do not need to list it below. *Please use the format given in the following example when typing in your responses: rougheye (blackspotted, small shortraker); aurora (splitnose). That is, please type the name of the species you are focusing on and place the ones you are concerned with mistaking it for inside parentheses, each separated by a comma. If age or size differences – adult, juvenile or small – are important to identification, please note this as well.*

*[Space for write-in]*

**Final questions**

Q28 Do you have any additional comments you would like to share?

*[Space for write-in]*

**Thank you for your participation!**

**If you have any questions about this survey, please contact one of the following GMT representatives:**

| | | |
|---|---|---|
| Bob Leos, CDFW | 831-649-2889 | rleos@dfg.ca.gov |
| Dan Erickson, ODFW | 541-961-2053 | daniel.l.erickson@state.or.us |
| Corey Niles, WDFW | 360-249-1223 | corey.niles@dfw.wa.gov |

# GROUNDFISH ADVISORY SUBPANEL REPORT ON CONSIDER STOCK COMPLEX AGGREGATIONS

The Groundfish Advisory Subpanel (GAP) was briefed by the Groundfish Management Team (GMT) on the analyses done in consideration of restructuring stock complex aggregations and offers the following comments and recommendations.

The GAP repeats concerns about the disruption of fisheries that can occur by a restructuring of current stock complexes (see Agenda Item F.8.b, Supplemental GAP Report, June 2013 for further details regarding the costs associated with stock complex restructuring). As more management units are created by either removing too many stocks from stock complexes and managing them with stock-specific harvest specifications or by a proliferation of more complexes to address concerns about potential overfishing, the fishery will face more constraints and will become much less efficient (e.g., negating gains brought about by trawl rationalization). The GAP understands this action is being considered to address perceived concerns regarding potential overfishing of more vulnerable stocks. However, the GAP believes recent information indicates these concerns may be unwarranted. Further, the GAP believes there are other less onerous actions that should be contemplated to address potential overfishing concerns that will not incur the high costs to fisheries that would be created by restructuring stock complexes. The following points are offered regarding the GMT analyses and concerns raised by the GMT for individual stocks that appear to be more vulnerable to overfishing. The GAP also offers alternative measures that should first be considered to address potential overfishing concerns that will be less disruptive to fisheries.

Vulnerability to potential overfishing was first raised with the GMT's Productivity and Susceptibility Assessment (PSA), a subjective scoring mechanism to rank a stock's relative productivity and susceptibility to overfishing. The PSA tool may have some value when there is little other information regarding a stock's vulnerability to overfishing. However, the GAP believes that the performance of the PSA and the PSA scores themselves have not been fully evaluated and the GAP cautions against using PSA results alone to unnecessarily overhaul the fishery. For example, three of the six most vulnerable stocks from the GMT's PSA analysis (i.e., aurora rockfish, rougheye rockfish, and copper rockfish)[1] were assessed this year and each stock was estimated to have a healthy status. Clearly, the vulnerability to overfishing of these three stocks is not as high as the PSA analysis would suggest. The GAP also notes the data-poor overfishing limit (OFL) estimates using depletion based stock reduction analysis (DB-SRA) were significantly lower than the OFLs estimated from the new assessments of these stocks. This underscores the need to evaluate all sources of information, and not just PSA scores, before reacting aggressively to address potential overfishing concerns.

[1] The other three most vulnerable stocks from the GMT's PSA analysis are China rockfish, quillback rockfish, and shortraker rockfish. Concerns with managing quillback and China rockfish, component species in our current nearshore rockfish complexes, can be addressed with management measures, and the GAP poses arguments in this report why shortraker rockfish should not be a concern in west coast groundfish management.

Despite these cautions, the GAP agrees some changes to our current stock complexes may be in order. The GAP also believes there are measures other than complex restructuring that should be considered for many of those stocks where there is a concern of vulnerability to overfishing. In this spirit, the GAP addresses each of the five species groups under consideration for this action (i.e., slope rockfish, shelf rockfish, flatfish, cartilaginous fish, and roundfish) and poses solutions to potential stock vulnerabilities to overfishing for component stocks in each group.

Slope Rockfish

The GAP recommends maintaining the status quo slope rockfish complexes north and south of 40º10' N lat. Any restructuring of these complexes will require a change in the formal Amendment 21 sector allocations for slope rockfish complexes. Removing any of these stocks from these complexes will require a sector allocation process since the trawl and non-trawl allocations differ for these complexes north and south of 40º10' N lat. Not only would the reallocation for the removed stock be necessary, a reallocation of the remaining stock complexes would also be required. This is because sector allocations are decided on historical and current dependence of these stocks by trawl and non-trawl sectors and sector constraints. The need for the harvestable surplus changes as the mix of stocks in each complex change. The GAP does not believe the disruption of a sector allocation process is worth the perceived benefit of restructuring the slope rockfish complexes. This process will consume time and resources better dedicated to preparing a comprehensive Tier 1 specifications environmental impact statement or addressing other higher priority items such as trawl rationalization trailing actions or sablefish permit stacking and control issues.

There are three component species within these complexes that have very high PSA vulnerability scores (i.e., aurora rockfish, rougheye rockfish, and shortraker rockfish) and one with a high vulnerability score (i.e., blackgill rockfish). As stated before, the new assessments for aurora and rougheye rockfish indicate a healthy status for these two stocks and the OFLs estimated from these new assessments are significantly higher than those previously estimated using the data-poor DB-SRA method. The GAP focused on the GMT's catch-based risk analysis by comparing coastwide OFLs for these stocks to recent total catches. Recent catches of aurora rockfish have been well below the new OFLs estimated in the aurora rockfish assessment indicating little risk of future overfishing. A similar comparison for rougheye rockfish indicates catches have exceeded the OFLs estimated in some recent years, particularly in the 2009-2011 period. Rougheye catches in the bottom trawl sector were relatively high in 2009 and 2010 due to higher trip limits and the lack of consequence for targeting slope rockfish prior to trawl rationalization. Since 2011, slope rockfish targeting has decreased dramatically (only 17% of the 2011 quota of the northern slope rockfish was attained) under management with individual fishing quotas (IFQs). The 2011 catch levels are more likely than those preceding implementation of trawl rationalization given how IFQ management works. Higher than normal catch of rougheye in the 2011 catcher-processor (CP) sector occurred because the CP sector fished much later in the year and more concentrated than usual off northern Washington that year. This is not typical behavior. Rougheye bycatch is highly variable in the CP sector and largely depends upon where the fleet operates. For instance, this year fishing is concentrated off Oregon where rougheye are less prevalent and the rougheye bycatch is considerably lower (at present less than 5 mt). The CP fleet is employing measures to avoid rougheye, which should reduce the risk of future high bycatch of rougheye.

Shortraker rockfish is a minor species on the west coast and at the tail end of the distribution of the stock. They are only caught incidentally in the bottom trawl fishery off northern Washington and that bycatch is effectively controlled with current management. The vast majority of the shortraker rockfish biomass and catch occurs north of the West Coast Exclusive Economic Zone in waters off British Columbia and Alaska. Therefore, catches in west coast fisheries have little effect on overall stock status.

Blackgill rockfish occur primarily south of 40º10’ N lat. and are caught in trawl and fixed gear fisheries. This stock was assessed in 2011 and estimated to be in the precautionary zone. Conservation measures were implemented in 2013 (e.g., a harvest guideline (HG) and significantly reduced fixed gear trip limits) to address concerns for blackgill rockfish. The inseason tracking of blackgill catch using PacFIN’s quota species monitoring indicates current management has effectively reduced blackgill catches by eliminating target opportunities.

Specific to Council action for this stock complex, the GAP recommends development of harvest guidelines and reliance upon voluntary industry actions. The GAP opposes addressing slope rockfish stock concerns with stock complex restructuring.

Shelf Rockfish

The GAP believes there is no reason to consider restructuring the current shelf rockfish complexes north and south of 40º10’ N lat. given the protections afforded by the comprehensive network of Rockfish Conservation Areas (RCAs) in place since 2003. An example of this is the biomass trajectory of greenspotted rockfish from the 2011 assessment. Prior to implementation of RCAs and other conservation management measures in the 2000s, greenspotted rockfish experienced overfishing and spawning stock biomass was driven to low levels of depletion. Since RCA implementation, the catch of greenspotted rockfish has been reduced dramatically and spawning stock biomass has quickly increased as a result. Lack of access to shelf rockfish alleviates concerns of potential overfishing.

The GMT’s catch-based risk analysis indicates there are no concerns for shelf rockfish except for some slight catch overages of tiger rockfish, a minor species on the west coast. The OFL contribution of tiger rockfish is 1 mt and slight catch overages of such a minor species should not be a concern. The stock is distributed from Cape Mendocino north through the Gulf of Alaska and the Aleutian Islands. A major restructuring of the shelf rockfish complexes to address slight catch overages of such a minor species appears to be a needless and resource-intensive exercise.

Other Flatfish

The current Other Flatfish complex is comprised of species with very low vulnerabilities to overfishing and is a well-constructed complex of mostly trawl-dominant species. The GAP does not believe there should be any restructuring of this complex, which might also entail an Amendment 21 reallocation process.

The GMT identified two species, curlfin sole and flathead sole, with some slight catch overages in recent years relative to their contribution OFLs. Curlfin sole is a very shallow water species with highest densities in the 4-50 fm depth range. This is a species that has only been incidentally caught in bottom trawl gear primarily in efforts targeting California halibut. The GAP notes the bottom trawl groundfish fishery is not allowed to operate in state territorial waters off California and Washington and very little trawling occurs in such shallow depths off Oregon. This is a species that is not targeted and is hardly one that would compel a restructuring of the complex. Flathead sole catch overages relative to the contribution OFL of 35 mt occurred prior to 2007 and catches have not been a concern since (annual catches have been less than 5 mt since 2007). This is another fringe species on this coast with the bulk of its distribution off British Columbia and the Gulf of Alaska. West coast catches of any magnitude should not affect flathead sole, a species which sustains catches of about 18,000 mt annually in the Gulf of Alaska. The GAP suspects the drop in catch since 2007 may be due to the closure of shallow water trawling north of Cape Alava, Washington to protect canary rockfish. Current management will likely keep flathead sole catches down in the future and there should be no stock concerns for either species on the west coast.

Other Fish (Cartilaginous Fishes and Roundfishes)

The GAP agrees with the Council priority to consider restructuring the Other Fish complex. This complex is an assemblage of species with disparate life histories, distributions, co-occurrence in the fishery, and vulnerabilities to overfishing which should not be managed together. The GAP also agrees with the recommendation to first consider splitting the cartilaginous stocks from the roundfish stocks currently managed under the Other Fish complex.

*Cartilaginous Stocks:*
The GAP prefers an alternative for cartilaginous species that manages skates from the other cartilaginous species (spiny dogfish and ratfish). The GAP believes this is sensible given their disparate life histories, distributions, and vulnerabilities. The GAP does not recommend further subdividing skates into shallow and deep complexes, as it would unnecessarily create an additional complex that is not fully supported by the analyses. Skate species caught in west coast groundfish fisheries have a wide depth range with a great deal of overlap of the stocks contemplated for the shallow and deep skate complexes.

If the Council decides to remove spiny dogfish from the complex and manage the stock with stock-specific harvest specifications, then the GAP strongly recommends the use of harvest guidelines as the preferred management tool. The GAP opposes development of spiny dogfish quota shares.

Additionally, the GAP does not recommend an alternative that adds brown catshark to the fishery management plan (FMP) and complex. Brown catshark is a species not caught in great amounts in any groundfish fishery with a depth distribution far deeper than the trawl fishery can be prosecuted (i.e., deeper than 700 fm), which is the only fishery with any kind of historical bycatch of this species.

*Roundfish:*
The GAP recommends creating a nearshore roundfish complex. The GAP also recommends removing Pacific grenadier from the Other Fish complex and not adding the other grenadier species to the FMP, as well as removing finescale codling (aka Pacific flatnose) from the FMP

since the distribution of grenadiers and finescale codling extends far deeper than the 700 fm trawl limit and no fisheries target these species on the west coast.

The GAP does not recommend adding California slickhead, a deepwater species, which is distributed deeper than 700 fm and is not targeted on the west coast. The GAP also does not recommend adding the California and Oregon cabezon substocks into a new nearshore roundfish complex. The GAP is satisfied that under state and federal management, these stocks are managed well with stock-specific harvest specifications and management measures (e.g., state trip limits). Further, it is not clear to the GAP how management of stock complexes in general using indicator stocks is done or how it improves our current management system.

PFMC
09/15/13

**Agenda Item G.8.b**
**Supplemental GMT Report 4**
**September 2013**

# Stock Complex Reorganization

A Summary of Reports and Results by the Groundfish Management Team

September, 2013

# Where did We Leave Off? June Meeting

- GMT provided methods and a process for reorganizing stock complexes
- GMT provided partial analysis for Slope Rockfish and Other Fish (Cartilaginous and Roundfish)
- Council requested further analysis and Alternatives for:
  - Slope Rockfish, Roundfish, Cartilaginous Fish, and Other Flatfish (lower priority)
  - Evaluate the need for restructuring Shelf Rockfish
    - Specifically examine potential risk of overfishing Vermillion Rockfish

# SHELF ROCKFISH

- Evaluated Vermillion Rockfish Issue
  - Coastwide: Catch below OFL and ABC, All Years
- Of 32 Species, Tiger Rockfish found to exceed OFL and ABC
  - OFL = 1 mt; ABC = 0.8 mt
  - Average catch (2004-2011) = 1.1 mt
    - Maximum catch = 1.6 mt (2011)

# GMT Recommendation – Shelf Rockfish

Supplemental GMT Report 7, Page 1

- Team does not see urgent need that would change the Council's preference to not reorganize the Shelf Rockfish Complexes at this Time.
  - SSC was consulted about Tiger Rockfish: our interpretation is that risk does not necessarily call for taking species out of the complex now (Agenda Item G.8.b, Supplemental SSC Report)
  - Catches for all other species in the complex were below ABC
  - RCA protects most of these species from excessive harvest

# Where are we now? September Briefing Book

- GMT Report 1:
  - Description of risk analysis

- GMT Report 2:
  - Description of Stock Classification (in or out of the fishery)

- GMT Report 3:
  - Results of GMT Survey to Port Biologists

# Supplemental Briefing Book

- Supplemental GMT Report 5:
  - Stock Complex Reorganization - Description of Process
  - Slope Rockfish Alternatives

- Supplemental GMT Report 6
  - Classification of Stocks in the Groundfish FMP
  - Alternatives (in the FMP; out of the FMP; EC Species)

- Supplemental GMT Report 7
  - Stock Complex Alternatives
    - Slope Rockfish
    - Other Fish (Cartilaginous Fish and Roundfish separately)
    - Other Flatfish

# GMT’s Aim

- Help the Council address National Standard 1 Guidelines on stock complexes and classification of stocks in the FMP.

- This presentation will describe the process and a few important tables/figures that will help with your decision.

- We will not describe or go into details of every complex and numerous potential alternatives
  - We will provide a summary of species that are potentially at risk of overfishing for each complex, as well identify some potential inflator stocks

# Overview of the Process

- 1st Step
  - Identify candidate species for FMP classification evaluation and identify alternatives.
- 2nd Step
  - Determine whether Stock Complex Reorganization is Necessary based on risk (by complex) or otherwise beneficial.
  - Follow the process to identify and make necessary changes
    - Dependent on objective(s)
    - Dependent on benefits vs cost

# Classifying Stocks

- NS1 Guidelines: Which stocks need Annual Catch Limits (ACLs)?

- Stocks with similar conservation need should be similarly classified:
  - In the fishery: target stocks and non-target stocks where overfishing risk is of concern or are valuable/desirable.
  - EC species: non-target stocks w/o concerning overfishing risk yet some monitoring or other interest.
  - Not in the FMP: not at risk of overfishing or managed elsewhere.
- Compare relative “need” using PSA and catch.

# Classifying Stocks

- Report 2
  - Look at all catch (landings + discard) over 2007-11.
  - Filtering out (state/nearshore, other FMPs, invertebrates).
  - Non-FMP species/species groups with > 1 mt avg catch.
  - FMP species with 150 mt average catch and less.
  - PSA Scores less than ~2.0

# Classifying Stocks

- Report 6
  - Further filtering to list of candidates
    - FMP stocks

      < 1 mt of catch

      or

      < 50% retention and PSA score < ~2.0
    - Non-FMP stocks > 1 mt catch
  - Arranging into Alternatives (Table 1)
    - Three Alternatives – Inclusive to Narrow

# Classifying Stocks

- GMT Recommendations
  - Adopt the Alternatives or similar approach: there are possible inconsistencies in how stocks are treated.
  - So far “rapid, broad” look. Direct the GMT and staff to further scrutinize candidate list and data and provide more species specific analysis.
  - Guidance on FMP nearshore species – interest in moving leopard shark, greenlings, cabezon, others to state management?

# Restructuring Stock Complexes - Overview

- Describe
  - The General Framework/Thought Process
  - 3 tables and 1 figure (important information to assist with decisions)
  - Summary Table/Template
  - Steps that lead to one result (Slope Rockfish)
  - Summary of Results for Remaining Complexes

- Step 1. In or out of the FMP and EC (Corey Just described)
  - Concurrent consideration of adding or removing species to and from the FMP
    - Example: Other Roundfish – if you end up with few species with an OFL, and numerous other species with no OFL contributions → PROBLEM?

# Beginning of Step 2 of the Process

- Are Any Stocks Within the Complex at Potential Risk of Overfishing?
  - Catch versus OFL/ABC
  - IF YES, and if the species is managed by area (e.g., North and South of 40 10), then assess on Coastwide basis
    - Discussed in detail in June
- IF YES on a coastwide basis, then need for further consideration  (Presumption is to Manage Individually*)

*Per Council practice, the same presumption is followed for stocks that are newly assessed regardless of their catch risk.

# Step 2 Cont.: Is Individual Management Necessary/Possible ?

- Considerations
  - Similarity in Appearance
  - Co-Occurrence
  - Allocation Impacts
  - Impact on Sampling Programs (program impacts/data quality improved or compromised)
  - Impact on Fishing Operations and Buyers
    - Note GMT Report 3; ODFW Report (June)
- Other Measures May be Available (pg 3) to leave stock in complex while addressing risk:
    - Harvest Guidelines/Trip Limits – considered in detail later in process

# Step 2 Continued: Inflator Species?

- Are Inflator Species in the complex?
  - A stock with a high OFL/ABC relative to catch allows more catch of less abundant species
- What should be done?
  - Individual Management can mitigate risk to stock of concern (removed together or indicator removed on its own).

# Step 2 Cont. – Considerations

- We look to same factors for Inflator Species as for species that are at risk of overfishing (e.g. similarity of appearance, co-occurrence, etc.)

# Step 3 – Create New Complexes?

- After looking at removing stocks at risk and inflator stocks, the stock complex factors, how do species best group?
- This is addressed in our Report 7(see roundfish complex; cartilaginous complex)
  - “Vulnerable Species Complex”
  - Skate Complex
  - Shark Complex

# Final Step: Summarize Your Action

**Slope Rockfishes**

*Species to add to FMP, delete from FMP, or make EC species:*
- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013

*Select a Geographical Option for Managing the Complex (circle one or create one):*
- Status Quo
- GMT Alternative 1
- GMT Alternative 2
- Other

*Select none to all of the following species for individual management that may be at risk of overfishing (circle all that you would like to manage individually):*
- Rougheye
- Shortraker
- Aurora
- Blackgill
- Other?

*Select none to all of the following species for individual management that may be considered inflator species (circle all that you would like to manage individually):*
- Splitnose Rockfish (Area or Coastwide)
- Bank Rockfish (Area or Coastwide)

*Select none to one of the following if a new complex is desired (or create your own):*
- Rougheye-Shortraker
- Rougheye-Shortraker-Aurora
- Rougheye-Shortraker-Blackgill

# Overview of Data Sources

- Risk of Overfishing
  - Supplemental GMT Report 5, Appendix B (begins on Page 26)
  - Catch versus OFL / ABC
  - Did not use PSA

# Potential Risk of Overfishing (Catch relative to OFL/ABC) – Slope Rockfish

## Appendix B (Table 1)

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurora Data-Poor Assessment | 15.4 | 12.8 | 161% | 285% | 232% | 88% | 134% | 237% | 193% | 75% | 37% |
| Aurora Full Assessment 2015 | 17.4 | 16.6 | 124% | 220% | 179% | 75% | 119% | 210% | 171% | 75% | 19% |
| Bank | 17.2 | 14.4 | 5% | 5% | 10% | 0% | 4% | 4% | 8% | 0% | 3% |
| Blackgill | 4.7 | 3.9 | 119% | 199% | 177% | 88% | 99% | 165% | 147% | 75% | 3% |
| Redbanded | 45.3 | 37.7 | 0% | 60% | 80% | 25% | 0% | 50% | 66% | 0% | 81% |
| Rougheye Data-Poor Assessment | 71.1 | 59.3 | 349% | 396% | 315% | 100% | 291% | 331% | 263% | 100% | 99% |
| Rougheye Full Assessment 2015 | 201.9 | 193 | 107% | 122% | 97% | 50% | 103% | 116% | 92% | 63% | 98% |
| Sharpchin | 214.5 | 178.9 | 4% | 4% | 6% | 0% | 3% | 4% | 5% | 0% | 96% |
| Shortraker | 18.7 | 15.6 | 181% | 191% | 162% | 75% | 151% | 159% | 135% | 75% | 99% |
| Yellowmouth | 192.4 | 160.5 | 0% | 2% | 3% | 0% | 0% | 2% | 3% | 0% | 100% |
| Splitnose | 939 | 897.7 | 3% | 9% | 11% | 0% | 3% | 9% | 10% | 0% | 36% |
| Pacific Ocean Perch* | 844 | 807 | 8% | 16% | 15% | 0% | 7% | 16% | 15% | 0% | 100% |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

# Coastwide: Catch relative to OFL/ABC

**Table 10. Coastwide analysis of metrics that may be used to evaluate the risk of overfishing for species in complexes identified to exceed an ABC or OFL in each complex. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL and (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC.**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aurora Data-Poor | 41.5 | 34.5 | 80% | 132% | 162% | 88% | 67% | 110% | 134% | 75% |
| Aurora Full Assessment 2015 | 91.67 | 87.33 | 32% | 52% | 64% | 0% | 30% | 50% | 61% | 0% |
| Blackgill | 134.7 | 122.6 | 126% | 126% | 97% | 50% | 115% | 114% | 88% | 50% |
| Rougheye Data-Poor | 71.5 | 59.6 | 348% | 396% | 315% | 100% | 290% | 330% | 263% | 100% |
| Rougheye Full Assessment 2015 | 206 | 197 | 105% | 120% | 95% | 50% | 101% | 115% | 91% | 50% |
| Shortraker | 18.8 | 15.7 | 180% | 199% | 166% | 75% | 150% | 166% | 138% | 75% |
| Tiger** | 1 | 0.8 | 201% | 123% | 134% | 63% | 161% | 98% | 107% | 50% |
| Vermilion | 279 | 232.7 | 97% | 78% | 89% | 25% | 81% | 65% | 75% | 13% |
| Curlfin sole | 8.2 | 5.7 | 31% | 62% | 186% | 63% | 22% | 43% | 130% | 50% |
| Flathead sole | 35 | 24.3 | 33% | 29% | 124% | 38% | 23% | 20% | 86% | 38% |

**Trace amount caught; i.e., the average catch does not round to 0.1 mt

# Co-occurrence

- C-Scores
  - – Supplemental GMT Report 5 (Appendix A, Pg 13)

- Distribution
  - – Supplemental GMT Report 5 (Appendix A, Pg 22)

# C-SCORE TABLE

## Supplemental GMT Report 5, Appendix A, Pg 13)

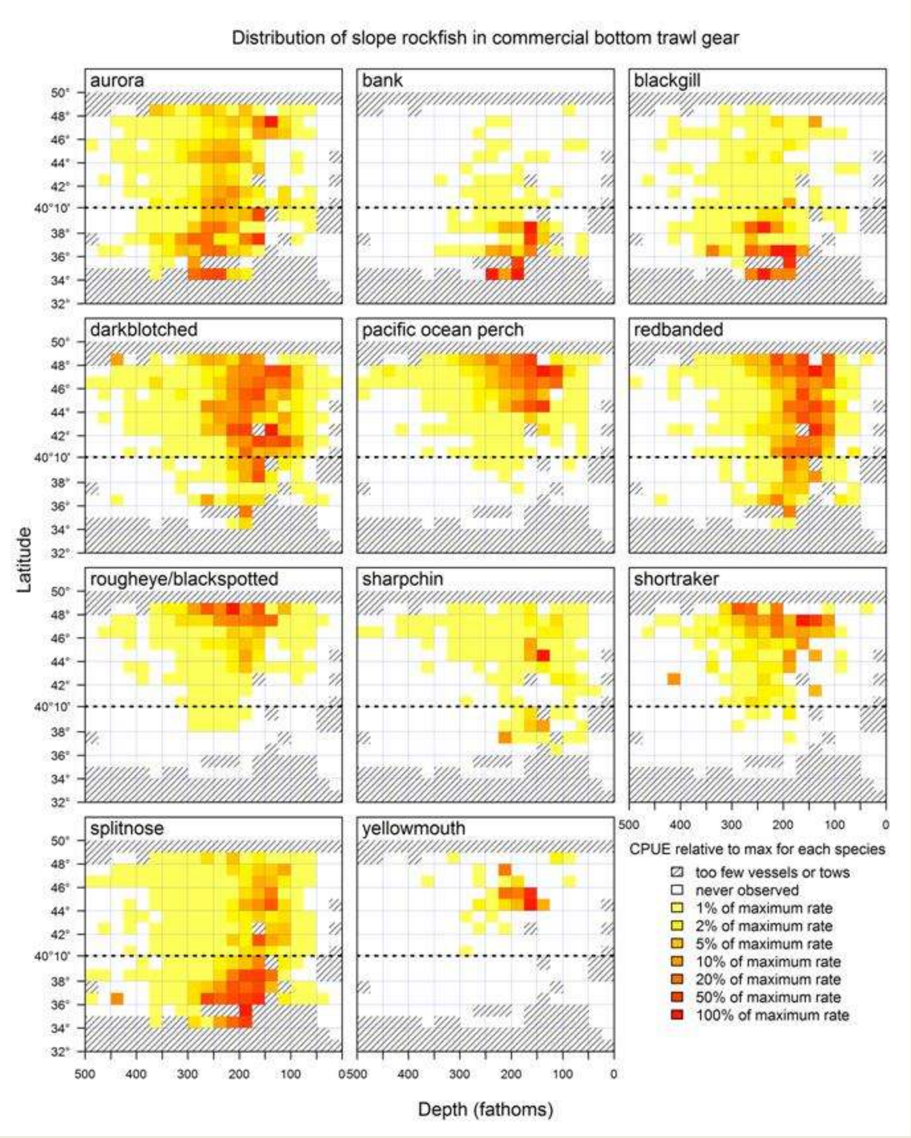
**(c) Matrix of normalized C-scores for Slope Rockfish North of 40°10' N lat.**

| | Splitnose R | Aurora | POP | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| Darkblotched | 0.263 | 0.482 | 0.22 | 0.228 | 0.298 | 0.323 | 0.295 | 0.428 | 0.302 | 0.281 |
| Splitnose | | 0.405 | 0.237 | 0.145 | 0.346 | 0.371 | 0.189 | 0.466 | 0.446 | 0.229 |
| Aurora | | | 0.511 | 0.49 | 0.484 | 0.288 | 0.748 | 0.475 | 0.547 | 0.639 |
| POP | | | | 0.268 | 0.359 | 0.563 | 0.273 | 0.438 | 0.649 | 0.331 |
| Redbanded | | | | | 0.41 | 0.586 | 0.354 | 0.567 | 0.559 | 0.509 |
| Rougheye/ Blackspotted | | | | | | 0.684 | 0.677 | 0.444 | 0.805 | 0.558 |
| Blackgill | | | | | | | 0.841 | 0.77 | 0.753 | 0.787 |
| Sharpchin | | | | | | | | 0.863 | 0.875 | 0.578 |
| Shortraker | | | | | | | | | 0.92 | 0.891 |
| Bank | | | | | | | | | | 0.773 |

Note: the GMT considered C-scores < 0.200 as high co-occurrence and > 0.700 as very low co-occurrence.

# Distribution of Catch (Slope RF North)

## Supplemental Report 5, Appendix A, Pg 22



# Status Quo Slope Rockfish

## Supplemental GMT Report 5, Page 5

**Status Quo Slope Rockfish Alternative**

Table 1. Status quo slope rockfish stocks and stock complexes.

| **Slope Rockfish Stocks** | **Slope Rockfish Stock Complexes** | |
|---|---|---|
| | **N of 40$^{0}$10’** | **S of 40$^{0}$10’** |
| **Overfished Stocks** | Aurora | Aurora |
| Darkblotched | Bank | Bank |
| POP N of 40º10’ | Blackgill | Blackgill |
| **Non-overfished Stocks** | Redbanded | POP |
| Longspine thornyhead N and S of 34º27' | Rougheye | Redbanded |
| Shortspine thornyhead N and S of 34º27' | Sharpchin | Rougheye |
| Splitnose S of 40$^{0}$10’ | Shortraker | Sharpchin |
| | Splitnose | Shortraker |
| | Yellowmouth | Yellowmouth |

# GMT Alternative 1 (Slope RF)

## Supplemental GMT Report 5, Pg 7

**Slope Alternative #1**

*Individual Management Coastwide*
Rougheye
Shortraker
Aurora
Splitnose
POP

*Slope Rockfish Complex A Coastwide*
Yellowmouth
Redbanded
Sharpchin

*Slope Rockfish Complex B Coastwide*
Bank
Blackgill

*Note*: this alternative approach to apportioning OFLs/ABCs across management lines. Other measures for allocating between areas might be necessary (e.g. how to address areas/fisheries at the tail end of a stock).

# GMT Alternative 2 (Slope RF)

## Page 6

**Slope Alternative #2**

*Individual Management Coastwide*
Splitnose
Bank
POP

*Slope Rockfish North of 40°10' Complex*
Yellowmouth
Sharpchin
Shortraker
Rougheye
Redbanded
Aurora
Blackgill*

*Slope Rockfish South of 40°10' Complex*
Yellowmouth*
Sharpchin*
Shortraker*
Rougheye*
Redbanded
Aurora
Blackgill

*These species have low OFL/ABC contribution to this complex for this area. The determination of whether the policy to prevent overfishing is being violated should be evaluated at the total coastwide OFL.

# Summary: Slope Rockfish

## GMT Supplemental Report 5, page 11

**Slope Rockfishes**

*Species to add to FMP, delete from FMP, or make EC species:*

- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013

*Select a Geographical Option for Managing the Complex (circle one or create one):*

- Status Quo
- GMT Alternative 1
- GMT Alternative 2
- Other

*Select none to all of the following species for individual management that may be at risk of overfishing (circle all that you would like to manage individually):*

- Rougheye
- Shortraker
- Aurora
- Blackgill
- Other?

*Select none to all of the following species for individual management that may be considered inflator species (circle all that you would like to manage individually):*

- Splitnose Rockfish (Area or Coastwide)
- Bank Rockfish (Area or Coastwide)

*Select none to one of the following if a new complex is desired (or create your own):*

- Rougheye-Shortraker
- Rougheye-Shortraker-Aurora
- Rougheye-Shortraker-Blackgill

# Summary: Cartilaginous Complex

**Cartilaginous Fishes**

*Species to add to FMP, delete from FMP, or make EC species:*

- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that may be at risk of overfishing:*

- Spiny dogfish
- Other?

*Select none to all of the following species for individual management that may be considered inflator species:*

- Spotted ratfish
- Dogfish shark
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following if a new complex is desired:*

- Shark and ratfish complex
- Skate complex
- Other?

# Summary: Roundfish Complex

**Other Roundfish**

*Species to <u>add to FMP, delete from FMP, or make EC species</u>:*

- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that <u>may be at risk of overfishing</u>:*

- None
- Other?

*Select none to all of the following species for individual management that <u>may be considered inflator species</u>:*

- Pacific rattail/grenadier
- Kelp greenling
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following <u>if a new complex is desired</u>:*

- Pacific rattail/grenadier-giant rattrail/grenadier-other rattails/grenadiers
- Other?

# Other Flatfish

**Other Flatfish**

*Species to <u>add to FMP, delete from FMP, or make EC species</u>:*

- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that <u>may be at risk of overfishing</u>:*

- Curlfin sole
- Flathead sole
- Other?

*Select none to all of the following species for individual management that <u>may be considered inflator species</u>:*

- Pacific sanddab
- Rex sole
- Sand sole
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following <u>if a new complex is desired</u>:*

- Curlfin-flathead
- Butter-curlfin-flathead-rock soles
- Other?

# Conclusion

Stocks in an ideal complex would look alike, or be caught together, have similar vulnerabilities to the fishery, etc.  The FMP’s complexes are not ideal. The GMT’s recommendation is to prioritize addressing catch risks. Doing so may be possible without major restructuring. Management options for doing so can be explored in detail through the 2015-16 process. The team sees benefits of reorganizing complexes regardless of catch risk, yet costs also need to be thoroughly examined.

# Conclusion cont.

Secondly, apportioning of OFLs/ABCs across the north/south management lines raises questions for many stocks. An alternative is to group stocks more based on co-occurrence and without drawing management lines (i.e. slope rockfish Alt. 1). Some form of allocation or set aside would need to be discussed for treating areas where catch is unlikely or abundance low.

GROUNDFISH MANAGEMENT TEAM REPORT ON RESTRUCTURING WEST COAST GROUNDFISH STOCK COMPLEXES

**Introduction and Background**

This document provides a GMT-recommended process for reorganizing groundfish stock complexes, along with stock complex alternatives for Council consideration. The process described herein may be used by the Council to develop its own alternative(s) based on the Council's objectives. This statement provides alternatives, rationale, and the completed process for Slope and Shelf rockfish. Alternatives, rationale, and the process for consideration of reorganizing the remaining complexes will be provided in a separate statement. The remaining complexes include Other Fish (cartilaginous fish and roundfish), Other Flatfish, and Shelf Rockfish.

Much of the background information developed by Council Staff and the Groundfish Management Team (GMT) for reorganizing stock complexes was provided in "Considerations for Restructuring West Coast Groundfish Stock Complexes: Preliminary Alternatives and Analyses" (Agenda Item F.8.a, Attachment 1, June 2013) and in "Groundfish Management Team Report on Considerations for Restructuring West Coast Groundfish Stock Complexes" (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013). These documents, as well as the Scientific and Statistical Committee Report on Adopt Preliminary Stock Complex Aggregations (Agenda Item F.8.b, Supplemental SSC Report, June 2013) provide background, detail, and discussion on various considerations that should be made while reorganizing stock complexes including: (a) inflator stocks, (b) coast-wide versus area management, (c) indicator species, and (d) other attributes and considerations.

The GMT developed and applied numerous tools that may be used for restructuring stock complexes. First, the GMT developed a four-step process that may result in logical and consistent decisions regarding stock complexes (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013). Second, the GMT developed numerous tools that may be used to support objectives and decisions including (a) co-occurrence tables and maps describing co-occurrence (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013), (b) catch relative to overfishing levels (OFLs) and allowable biological catch (ABCs) to evaluate risk of overfishing (Agenda Item G.8.b, GMT Report 1, September 2013), (c) productivity and susceptibility analysis (PSA) and catch analyses to evaluate whether stock should be in or out of the fishery (Agenda Item G.8.b, GMT Report 2, September 2013), and potential costs to state sampling programs, data quality, and to the fishing industry (Agenda Item G.8.b, GMT Report 3, September 2013). A state report provided by Oregon Department of Fish and Wildlife (ODFW) also evaluated potential costs of restructuring stock complexes to their state sampling program (Agenda Item F.8.b, ODFW Report, June 2013).

In June, the Council adopted a range of alternatives for restructuring the slope and Other Fish complexes from the GMT Report (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013). Further, the Council tasked the GMT with analyzing the impacts associated with those alternatives. The Council asked the GMT to examine the need to reconfigure the shelf rockfish complex, adding that if the GMT determines there is a need to develop alternatives for reconfiguring the shelf rockfish complex, the GMT should apply the same approach and analysis. Restructuring the Other Flatfish complex was given a low priority and alternatives for restructuring the nearshore rockfish complexes were dropped from further consideration during this cycle.

At this meeting, the GMT not only provides additional analytical methods to evaluate stock complexes, we also expand and improve upon the four-step process described in June such that it can be employed to fully help the decision making process of stock reorganization depending on the objectives. This decision making process is described in more detail below.

**The GMT provides no additional alternatives from those adopted in June**. Instead, we provide the decision-making process so that the Council may develop the most effective alternatives to satisfy Council objectives. This process allows the Council to make policy choices, while the GMT provides the tools and analysis.

**Objectives**

There is a need to evaluate and consider changes to the current structure of stock complex groupings to ensure that the species in each complex are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that management impacts are similar.

The GMT notes that stock complexes may be reorganized for biological purposes (e.g., remove species from complexes to reduce the probability of overfishing a particular stock), for logical purposes (e.g., match stocks with similar life histories, distributions, and vulnerabilities), or some combination of the two. There are logical issues with some of the current stock complexes in the groundfish FMP. For instance, the Other Fish stock complex includes species with dissimilar life histories and species that do not co-occur. Yet, as shown below, only one species within that complex has had historical catches that have approached the component OFL (i.e., dogfish shark), whereas the other species within the Other Fish complex may be at much lower risk of overfishing (e.g., cabezon). Additionally, many complexes include stocks that have extremely low OFLs (e.g., shortraker) and very high OFLs (e.g., splitnose rockfish, an inflator species). Disparate OFLs within a single complex may cause overfishing for susceptible stocks with relatively low OFLs. This provides an example of a logical and biological purpose for reorganizing a complex. The ideal complex would be of stocks that co-occur in proportion to their component OFLs-ABCs.

The SSC has noted that no two stocks are exactly alike, and in establishing stock complexes there will always be tradeoffs between management practicality and concerns about individual species (Agenda Item I.3.b, Supplemental SSC Report, April 2012).

**Process for Identifying Needed Changes**

The process proposed by the GMT consists of two general steps. The first step is to decide what species to include in the FMP and whether any stocks should be designated Ecosystem Component (EC) species. The first step should be completed before developing alternative complex configurations. The second step identifies species that may be at risk of overfishing, and provides a decision-making process for stock reorganization, depending on Council objectives.

***Step 1: In or out of the Groundfish FMP and EC:*** As described above, the decisions regarding adding stocks to the FMP, removing stocks from FMP, or designating stocks as EC species may occur independently of stock reorganization. The GMT provided new methods for evaluating whether a species is in or out of the fishery (Agenda Item G.8.b, GMT Report 2, September 2013), and provides the Council with clear direction in a supplemental GMT statement to help make the decision (Agenda Item G.8.b, Supplemental GMT Report 6). That supplemental GMT statement should be used to follow this decision-making process. Once the "in or out" decision is made, then results of that decision can be applied to the stock-reorganization step. Some considerations for removing or adding species to the FMP include:

1. What are the implications of adding new species to the FMP, or adding new species to the FMP as an EC species?
2. What are the implications of adding new species to the FMP (and a particular complex) that have no calculated OFLs?
3. What are the implications of removing species from the FMP (and a particular complex) that have OFLs, leaving a complex with only a few of the remaining species with contributing component OFLs?
4. Other?

***Step 2: Reorganization of Stock Complexes:*** This second step involves numerous processes, depending on Council objectives. That process is shown below.

(a) Are any stocks within the complex potentially at high risk of overfishing? The GMT considered using two methods to evaluate this risk: (1) PSA analysis and (2) ratios between catch and component OFLs/ABCs (Appendix B). The GMT stresses that for those species with component OFLs available, the ratio of catch to OFL/ABC should be used to evaluate risk of overfishing. The PSA scores are subjective, and should only be used to evaluate risk for those species that do not have associated OFLs.

Considerations for determining whether stocks may be at risk for overfishing include:

- If potential overfishing is identified for a stock in one of two management areas, and if there is no biological reason for separate OFLs/ABCs, then a coast-wide evaluation of catch relative to OFL/ABC should be made to determine whether a potential biological problem exists. This was recommended by the SSC (Agenda Item F.8.b Supplemental SSC Report, June 2013) and discussed by the GMT when developing alternatives for Slope Rockfish during the June Council meeting (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013).

(b) Stocks that are at risk of overfishing or newly assessed stocks – Individual Management? If there is a risk of overfishing, or if stocks are newly assessed, then we presume that individual management is the best option. Indeed, that is the action most often taken by the Council in the past. However, there have been some instances where the Council has chosen to continue complex management because of management practicality (e.g., blue rockfish in CA and blackgill rockfish south of 40°10 N. latitude). As such, this presumption should be tested while attempting to balance the tradeoffs between management practicality and concerns about individual species. We have clearly heard from the GAP and members of the public that removing a species from a complex may reduce their ability to achieve annual catch limits (ACLs) for other species, may cause allocation issues, may create additional constraining species, and may be an additional burden for processors and vessels (e.g., extra sorting requirements).

The presumption that species at risk of overfishing or newly assessed species should be removed from the complex should be explored by the Council. In some cases, individual species management may not be necessary for implementing the management measures necessary to prevent the risk of biological overfishing (as demonstrated under the current management regime for blue rockfish in CA where the component OFL has not been exceeded since the stock was assessed in 2007 and HG implemented). Considerations for removing a species from a complex include:

- Co-occurrence: National Standard 1 Guidelines recommend that management measures should have similar effects on the species within a complex.
- Similarity of appearance: Separating species that look very similar may cause additional burden to the fishing industry and may result in increased “contamination” of market categories.
- Impact on fishing operations and buyers: Additional market categories may result in additional bins, sorting, etc.; sampling the species within a complex rather than individually might achieve adequate catch accounting with less disruption to fishing communities.
- Impact on the management and administration of the state sampling programs
- Complexes containing relatively few species and thus few component OFLs
- Complexes that contain species with OFLs based on data poor methods

**Alternatives**

The alternatives described here are intended to better align species according to their ecological distributions, interactions with the fishery, and relative vulnerabilities to overfishing. Following the process described above, the Council may mix and match past alternatives (i.e., those provided at the June meeting) and create new alternatives to meet their objectives.

Alternatives are stratified into five major species groups (Slope Rockfish, Shelf Rockfish, Flatfishes, Roundfishes, and Cartilaginous Fish). Considerations for restructuring stock complexes for these five species groups can be decided independently and are thus presented and analyzed independently. Status Quo is shown for each alternative. Alternatives adopted by the Council at the June Council meeting are shown for Slope Rockfish and for Other Fish complexes. Results and discussion for species that may be potentially at risk of overfishing are provided for each complex (Appendix B).

Recommendations to add or remove species from the FMP or recommendations to designate EC species within a complex should be considered while using information provided by Supplemental GMT Report 6. If those recommendations were made prior to creating additional complex alternatives, then those additions/removals/EC designations should be reflected in any newly created alternative below.

## Slope Rockfish Alternatives

Status quo and two alternatives created by the GMT at the June meeting are provided in this section for slope rockfish. In addition, results of our process that may be used to create additional alternatives are provided. The Council may use the results of this process, along with information provided in Status Quo and Alternatives 1 and 2, to create additional alternatives that better align with the Council's objectives.

### Status Quo Slope Rockfish Alternative

Table 1. Status quo slope rockfish stocks and stock complexes.

| **Slope Rockfish Stocks** | **Slope Rockfish Stock Complexes** | |
|---|---|---|
| | **N of 40$^{0}$10'** | **S of 40$^{0}$10'** |
| **Overfished Stocks** | Aurora | Aurora |
| Darkblotched | Bank | Bank |
| POP N of 40º10' | Blackgill | Blackgill |
| **Non-overfished Stocks** | Redbanded | POP |
| Longspine thornyhead N and S of 34º27' | Rougheye | Redbanded |
| Shortspine thornyhead N and S of 34º27' | Sharpchin | Rougheye |
| Splitnose S of 40$^{0}$10' | Shortraker | Sharpchin |
| | Splitnose | Shortraker |
| | Yellowmouth | Yellowmouth |

### Slope Rockfish Alternative 1

Alternative 1 would result in a northern-distributed slope rockfish (redbanded, sharpchin, and yellowmouth rockfishes), denoted here as Slope Rockfish Complex A, and southern-distributed slope rockfish complex (bank and blackgill rockfishes) called Slope Rockfish Complex B. Although these stocks are caught primarily either in the north or in the south, the complex would be managed using coastwide ABCs under this alternative.

Further, under Alternative 1, several species are removed from the complexes and managed separately (rougheye, shortraker, aurora, splitnose, and POP). Rougheye, shortraker, and aurora rockfishes are managed individually on the presumption that species vulnerable to overfishing might be easier to manage under individual specification. At the time of the June Council meeting, it was thought that all species were vulnerable to overfishing, based on catches relative to 2013 OFLs and on PSA scores. In this alternative, splitnose rockfish is also managed individually (i.e., as it currently is south of 40$^{o}$ 10' N. lat.) as it would have a very large relative OFL/ABC contribution and could act as an inflator species in the complex. In addition, POP could be removed from the southern slope complex all together and managed separately using a coastwide OFL/ABC/annual catch limit (ACL).

The GMT points out that there is no full assessment for shortraker rockfish. The OFL for this species was provided using data poor assessment methods (i.e., data quality is listed as category 3, sub-category c). Although most species managed separately are category 1 or 2 stocks, Pacific cod is managed separately (coastwide) and is listed as a category 3 (sub-category b) stock (Agenda Item G.7.a, Attachment 1, September 2013).

**Slope Alternative #1**

*Individual Management Coastwide*
Rougheye
Shortraker
Aurora
Splitnose
POP

*Slope Rockfish Complex A Coastwide*
Yellowmouth
Redbanded
Sharpchin

*Slope Rockfish Complex B Coastwide*
Bank
Blackgill

**Slope Rockfish Alternative 2**

The second slope alternative recommends managing splitnose and POP coastwide rather than in any complex (as in Alternative 1) as well as bank rockfish, under the similar rationale that it may serve as an inflator species.

This alternative also maintains the status quo management line with separate north and south complexes, but with the caveat that those species with low occurrence on one side of the management line are highlighted to indicate that evaluation of overfishing should be done on the entire coastwide OFL rather than small contributions on one side of the line.

**Slope Alternative #2**

*Individual Management Coastwide*
Splitnose
Bank
POP

*Slope Rockfish North of 40°10' Complex*
Yellowmouth
Sharpchin
Shortraker
Rougheye
Redbanded
Aurora
Blackgill*

*Slope Rockfish South of 40°10' Complex*
Yellowmouth*
Sharpchin*
Shortraker*
Rougheye*
Redbanded
Aurora
Blackgill

*These species have low OFL/ABC contribution to this complex for this area. The determination of whether the policy to prevent overfishing is being violated should be evaluated at the total coastwide OFL.

**Slope Rockfish Process for Developing Additional Alternatives**

*Step 1*: *Are there any species that the Council desires to add to or drop from the slope rockfish complex, or designate as EC species?* See Agenda Item G.8.c, Supplemental GMT Report 6.

*Step 2a: Which species in the Status Quo slope rockfish complex (Table 1) may be vulnerable to overfishing.* For this test, the GMT refers to coastwide catches and coastwide component OFLs/ABCs to assess biological risk of overfishing (see Appendix B). The PSA scores were not used for this evaluation, because catch relative to OFL is a more reliable indicator for species with OFLs. The ratio of catch to OFLs or catch to ABCs may suggest vulnerability to overfishing if the catch:OFL ratio exceeds 100 percent. Distributions relative to the 40°10 N. latitude management line are included to help evaluate slope rockfish Alternatives 1 and 2.

Rougheye Rockfish: Coastwide catches relative to 2013 component OFLs/ABCs suggest that rougheye rockfish may have been at risk of overfishing during certain years (Appendix B). Using 2013 component OFLs from a data poor assessment (71.5 mt), the ratio of 2009-2011 average catches to the 2013 component OFL is 330 percent. The recent full-stock assessment for rougheye rockfish shows the 2015 coastwide component OFL to be substantially higher (206 mt). Using this new information, the ratio of 2009-2011 average catches to the 2015 component OFL is 115 percent. Average catches were higher during the 2009-2011 period than during the 2004-2009 period.

The distribution of rougheye rockfish is disproportionate north and south of $40^{o}$ 10' N. latitude. For the data poor assessment associated with 2013 component OFL/ABC, the distribution was shown as 99 percent of the stock in the north and 1 percent of the stock in the south. The most recent full stock assessment for rougheye rockfish associated with 2015 component OFLs show the distribution to be 98 percent north and 2 percent south.

Shortraker Rockfish: Coastwide catches relative to 2013 component OFLs/ABCs suggest that shortraker rockfish may be at risk of overfishing during certain years (Appendix B). Using 2013 component OFLs from a data poor assessment (18.8 mt), the ratio of 2009-2011 average catches to the 2013 component OFL is 166 percent. Average catches were higher during the 2009-2011 period than during the 2004-2009 period. The 2013 component OFL was exceeded 6 out of 8 years using 2004-2011 catches.

The distribution of shortraker rockfish is disproportionate north and south of $40^{o}$ 10' N. latitude. For the data poor assessment associated with 2013 component OFL/ABC, the distribution was shown as 99 percent of the stock in the north and 1 percent of the stock in the south.

Blackgill Rockfish: Blackgill rockfish has a Category 1 assessment south of $40^{o}$ 10' N. latitude, and a Category 3 assessment north of the management line. This species is managed within the slope rockfish complex both in the north and south management areas. In the south, it is managed using harvest guidelines.

The coast-wide catches relative to 2013 component OFLs/ABCs suggest that blackgill rockfish may be at risk of overfishing during certain years (Appendix B). Using 2013 coastwide component OFLs from a full assessment (122.6 mt), the ratio of 2009-2011 average catches to the 2013 component OFL is 114 percent. Average catches were higher during the 2009-2011 period than during the 2004-2009 period. The 2013 component OFL was exceeded 4 out of 8 years using 2004-2011 catches. The year 2011 showed the highest catch of the 8-year period.

The distribution of blackgill rockfish is disproportionate north and south of $40^{o}$ 10' N. latitude. For the data poor assessment associated with 2013 component OFL/ABC, the distribution was shown as 3 percent of the stock in the north and 97 percent of the stock in the south.

It is important to note that trip limits have recently been implemented for blackgill rockfish south of $40^{o}$ 10' N. latitude. Results of those trip limits are not yet known.

Aurora Rockfish: The risk analysis for aurora rockfish show contradictory results, depending on whether the 2013 component OFLs/ABCs (data-poor assessment) or 2015 component OFLs/ABCs (full assessment) are used. Coastwide catches relative to 2013 component OFLs/ABCs suggest that aurora rockfish may be at risk of overfishing during certain years (Appendix B). Using 2013 component OFLs from a data poor assessment (41.5 mt), the ratio of 2009-2011 average catches to the 2013 component OFL is 110 percent. The recent full-stock assessment for aurora rockfish shows the 2015 coastwide component OFL to be substantially higher (92 mt). Using this new information, the ratio of 2009-2011 average catches to the 2015 component OFL is 50 percent. In addition, the 2015 ABC would not have been exceeded during any year during the 2004-2009 period. Average catches were lower during the 2009-2011 period than during the 2004-2009 period.

The distribution of aurora rockfish is more evenly distributed north and south of 40$^{o}$ 10' N. latitude than shown for rougheye and shortraker rockfish. For the data poor assessment associated with 2013 component OFL/ABC, the distribution was shown as 37 percent of the stock in the north and 63 percent of the stock in the south. The most recent full stock assessment for aurora rockfish associated with 2015 component OFLs show the distribution to be 19 percent north and 81 percent south.

*Presumption*: The typical presumption is that for species with full assessments, or species that may be at risk of overfishing, stocks may be best managed individually (i.e., out of the complex). There are other options, however, so this is a decision that should be made by the Council. Other options include leaving some or all of the stocks within a complex and managing using other management measures, such as harvest guidelines (e.g., as blackgill rockfish south is currently managed).

The Council may decide to remove all four species at risk of overfishing from the complex for individual management, or remove most of these species from the complex for individual management (i.e., only rougheye, shortraker, and blackgill rockfish). The Council may also consider retaining one, two, three, or all of the stocks within the slope rockfish complex and managing using other measures. Finally, a new complex could be considered (e.g., a vulnerable species complex consisting of rougheye-shortraker or rougheye-shortraker-blackgill rockfishes) as suggested under Agenda Item F.8.a, Attachment 1, June 2013.

*Considerations*:

- Coast-wide or North/South Management: Whether species are retained in complexes or removed and managed individually, the Council may consider managing coastwide (e.g., Alternatives 1 and 2) or within the management areas (i.e., Status Quo). Implications of managing coastwide were described under Agenda Item F.8.b, Supplemental GMT Report 2, June 2013.
- Co-occurrence: None of the species have especially high co-occurrence values (Appendix B). All values were deemed to co-occur with other slope rockfish species at moderate to low levels (Appendix B). This suggests that low implication of managing separately.
- Similarity to Other Species: Each of the vulnerable species shown above are similar to one or more other species (Agenda Item G.8.b, GMT Report 3, September 2013). For example, rougheye rockfish, shortraker rockfish, and blackgill rockfish are similar in appearance (also see FEIS 2013-2014, page. C-43, Appendix C). This may result in sorting implications for fishermen and processors (Agenda Item G.8.b, GMT Report 3, September 2013). Port sampling would likely still be adequate, however, sampling coverage levels may need to be examined.
- Implications to buyers and fishermen: Concerns may include (a) identification and therefore sorting problems (Agenda Item G.8.b, GMT Report 3, September 2013), (b) additional bins needed for sorting the new market category, and c) potentially additional constraining species.
- Cost to the management system

- The affects of adding an additional market category and strata on the reliability of the estimates
- Allocations: Slope rockfish have FMP trawl and non-trawl allocations, established under Amendment 21. Further, each biennium set-asides are established to accommodate bycatch in the at-sea whiting fisheries
- IFQ program has default rules for QS allocation in the event a species is removed from a complex or management line implemented
- IFQ program does not yet have an automatic methodology for issuing shorebased carryover when management lines are modified

*Potential Inflator Stocks:* The Council may consider removing potential inflator stocks from the complexes and managing separately. The GMT generally agreed with discussion presented with the Preliminary Alternatives (Agenda Item F.8.a, Attachment 1, June 2013) regarding potential impacts of inflator stocks to other species within a complex. In other words, the presence of inflator stocks in a complex can increase the risk of overfishing other stocks in the complex since it inflates the complex OFL. The GMT identified two stocks that may be considered "inflator stocks" within the slope rockfish complex (see Appendix B):

- Splitnose Rockfish (north and south)
- Bank Rockfish (south)

Implications and concerns with managing these stocks individually are similar to those shown at risk of overfishing species above.

**Slope Rockfishes**

*Species to add to FMP, delete from FMP, or make EC species:*
- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013

*Select a Geographical Option for Managing the Complex (circle one or create one):*
- Status Quo
- GMT Alternative 1
- GMT Alternative 2
- Other

*Select none to all of the following species for individual management that may be at risk of overfishing (circle all that you would like to manage individually):*
- Rougheye
- Shortraker
- Aurora
- Blackgill
- Other?

*Select none to all of the following species for individual management that may be considered inflator species (circle all that you would like to manage individually):*
- Splitnose Rockfish (Area or Coastwide)
- Bank Rockfish (Area or Coastwide)

*Select none to one of the following if a new complex is desired (or create your own):*
- Rougheye-Shortraker
- Rougheye-Shortraker-Aurora
- Rougheye-Shortraker-Blackgill

**Appendix A. Tables and figures of species co-occurrence and distribution related to complex alternatives.**

Note: this appendix represents an extension of Agenda Item F.8.b Supplemental GMT Report 2 June 2013. It has been expanded to included figures and tables for flatfish.

Table 1. Slope rockfish occurrences (a), co-occurrences (c), and normalized C-scores (e) in the West Coast Groundfish Observer Program (WCGOP) bottom trawl data (2002-2011) North of 40°10’ N lat. The shading in (c) is darkest for values less than 0.20 indicating the highest level of co-occurrence, and lighter for values between 0.20 and 0.70, indicating moderate levels of co-occurrence. Values greater than 0.70 are un-shaded indicating the lowest level of co-occurrence. Further explanation of these co-occurrence tables is provided in Agenda Item F.8.b, June 2013.

**(a) Total occurrences of Slope Rockfish North of 40°10’ N lat.**

| Darkblotched | Splitnose | Aurora | Pacific Ocean Perch | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| 6487 | 5033 | 4795 | 4334 | 2744 | 1508 | 788 | 778 | 597 | 69 | 39 |

**(b) Matrix of common occurrences of Slope Rockfish North of 40°10’ N lat.**

| | Splitnose | Aurora | POP | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| Darkblotched | 2743 | 1679 | 2700 | 1867 | 978 | 512 | 528 | 328 | 48 | 28 |
| | Splitnose | 1784 | 2383 | 2068 | 877 | 466 | 611 | 301 | 38 | 30 |
| | | Aurora | 1297 | 1031 | 661 | 533 | 174 | 295 | 31 | 14 |
| | | | POP | 1584 | 837 | 310 | 536 | 315 | 24 | 26 |
| | | | | Redbanded | 685 | 275 | 449 | 228 | 30 | 19 |
| | | | | | Rougheye/ Blackspotted | 177 | 180 | 273 | 13 | 17 |
| | | | | | | Blackgill | 65 | 83 | 16 | 8 |
| | | | | | | | Sharpchin | 48 | 8 | 16 |
| | | | | | | | | Shortraker | 5 | 4 |
| | | | | | | | | | Bank | 6 |

**(c) Matrix of normalized C-scores for Slope Rockfish North of 40°10' N lat.**

| | Splitnose R | Aurora | POP | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| Darkblotched | 0.263 | 0.482 | 0.22 | 0.228 | 0.298 | 0.323 | 0.295 | 0.428 | 0.302 | 0.281 |
| | Splitnose | 0.405 | 0.237 | **0.145** | 0.346 | 0.371 | **0.189** | 0.466 | 0.446 | 0.229 |
| | | Aurora | 0.511 | 0.49 | 0.484 | 0.288 | 0.748 | 0.475 | 0.547 | 0.639 |
| | | | POP | 0.268 | 0.359 | 0.563 | 0.273 | 0.438 | 0.649 | 0.331 |
| | | | | Redbanded | 0.41 | 0.586 | 0.354 | 0.567 | 0.559 | 0.509 |
| | | | | | Rougheye/ Blackspotted | 0.684 | 0.677 | 0.444 | 0.805 | 0.558 |
| | | | | | | Blackgill | 0.841 | 0.77 | 0.753 | 0.787 |
| | | | | | | | Sharpchin | 0.863 | 0.875 | 0.578 |
| | | | | | | | | Shortraker | 0.92 | 0.891 |
| | | | | | | | | | Bank | 0.773 |

Table 2. Slope rockfish occurrences (a), co-occurrences (c), and normalized C-scores (e) in the WCGOP bottom trawl data (2002-2011) South of 40°10' N lat. The shading in (c) is darkest for values less than 0.20 indicating the highest level of co-occurrence, and lighter for values between 0.20 and 0.70, indicating moderate levels of co-occurrence. Values greater than 0.70 are un-shaded indicating the lowest level of co-occurrence. Further explanation of these co-occurrence tables is provided in Agenda Item F.8.b, June 2013.

**(a) Total occurrences of Slope Rockfish South of 40°10' N lat.**

| Darkblotched | Splitnose | Aurora | Pacific Ocean Perch | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| 446 | 1501 | 855 | 24 | 274 | 13 | 461 | 77 | 7 | 268 | 0 |

**(b) Matrix of common occurrences of Slope Rockfish South of 40°10' N lat.**

| | Splitnose | Aurora | POP | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| Darkblotched | 347 | 129 | 8 | 134 | 4 | 112 | 23 | 3 | 113 | 0 |
| | Splitnose | 404 | 14 | 252 | 8 | 337 | 56 | 5 | 238 | 0 |
| | | Aurora | 13 | 91 | 9 | 233 | 5 | 4 | 67 | 0 |
| | | | POP | 6 | 2 | 7 | 0 | 1 | 4 | 0 |
| | | | | Redbanded | 3 | 78 | 18 | 3 | 64 | 0 |
| | | | | | Rougheye/ Blackspotted | 8 | 1 | 0 | 4 | 0 |
| | | | | | | Blackgill | 2 | 4 | 71 | 0 |
| | | | | | | | Sharpchin | 0 | 18 | 0 |
| | | | | | | | | Shortraker | 1 | 0 |
| | | | | | | | | | Bank | 0 |

**(c) Matrix of normalized C-scores for Slope Rockfish South of 40°10’ N lat.**

| | Splitnose | Aurora | POP | Redbanded | Rougheye/ Blackspotted | Blackgill | Sharpchin | Shortraker | Bank | Yellowmouth |
|---|---|---|---|---|---|---|---|---|---|---|
| Darkblotched | **0.171** | 0.604 | 0.655 | 0.357 | 0.686 | 0.567 | 0.665 | 0.568 | 0.432 | NA |
| Splitnose | | 0.386 | 0.413 | **0.067** | 0.383 | 0.209 | 0.263 | 0.285 | **0.094** | NA |
| Aurora | | | 0.451 | 0.597 | 0.304 | 0.36 | 0.93 | 0.427 | 0.691 | NA |
| POP | | | | 0.734 | 0.776 | 0.698 | 1 | 0.821 | 0.821 | NA |
| Redbanded | | | | | 0.761 | 0.594 | 0.716 | 0.565 | 0.583 | NA |
| Rougheye/ Blackspotted | | | | | | 0.378 | 0.911 | 1 | 0.682 | NA |
| Blackgill | | | | | | | 0.97 | 0.425 | 0.622 | NA |
| Sharpchin | | | | | | | | 1 | 0.715 | NA |
| Shortraker | | | | | | | | | 0.854 | NA |
| Bank | | | | | | | | | | NA |

Table 3. Cartilaginous Species occurrences (a), co-occurrences (b), and normalized C-scores (c) in the WCGOP bottom trawl data (2002-2011) coastwide. The shading in (c) is darkest for values less than 0.20 indicating the highest level of co-occurrence, and lighter for values between 0.20 and 0.70, indicating moderate levels of co-occurrence. Values greater than 0.70 are un-shaded indicating the lowest level of co-occurrence. Further explanation of these co-occurrence tables is provided in Agenda Item F.8.b, June 2013.

**(a) Total occurrences of Cartilaginous Species coastwide**

| Longnose Skate | All Other Skates | Spiny Dogfish | Spotted Ratfish | Brown Cat Shark | Bering/ Sandpaper Skate | Big Skate | Black Skate | California Skate | Aleutian Skate | Leopard Shark | Soupfin Shark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19318 | 18043 | 16993 | 16959 | 15076 | 15040 | 6029 | 5279 | 2720 | 539 | 358 | 113 |

**(b) Matrix of common occurrences of Cartilaginous Species coastwide**

| | All Other Skates | Spiny Dogfish Shark | Spotted Ratfish | Brown Cat Shark | Bering/ Sandpaper Skate | Big Skate | Black Skate | California Skate | Aleutian Skate | Leopard Shark | Soupfin Shark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Longnose Skate | 7581 | 10163 | 10561 | 8501 | 11531 | 2460 | 2152 | 974 | 408 | 22 | 29 |
| | All Other Skates | 9115 | 9604 | 5313 | 6927 | 2764 | 918 | 875 | 304 | 133 | 52 |
| | | Spiny Dogfish | 10426 | 4804 | 8391 | 2976 | 836 | 1190 | 294 | 186 | 57 |
| | | | Spotted Ratfish | 4059 | 8420 | 3113 | 543 | 744 | 288 | 41 | 42 |
| | | | | Brown Cat Shark | 7448 | 159 | 4165 | 73 | 360 | 1 | 3 |
| | | | | | Bering/ Sandpaper Skate | 1596 | 1478 | 135 | 312 | 1 | 9 |
| | | | | | | Big Skate | 24 | 1245 | 13 | 289 | 69 |
| | | | | | | | Black Skate | 19 | 115 | 1 | 0 |
| | | | | | | | | Cal. Skate | 1 | 223 | 64 |
| | | | | | | | | | Aleutian Skate | 0 | 0 |
| | | | | | | | | | | Leopard Shark | 25 |

**(c) Matrix of normalized C-scores for Cartilaginous Species coastwide**

| | All Other Skates | Spiny Dogfish Shark | Spotted Ratfish | Brown Cat Shark | Bering/ Sandpaper Skate | Big Skate | Black Skate | California Skate | Aleutian Skate | Leopard Shark | Soupfin Shark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Longnose Skate | 0.352 | **0.19** | **0.171** | 0.244 | **0.094** | 0.517 | 0.526 | 0.61 | 0.238 | 0.937 | 0.742 |
| All Other Skates | | 0.229 | 0.203 | 0.457 | 0.332 | 0.459 | 0.784 | 0.645 | 0.429 | 0.624 | 0.538 |
| Spiny Dogfish Shark | | | **0.149** | 0.489 | 0.224 | 0.418 | 0.8 | 0.523 | 0.447 | 0.475 | 0.494 |
| Spotted Ratfish | | | | 0.556 | 0.222 | 0.395 | 0.868 | 0.695 | 0.458 | 0.883 | 0.627 |
| Brown Cat Shark | | | | | 0.255 | 0.963 | **0.153** | 0.968 | 0.324 | 0.997 | 0.973 |
| Bering/ Sandpaper Skate | | | | | | 0.657 | 0.649 | 0.942 | 0.412 | 0.997 | 0.92 |
| Big Skate | | | | | | | 0.991 | 0.43 | 0.974 | **0.183** | 0.385 |
| Black Skate | | | | | | | | 0.989 | 0.77 | 0.997 | 1 |
| California Skate | | | | | | | | | 0.998 | 0.346 | 0.423 |
| Aleutian Skate | | | | | | | | | | 1 | 1 |
| Leopard Shark | | | | | | | | | | | 0.724 |

Table 4. Other Roundfish occurrences (a), co-occurrences (b), and normalized C-scores (c) in the WCGOP bottom trawl data (2002-2011) coastwide. The shading in (c) is darkest for values less than 0.20 indicating the highest level of co-occurrence, and lighter for values between 0.20 and 0.70, indicating moderate levels of co-occurrence. Values greater than 0.70 are un-shaded indicating the lowest level of co-occurrence. Further explanation of these co-occurrence tables is provided in Agenda Item F.8.b, June 2013.

**(a) Total occurrences of Other Roundfish coastwide**

| Giant Grenadier | Pacific Grenadier | California Slickhead | Pacific Flatnose | All Other Grenadiers | California Scorpionfish | Kelp Greenling | Cabezon | All Other Greenlings |
|---|---|---|---|---|---|---|---|---|
| 7032 | 6433 | 4465 | 4120 | 3867 | 148 | 108 | 29 | 28 |

**(b) Matrix of common occurrences of Other Roundfish coastwide**

| | Pacific Grenadier | California Slickhead | Pacific Flatnose | All Other Grenadiers | California Scorpionfish | Kelp Greenling | Cabezon | All Other Greenlings |
|---|---|---|---|---|---|---|---|---|
| Giant Grenadier | 4241 | 3262 | 2628 | 1399 | 0 | 1 | 0 | 0 |
| | Pacific Grenadier | 2944 | 2375 | 1077 | 0 | 1 | 0 | 0 |
| | | California Slickhead | 1929 | 1566 | 0 | 1 | 0 | 0 |
| | | | Pacific Flatnose | 1516 | 0 | 1 | 0 | 0 |
| | | | | All Other Grenadiers | 0 | 2 | 0 | 0 |
| | | | | | California Scorpionfish | 0 | 1 | 0 |
| | | | | | | Kelp Greenling | 0 | 0 |
| | | | | | | | Cabezon | 0 |

**(c) Matrix of normalized C-scores for Other Roundfish coastwide**

| | Pacific Grenadier | California Slickhead | Pacific Flatnose | All Other Grenadiers | California Scorpionfish | Kelp Greenling | Cabezon | All Other Greenlings |
|---|---|---|---|---|---|---|---|---|
| Giant Grenadier | **0.135** | **0.144** | 0.227 | 0.511 | 1 | 0.991 | 1 | 1 |
| | Pacific Grenadier | **0.185** | 0.267 | 0.601 | 1 | 0.991 | 1 | 1 |
| | | California Slickhead | 0.302 | 0.386 | 1 | 0.991 | 1 | 1 |
| | | | Pacific Flatnose | 0.384 | 1 | 0.991 | 1 | 1 |
| | | | | All Other Grenadiers | 1 | 0.981 | 1 | 1 |
| | | | | | California Scorpionfish | 1 | 0.959 | 1 |
| | | | | | | Kelp Greenling | 1 | 1 |
| | | | | | | | Cabezon | 1 |

Table 5. Flatfish occurrences (a), co-occurrences (b), and normalized C-scores (c) in the WCGOP bottom trawl data (2002-2011) coastwide. The shading in (c) is darkest for values less than 0.20 indicating the highest level of co-occurrence, and lighter for values between 0.20 and 0.70, indicating moderate levels of co-occurrence. Values greater than 0.70 are un-shaded indicating the lowest level of co-occurrence. Further explanation of these co-occurrence tables is provided in Agenda Item F.8.b, June 2013.

**(a) Total occurrences of flatfish coastwide**

| Dover Sole | A-tooth Flounder | Rex Sole | Petrale Sole | English Sole | Slender Sole | Pacific Sanddab | Deepsea Sole | Sand Sole | Starry Flounder | Flathead Sole | Curlfin Turbot | Rock Sole | Butter Sole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32418 | 22768 | 21300 | 17273 | 14637 | 9562 | 9101 | 8521 | 3232 | 3015 | 2750 | 2537 | 1375 | 563 |

**(b) Matrix of common occurrences of flatfish coastwide**

| | A-tooth Flounder | Rex Sole | Petrale Sole | English Sole | Slender Sole | Pacific Sanddab | Deepsea Sole | Sand Sole | Starry Flounder | Flathead Sole | Curlfin Turbot | Rock Sole | Butter Sole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dover Sole | 21185 | 18878 | 13847 | 9817 | 8960 | 5598 | 8262 | 556 | 305 | 2483 | 564 | 532 | 178 |
| A-tooth Flounder | | 15247 | 12438 | 8473 | 8042 | 4536 | 3194 | 272 | 137 | 2531 | 236 | 416 | 119 |
| Rex Sole | | | 13462 | 11222 | 8492 | 6979 | 2658 | 987 | 651 | 2623 | 1037 | 786 | 292 |
| Petrale Sole | | | | 11907 | 7120 | 7341 | 607 | 1145 | 946 | 2502 | 1434 | 959 | 287 |
| English Sole | | | | | 5717 | 8294 | 171 | 2588 | 2297 | 2203 | 2241 | 1269 | 507 |
| Slender Sole | | | | | | 3468 | 619 | 186 | 112 | 1749 | 285 | 171 | 79 |
| Pacific Sanddab | | | | | | | 16 | 2088 | 1915 | 1383 | 1981 | 1079 | 387 |
| Deepsea Sole | | | | | | | | 2 | 2 | 7 | 1 | 3 | 0 |
| Sand Sole | | | | | | | | | 2427 | 75 | 1207 | 539 | 462 |
| Starry Flounder | | | | | | | | | | 39 | 1393 | 511 | 373 |
| Flathead Sole | | | | | | | | | | | 64 | 164 | 25 |
| Curlfin Turbot | | | | | | | | | | | | 758 | 98 |
| Rock Sole | | | | | | | | | | | | | 54 |

**(c) Matrix of normalized C-scores for flatfish coastwide**

| | A-tooth Flounder | Rex Sole | Petrale Sole | English Sole | Slender Sole | Pacific Sanddab | Deepsea Sole | Sand Sole | Starry Flounder | Flathead Sole | Curlfin Turbot | Rock Sole | Butter Sole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dover Sole | **0.024** | **0.047** | **0.114** | 0.23 | **0.046** | 0.318 | **0.023** | 0.814 | 0.89 | **0.09** | 0.764 | 0.603 | 0.68 |
| A-tooth Flounder | | **0.094** | **0.127** | 0.264 | **0.103** | 0.402 | 0.537 | 0.905 | 0.949 | **0.071** | 0.898 | 0.685 | 0.785 |
| Rex Sole | | | **0.081** | **0.11** | **0.067** | **0.157** | 0.602 | 0.662 | 0.76 | **0.04** | 0.562 | 0.413 | 0.475 |
| Petrale Sole | | | | **0.058** | **0.15** | **0.111** | 0.896 | 0.603 | 0.649 | **0.077** | 0.399 | 0.286 | 0.482 |
| English Sole | | | | | 0.245 | **0.038** | 0.968 | **0.164** | 0.201 | **0.169** | **0.099** | **0.07** | **0.096** |
| Slender Sole | | | | | | 0.394 | 0.867 | 0.924 | 0.952 | 0.297 | 0.861 | 0.86 | 0.853 |
| Pacific Sanddab | | | | | | | 0.996 | 0.273 | 0.288 | 0.422 | **0.171** | **0.19** | 0.299 |
| Deepsea Sole | | | | | | | | 0.999 | 0.999 | 0.997 | 0.999 | 0.997 | 1 |
| Sand Sole | | | | | | | | | **0.049** | 0.95 | 0.328 | 0.507 | **0.154** |
| Starry Flounder | | | | | | | | | | 0.973 | 0.243 | 0.522 | 0.296 |
| Flathead Sole | | | | | | | | | | | 0.952 | 0.828 | 0.947 |
| Curlfin Turbot | | | | | | | | | | | | 0.315 | 0.794 |
| Rock Sole | | | | | | | | | | | | | 0.869 |

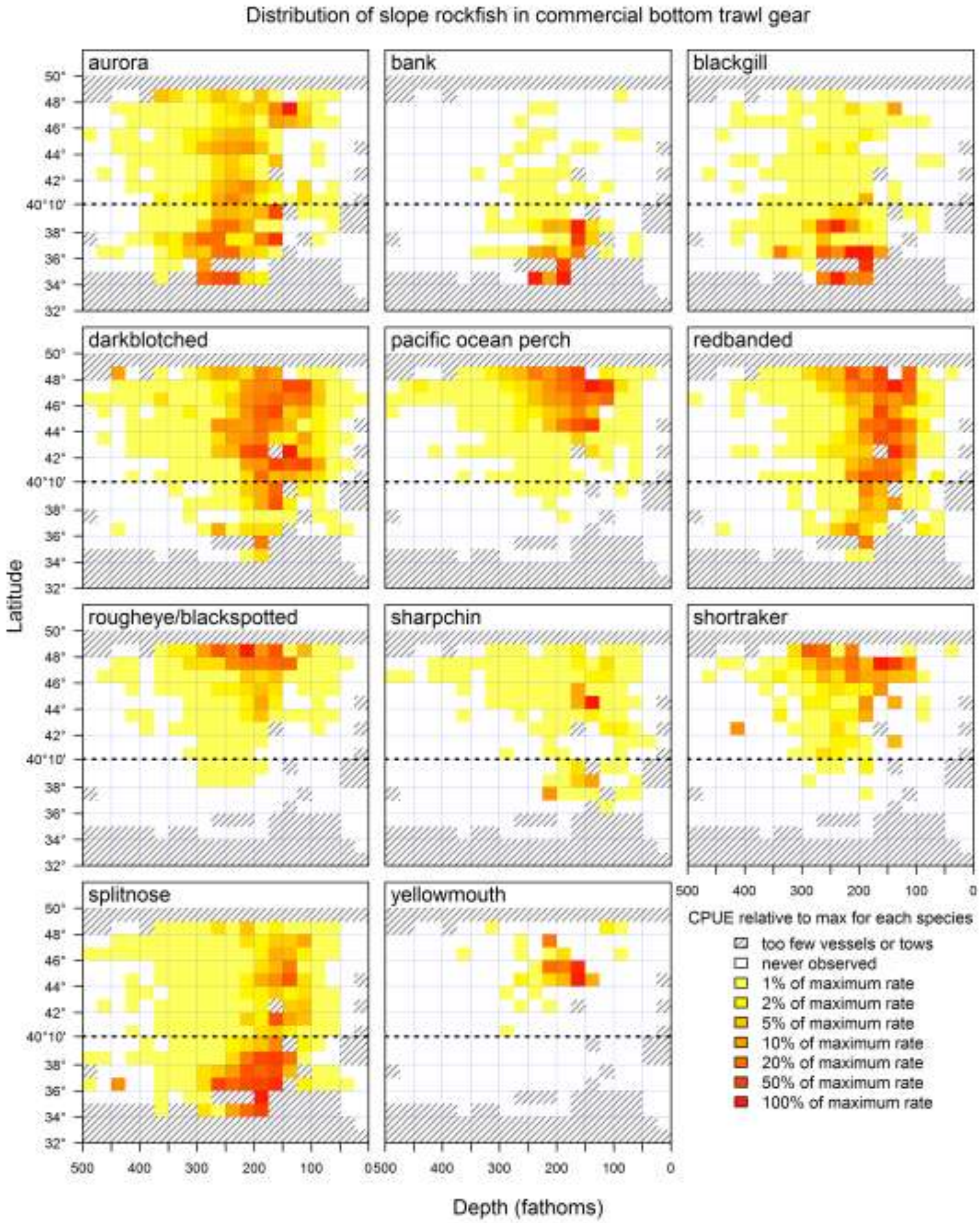



Figure 1. Spatial distribution of Slope Rockfish in WCGOP trawl data (2002 – 2011) for alternatives above. Colors represent CPUE relative to the maximum within each species (see the legend). Darkest red = highest CPUE; lightest yellow = lowest CPUE. Data for hatched boxes could not be displayed because of confidentiality (only 1 or 2 vessels carrying observers fished in the area) or because no vessels carrying observers fished in the area. White areas are places where 3 or more vessels fished and carried observers, but the species in question was not caught.

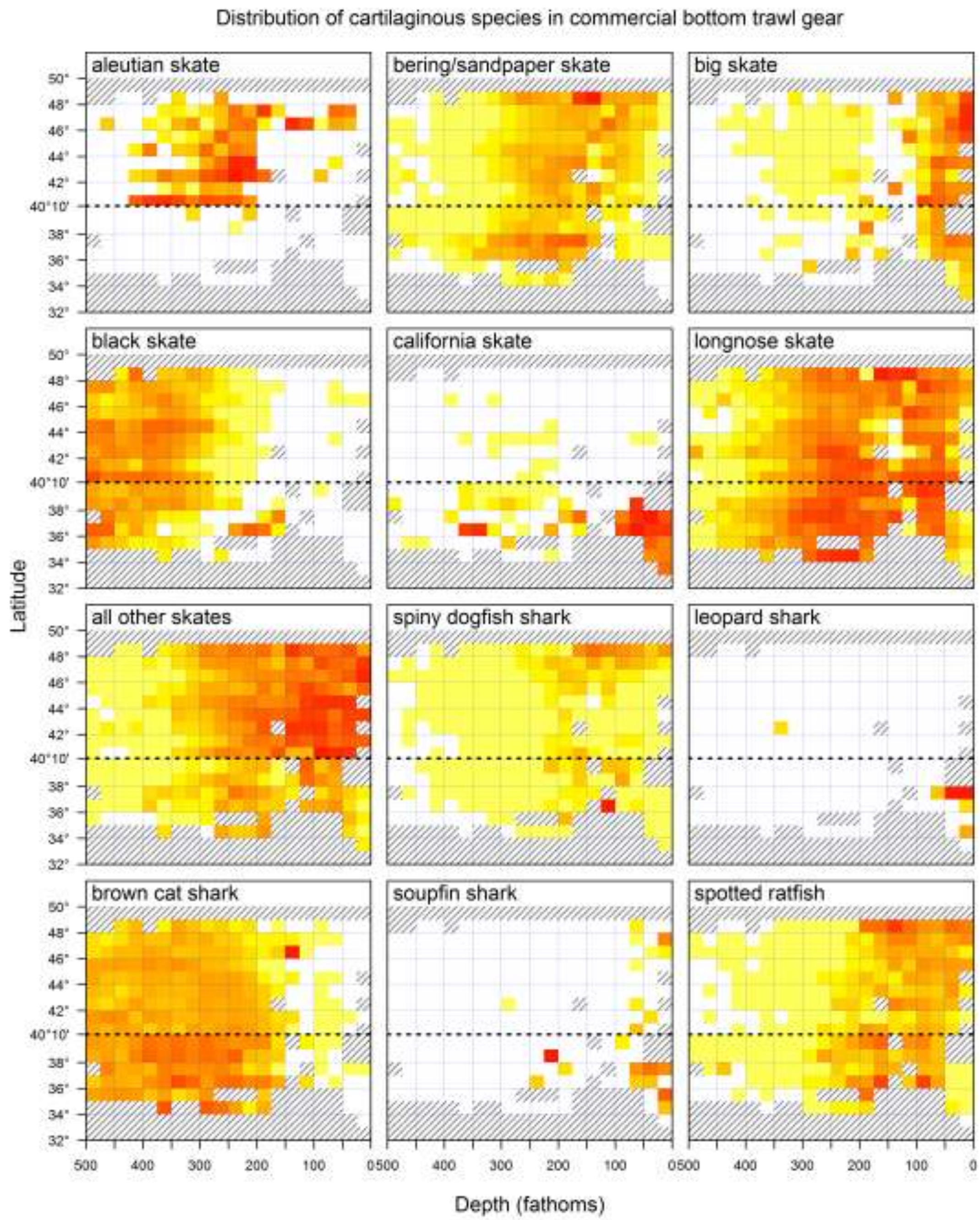



Figure 2. Spatial distribution of Cartilaginous Species in WCGOP trawl data (2002 – 2011) for alternatives above. Colors and hashed areas are described in Figure 1 caption.

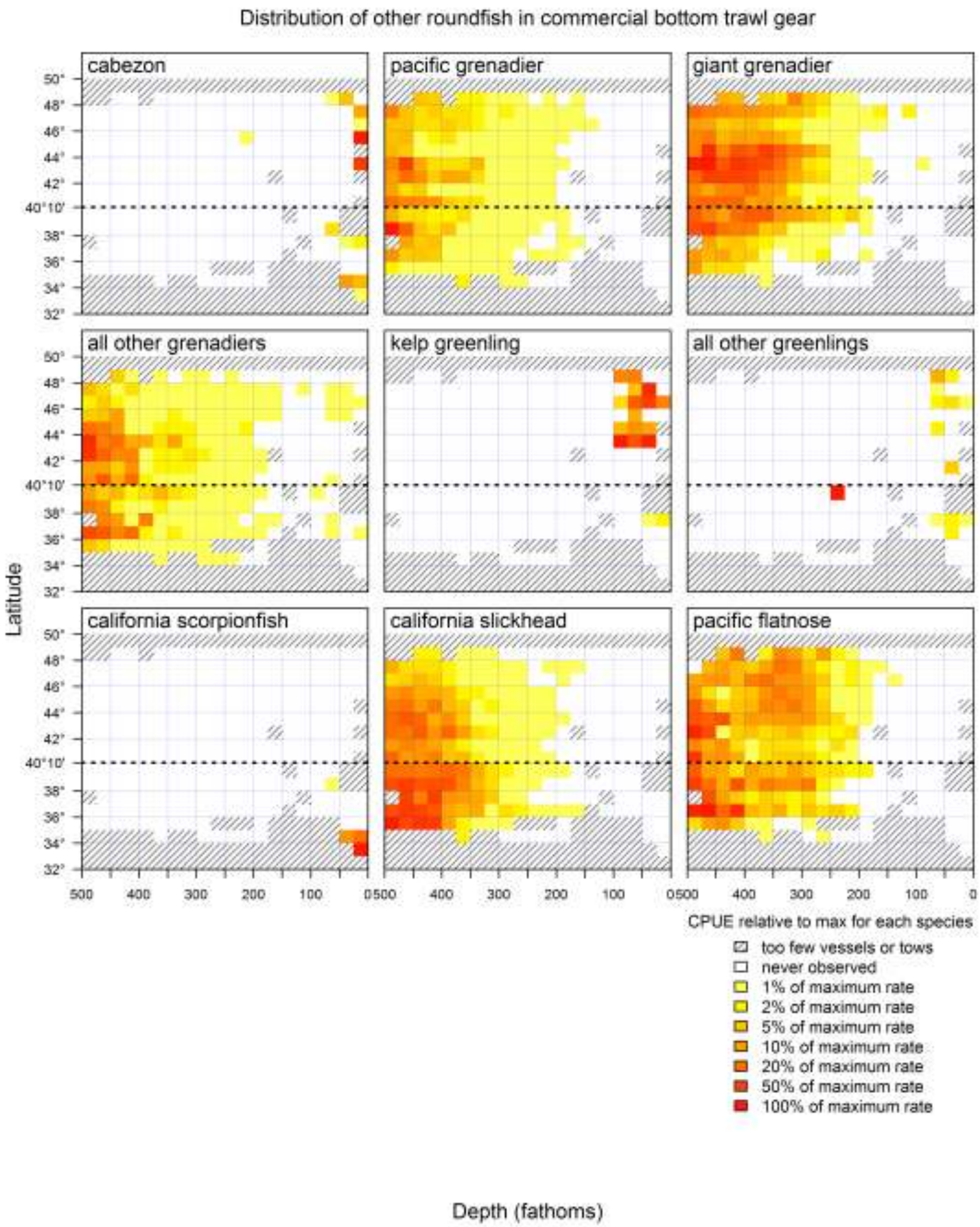



Figure 3. Spatial distribution of Other Roundfish in WCGOP trawl data (2002 – 2011) for alternatives above. Colors and hashed areas are described in Figure 1 caption.

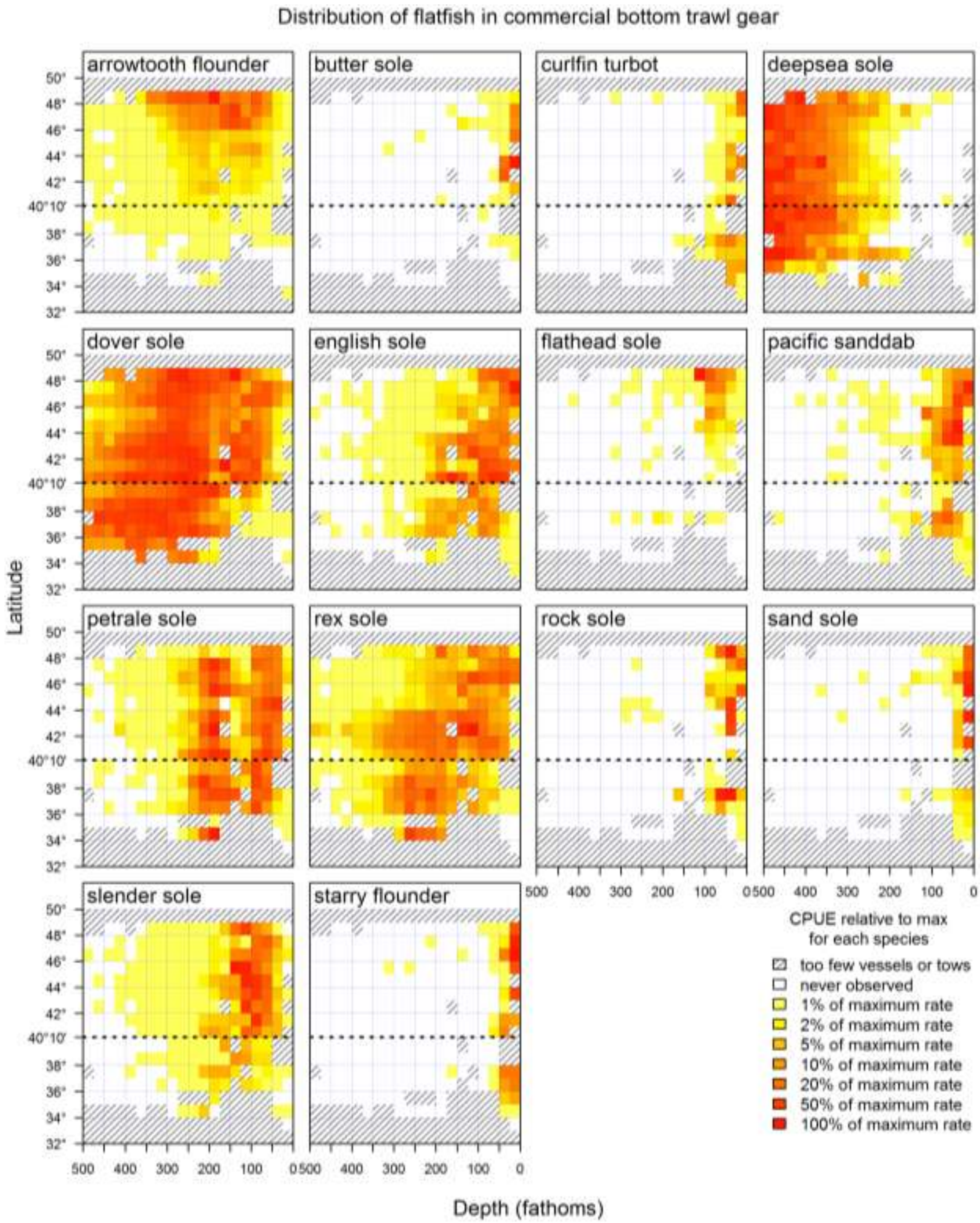



Figure 4. Spatial distribution of Other Roundfish in WCGOP trawl data (2002 – 2011) for alternatives above. Colors and hashed areas are described in Figure 1 caption.

**Appendix B.**

**Table 1. Metrics that may be used to evaluate the risk of overfishing for Minor Slope Rockfishes Rockfish north of 40ₒ10´ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40ₒ10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurora Data-Poor Assessment | 15.4 | 12.8 | 161% | 285% | 232% | 88% | 134% | 237% | 193% | 75% | 37% |
| Aurora Full Assessment 2015 | 17.4 | 16.6 | 124% | 220% | 179% | 75% | 119% | 210% | 171% | 75% | 19% |
| Bank | 17.2 | 14.4 | 5% | 5% | 10% | 0% | 4% | 4% | 8% | 0% | 3% |
| Blackgill | 4.7 | 3.9 | 119% | 199% | 177% | 88% | 99% | 165% | 147% | 75% | 3% |
| Redbanded | 45.3 | 37.7 | 0% | 60% | 80% | 25% | 0% | 50% | 66% | 0% | 81% |
| Rougheye Data-Poor Assessment | 71.1 | 59.3 | 349% | 396% | 315% | 100% | 291% | 331% | 263% | 100% | 99% |
| Rougheye Full Assessment 2015 | 201.9 | 193 | 107% | 122% | 97% | 50% | 103% | 116% | 92% | 63% | 98% |
| Sharpchin | 214.5 | 178.9 | 4% | 4% | 6% | 0% | 3% | 4% | 5% | 0% | 96% |
| Shortraker | 18.7 | 15.6 | 181% | 191% | 162% | 75% | 151% | 159% | 135% | 75% | 99% |
| Yellowmouth | 192.4 | 160.5 | 0% | 2% | 3% | 0% | 0% | 2% | 3% | 0% | 100% |
| Splitnose | 939 | 897.7 | 3% | 9% | 11% | 0% | 3% | 9% | 10% | 0% | 36% |
| Pacific Ocean Perch* | 844 | 807 | 8% | 16% | 15% | 0% | 7% | 16% | 15% | 0% | 100% |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

**Table 2. Metrics that may be used to evaluate the risk of overfishing for Minor Slope Rockfish south of 40ₒ10′ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40ₒ10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurora Data-Poor Assessment | 26.1 | 21.7 | 32% | 42% | 120% | 50% | 27% | 35% | 100% | 50% | 63% |
| Aurora Full Assessment | 74.3 | 70.7 | 10% | 13% | 37% | 0% | 9% | 12% | 35% | 13% | 81% |
| Bank | 503.2 | 459.4 | 6% | 7% | 12% | 0% | 6% | 7% | 11% | 0% | 97% |
| Blackgill | 130 | 118.7 | 127% | 123% | 95% | 50% | 116% | 112% | 86% | 50% | 97% |
| Redbanded | 10.4 | 8.7 | 6% | 21% | 28% | 0% | 5% | 18% | 24% | 0% | 19% |
| Rougheye Data-Poor Assessment | 0.4 | 0.3 | 119% | 390% | 365% | 50% | 90% | 292% | 273% | 38% | 1% |
| Rougheye Full Assessment | 4.1 | 3.9 | 9% | 30% | 28% | 0% | 9% | 29% | 27% | 0% | 2% |
| Sharpchin | 9.8 | 8.2 | 5% | 24% | 19% | 0% | 4% | 20% | 16% | 0% | 4% |
| Shortraker | 0.1 | 0.1 | 0% | 1391% | 708% | 50% | 0% | 1391% | 708% | 50% | 1% |
| Yellowmouth | 0.8 | 0.7 | 0% | 2% | 1% | 0% | 0% | 2% | 1% | 0% | 0% |
| Splitnose* | 1,684 | 1,610 | 3% | 7% | 10% | 0% | 2% | 6% | 9% | 0% | 64% |
| Pacific ocean perch** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

**Table 3. Metrics that may be used to evaluate the risk of overfishing for Minor Shelf Rockfish north of 40₀10´ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40₀10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bronzespotted** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Bocaccio | 284 | 236.9 | 2% | 1% | 2% | 0% | 1% | 1% | 2% | 0% | 24% |
| Chameleon** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Chilipepper | 156 | 111 | 2% | 10% | 14% | 0% | 2% | 7% | 10% | 0% | 8% |
| Cowcod** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Dusky** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dwarf-red** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Flag | 0.1 | 0.1 | 1% | 15% | 11% | 0% | 1% | 15% | 11% | 0% | 0% |
| Freckled** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Greenblotched | 1.3 | 1.1 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 5% |
| Greenspotted | 15.5 | 14.1 | 1% | 1% | 1% | 0% | 1% | 1% | 1% | 0% | 16% |
| Greenstriped | 1,252 | 1,143 | 1% | 1% | 2% | 0% | 1% | 1% | 2% | 0% | 84% |
| Halfbanded** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Harlequin** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Honeycomb** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Mexican** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Pink** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Pinkrose** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |

**Table 3. cont.**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Puget Sound** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Pygmy** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Redstripe | 269.9 | 225.1 | 4% | 4% | 3% | 0% | 3% | 3% | 2% | 0% | 100% |
| Rosethorn | 12.9 | 10.8 | 49% | 44% | 39% | 0% | 41% | 36% | 33% | 0% | 86% |
| Rosy | 3 | 2.5 | 1% | 3% | 4% | 0% | 1% | 2% | 4% | 0% | 6% |
| Silvergray | 159.4 | 133 | 1% | 2% | 6% | 0% | 1% | 1% | 5% | 0% | 100% |
| Speckled | 0.2 | 0.1 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% |
| Squarespot | 0.2 | 0.1 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% |
| Starry** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Stripetail | 40.4 | 33.7 | 5% | 5% | 14% | 0% | 4% | 4% | 11% | 0% | 63% |
| Swordspine** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Tiger | 1 | 0.8 | 168% | 102% | 116% | 50% | 134% | 82% | 93% | 50% | 100% |
| Vermilion | 9.7 | 8.1 | 279% | 231% | 221% | 100% | 233% | 193% | 184% | 100% | 3% |
| Yellowtail* | 4579 | 4378 | 31% | 23% | 17% | 0% | 30% | 22% | 16% | 0% | 100% |

*Managed outside of complex
**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

**Table 4. Metrics that may be used to evaluate the risk of overfishing for Minor Shelf Rockfish south of 40ₒ10´ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40ₒ10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | %Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bronzespotted | 3.6 | 3 | 0% | 0% | 1% | 0% | 0% | 0% | 1% | 0% | 100% |
| Bocaccio* | 884 | 845 | 13% | 10% | 9% | 0% | 13% | 9% | 8% | 0% | 76% |
| Chameleon** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Chilipepper* | 1768 | 1690 | 19% | 19% | 12% | 0% | 19% | 18% | 11% | 0% | 92% |
| Cowcod* | 11 | 9 | 11% | 8% | 8% | 0% | 9% | 6% | 7% | 0% | 100% |
| Dusky** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Dwarf-red** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Flag | 23.4 | 19.5 | 43% | 34% | 37% | 0% | 35% | 28% | 31% | 0% | 100% |
| Freckled** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Greenblotched | 23.1 | 19.3 | 7% | 4% | 5% | 0% | 6% | 3% | 4% | 0% | 95% |
| Greenspotted | 80.3 | 73.3 | 25% | 21% | 21% | 0% | 23% | 19% | 19% | 0% | 84% |
| Greenstriped | 229.7 | 212.4 | 0% | 1% | 2% | 0% | 0% | 1% | 2% | 0% | 16% |
| Halfbanded** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Harlequin** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Honeycomb | 9.9 | 8.2 | 98% | 66% | 52% | 0% | 81% | 55% | 43% | 0% | 100% |
| Mexican | 5.1 | 4.2 | 0% | 0% | 4% | 0% | 0% | 0% | 3% | 0% | 100% |
| Pink | 2.5 | 2.1 | 0% | 0% | 2% | 0% | 0% | 0% | 2% | 0% | 100% |
| Pinkrose** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |

**Table 4. cont.**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | %Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Puget Sound** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Pygmy** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Redstripe | 0.5 | 0.4 | 0% | 9% | 5% | 0% | 0% | 8% | 4% | 0% | 4% |
| Rosethorn | 2.1 | 1.8 | 7% | 7% | 13% | 0% | 6% | 6% | 11% | 0% | 41% |
| Rosy | 44.5 | 37.1 | 17% | 15% | 14% | 0% | 14% | 12% | 11% | 0% | 22% |
| Silvergray | 0.5 | 0.4 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 71% |
| Speckled | 39.4 | 32.8 | 25% | 22% | 12% | 0% | 21% | 19% | 10% | 0% | 99% |
| Squarespot | 11.1 | 9.2 | 60% | 35% | 28% | 0% | 50% | 29% | 23% | 0% | 100% |
| Starry | 62.6 | 52.2 | 43% | 16% | 7% | 0% | 36% | 14% | 5% | 0% | 61% |
| Stripetail | 23.6 | 19.7 | 20% | 47% | 41% | 0% | 16% | 39% | 35% | 0% | 100% |
| Swordspine | 14.2 | 11.9 | 1% | 1% | 0% | 0% | 1% | 0% | 0% | 0% | 93% |
| Tiger** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Vermilion | 269.3 | 224.6 | 90% | 72% | 85% | 25% | 75% | 60% | 71% | 13% | 97% |
| Yellowtail | 1064.4 | 887.7 | 5% | 8% | 17% | 0% | 4% | 6% | 14% | 0% | 100% |
| | | | | | | | | | | | |

*Managed outside
of complex
**Trace amount caught; i.e., the average catch does not round to 0.1
mt.

**Table 5. Metrics that may be used to evaluate the risk of overfishing for Minor Nearshore Rockfish north of 40o10´ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40o10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black and yellow** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| China | 9.8 | 8.2 | 237% | 186% | 162% | 100% | 198% | 155% | 136% | 88% | 37% |
| Gopher** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Grass | 0.7 | 0.5 | 312% | 177% | 204% | 75% | 223% | 126% | 146% | 75% | 1% |
| Kelp** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Blue (CA) | 59.7 | 51.9 | 85% | 74% | 88% | 13% | 74% | 64% | 76% | 13% | 19% |
| Brown | 5.5 | 4.6 | 32% | 25% | 22% | 0% | 26% | 21% | 18% | 0% | 3% |
| Calico** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Copper | 26 | 21.6 | 54% | 43% | 40% | 0% | 45% | 36% | 33% | 0% | 16% |
| Olive | 0.3 | 0.2 | 515% | 305% | 159% | 50% | 343% | 203% | 106% | 50% | 0% |
| Quillback | 7.4 | 6.2 | 214% | 169% | 203% | 100% | 179% | 141% | 170% | 100% | 58% |
| Treefish | 0.2 | 0.1 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

**Table 6. Metrics that may be used to evaluate the risk of overfishing for Minor Nearshore Rockfish south of 40o10´ N latitude. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40o10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 | Percent Coastwide OFL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black and yellow | 27.5 | 23 | 102% | 116% | 78% | 38% | 85% | 97% | 65% | 13% | 100% |
| China | 16.6 | 13.8 | 98% | 133% | 112% | 63% | 81% | 111% | 93% | 25% | 63% |
| Gopher | 182.6 | 171.5 | 58% | 59% | 44% | 0% | 54% | 55% | 41% | 0% | 100% |
| Grass | 59.6 | 49.7 | 45% | 37% | 34% | 0% | 37% | 31% | 29% | 0% | 99% |
| Kelp | 27.7 | 23.1 | 3% | 19% | 19% | 0% | 3% | 16% | 15% | 0% | 100% |
| Blue | 260.7 | 232.2 | 25% | 22% | 62% | 25% | 22% | 20% | 55% | 25% | 81% |
| Brown | 204.6 | 170.6 | 67% | 58% | 48% | 0% | 56% | 48% | 40% | 0% | 97% |
| Calico** | 0 | 0 | NA | NA | NA | NA | NA | NA | NA | NA | 0% |
| Copper | 141.5 | 118 | 55% | 50% | 45% | 0% | 46% | 41% | 38% | 0% | 84% |
| Olive | 224.6 | 187.4 | 13% | 11% | 20% | 0% | 10% | 9% | 17% | 0% | 100% |
| Quillback | 5.4 | 4.5 | 2% | 33% | 42% | 0% | 2% | 27% | 35% | 0% | 42% |
| Treefish | 13.2 | 11 | 124% | 91% | 70% | 13% | 103% | 76% | 59% | 13% | 99% |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

**Table 7. Metrics that may be used to evaluate the risk of overfishing for the Other Flatfish Complex. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40o10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Component Stock | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Butter sole | 4.6 | 3.2 | 28% | 28% | 36% | 13% | 20% | 20% | 25% | 0% |
| Curlfin sole | 8.2 | 5.7 | 31% | 62% | 186% | 63% | 22% | 43% | 130% | 50% |
| Flathead sole | 35 | 24.3 | 33% | 29% | 124% | 38% | 23% | 20% | 86% | 38% |
| Pacific sanddab | 4801 | 3331.9 | 10% | 12% | 15% | 0% | 7% | 8% | 10% | 0% |
| Rex sole | 4371.5 | 3033.8 | 15% | 19% | 22% | 0% | 10% | 13% | 15% | 0% |
| Rock sole | 66.7 | 46.3 | 17% | 13% | 24% | 0% | 12% | 9% | 16% | 0% |
| Sand sole | 773.2 | 536.6 | 15% | 12% | 12% | 0% | 10% | 9% | 8% | 0% |
| Slender Sole*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Deep Sea Sole*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

*Managed outside of complex

**Table 8. Metrics that may be used to evaluate the risk of overfishing for the Cartilaginous Fish Complex. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40o10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Component Stock | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Longnose skate* | 2902 | 2774 | 41% | 47% | 32% | 0% | 39% | 45% | 31% | 0% |
| Big skate | 458 | 317.9 | 25% | 23% | 43% | 0% | 17% | 16% | 30% | 0% |
| California skate | 86 | 59.7 | 16% | 20% | 54% | 13% | 11% | 14% | 38% | 13% |
| Leopard shark | 167.1 | 116 | 18% | 28% | 36% | 0% | 13% | 19% | 25% | 0% |
| Ratfish | 1441 | 1000.1 | 7% | 10% | 19% | 0% | 5% | 7% | 13% | 0% |
| Soupfin shark | 61.6 | 42.8 | 12% | 10% | 37% | 0% | 8% | 7% | 26% | 0% |
| Spiny dogfish | 2980 | 2044 | 81% | 66% | 83% | 25% | 56% | 45% | 57% | 0% |
| Aleutian Skate*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Black Skate*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bering/Sandpaper skate*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| All other skates (not in the BB)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Brown cat shark*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

***No estimate of OFL available

**Table 9. Metrics that may be used to evaluate the risk of overfishing for the Other Roundfish Complex. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL, (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC, and (3) percent contribution of the management-unit OFL (i.e., north or south of 40o10' N latitude) OFL to the coastwide OFL. Shaded areas represent potential areas of concern (i.e., higher risk of overfishing).**

| Component Stock | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Finescale codling/Pacific flatnose | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Pacific rattail/grenadier** | 1519 | 1054.2 | 11% | 14% | 10% | 0% | 8% | 10% | 7% | 0% |
| Giant rattail/grenadier | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| All other rattails/grenadiers | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cabezon (WA) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cabezon (OR and CA) | 219 | 210 | 47% | 38% | 37% | 0% | 45% | 36% | 36% | 0% |
| California Scorpionfish* | 126 | 120 | 87% | 67% | 60% | 0% | 83% | 64% | 57% | 0% |
| Kelp Greenling | 118.9 | 82.5 | 90% | 61% | 48% | 0% | 63% | 43% | 33% | 0% |
| All other greenlings*** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

*Managed outside of complex

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

***No estimate of OFL available

**Table 10. Coastwide analysis of metrics that may be used to evaluate the risk of overfishing for species in complexes identified to exceed an ABC or OFL in each complex. Metrics include (1) average annual catch (2011, 2009-2011, and 2004-2011) as a percent of the 2013 ABC and the 2013 OFL and (2) percent of years (N = 8 years) that catch would have exceeded the 2013 OFL or the 2013 ABC.**

| Species | 2013 OFL | 2013 ABC | Percent ABC 2011 | Percent ABC 2009-2011 | Percent ABC 2004-2011 | Percent Years Over ABC 2004-2011 | Percent OFL 2011 | Percent OFL 2009-2011 | Percent OFL 2004-2011 | Percent Years Over OFL 2004-2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aurora Data-Poor | 41.5 | 34.5 | 80% | 132% | 162% | 88% | 67% | 110% | 134% | 75% |
| Aurora Full Assessment 2015 | 91.67 | 87.33 | 32% | 52% | 64% | 0% | 30% | 50% | 61% | 0% |
| Blackgill | 134.7 | 122.6 | 126% | 126% | 97% | 50% | 115% | 114% | 88% | 50% |
| Rougheye Data-Poor | 71.5 | 59.6 | 348% | 396% | 315% | 100% | 290% | 330% | 263% | 100% |
| Rougheye Full Assessment 2015 | 206 | 197 | 105% | 120% | 95% | 50% | 101% | 115% | 91% | 50% |
| Shortraker | 18.8 | 15.7 | 180% | 199% | 166% | 75% | 150% | 166% | 138% | 75% |
| Tiger** | 1 | 0.8 | 201% | 123% | 134% | 63% | 161% | 98% | 107% | 50% |
| Vermilion | 279 | 232.7 | 97% | 78% | 89% | 25% | 81% | 65% | 75% | 13% |
| Black and yellow | 27.5 | 23 | 116% | 121% | 80% | 38% | 97% | 101% | 67% | 13% |
| China | 26.4 | 22 | 150% | 153% | 130% | 88% | 125% | 127% | 109% | 63% |
| Grass | 60.3 | 50.2 | 47% | 39% | 36% | 0% | 39% | 32% | 30% | 0% |
| Olive | 224.9 | 187.6 | 13% | 11% | 20% | 0% | 11% | 9% | 17% | 0% |
| Quillback | 12.8 | 10.7 | 125% | 112% | 135% | 88% | 104% | 93% | 113% | 63% |
| Treefish | 13.4 | 11.1 | 123% | 90% | 70% | 13% | 102% | 75% | 58% | 13% |
| Curlfin sole | 8.2 | 5.7 | 31% | 62% | 186% | 63% | 22% | 43% | 130% | 50% |
| Flathead sole | 35 | 24.3 | 33% | 29% | 124% | 38% | 23% | 20% | 86% | 38% |

**Trace amount caught; i.e., the average catch does not round to 0.1 mt.

GROUNDFISH MANAGEMENT TEAM REPORT – PROPOSED ALTERNATIVES FOR CLASSIFYING STOCKS IN THE GROUNDFISH FISHERY MANAGEMENT PLAN

This report follows up on an earlier report, Agenda Item G.8.b Report 2 ("Report 2"), and further narrows the candidates for potential classification as "in the fishery" or ecosystem component (EC) species in the FMP. Here we also arrange this proposed candidate list into a set of three alternatives. We envision that the Council would adopt these alternatives for review and additional analysis. We describe the approach in more detail below.

*Changes from Report 2*

First, the PSA score for Brown Cat Shark were incorrectly reported in Report 2. The overall score has been corrected here.

Second, we filtered out a number of species in Report 2 because they are thought to occur chiefly in state waters. Here we identified additional species that should have been filtered out on that same reasoning: Bat Ray, Shovelnose Guitarfish, Brown Smoothhound Shark, and Gray Smoothhound Shark.

Also, Leopard Shark was the one FMP species that has been proposed for possible removal of the FMP on the same reasoning that it is caught in state waters. Here we add Kelp Greenling and Cabezon to the candidate list because they too are caught mainly in state waters to a similar degree as those that have been filtered out.

*The Criteria for Identifying Candidates*

Following the approach from Report 2, our intent was to identify candidates for classification by applying basic criteria of total catch over 2007-2011, retention/discard percentages, and Productivity-Susceptibility Analysis (PSA) scores. The proposed candidates are displayed in Table 1.

For FMP species, we first included species with less than 1 mt of average catch over 2007-11. Then for species with more than 1 mt of average catch we included species that were retained less than 50 percent of the time and had PSA scores of ~2.0 or lower. We chose the PSA score range because a score of 1.8, as explained in Report 2, has been identified as signaling a relatively low concern of overfishing. We included stocks with scores higher than that because the PSA scores provide only a general indication of risk and because the scores for each stock could be scrutinized further.

The reason we focused on 50 percent retention is that the National Standard 1 Guidelines recommend that the Council classify target stocks and valuable/desired non-target stocks as "in the fishery." As shown in Table 2 of Report 2, there is somewhat of a natural break in the FMP stocks with stocks either being retained well above or below 50 percent. More scrutiny can be given to each stock in the next stage of the analysis.

Lastly, to get a comparable list of non-FMP species we included every species or species group with at least 1 mt of average catch. We do not have PSA scores for several of these species because we only had time to calculate scores for stocks with an average catch of at least 10 mt (Filetail Cat Shark is the exception: it is assumed to have a score similar to Brown Cat Shark).

*Organization of the Alternatives*

We have arranged the proposed candidate species into three alternatives (Table 1). Their current FMP status is displayed under the No Action alternative.

In essence, the Council's recommendation focused on each candidate stock individually. There are three basic choices for each: (1) in the fishery ("in"); (2) EC Species ("EC"); or (3) removal or continued exclusion from the FMP ("out"). As discussed in Report 2, the main factor to compare and contrast in classifying a stock as in the fishery is the stock's risk of overfishing or overfished status. EC species are those for which that risk is non-concerning yet for which there may be other conservation and management interest (e.g. minimizing bycatch, monitoring for changes in catch or susceptibility to the fishery). And lastly, a recommendation to remove a stock, as NMFS advised the Council with Amendment 24, equates to a determination that conservation and management is not necessary.

As explained in Report 2, the core logic that we are following is the idea that species facing similar conservation and management needs should be similarly classified in the FMP. The three action alternatives we propose here follow slightly different approaches toward achieving that consistency:

- *Alternative 1*: this alternative is intended to provide an inclusive option where we look to catch and PSA scores and propose classifying close cases as "in the fishery" and low vulnerability stocks as EC species.
- *Alternative 2*: in this intermediate approach we propose classifying more of the close cases and low vulnerability stocks as EC species.
- *Alternative 3*: in this narrow or exclusive option, the close cases and the non-target stocks not thought to face a concerning risk of overfishing are removed from the FMP. No EC species are proposed under this option.

If the Council adopts this approach, the GMT would give additional scrutiny to and provide more reasoning for each candidate species or species group.

*Potential Consequences of the EC species Classification*

Before presenting the Alternatives, we imagine there may be some question about the value of an EC species classification or what it might entail. In general, the team has considered them largely as “monitored species”, a classification the Council had used in some other FMPs. As Report 2 discussed, the data used here and in the evaluation of the stock complexes allows monitoring of hundreds of species—not just those included on the candidate list. So the capability could be there to continue regular reporting regardless of any reclassification. Generally, the EC species classification could help guide and prioritize monitoring and reporting efforts by the Science Centers, states, tribes, and others. The team has also discussed the possibility of grouping EC species into complexes to facilitate monitoring and reporting.  It would also clearly delineate which species are not thought to be vulnerable to overfishing in this fishery. Lastly, we understand that other rules might apply to EC species (e.g. caps on landing) but the team has not had time to discuss the need or appropriateness of such measures. The team could provide further discussion in November.

**Recommendation**

- **Adopt the alternatives for review and direct the GMT to provide further analysis in November.**

## Table 1. GMT Proposed Alternatives for Classifying Stocks in the FMP

Table overview: Stocks are grouped for ease of comparison and do not indicate proposed stock complexes. Within each group, stocks are presented in alphabetical order. The groupings are arranged in no particular order. "Other" refers to any other species within the general taxonomic order not reported to species. Abbreviations: in the fishery ("in"), EC Species ("EC"), not in the FMP ("out").

| | Species | PSA score | Catch (avg.) | No Action | Alt. 1 | Alt. 2 | Alt. 3 | Notes |
|---|---|---|---|---|---|---|---|---|
| Skates & Rays | Aleutian Skate | 1.71 | 3 | Out | EC | EC | Out | |
| | Bering/Sandpaper Skate | 1.80 | 70 | Out | In | EC | Out | |
| | Big Skate | 1.99 | 95 | In | In | EC | EC | |
| | Black/Roughtail Skate | 1.68 | 44 | Out | In | EC | Out | |
| | California Skate | 2.12 | 14* | In | In | EC | EC | *Only 29% from FMP sectors |
| | Deepsea Skate | -- | 1 | Out | EC | EC | Out | |
| | Other Skates | -- | 725* | Out | EC | EC | Out | *Unidentified catch |
| | Thornback Skate | -- | 2 | Out | EC | EC | Out | |
| Other Sharks | Leopard Shark | 2.00 | 35* | In | In | EC | Out | *Only 3% from FMP sectors (other than CA Recreational = 82%). |
| | Pacific Black Dogfish | -- | 1 | Out | EC | EC | Out | |
| | Pacific Sleeper Shark | -- | 8 | Out | EC | EC | Out | |
| | Salmon Shark | -- | 1 | Out | EC | EC | Out | |
| | Soupfln Shark | 2.02 | 8* | In | In | EC | Out | *Only 16% from FMP sectors |
| Slickheads | California Slickhead | 1.10 | 28 | Out | EC | EC | Out | |
| | Threadfln Slickhead | -- | 1 | Out | EC | EC | Out | |
| | Other (incl. Tubeshoulders) | -- | 1 | Out | EC | EC | Out | |
| Grenadiers | California Grenadiers | -- | 4 | Out | EC | EC | Out | |
| | Giant Grenadiers | 1.87 | 170 | Out | In | EC | Out | |
| | Other Grenadiers | -- | 135* | Out | EC | EC | Out | *135 mt of unidentified catch. Other species in data all < 1 mt per year. |
| | Pacific Grenadier | 1.82 | 131 | In | In | EC | Out | |
| | | | | | | | | |

| Group | Species | PSA score | Catch (avg.) | No Action | Alt. 1 | Alt. 2 | Alt. 3 | Notes |
|---|---|---|---|---|---|---|---|---|
| Eelpouts | Bigfin Eelpout | -- | 3 | Out | EC | EC | Out | |
| | Twoline Eelpout | -- | 3 | Out | EC | EC | Out | |
| | Other Eelpouts | 1.51 | 43 | Out | EC | EC | Out | |
| Cat Sharks | Brown Cat Shark | 1.84 | 90 | Out | In | EC | Out | |
| | Filetail Cat Shark | -- | 11 | Out | In | EC | Out | |
| | Longnose Cat Shark | -- | 3 | Out | EC | EC | Out | |
| Flatfish | Butter Sole | 1.18 | 1* | In | In | EC | Out | |
| | Curlfin Sole/Turbot | 1.23 | 5* | In | In | EC | Out | *51% from FMP. Has exceeded current OFL/ABC contrib. 2002-2007. |
| | Deepsea Sole | 1.22 | 32 | Out | In | EC | Out | |
| | Flathead Sole | 1.26 | 6* | In | In | EC | Out | *Also exceeded current OFL/ABC levels prior to 2008. |
| | Other Sanddabs | -- | 22* | Out | EC | EC | Out | *Unidentified Sanddab. |
| | Slender Sole | 1.14 | 149* | Out | In | EC | Out | *Only 14% from FMP sectors |
| Rockfish | Bronzespotted Rockfish | 2.12 | 0 | In | In | EC | Out | |
| | Calico Rockfish | 1.46 | 1 | In | In | EC | Out | |
| | Chameleon Rockfish | 2.03 | 0 | In | In | EC | Out | |
| | Dusky Rockfish | 1.72 | 0 | In | EC | EC | Out | |
| | Dwarf Red Rockfish | 1.17 | 0 | In | EC | EC | Out | |
| | Freckled Rockfish | 1.44 | 0 | In | In | EC | Out | |
| | Harlequin Rockfish | 1.94 | 0 | In | In | EC | Out | |
| | Mexican Rockfish | 1.80 | 0 | In | In | EC | Out | |
| | Pink Rockfish | 2.02 | 0 | In | In | EC | Out | |
| | Pinkrose Rockfish | 1.82 | 0 | In | In | EC | Out | |
| | Pygmy Rockfish | 1.42 | 0 | In | In | EC | Out | |
| | Rosethorn Rockfish | 2.09 | 4 | In | In | EC | Out | |
| | Sharpchin Rockfish | 2.05 | 8 | In | In | EC | Out | |
| | Shortbelly Rockfish | 1.13 | 6 | In | In | EC | Out | |
| | Swordspine Rockfish | 1.94 | 0 | In | In | EC | Out | |

| | Species | PSA score | Catch (avg.) | No Action | Alt. 1 | Alt. 2 | Alt. 3 | Notes |
|---|---|---|---|---|---|---|---|---|
| Misc. Fish | Cabezon* | 1.68 | 101 | In | In | In | Out | *Included b/c they're potentially distributed Instate waters |
| | Duckbill Barracudina | -- | 1 | Out | EC | EC | Out | |
| | Finescale Codling/Pacific Flatnose | 1.48 | 13 | In | EC | EC | Out | |
| | Kelp Greenling* | 1.59 | 43 | In | In | In | Out | *Included b/c they're potentially distributed Instate waters |
| | King of the Salmon | -- | 6 | Out | EC | EC | Out | |
| | Longnose Lancetfish | -- | 1 | Out | EC | EC | Out | |
| | Ragfish | 1.80 | 43 | Out | EC | EC | Out | |
| | Snailfish spp. | -- | 5 | Out | EC | EC | Out | |
| | Walleye Pollock | -- | 4 | Out | EC | EC | Out | *Prior to 2007, catch has reached 1,000s of metric tons Insome years |

GROUNDFISH MANAGEMENT TEAM REPORT ON
CONSIDER STOCK COMPLEX AGGREGATIONS

## Introduction

This is the third Groundfish Management Team (GMT) document presented at this Council meeting that provides stock complex alternatives along with a GMT-recommended process for reorganizing groundfish stock complexes. The first GMT document provided background information, a full description of the process, and Slope Rockfish Alternatives (Supplemental GMT Report 5). This statement provides alternatives, rationale, and the process for reorganizing the remaining complexes: Other Fish (cartilaginous fish and other roundfish), Other Flatfish, and Shelf Rockfish. Nearshore rockfish complex was not evaluated by the GMT at this meeting for reasons shown in Supplemental GMT Report 5. The GMT process may be used by the Council to develop its own complex-alternative(s) based on the Council's objectives. A template is provided at the end of each section within this document that may useful as both a summary sheet and a guide to help develop alternatives.

Recommendations to add or remove species from the Fishery Management Plan (FMP) or recommendations to designate Ecosystem Component (EC) species within a complex should be considered while using information provided by Supplemental GMT Report 6. If those recommendations were made prior to creating additional complex alternatives, then those additions/removals/EC designations should be reflected in any newly created alternative below.

## Shelf Rockfish – North and South

Catches in the Shelf Rockfish Complexes North and South of 40°10' N. latitude has remained below the acceptable biological catch (ABC). This is largely due to the Rockfish Conservation Area (RCA) closures on the shelf, which are closed to groundfish fishing gears. Of the 32 species in these complexes, only one was found to have had its component overfishing limit (OFL) exceeded on average: tiger rockfish. However, tiger rockfish has an OFL contribution of 1.0 mt and an ABC contribution of 0.8 mt. The average catch of tiger rockfish for the years 2004 - 2011 has been 1.1 mt. This average overage of 0.1 mt (although 2011 catch was 1.6 mt) suggests that tiger rockfish could benefit from additional research but the GMT feels that it is insufficient reason to consider restructuring the management of the entire shelf rockfish complexes. The GMT discussed tiger rockfish with the Scientific and Statistical Committee (SSC). Our interpretation of their advice is that the risk does not necessarily rise to the level of pulling the stock out of the complex (Agenda Item G.8.b, Supplemental SSC Report, September 2013). The GMT is therefore not proposing any action alternatives and is recommending that no change be made to the north and south shelf rockfish complexes at this time.

## Other Fish

The species comprising the Other Fish complex have disparate life histories, ecological relationships, distributions, and vulnerabilities to overfishing. All the action alternatives and GMT discussion contemplated a complete restructuring of the Status Quo Other Fish complex since that aggregation of disparate stocks does not meet the purpose and need to manage stocks with similar distributions, similar fishery interactions, similar life histories, and similar vulnerabilities to potential overfishing. The cartilaginous fish are comprised of elasmobranches species (e.g., sharks and skates) and chimaeras (e.g., ratfish).

For this document, Other Fish was divided into two groups: (a) cartilaginous fish and (b) other roundfish, similar to that shown by the Council staff analysis in June (Agenda Item F.8.a, Attachment 1, June 2013). In addition, the GMT provided one cartilaginous fish alternative and one roundish alternative in June under Agenda Item F.8.b, Supplemental GMT Report 2, June 2013. Those GMT alternatives are also shown in this section.

In addition to Status Quo and the GMT alternatives that were provided in June, results of our process may be used to create additional alternatives (shown below). The Council may use the results of this process, along with information provided in Status Quo, Cartilaginous Alternative 1, and Roundfish Alternative 1 to create additional alternatives that better fit Council objectives.

**Status Quo Cartilaginous Fish Alternative**

The cartilaginous fish stocks in the FMP, including those managed in the status quo Other Fish complex, are depicted in Table 1.

Table 1. Status quo cartilaginous fish stocks and stock complex.

| **Cartilaginous Fish Stocks** | **Cartilaginous Fish in the Other Fish Complex** |
|---|---|
| **Non-overfished Stocks**<br>Longnose skate | Big skate<br>California skate<br>Leopard shark<br>Ratfish<br>Soupfin shark<br>Spiny dogfish |

**Cartilaginous Alternative 1**

Two species were proposed for individual management by the GMT in June (Agenda Item F.8.b, Supplemental GMT Report 2, June 2013): longnose skate and spiny dogfish. Both species have large OFL contributions relative to the other cartilaginous species, as such these species might inflate the OFL of a complex that included them. Longnose skate and spiny dogfish have OFLs based on Category 1 stock assessments. In this alternative, the remaining species under consideration would be grouped into a (a) Shark and Ratfish Complex and a (b) Skate Complex. There are good reasons for separating the two complexes. The species do not co-occur to a high degree. And species are easily differentiable from one another. At the same time, the conservation need for separation may not be high. In general, cartilaginous species have life histories that are more similar to each other than to bony fishes, making their vulnerability to overfishing somewhat similar. The GMT notes that further research is required on the concept of indicator species for status determination but the SSC supports the possibility that longnose skate could be used as an indicator species for the skate complex (see Agenda Item F.8.b, Supplemental SSC Report).

*Individual management - Coastwide*
Longnose skate
Spiny dogfish

*Shark and Ratfish Complex - Coastwide*
Soupfin shark
Brown cat shark
Leopard shark[#]
Spotted ratfish

[#] could be considered for state-management by California

*Skate Complex - Coastwide*
Aleutian skate
Big skate
Roughtail/black skate
California skate
All other skates
Bering/sandpaper skate

**Cartilaginous Fish Process for Developing Additional Alternatives**

*Step 1*: *Are there any species that the Council desires to add to or drop from the cartilaginous fish complex, or designate as EC species?* See Agenda Item G.8.b, Supplemental GMT Report 6.

*Step 2: Which species in the Status Quo cartilaginous fishes (Table 1) may be vulnerable to overfishing.* For this test, the GMT refers to coastwide catches and coastwide component OFLs/ABCs to assess biological risk of overfishing (see Agenda Item G.8.b, Supplemental GMT Report 5, Appendix B, Table 8, Page 35). The ratio of catch to OFLs or catch to ABCs may suggest vulnerability to overfishing if the catch:OFL ratio exceeds 100 percent.

Spiny dogfish shark:

Catches of spiny dogfish shark during the years 2004-2011 would not have exceeded the 2013 OFL (2,980 mt). Although the maximum catches during that period (2,455 mt and 2,464 mt in 2005 and 2006, respectively) were below the 2013 OFL, those levels of catches would have exceeded the 2013 ABC (2,044 mt) in 2005 (when catch was 2,455 mt) and in 2008 (when catch was 2,464 mt).

The GMT remains cautious for this species because the 2015 OFL and ABC may be lower than values shown in 2013. The GMT reviewed the SSC groundfish subcommittee report on the target spawning potential ratio (SPR) for west coast elasmobranch species (Agenda Item G.7.b, SSC Groundfish Subcommittee Report, September 2013). The new SPR of $F_{SPR50\%}$ will produce a spiny dogfish OFL for 2015 of 2,523 mt, which is lower than the 2013 OFL (2,980 mt) shown in Appendix B (Table 8) that was calculated under the previous SPR of $F_{SPR45\%}$. Although maximum catches during 2004-2011 would not have exceeded that OFL, they approached it.

Under the new SPR, using the status quo p-star (P*) of 0.30, the resulting 2015 ABC would be 1,731 mt. This ABC would have been exceeded during 3 of 8 years between 2004 and 2011. Note the most recent reported catch of spiny dogfish was 1,662 mt in 2010.

*Presumption*: The typical presumption is that for species with full assessments or species that may be at risk of overfishing, stocks may be best managed individually (i.e., out of the complex). However, there have been instances where the Council has chosen to keep species within the complex after weighing the tradeoffs between management practicality and concerns about individual species (e.g., black rockfish in CA and blackgill rockfish south of 40°10' N. latitude). In these instances, management measures, such as harvest guidelines and trip and bag limits, have been used to control catch. The Council should also weigh such factors when considering modifications to the Other Fish Complex.

The Council may decide to remove spiny dogfish from the complex for individual management if there is concern that catch will exceed the OFL. On the other hand, the Council may elect to retain spiny dogfish in one of the complexes shown in Status Quo or in the Cartilaginous Alternative 1. Management measures (e.g., trip limits, closed areas, and RCA adjustments) were analyzed to keep spiny dogfish below its ACL (See 2013-2014 FEIS).

*Considerations*:

- Coast-wide or North/South Management: All species within the Cartilaginous Fish Complex are managed coastwide.
- Co-occurrence: For the species shown under Status Quo, high co-occurrence was suggested between the following species: spiny dogfish-longnose skate, ratfish-longnose skate, ratfish-spiny dogfish, and leopard shark-big skate (see Appendix B in Agenda Item G.8.b, GMT Report 5). Although these data suggest high co-occurrence of spiny dogfish with longnose skate and ratfish, the GMT suggests that behavior and latitudinal differences are sufficiently different that co-occurrence would have a low implication to management if the decision was made to manage spiny dogfish separately.
- Similarity to Other Species: Spiny dogfish are easily identified (Agenda Item G.8.b, GMT Report 3, September 2013).
- Implications to buyers and fishermen: Concerns may include (a) additional bins needed for sorting the new market category, and b) potentially additional constraining species.
- Cost to the management system
- Allocations: 2-year allocations or development of a long-term allocation could be required between the trawl and non-trawl sectors and possibly within trawl.
- IFQ Quota Share: If trip limits and/or RCA adjustments are insufficient to keep catch within the trawl allocation, IFQ may need to be established. Determining the initial allocation at the permit level may be challenging, given the historical discard, therefore alternative allocations schemes may need to be explored.

*Step 3: Potential Inflator Stocks.* The GMT identified ratfish as an inflator species within the Status Quo Other Fish complex. The 2013 OFL for ratfish is 1,441 mt, whereas the next highest OFL in this complex is big skate (458 mt). If spiny dogfish is not removed because of potential risk of overfishing, the Council may also consider removing it from the Status Quo complex because of its disproportionately large OFL contribution to the complex. Note, however, that if spiny dogfish is removed from this complex due to potential risk of overfishing (see above), the remaining species within the Cartilaginous Fish Complex are at low risk of overfishing (Agenda Item G.8.b, Supplemental GMT Report 5, Appendix B, Table 8, Pg. 35). Hence, there may be no pending need to remove ratfish from this complex if spiny dogfish is managed separately. Potential inflator stocks in this complex may be:

- Ratfish
- Spiny dogfish shark

Implications and concerns with managing these stocks individually are similar to those shown at risk of overfishing species above.

**Cartilaginous Fishes**

*Species to add to FMP, delete from FMP, or make EC species:*

- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that may be at risk of overfishing:*

- Spiny dogfish
- Other?

*Select none to all of the following species for individual management that may be considered inflator species:*

- Spotted ratfish
- Spiny dogfish
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following if a new complex is desired:*

- Shark and ratfish complex
- Skate complex
- Other?

**Status Quo Roundfish Alternative**

The roundfish stocks in the FMP, including those managed in the status quo Other Fish complex, are depicted in Table 2.

Table 2. Status quo roundfish stocks and stock complexes.

| Roundfish Stocks | Stock Complex<br>Roundfish in the Other Fish Complex |
|---|---|
| **Non-overfished Stocks**<br>Cabezon (CA)<br>Cabezon (OR)<br>California scorpionfish<br>Lingcod N and S of 40º10'<br>Pacific cod<br>Pacific whiting<br>Sablefish N and S of 36º N. latitude | Cabezon (WA)<br>Finescale codling<br>Kelp greenling<br>Pacific grenadier |

**Other Roundfish Alternative 1**

The Other Roundfish Alternative 1 complex would be managed using coastwide ABCs. Consistent with the Status Quo, California scorpionfish and cabezon in Oregon and California are removed from the complexes and managed separately. The GMT recommends that they continue to be managed individually since they are targeted stocks where catch is currently tracked individually. The remaining roundfish were divided into the Deepwater Roundfish Complex and the Shallow Roundfish Complex due to their disparate depth distributions. The species contained in the Shallow Roundfish Complex (kelp greenling, other greenlings, and cabezon (WA)) are also managed under state fishery regulations.

*Individual Management*
California scorpionfish
Cabezon (Oregon and California, as in status quo)

*Deepwater Roundfish Complex*
Pacific rattail/grenadier
Giant rattail/grenadier
All other rattails/grenadiers
Finescale codling/Pacific flatnose (Consider making this an EC species)
California slickhead (Consider making this an EC species)

*Shallow Roundfish Complex (consider individual management)*
Kelp Greenling
All other greenlings
Cabezon (Washington only)

**Other Roundfish Process for Developing Additional Alternatives**

*Step 1*: *Are there any species that the Council desires to add to or drop from the other roundfish, or designate as EC species?* See Agenda Item G.8.b, Supplemental GMT Report 6, September 2013.

*Step 2: Which species in the roundfish complex (Table 2) may be vulnerable to overfishing.* None of the coastwide catches exceeded coastwide component OFLs/ABCs providing no indication of a biological risk of overfishing (see Agenda Item G.8.b, Supplemental GMT Report 5, Appendix B, Table 9, page 36).

*Presumption*: The typical presumption is that for species with full assessments (i.e., California scorpionfish, cabezon in Oregon and California) may be best managed individually (i.e., out of the complex). However, there have been instances where the Council has chosen to keep species within the complex after weighing the tradeoffs between management practicality and concerns about individual species. In these instances, management measures, such as harvest guidelines and trip and bag limits, have been used to control catch. The Council should also weigh such factors when considering modifications to this complex.

*Considerations*:

- Co-occurrence: Pacific grenadier, giant grenadier and California slickhead were all found to have especially high co-occurrence values and were moderate co-occurrence with Pacific flatnose (Agenda Item G.8.b, Supplemental GMT Report 5, Appendix A, Table 4, page 19). This suggests that low implication of managing the deeper other roundfish separately. The Shallow Other Roundfish did not display strong co-occurrence in the WCGOP data used in the analysis though their depth distribution would imply that they occupy the same depth distribution.
- Similarity to Other Species: Each of the grenadier are similar to one another as are the greenlings, though experienced samplers and fishermen may be able to easily discriminate them.
- Implications to buyers and fishermen: a) additional bins needed for sorting the new market category of Shallow Roundfish and Deeper Roundfish.
- Cost to the management system
- The effects of adding an additional market category and strata on the reliability of the estimates
- Pacific flatnose and California slickhead are being considered for addition to the FMP. These species are candidates for EC species.
- No OFL contributions are available for Pacific flatnose, California slickhead, Cabezon (Washington), giant rattail/grenadier, all other rattails/grenadiers or all other greenlings, which means that catch accrues against the contribution of other component stock OFLs. Thus Pacific grenadier is providing the entire OFL for the deeper other roundfish, while kelp greenling provides the entire OFL for the shallow roundfish. This should be born in mind while considering addressing complex overages inseason or during specifications.

*Step 3: Potential Inflator Stocks*. The GMT identified two stocks that may be considered "inflator stocks" within the other roundfish complex (see Appendix B):

Pacific rattail/grenadier

Kelp greenling

**Other Roundfish**

*Species to add to FMP, delete from FMP, or make EC species:*
- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that may be at risk of overfishing:*
- None
- Other?

*Select none to all of the following species for individual management that may be considered inflator species:*
- Pacific rattail/grenadier
- Kelp greenling
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following if a new complex is desired:*
- Pacific rattail/grenadier-giant rattail/grenadier-other rattails/grenadiers
- Other?

**Flatfish Alternatives**

The status quo flatfish complex and an additional Alternative 1 is provided in this section for flatfish. In addition, results of our process that may be used to create additional alternatives are provided. The Council may use the results of this process, along with information provided in Status Quo, to create additional alternatives that better fit within Council objectives.

**Table 3: Status Quo Flatfish Alternative**

| **Flatfish stocks (coastwide)** | **Flatfish Stock Complex (coastwide)** |
|---|---|
| **Overfished Stocks** | Butter sole |
| Petrale sole | Curlfin sole |
| **Non-overfished Stocks** | Flathead sole |
| English sole | Pacific sanddab |
| Dover sole | Rex sole |
| Arrowtooth flounder | Rock sole |
| Starry flounder | Sand sole |
| | Slender Sole |
| | Deep Sea Sole |

**Flatfish Stock Complex Alternative 1 (coastwide)**

Flatfish Alternative 1 complex would be managed using coastwide ABCs under this alternative. Further, under Alternative 1, several species are removed from the complexes and managed separately (Pacific sanddab and Rex sole) due to the fact that these two species are substantial inflator species, contributing to 91 percent of the complex OFL.

Table 4: Flatfish Stock Complex Alternative 1

| **Flatfish stocks (coastwide)** | **Flatfish Stock Complex (coastwide)** |
|---|---|
| **Overfished Stocks** | Butter sole |
| Petrale sole | Curlfin sole |
| **Non-overfished Stocks** | Flathead sole |
| English sole | Rock sole |
| Dover sole | Sand sole |
| Arrowtooth flounder | Slender Sole |
| Starry flounder | Deep Sea Sole |
| *Pacific sanddab* | |
| *Rex sole* | |

**Other Flatfish Complex Process for Developing Additional Alternatives**

*Step 1*: *Are there any species that the Council desires to add to or drop from the other flatfish, complex or designate as EC species?* See Agenda Item G.8.b, Supplemental GMT Report 6, September 2013.

*Step 2: Which species in the current other flatfish complex (see Status Quo) may be vulnerable to overfishing?* For this test, the GMT refers to coastwide catches and coastwide component OFLs/ABCs to assess biological risk of overfishing (see Agenda Item G.8.b, Supplemental GMT Report 6, September 2013, Appendix B). The PSA scores were not used for this evaluation, because catch relative to OFL is a more reliable indicator for species with OFLs. The ratio of catch to OFLs or catch to ABCs may suggest vulnerability to overfishing if the catch:OFL ratio exceeds 100 percent. However, none of the species in the remaining flatfish stock complex have exceeded their OFL contribution since 2007.

Two species remaining in the flatfish stock complex under Alternative 1 have exceeded their average ABC contributions between 2004 through 2011, curlfin and flathead sole (186 percent and 124 percent of their ABC contributions, respectively).

Curlfin sole: Average coastwide catches relative to 2013 component OFLs/ABCs that curlfin sole exceeded its ABC/OFL contribution during certain years prior to 2007 (Agenda Item G.8.b, Supplemental GMT Report 6, September 2013, Appendix B). Using 2013 component OFLs from a data poor assessment (8.2 mt), the ratio of 2004-2011 average catches to the 2013 component OFL is 130 percent. However, average catches were lower during the 2009-2011 period (43 percent of its component OFL) than during the 2004-2011 period. The distribution of curlfin sole is well distributed north and south of 40° 10' N. latitude, and rarely encountered outside of 100 fm (Appendix A). Given that curlfin sole have not exceed its OFL contribution since 2007, managing them within a coastwide flatfish sole complex may be sufficient to control catch (with substantial inflator species, Pacific sanddabs and rex sole removed for single species management).

Flathead sole: Coastwide catches relative to 2013 component OFLs/ABCs suggest that flathead sole may have been at slight risk of overfishing during certain years prior to 2006 (Agenda Item G.8.b, Supplemental GMT Report 6, September 2013, Appendix B). Using 2013 component OFLs from a data poor assessment (35 mt), the ratio of 2004-2011 average catches to the 2013 component OFL is 86 percent (124 percent of its component ABC). However, average catches were lower during the 2009-2011 (20 percent of its component OFL, 29 percent of its component ABC) period than during the 2004-2011 period. The distribution of flathead sole is mostly distributed north of 40° 10' N. latitude, although some catch is encountered south of 40° 10' N. latitude. Furthermore, catch is typically inside of 300 fm, with highest concentrations inside of 200 fm (Agenda Item G.8.b, Supplemental GMT Report 5, Appendix A). Given that flathead sole have not exceed its OFL contribution since 2006, managing them within a coastwide flatfish sole complex may be sufficient to control catch (with Pacific sanddabs and rex sole, substantial inflator species removed for single species management).

*Presumption:* The Council may decide to remove both species historically at potential risk to overfishing from the complex for individual management, although given that catch has remained well within ABC/OFL contributions in recent years, catch of these species may be easily managed and tracked by removing the substantial inflator species.

*Step 3: Potential Inflator Stocks.* The Council may consider removing potential inflator stocks from the complexes and managing separately. The GMT generally agreed with discussion presented with the Preliminary Alternatives (Agenda Item F.8.a, Attachment 1, June 2013) regarding potential impacts of inflator stocks to other species within a complex. In other words, the presence of inflator stocks in a complex can increase the risk of overfishing other stocks in the complex since it inflates the complex OFL. The GMT identified three stocks that may be considered "inflator stocks" within the Other Flatfish complex (see Agenda Item G.8.b, Supplemental GMT Report 6, September 2013, Appendix B):

- Pacific sanddab
- Rex sole
- Sand sole

As mentioned above, 91 percent of the status quo flatfish complex OFL is from Pacific sanddab and Rex sole. Furthermore, 98 percent of the status quo flatfish complex OFL is from Pacific sanddab, Rex sole, and Sand sole. Therefore, the Council may find merit in an additional flatfish stock complex Alternative 2 with Pacific sanddab, Rex sole, and sand sole pulled from the complex for single species management.

*Considerations*:

- Implications to buyers and fishermen: Due to market considerations, Pacific sanddab and Rex sole are already frequently separated. Therefore, disruption to fishing vessel and processor operations are not expected by separating these species for single species management.

**Other Flatfish**

*Species to add to FMP, delete from FMP, or make EC species:*
- See Agenda Item G.8.b, GMT Supplemental Statement 6, September 2013 for a complete list of species.

*Select none to all of the following species for individual management that may be at risk of overfishing:*
- Curlfin sole
- Flathead sole
- Other?

*Select none to all of the following species for individual management that may be considered inflator species:*
- Pacific sanddab
- Rex sole
- Sand sole
- Other?

*Or, for stocks that may be at risk of overfishing, or for stocks that may be considered inflator species, or for any other combinations, select none to all of the following if a new complex is desired:*
- Curlfin-flathead
- Butter-curlfin-flathead-rock soles
- Other?

PFMC
09/15/13

Agenda Item G.8.b
Supplementary SSC Report
September 2013

# SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON CONSIDER STOCK COMPLEX AGGREGATIONS

Mr. Dan Erickson provided an overview of the methods the Groundfish Management Team (GMT) plans to use to identify stocks which may be at risk of overfishing and hence which the Council may choose to manage individually, and Mr. Corey Niles outlined how the GMT plans to summarize information which can be used to determine which stocks are "in the fishery".

The summary table developed by the GMT to identify stocks which may be at risk of overfishing included the Productivity-Susceptibility Analysis (PSA) score, the recent average catches for three groups of years relative to the 2013 Acceptable Biological Catch (ABC) and the 2013 Overfishing Limit (OFL), the fraction of years during which the recent average catches have exceeded the 2013 ABC and OFL, and the fraction of the coastwide catch north of 40°10' N. Latitude. The latter statistic provides guidance on the weight which should be assigned to the other statistics for areas north and south of 40°10' N. Latitude. The GMT plans to aggregate the statistics on a coastwide basis for final decision-making. The Scientific and Statistical Committee (SSC) supports the methods selected by the GMT, but recommends that the fractions north and south of 40°10' N. Latitude should be updated using recent data. The SSC also notes that statistics based on the most recent catch level may be more informative, particularly if there is a change in catch over time, given changes in the fishery in recent years.

The GMT highlighted the situation of tiger rockfish. The OFL for this species is 1 mt and has been exceeded frequently. The GMT requested the SSC provide advice on whether a stock such as this should be removed from the complex. The SSC is unable to provide definitive advice in this case, but notes that complexes are intended to account for species whose catches are small and variable. It recommends that focus should be on long-term average catches rather than recent catches for species whose catches are small. For tiger rockfish in particular, knowledge of the range of the stock and its relative density spatially could inform a decision on its treatment.

In relation to deciding which species should be "in the fishery", the GMT plans to categorize species in terms of catch (less or greater than 1 mt), the PSA score, and the percentage retained, and to develop options for selecting species. The GMT is planning to consider a large number of species (approximately 500). The SSC agrees that the factors the GMT plan to consider are useful and appropriate, and suggests that where possible, catches should be compared to survey estimates of abundance, as this may provide some measure of relative risk. However, survey data may not be informative for many of the species under consideration.

PFMC
09/14/13

# TRAWL RATIONALIZATION TRAILING ACTIONS SCOPING, PROCESS, AND PRIORITIZATION

At its September 2010 meeting, the Council began an annual process of considering trailing actions for the trawl rationalization program and intersector allocation, which has continued each year up through the present. These trailing actions address issues of concern which were outstanding as of the completion of the Council's initial work on the program (e.g. rules for the distribution of the quota set aside for the Adaptive Management Program (AMP) and safe harbors from control rules for risk pools), as well as addressing new provisions needed to complete, clarify, or improve the program after its initial implementation. An annual process for developing these trailing actions has been followed under which scoping is conducted in September of each year, alternatives for analysis selected in November, analysis completed over the winter, and preliminary and final action taken at the March and April Council meetings, so that the Secretarial review process and implementation can be completed by the following calendar year. Trailing actions for a particular cycle are generally implemented together in a single combined rule package (Program Improvement and Enhancement Rules, PIE Rules), though after Council final action the rule packages have sometimes been reorganized to facilitate efficient implementation. Information about past trailing actions is provided on the Council website: http://www.pcouncil.org/groundfish/fishery-management-plan/trailing-actions/.

At this meeting, the Council will conduct its third round of scoping on trawl trailing actions. Agenda Item G.9.a, Attachment 1 provides an overview of information to support the Council deliberations, including possible criteria to consider in setting priorities, current workload issues, and a list of possible issues that the Council may wish to prioritize for action during this round of scoping. At the end of the main text of Attachment 1, a template is provided that may aid the Council in its decision process.

There are two matters ripe for Council consideration under this agenda item based on specific advisory body recommendations. As part of the last scoping process (in 2011), the Council convened its Trawl Rationalization Regulatory Evaluation Committee (TRREC) to address the trawl fishery regulatory issues identified at the September 2011 Council meeting. Issues covered in the TRREC report are itemized in Attachment 1 and the full report is provided for reference (Agenda Item G.9.a, Attachment 2). In the summer of 2012, the Council convened a gear workshop to address gear-related issues relevant to the trawl rationalization program. This workshop report was presented at the Council's November 2012 meeting, but no action was taken on the report at that time due to other workload priorities. Issues covered in the gear workshop report are itemized in Attachment 1 and the full report is provided for reference (Agenda Item G.9.a, Attachment 3).

Related to the potential issues summarized in Agenda Item G.9.a, Attachment 1 are two reports provided by National Marine Fisheries Service (NMFS) regarding candidate trailing action matters. The first is a trawl flexibility package that rolls together and prioritizes for consideration measures remaining from the old trip limit framework, which might unnecessarily decrease flexibility, reduce efficiency, or increase regulatory complexity. NMFS identified these measures as part of a broad review of Federal regulations applying to the groundfish trawl fishery, during which they assessed the utility of particular regulations in addressing conservation and management priorities, while taking into account previous Council work on these issues (Agenda Item G.9.b, NMFS Report 1). NMFS Report 1 includes a purpose and need statement drafted to cover the entire trawl flexibility package. The second NMFS report presents some initial ideas to complete the AMP adopted by the Council but delayed through 2014 (Agenda Item G.9.b, NMFS Report 2). NMFS Report 2 deals with alternative annual distributions of the quota pounds (QP) issued for the quota shares (QS) and halibut individual bycatch quota (IBQ) that the regulations reserve for the AMP)(10 percent of all non-whiting QS and halibut IBQ). Currently the QP issued for the AMP QS/IBQ are distributed annually to QS/IBQ holders, in proportion to their QS/IBQ holdings, i.e. distributed based on QS/IBQ percentages. The "pass thru" regulations are scheduled to sunset prior to the 2015 distribution.

As part of the Council's prioritization of actions for the coming cycle, it may wish to consider the impact of new work on the completion of Secretarial review and implementation of past Council actions (see Agenda Item G.9.a, Attachment 1, sections on "Implementation in Progress on Previous Council Actions" (page 2) and "Implementation Delayed on Previous Council Actions" (page 3)).

**Council Action:**

**Set priorities for upcoming trailing action cycle, including guidance on priorities for implementing past actions.**

Reference Materials:

1. Agenda Item G.9.a, Attachment 1: Trawl Trailing Action Scoping Issue Overview.
2. Agenda Item G.9.a, Attachment 2. Trawl Rationalization Regulatory Evaluation Committee Report on Trailing Actions (From 2011).
3. Agenda Item G.9.a, Attachment 3. Trawl Gear Regulation Change Proposals Developed at Trawl Fishery Gear Workshop.
4. Agenda Item G.9.b, NMFS Report 1: Initial Review of Pre- and Post-Trawl Rationalization Regulations.
5. Agenda Item G.9.b, NMFS Report 2: National Marine Fisheries Service Report on the Adaptive Management Program for the Trawl Rationalization Program.
6. Agenda Item G.9.d, Public Comment.

Agenda Order:

a. Agenda Item Overview — Jim Seger
b. NMFS Report — Frank Lockhart
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Prioritize Trailing Actions for the Trawl Rationalization Program.

PFMC
08/23/13

Agenda Item G.9.a
Attachment 1
September 2013

# TRAWL TRAILING ACTION SCOPING ISSUE OVERVIEW

As described in the situation summary, at this meeting the Council will set priorities for work on trawl trailing actions during the upcoming trailing action cycle. This document includes sections identifying possible criteria to use in prioritization, ongoing workload issues and potential issues for scoping based on previous Council discussion and actions, as well as possible issues NMFS and Council staff have become aware of. During this meeting, additional issues for consideration may be raised by Council advisory bodies and the public. At the end of the main text, a decision template is provided which identifies the issues outlined in this document together with an assessment of the relative Council workload associated with each identified issue. Finally, an appendix is provided identifying minor changes and housekeeping corrections to the regulations. These will be implemented without further Council attention unless an issue is identified that requires additional consideration. The housekeeping list may be updated as Council deliberations proceed. In addition, housekeeping items may be added during NMFS implementation and rulemaking.

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## Criteria for Prioritization

The Council may want to consider criteria to use in prioritization of trawl trailing actions. A few possible criteria to consider are:

- Response to litigation.
- Implementation of the original Amendment 20 and 21 provisions.
- Maximizing conservation, social and economic benefits accruing prior to the 5 year review
- Maximizing conservation, social and economic benefits over the long term consistent with the FMP and MSA.

The groundfish FMP goals, in priority order, are:

*Goal 1.* Conservation. Prevent overfishing and rebuild overfished stocks by managing for appropriate harvest levels and prevent, to the extent practicable, any net loss of the habitat of living marine resources.
*Goal 2.* Economics. Maximize the value of the groundfish resource as a whole.
*Goal 3.* Utilization. Within the constraints of overfished species rebuilding requirements, achieve the maximum biological yield of the overall groundfish fishery, promote year-round availability of quality seafood to the consumer, and promote recreational fishing opportunities.

The National standards and FMP goals and objectives can be found at http://www.pcouncil.org/wp-content/uploads/TRatFEIS_chapter_six_June2010.pdf. The goals and objectives for Amendment 20 are as follows.

Goal

*Create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch.*

Objectives

The above goal is supported by the following objectives:
1. Provide a mechanism for total catch accounting.
2. Provide for a viable, profitable, and efficient groundfish fishery.
3. Promote practices that reduce bycatch and discard mortality and minimize ecological impacts.
4. Increase operational flexibility.
5. Minimize adverse effects from an IFQ program on fishing communities and other fisheries to the extent practical.
6. Promote measurable economic and employment benefits through the seafood catching, processing, distribution elements, and support sectors of the industry.
7. Provide quality product for the consumer.
8. Increase safety in the fishery.

Constraints and Guiding Principles

The above goals and objectives should be achieved while the following occurs:

1. Take into account the biological structure of the stocks including, but not limited to, populations and genetics.
2. Take into account the need to ensure that the total OYs and allowable biological catch (ABC) are not exceeded.
3. Minimize negative impacts resulting from localized concentrations of fishing effort.
4. Account for total groundfish mortality.
5. Avoid provisions where the primary intent is a change in marketing power balance between harvesting and processing sectors.
6. Avoid excessive quota concentration.
7. Provide efficient and effective monitoring and enforcement.
8. Design a responsive mechanism for program review, evaluation, and modification.
9. Take into account the management and administrative costs of implementing and oversee the IFQ or co-op program and complementary catch monitoring programs, as well as the limited state and Federal resources available.

## Workload Considerations

Implementation of trawl trailing actions involves the efforts of Council, NMFS and NOAA GC staff. Planning and prioritization of trailing actions for the coming year needs to take into account the full spectrum of groundfish related workload and, in particular, on delayed progress of the Secretarial review and implementation process for actions previously completed by the Council. NMFS provided a report under G.1 on the status of rulemakings in progress for 2013, including those rulemakings listed below under implementation in progress. The following section provides the current implementation status of recommendations previously completed by the Council:

**Implementation in Progress on Previous Council Actions** (see also Agenda Item G.1.b, NMFS Report)

*Whiting Allocation Reconsideration.* While implementation of the rules related to the whiting reconsideration in response to the first lawsuit is complete, there is a second lawsuit on this issue which continues to consume staff time and depending on the outcome may have further repercussions.

*Cost Recovery.* This action would provide for the recovery of a portion of the trawl rationalization program costs. The public comment period on the cost recovery rule closed on March 18. NMFS is currently drafting the final rule and developing the additional processes to implement the program. Cost recovery is expected to commence at the start of 2014. Also, see section below on Council Deliberations delayed for Cost Recovery Committee task.

*Chafing Gear.* This action would allow an increase in the extent to which chafing gear is allowed to cover midwater trawl codends. Proposed rule yet to be published. Implementation is expected for the 2014 season.

*Program Improvements and Enhancement Rule 2 (PIE 2).* This action would:

- Establish quota share (QS) permit application and QS transfer regulations,
- Change the opt-out requirement for quota pound (QP) deficits,
- Eliminate double filing of whiting co-op reports,
- Clarify exceptions for lenders from QS/QP Control Rules
- Revise first receiver site license requirements (FRSL), including site inspection and expiration date,
- Remove the end-of-year ban on QP transfers between vessel accounts,
- Clarify that the processor obligation may be to more than one mothership (MS) permit,
- Remove the term “permit holder” from groundfish regulations and replace with “vessel owner”, “permit owner”, or “owner of a vessel registered to a limited entry permit” as applicable, and
- Revise the process for vessel owners to request a change in vessel ownership.

The proposed rule published and the public comment period closed on August 19, 2013. Implementation is expected by December 15, 2013 for the removal of the ban on end of year trading, and by January 1, 2014 for the remaining actions.

*Observer/Catch Monitoring Rule.* Some actions originally approved by the Council as part of PIE 2 are being packaged separately in an Observer/Catch Monitoring Rule, including permitting for new observer providers and observer safety. Implementation is expected for 2014.

**Implementation Delayed on Previous Council Actions**

For the following issues, the Council has taken final action but Secretarial review and implementation work has not yet started. Once NMFS begins review of Council analyses and implementation work, for the trawl trailing actions NMFS has often brought analysis or implementation questions back to the Council and expects that this will be the case for some of these issues. ***The Council may wish to indicate the relative priority between completing transmission and implementation on these issues and taking up new trailing action issues.***

*Create Risk Pool Safe Harbor Provision for Quota Share/Quota Pound (QS/QP) Control Rules*. Safe Harbors for Risk Pools. At its September 2011 meeting, the Council recommended providing risk pools a safe harbor from the QS control rules. NMFS has not yet reviewed the draft environmental assessment nor scheduled this issue for implementation. NMFS is interested in the Council’s feedback on the urgency of this action given other workload. Because risk pools can operate under existing regulations, NMFS is interested in Council feedback on whether this action might be better addressed after the MSA 5-year review if a need for the action has developed.

*Allow Fixed Gear and Trawl Permit Stacking.* At its April 2012 meeting, the Council recommended allowing a fixed gear permit and a trawl permit to be registered to the same vessel at the same time. NMFS has not yet reviewed the draft analysis. NMFS plans to begin implementation work on this issue over 2014 and may implement through one of several vehicles: a rulemaking that results from the sablefish program review (see Agenda Item G.2) or from the trawl flexibility review (see Agenda Item G.9.b, NMFS Report 2). This issue is related to the sablefish at-sea processing exemption and could be coordinated with that action, but not implemented before that action.

*Remove the Sablefish At-sea Processing Exemption from IFQ Fishery Regulations.* At its April 2012 meeting, as part of its action recommending that it be allowable for fixed gear and trawl permits to be registered to the same vessel at the same time (trawl-fixed gear stacking), the Council recommended that vessels with a sablefish at-sea processing exemption in the limited entry fixed gear primary sablefish fishery should not be allowed to process sablefish at-sea in the trawl IFQ fishery. NMFS plans to begin implementation work on this issue over 2014 and may implement through one of several vehicles: a rulemaking that results from the sablefish program review (see Agenda Item G.2) or from the trawl flexibility review (see Agenda Item G.9.b, NMFS Report 2). This issue could be coordinated with or implemented before the action on fixed gear/trawl permit stacking.

*Change in the Whiting Season Opening Date.* At its November 2012 meeting, the Council recommended moving the shoreside sector primary whiting season opening date to May 15, starting in 2013. NMFS has not yet reviewed the draft analysis or the revised FMP language. NMFS plans to begin implementation work on this issue over 2014 and may implement with any rulemaking that results from the trawl flexibility review (see Agenda Item G.9.b, NMFS Report 2).

## Possible Issues for Prioritization in Upcoming Trailing Action Cycle

### Consideration Initiated but Council Progress Delayed

During an earlier cycle the Council initiated work on the following issues but then delayed further action to accommodate other priorities (in particular, reconsideration of the whiting allocation).

*Regulatory Review and Gear Issues.* In 2011, the Council convened the Trawl Rationalization Regulatory Evaluation Committee (TRREC) to identify regulations which were made obsolete by implementation of the new trawl rationalization program in 2011. The first priority the Council gave to the TRREC was to review regulations related to (a) making it permissible to stack both a limited entry trawl and fixed gear permit on a single vessel at the same time, (b) modifying the season opening date for whiting, (c) allowing vessels to carry multiple gears at the same time, and (d) modifying a number of trawl gear regulations that impair increased efficiency and selectivity. The TRREC met in October 2011 and a report from that meeting is included at Agenda Item G.9.a, Attachment 2. The TRREC report led to a gear regulation workshop in August 2012. That workshop report was provided to the Council at its November 2012 meeting but the Council did not deliberate on it at that time due to other workload issues. The gear workshop report is included at Agenda Item G.9.a, Attachment 3.

The "trawl flexibility" (TFlex) package proposed by NMFS (Agenda Item G.9.b, NMFS Report 2) would review pre and post trawl rationalization regulations to determine which pre-trawl rationalization regulations may need revised or removed given the new program. NMFS review may cover some or all of the types of policy issued addressed by the TRREC and the gear regulation workshop. The following is a listing of issues from the TRREC meeting and gear regulations workshop.

Table 1. Outstanding issues from the TRREC report on its October 2011 meeting and the report on the August 2012 trawl gear workshop on which the Council has not taken final action, potential inclusion in Trawl Flexibility package, and corresponding item numbers in Agenda Item G.9.b, NMFS Report 2 (grey rows are addressed in NMFS Report 2).

| ***Issue from TRREC or Gear Workshop*** | ***TRREC Recommendation*** | ***Addressed by Gear Workshop*** | ***Would be Covered by Council Action on Trawl Flex? Corresponding Item Number in NMFS Report 2.*** |
|---|---|---|---|
| A. Allow multiple trawl gears on board at the same time | Options provided (including option for year-round use of midwater gear coastwide and year-round in RCA north of 40°10') | Options provided | Potentially NMFS Item 11 |
| B. Allow trawl and fixed gear on board at the same time. | Options provided. | Options provided | Potentially NMFS Item 11 |
| C. Trawl gear modifications. | i. Update other midwater gear regs. | | Potentially |
| | ii. Eliminate numerous gear requirements and restrictions. | Yes (reduce min mesh size and eliminate selective flatfish trawl) | Potentially NMFS Items 5-8 |
| D. Identification of other obsolete regulations (TRREC provided a list to consider) | i. Consider elimination of permit length endorsements | Recommended the Council address the length endorsement issue | No |
| | ii. Consider numerous whiting fishery issues (but not sector allocations), including possibility of a year round fishery and processing of waste at sea. | | Potentially NMFS Items 4 and 12 |
| | iii. Consider electronic monitoring for vessel discards | Recommended the Council address the issue | No (Being addressed in a separate Council process) |
| | iv. Consider fishing across management lines (currently not allowed) | | Potentially NMFS Item 21 (bullet 2) |
| | v. Consider revising large and small footrope definitions. | | Potentially NMFS Item 7 |
| E. Moving fixed gear across management lines | Not Addressed | Options provided. | Potentially NMFS Item 21 (bullet 2) |
| F. Require logbooks for fixed gear | | Recommended the Council consider requiring LE and OA FG logbooks | No (Issue affects more than just the trawl sector) |

*Lender Issues other than Safe Harbors.* The topics under this category have been narrowed to the question of whether the NMFS QS tracking system should include a capability that would allow the QS owner and lender to attach lender information to the QS account. The Council has not selected a preliminary preferred alternative for other lender issues. In March 2012, the Groundfish Advisory Subpanel recommended no action on this issue.

*Reconsideration of the Widow QS Allocation.* At its April 2012 meeting, the Council decided to consider reallocation of the widow rockfish QS, now that widow rockfish is rebuilt. At its June 2012 meeting, the Council decided that for widow rockfish QS, the moratorium on QS trading should be continued until the widow rockfish reallocation process is complete or the Council decides not proceed. . Thus, when QS trading for all other species starts in 2014, the QS trading moratorium will continue to remain in place for widow rockfish QS.

*Whiting Surplus QP Carryover Provision.* A workshop was held in November 2012 to explore possibilities for fully implementing whiting surplus carryover in 2013 and a report was presented to the Council at its November 2012 meeting. The Council decided that it will review this issue again during the 5 year program review, scheduled for 2016.

*Non-Whiting Surplus QP Carryover Provision.* As part of its action on the 2013-2014 specifications, the Council adopted a process for the surplus carryover provision for nonwhiting species that includes a NMFS consultation with the Council when determining whether or not to issue carryover. The intent is to provide more assurance that surplus carryover QP will be issued for all nonwhiting IFQ species in the spring of each year. The Council requested further analysis and development of options to ensure that, in the long term, surplus carryover can be implemented with greater certainty.

**Issues for Possible Consideration Identified During Council Discussion**

During previous Council discussions or as part of the Amendment 20 decision, the following have been identified as issues potentially addressed during future trailing action scoping.

- Implement criteria for allocation of **Adaptive Management Program (AMP) QP** (see Agenda Item G.9.b, NMFS Report 1)
- Exempt vessels from **observer coverage when they are testing trawl gear** (catch prohibited)
- Add a vessel monitoring system **declaration code for "transiting with gear stowed"**
- Consider revisions to **weight conversion factors** for fish dressed at sea based on new information (may affect more than just trawl sector)
- Provide **credit for discards** of sablefish and lingcod
- **Extension of QP trading into a following year** (prior to the issuance of surplus carryover).

Of those issues, NMFS has provided a report on the development of alternatives for the AMP program. Additionally, the weight conversion factor consideration affects more than just the trawl IFQ program and so might be best considered as part of a broader process. During this meeting, Council advisory bodies and the public may bring additional issues forward for Council consideration.

**Issues Identified or Packaged by NMFS and Council Staff**

NMFS and Council staff have identified a number of other possible issues for Council consideration. These have been tentatively bundled into two packages for consideration: (1) a Trawl Flexibility Package, and (2) a Miscellaneous Issue Package.

**Issues Covered in Trawl Flex Package**

Potential items that NMFS has identified for the trawl flexibility package are described in Agenda Item G.9.b, NMFS Report 2.

**Miscellaneous Staff Identified Issues**

The following miscellaneous issues have been identified for Council consideration and possible inclusion in the upcoming round of trailing actions.

*Posting of First Receiver Site Licenses.* Add requirement that first receivers possess and display a valid first receiver site license at each processing site. This would be similar to existing requirements at 660.12(d)(1) and 660.25(b)(1)(iii) that require vessels registered to limited entry permits to carry valid permit onboard the vessel.

*Revise At-sea and Shoreside Flow Scale Requirements*. The North Pacific region is currently revising at-sea flow scale regulations because incidences of manipulation were discovered. West coast trawl rationalization program regulations at 660.15 may need to be revised in coordination with revisions to North Pacific regulations. New regulations are required to address the need for daily scale testing criteria for the new shoreside flow scales.

*Revise Length of Time Required for the Trawl Fleet to Retain Records.* Consider revising regulations that require the trawl fleet to retain records for three years and make them available upon request (660.113(a)(2)) to clarify how that works with regulations that require retention of records on board for 15 days into the next cumulative limit period (660.13(c)).

*Carryover When Management Units Change.* The regulations do not cover how carryover should be handled when there is a reallocation as a result of changes in management areas (area subdivision, combination, or line movement)' or subdivision of a species group that cause shifts in the distribution of QS. This issue was identified with the recent geographic subdivision of lingcod and relates to 660.140(c)(3)(vii).

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# Decision Template

The below listing of issues is provided for possible use in a Council motion identifying and prioritizing work for the next round of trawl trailing actions. While considering its prioritization action, the Council may want to keep in mind workload related to existing rulemakings and legal proceedings in progress.

- Whiting Allocation (Pacific Dawn II Legal Challenge)
- Cost Recovery (implementation expected by Jan 1, 2014)
- Chafing Gear (implementation expected in spring 2014)
- Program Improvements and Enhancement Rule 2 (PIE 2) (implementation expected by Jan 1, 2014)
- Observer/Catch Monitor Rule (implementation expected by January 1, 2014)

Table 2. Trailing Action Decision Template (WkLd = Relative workload thru initial implementation, H = Heavy, M= Medium, L = Light).

| **Issues** | WkLd[a/] | Council Action |
|---|---|---|
| **Implementation Delayed on Previous Council Actions** | | **Specify Target Transmission Time Frame** |
| Risk Pool Safe Harbor Provision for Quota Share/Quota Pound (QS/QP) Control Rules. | H | |
| Allow Fixed Gear and Trawl Permit Stacking | M | |
| Including Removal of Sablefish At-sea Processing Exemption from IFQ | L | |
| Move the Whiting Season Opening Date | M | |
| **Consideration Initiated but Council Progress Delayed** | | **Identify Issues to Be Included In Upcoming Trailing Action Process** |
| Regulatory Review and Gear Issues (issues from Table 1 not potentially covered below in Trawl Flex Package) | | |
| C.i. Update midwater trawl gear regulations. | ? | |
| D.i. Elimination of length endorsement | H | |
| D.iii Electronic monitoring | H | Being considered under a separate Council process |
| F. Require logbooks for fixed gear vessels | ? | |
| Lender Issues other than Safe Harbors | M | |
| Reconsideration of the Widow QS Allocation | H | |
| Whiting Surplus QP Carryover Provision | M | Previous Action (Nov 2012): Delay until 2016 |
| Non-Whiting Surplus QP Carryover Provision | M-H | |
| **Issues for Possible Consideration Identified During Previous Council Discussion (or in Amendment 20)** | | |
| AMP | M-H | |
| Exemption from Observer Coverage During Gear Testing | L | |
| Declaration code for "transiting with gear stowed" | L | |
| Weight conversion factors (affects more than trawl) | L | |
| Credit for discards | M | |
| Extension of QP trading into a following year | M-H | |

| Issues | WkLd[a/] | Council Action |
|---|---|---|
| **Issues Packaged or Identified by NMFS and Council Staff** | | |
| Issues Covered in Trawl Flex Package | | |
| WHO can catch and process fish? | | |
| **1. Sablefish at-sea processing exemption** | | Final Action Taken (implementation delayed) |
| **2. One limited entry permit per vessel** | | Final Action Taken (implementation delayed) |
| **3. Number of vessel registration changes per year - permit transfers** | | |
| **4. Processing fish waste at sea** | | |
| WHAT gear can be used to catch the fish? | | |
| Bottom trawl gear configuration | | |
| **5. Mesh size - minimum 4.5"** | | |
| **6. Selective flatfish trawl gear (small footrope)** | | |
| **7. Footrope specifications** | | |
| **8. Chafing gear** | | |
| Midwater trawl gear configuration | | |
| **9. Chafing gear** | | Final Action Taken (implementation in progress) |
| All trawl gear configuration | | |
| **10. None Identified** | | |
| Gear use | | |
| **11. One type of trawl gear onboard per trip. Multiple fixed gear allowed onboard per trip. Can't have trawl and fixed gear onboard per trip.** | | |
| WHEN can fish be caught? | | |
| **12. Primary whiting season (for vessels using midwater gear targeting whiting)** | | Final Action Taken on May 15 Opening (implementation delayed) |
| **13. Time of day - no night fishing for whiting south of 42°** | | |
| WHERE can fish be caught? | | |
| **14. RCAs - midwater gear in the trawl RCA only during whiting primary season** | | |
| **15. RCAs - selective flatfish trawl required shoreward of trawl RCA north of 40°10'** | | |
| **16. IFQ management areas – not more than one on a trip** | | |
| HOW much fish can be caught? | | |
| **17. IFQ species** | | |
| **18. Trip limit species** | | |
| **19. Lingcod size limits** | | |
| **20. Differential gear type trip limits** | | |
| **21. Crossover provisions**<br>• cumulative limits which apply when moving between limited entry and open access<br>• prohibitions on moving between management areas with different trip limits, on a single trip | | |
| Miscellaneous Staff Identified Issues | | |
| Posting of First Receiver Site Licenses | L | |
| Revise At-sea &Shoreside Flow Scale Requirements | ? | |
| Revise Record Retention Requirements | L | |
| Carryover When Management Units Change | L | |

| **Issues** | WkLd[a/] | Council Action |
|---|---|---|
| **Issues Raised During Advisory Body and Public Comment** | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

a/ Level of workload associated with each item is partially dependent on the nature of the alternatives developed.

## Appendix: Housekeeping Issues

The following identifies the types of regulatory modifications that may be implemented as housekeeping measures at the same time regulations are promulgated to implement some of the trawl trailing actions up for consideration. These housekeeping measures will proceed without further Council action unless policy issues are identified which warrant otherwise.

*Revise Observer Coverage Language While in Port.* Observer coverage while in port should apply to "all IFQ species", not "all fish." The prohibition at 660.112(b) is correct, the language at 660.140 needs to be revised:

> (h) Observer requirements —(1) Observer coverage requirements. (i) Coverage. —(A) Any vessel participating in the Shorebased IFQ Program must carry a NMFS-certified observer during any trip and must maintain observer or catch monitor coverage while in port until ~~all fish~~ all IFQ species from that trip have been offloaded. A vessel is exempted from this requirement while remaining docked in port, if the observer makes available to the catch monitor an observer program form reporting the weight and number of those overfished species identified in § 660.112(b)(1)(xiii) that were retained onboard the vessel during that trip and noting any discrepancy in those species between the vessel operator and observer. If a vessel gets underway in port or delivers fish from an IFQ trip to more than one IFQ first receiver, an observer must remain onboard the vessel while the vessel is underway and during any transit between delivery points.

*Revise requirement for Ownershiip Interest Forms (OI's) from vessels registered to MS/CV-endorsed permits.* (Unless they separately operate in the shoreside fishery with a vessel account, and then the OI would be required as part of the vessel account requirements for the shoreside sector only). Revise § 660.25 (b)(4)(vii)(C) to read as follows:

> (C) For a request to change permit ownership for an MS permit or ~~for a request to change a vessel registration and/or change in permit ownership or permit holder~~ for an MS/CV-endorsed limited entry trawl permit, an Identification of Ownership Interest Form must be completed and included with the application form.

# TRAWL RATIONALIZATION REGULATORY EVALUATION COMMITTEE REPORT ON TRAILING ACTIONS (FROM 2011)

The Trawl Rationalization Regulatory Evaluation Committee (TRREC) met October 27, 2011 to address the trawl fishery regulatory issues identified at the September 2011 Council meeting. The consensus recommendations of the group are presented in the following.

**Allowing limited entry trawl and fixed gear permits to be stacked on a vessel**

Recommendation 1: Allow a trawl gear permit to be stacked on a vessel which has a limited entry fixed gear permit(s) and *vice versa* (for example, allow a trawl permit to be stacked on a vessel with up to three fixed gear permits and allow from one to three fixed gear permits to be stacked on a vessel with a single trawl permit), and

a) use the established declaration process to specify for enforcement and monitoring purposes which permit is being used or if fishing is being conducted in the open access fishery, and
b) retain the current permit transfer limitation of once per year.

Rationale: Current regulations prohibit stacking of trawl and fixed gear permits on single vessels. This change would facilitate use of trawl and fixed gear by single vessels that wish to move between the individual fishing quota (IFQ) and limited entry fixed gear fisheries. The current declaration process would be used to notify National Marine Fisheries Service (NMFS) whether the vessel is fishing in the IFQ fishery or in the non-IFQ fixed gear fishery. Permit holders would be limited to the current once per year permit transfer provision in order to minimize administrative costs associated with permit transfer process (though some increase in activity will occur).

The committee noted that it should be permissible to stack trawl and fixed gear permits on the same vessel regardless of whether the first permit placed on the vessel is a trawl permit or a fixed gear permit.

**Allowing multiple gears on board**

Recommendation 2:

a) Remove trawl gear type (bottom and midwater) use and possession (on board) restrictions shoreward and seaward of the Rockfish Conservation Area (RCA), and
b) allow use--with declaration--of mid-water trawl gear for all IFQ species within the RCA and groundfish essential fish habitat (EFH) conservation areas coastwide year round, except whiting would also be subject to whiting regulations. Possession of midwater trawl gear on board within the RCA or groundfish EFH conservation areas would not require declaration, but when midwater gear is used within the RCA or groundfish EFH conservation areas that is the only gear which may be used on the trip.

Rationale: Current trawl regulations define the following trawl gear types: large footrope trawl, small footrope trawl, selective flatfish trawl, and midwater trawl. The permissible use and on board possession for each gear type varies whether fishing north or south of Cape Mendocino (40˚10ʹN. lat.) or shoreward, seaward or within the RCA. The specific gear restrictions can be found at Section 660.130 (c). These regulations were important when vessels were managed based on cumulative trip limits and fleet-wide impacts were modeled. Under trawl rationalization, individuals are accountable for their total fishery impacts and those impacts are observed on every trip and on every vessel. Thus, such specific gear type prohibitions no longer appear to be needed, with the exception that, until changes reflecting individual vessel accountability are made to trawl RCAs, fishing within the RCA should be restricted to mid-water (pelagic) trawl gear to avoid bottom dwelling species and bottom trawl gear should be restricted to waters shoreward of and seaward of the RCA. Under the proposed change, mid-water trawl could be used throughout the Exclusive Economic Zone (EEZ) year round, except for whiting which would be subject to whiting regulations. Fishing with midwater gear is already allowed in groundfish EFH conservation areas subject to other restrictions on the use of such gear. The committee's recommendations would treat possession and use of midwater gear the same both within the RCA and within groundfish EFH conservation areas.

Recommendation 3: Allow possession and use of fixed gear and trawl gear on the same trip subject to a declaration process and either:

Suboption 1 – The more restrictive RCA regulations, or
Suboption 2 – Gear and catch area reporting by the onboard observer.

Rationale: Current regulations do not allow for the use and possession of fixed gear and trawl gear on the same trip. The proposed change would allow a vessel participating in the IFQ fishery to use both gear types on the same trip, subject to one or the two suboptions described above. The committee believes that this recommendation is similar to others in that it provides flexibility in operations.

The committee emphasizes that progress on Recommendations 1 and 2 (fixed gear/trawl gear permit stacking and trawl gear onboard/usage on a single trip) should not be hindered by work on Recommendation 3 (possession and use of trawl and fixed gear on the same trip).

**Changing whiting season start date**

Recommendation 4: Use a single May 15 start date for all whiting sectors including California fisheries and eliminate the 5 percent California early season whiting fishery cap, to the extent that a fishery management plan (FMP) amendment is not required. This change would be implemented through the two-meeting process already authorized under the framework of the Pacific Coast Groundfish FMP.

Rationale: Current regulations start the at-sea fisheries on May 15 and the shore-based fisheries on June 15, except for the California shore-based fisheries which open either April 1 or April 15, depending on area (see Section 660.131 (b) (2) (iii). The proposed change would simplify the regulations and allow the northern area fisheries to start at the same time as the at-sea vessels. The California fisheries have been relatively dormant in recent years thus the change would be expected to have little impact on those fisheries. Having a uniform start date will provide all sectors a consistent basis on which to plan their operations in the context of other fisheries and provide the shore-based sector with additional flexibility.

**Trawl gear modifications**

Recommendation 5: At the November 2011 Council meeting, adopt for analysis a general alternative to status quo that addresses industry concerns with regard to midwater gear requirements and restrictions including chafing gear regulations in particular. Council staff should work with industry in developing the specifics of the alternative(s) for presentation at the March 2012 meeting so that a final preferred alternative can be adopted at the April 2012 meeting. It may be important as part of this process to develop two sections in the regulations, one that deals with bottom trawl gear and the other that deals with midwater trawl gear. The industry has indicated commitment to working with NMFS and the Council to complete this much needed regulatory change.

Rationale: Current mid-water trawl gear requirements and restrictions were developed many years ago and are no longer appropriate for the current fleet. Many West Coast midwater vessels also fish in the North Pacific Council area which has a substantially different set of gear restrictions. The intent is to update the Pacific Fishery Management Council mid-water trawl regulations to conform to current fishery needs.

Recommendation 6: Eliminate codend, chafing gear, mesh size and selective flatfish trawl gear requirements and restrictions. Retain large and small footrope requirements and restrictions because of the prohibitions on gear use in groundfish EFH (50 CFR 660.130(b)(4)).

Rationale: These regulations can be found at Section 660.130(b). While these regulations were important when vessels were managed based on cumulative trip limits, under trawl rationalization individuals are accountable for their total fishery impacts and such specific gear regulations are no longer needed and may hinder experimentation to develop more biologically and ecologically sound gear configurations.

**Secondary Priority Task**

After completing its work on the above primary priority tasks, the TRREC moved to its secondary priority task: identifying other regulations made obsolete by implementation of the new trawl rationalization program in 2011. In this regard, the TRREC identified the following examples:

- The trawl vessel length (capacity) endorsement may no longer be needed.
- The general whiting fishery management regime (other than the sector allocations) may need reconsideration (e.g. whiting as a year-round fishery, processing of waste at-sea).
- Whether RCAs are still needed for the trawl fishery should be examined.
- Alternatives to the 100 percent observer requirement - such as electronic monitoring – should be considered.
- Allowing fishing in two or more management areas on the same trip should be examined. (In 2012, for example, lingcod allocations will be split at OR/CA border, which will be in addition to the 40˚ 10' based management areas).
- The large and small footrope definitions may need to be modified.

These and other items, yet to be identified, would be issues for future TRREC meetings.

Recommendation 7: The Council should:

a) Prioritize the TRREC recommendations (above) within the current list of workload items, and
b) Schedule additional meeting(s) of the TRREC following the November 2011 Council meeting, as appropriate.

The meeting, which started at 8:00 a.m., was adjourned by Chairperson, Dave Hanson, at approximately 3:00 p.m.

PFMC
11/02/11

# Trawl Gear Regulation Change Proposals Developed at Trawl Fishery Gear Workshop

The trawl gear regulation workshop was held August 29-30, 2012 in Portland, Oregon. The primary purpose of the workshop was to review the gear restrictions (including area of use) that apply under the Trawl Fishery Rationalization program and discuss the need for such restrictions in the context of that program. The workshop included scoping of various gear restriction alternatives that were recommended by the Trawl Rationalization Regulatory Evaluation Committee (TRREC) at the November 2011 meeting of the Pacific Council. The following recommendations are offered for Council consideration for regulation implementation; they basically condense and refine the TRREC recommendations as they relate to current trawl fishery gear restrictions. A listing of the recommended regulation alternatives contained in the report follows (they are numbered based on the issue that they are intended to address; the issues are explained in the text):

The alternatives within each issue are not mutually exclusive.

**Issue 1: Use of Multiple Gears and Expended Area for Midwater Gear**

**Alternative 1a:** Allow expanded use of multiple trawl gear types and midwater trawl on the same trip.

**Option:** Allow year-round use of mid-water gear within and outside the RCA north of $40^{o}$ 10' north latitude.

**Alternative 1b:** Allow use of multiple gear types, midwater trawl and fixed gear types on the same trip.

**Issue 2: Trawl Gear Modifications**

**Alternative 2a:** Reduce minimum mesh size for bottom trawl ½ inch to 4 inches.

**Alternative 2b**: Eliminate the selective flatfish trawl requirement.

**Issue 3: Gear movement across management lines**

**Alternative 3a:** Allow individual fishing quota (IFQ) program vessels to move fixed gear across management lines.

**Issue 1: Allow Multiple Trawl Gear Types to be Onboard Simultaneously and Used on the Same Trip (Derived from TRREC recommendations 2 and 3):** There are two Alternatives under this recommendation: Alternative (1a) :Allows expanded use of multiple trawl gear types and midwater trawl on the same trip. Alternative (1b) : Allows expanded use of trawl gear types, midwater trawl and fixed gear types on the same trip.  These alternatives are explained below.

**Alternative 1a:  Allow expanded use of multiple trawl gear types and midwater trawl on the same trip.**

This option would allow vessels greater flexibility or expanded opportunity to use the various trawl gear types on the same trip [large footrope trawl, small footrope trawl (including selective flatfish trawl), and midwater trawl].  Under this alternative, vessels would be allowed to possess onboard and use all bottom trawl gear types on the same trip, depending on area fished.  On midwater trawl trips declared for the RCA, bottom trawl gear onboard possession would be prohibited.  Catches made with different bottom trawl types on the same trip would not need to be separated in holding bins or during offload, but existing Federal sorting requirements will still apply.  This is because net selectivity differences between the different bottom trawl gear types, with the same minimum mesh size restriction (4 ½ inch between the knots, BK), are believed to be negligible.  However trips on which bottom trawl and midwater trawl was used on the same trip, catches by the two gear classes would need to be kept separate in the vessel hold and at time of offloading so separate landing receipts could be made for the respective gear classes.  New declarations would be required for the following: possessing bottom trawl and midwater gear onboard on the same trip.

Current trawl regulations define the following trawl gear types: large footrope trawl, small footrope trawl, selective flatfish trawl, and midwater trawl. Selective flatfish trawl is a specific type of small footrope trawl.   Restrictions on the use and simultaneous possession for each gear type varies whether fishing north or south of Cape Mendocino (40˚10' N. lat.) or shoreward, seaward or within the RCA. The specific gear restrictions can be found at Section 660.130 (c)(4). The onboard gear type restrictions are shown in Table 1.

**Option:**  Allow year-round use of mid-water gear within and outside the RCA north of $40^{o}$ 10' north latitude.

Bottom trawl gear specific fishing area restrictions would continue in effect but midwater trawl gear for any species would be allowed year round in the entire EEZ (currently only allowed during the primary whiting season and for chilipepper south seaward of the RCA); the proposal here would not affect preseason trip limits and whiting season opening dates.

A new declaration would be required for the following: possessing bottom trawl and midwater gear onboard on the same trip; and midwater fishing in the RCA outside the whiting season.

Table 1. Summary of allowable (yes) and non-allowable (no) onboard gear type combinations for limited entry groundfish trawl vessels

| | Groundfish Trawl/Other Gear Combinations | | Groundfish Trawl Combinations | Bottom Trawl Combinations | |
|---|---|---|---|---|---|
| | Groundfish Trawl[a/] | | Bottom Trawl[c/] | Small Footrope[d/] | Small Footrope (Other than Selective Flatfish) |
| | Combined With | | | | |
| Area/Season | Groundfish Fixed Gear | Non-Groundfish Trawl[b/] | Midwater Trawl | Large Footrope Trawl | Selective Flatfish Trawl |
| S. 40˚ 10’ | No | No | No | No | Yes |
| N. 40˚ 10’ (shoreward) | No | No | No | Yes | No (SFF Only)[e/] |
| N. 40˚ 10’ (seaward) | No | No | No | Yes | Yes |

a/ Groundfish trawl includes all of the gears listed in this table except non-groundfish trawl and groundfish fixed gear.
b/ Shrimp, California halibut, sea cucumber, etc.
c/ Bottom trawl includes small footrope trawl (which includes selective flatfish trawl) and large footrope trawl.
d/ Small footrope includes selective flatfish trawl.
e/ Vessels may not fish shore-ward and sea-ward of the RCA on the same trip with small footrope trawl on the same trip.

The above restrictions were important when vessels targeting non-whiting species were managed based on landings and fleet-wide impacts were modeled. Under trawl rationalization, individuals are accountable for their total catch of groundfish and the catches observed on every trip and on every vessel. Thus, such specific onboard gear type prohibitions, generally, no longer appear to be needed.

The use of individual trawl gear type by area allowed under current regulations is summarized in the following:

- Large footrope trawl may be used coastwide, but only seaward of the RCA.
- Small footrope trawl (including selective flatfish trawl) may be used coastwide seaward of the RCA and shoreward of the RCA south of 40º10’ N. lat.
- Only selective flatfish trawl may be used shoreward of the RCA north of 40º10’.
- Midwater trawl is only allowed seaward of the RCA south of south of 40º10’ N. lat. and throughout the EEZ north of 40º10’ N. lat during the primary whiting season.

With the exception of midwater trawl, no change is recommended to the above area-specific gear type use restrictions. Under the proposed change, mid-water trawl could be used to target groundfish throughout the Exclusive Economic Zone (EEZ) year round including within the

RCAs, except for whiting which would be subject to whiting seasons. Cumulative limits for whiting would continue to restrict whiting catch prior to the start of the whiting season. Midwater trips planned for the EEZ would not allow for onboard possession of bottom trawl gear on the same trip; midwater trips planned shoreward or seaward of the RCA could have bottom trawl gear onboard and be used as described above, so long as catch is separated by gear type.

Fishing with midwater gear is currently allowed in groundfish EFH conservation areas subject to other restrictions on the use of such gear. The recommendation is to continue the allowance for possession and use of midwater gear in the RCAs and within groundfish EFH conservation areas. For now, fishing within the RCA would continue to be restricted to mid-water (pelagic) trawl gear to avoid bottom dwelling species and bottom trawl gear would be restricted to waters shoreward of and seaward of the RCA. Restrictions might be reduced in the future based on individual vessel accountability.

The proposed changes could have negative impacts on law enforcement efforts, including the declaration program. In addition, the proposed changes could have negative impacts on observer, shoreside sampling programs, and states data management programs. It is important to note that fishery samplers both shoreside and at-sea are biologists and not are not present to enforce fishery regulations although their reports might be used after the fact to alert enforcement personnel of possible regulation violators. The impacts on fishery management programs will need to be addressed in the environmental analysis if the Council decides to move forward with this recommendation.

**Alternative 1b: Allow use of multiple gear types, midwater trawl and fixed gear types on the same trip.**

This alternative is the same as Alternative 1a, but, in addition, allows for the onboard possession of fixed gear types (pot and/or longline) on the same trip as trawl gear is possessed. This alternative would allow vessel owners to use trawl gear, as described under Alternative 1a, and fixed gear on the same trip. A new declaration category would likely be required for vessels using trawl and fixed gear on the same trip. For enforcement purposes, the more restrictive RCA boundaries would be required on such trips. It would also likely be required that catches be separated in the hold by gear type (bottom trawl, midwater trawl and each fixed gear type) and weighed separately at time of offloading. This is due to important gear selectivity differences and potential impacts to stock assessment models.

The rationale for the modified trawl gear type possession and use provisions under this alternative are explained under Alternative 1a. Onboard possession of fixed gear types is currently prohibited on trips in which groundfish trawl gear is onboard the vessel (Table 1). Under the IFQ program gear switching provision (§ 660.140(k)), it is now possible for trawl vessels to fish for IFQ allocations using groundfish fixed gear types (pot and/or longline) on the same trip. This alternative would allow vessel owners greater flexibility in harvesting their IFQ allocations, which would likely lead to more efficient use of vessels and gear. It might also likely lead to larger landings which could benefit fish processors by making more efficient use of offloading and processing facilities and human resources. For example, a vessel would be able to use small footrope trawl (including selective flatfish trawl) to catch their shallow water flatfish, deep water groundfish (DTS, slope rockfish), and sablefish using fixed gear on the same trip. The current gear possession and use restrictions were important when vessels were managed based on cumulative trip limits and fleet-wide impacts were modeled. Under trawl rationalization, individuals are accountable for their total groundfish catch and that catch is observed on every trip and on every vessel. Thus, there might be limited need for prohibitions on carrying multiple gear types may.

The proposal here might add more complexity to law enforcement. In addition, the proposed changes could have negative impacts on observers, shoreside sampling, and data management programs, than the previous alternative. The observer program could be affected by reduced work space due to extra gear onboard and observer safety with fixed gear sliding around during rough weather. These complexities would be reduced somewhat by requiring that the more conservative RCA limits would apply. These impacts will be addressed if the Council decides to move forward with this recommendation.

**Issue 2: Trawl Gear Modifications.** There are two alternative under this issue. The TRREC report recommended a broader range of regulation changes than are presented here (TRREC recommendation #6). The alternatives recommended during the workshop relate to (1) minimum mesh size restriction for bottom trawl nets, and (2) the required use of selective flatfish trawl when fishing shoreward of the RCA north of 40º10' N. lat.

**Alternative 2a: Reduce minimum mesh size for bottom trawl ½ inch to 4 inches.** The recommendation here is to reduce the minimum mesh size provision for bottom trawl nets from 4 ½ inches to 4 inches. Minimum mesh size means the smallest distance allowed between the inside of one knot to the inside of the opposing knot, regardless of twine size (Between Knots, BK; § 660.11 Fishing gear (7)). The recommendation is not to remove all minimum mesh size provisions, as recommended by the TRREC, but rather to lower it for bottom trawl nets by ½ inch. The current mesh size restriction (4 ½ BK) was based on a study by Pikitch et. al. (1990 [1] ) who examined gross revenue per trawl hour in the West Coast trawl fishery targeting rockfish and flatfish using various codend mesh sizes . They determined that the small size mesh tested (3 inch BK) increased time spent sorting the catch while the larger mesh size (5 inch) resulted in increased loss of marketable fish.

The reason for the change is to accommodate the inconsistency, reported in the workshop, of available netting in meeting the minimum mesh size requirement of 4 ½ inches in all net sections. As part of this recommendation fishermen should be urged to continue to order or make bottom trawl nets with webbing spacing nominally specified as 4 ½ inches. If the fishermen continue to order the larger mesh-size net there will be less concern with violation of minimum mesh size regulations. However, if fishermen start ordering the smaller mesh size, then the problem with minimum mesh size violations will resurface. Use of the smaller mesh size could also result in increased catch of non-marketable size fish that individuals would be held accountable for in their total catch of groundfish. The impact to law enforcement and other

[1] Pikitch, E., Bergh, M., Erickson, D., and J. Wallace. (1990). Final report on the results of the 1988 West Coast groundfish mesh size study. Fish. Res. Inst., WH-10., Univ. Wash. 98195. Saltonstall-Kennedy Grant #NA88-ABH-00017.
https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/4141/9019.pdf?sequence=1

fishery management efforts would likely be neutral. These will be addressed if the Council decides to move forward with this proposal.

**Alternative 2b: Eliminate the selective flatfish trawl requirement.** Selective flatfish trawl is a type of small footrope trawl that is required shoreward of the RCA north of 40º10' N. lat. The regulation was implemented in 2005 (http://www.pcouncil.org/bb/2007/1107/D6c_ODFW-NWFSC.pdf ). The net construction specifics for this regulation are as follows:

> The selective flatfish trawl is a two-seamed net with no more than two riblines (lines that the run the full length of the net), excluding the codend. The breastline (a line that connects the headrope to the footrope) may not be longer than 3 ft (0.92 m) in length. There may be no floats along the center third of the headrope (a line across the top end of the net) or attached to the top panel except on the riblines. The footrope (the main line across the bottom front end of the net) must be less than 105 ft (32.26 m) in length. The headrope must be not less than 30 percent longer than the footrope (§660.130(b)(5)(i)).

As part of this recommendation, the above wording defining the gear and any linking regulations requiring its use would be removed from regulation. In its place, the small footrope trawl language would apply when fishing shoreward of the RCA north of 40º10' N. lat. (like it is to the south of that area). The main reason for the proposed change stems from the specificity of the regulation: it does not provide for the effective placement of flexible grates to exclude non-target fish species nor does it allow for experimentation with new net designs or net configurations.

The trawl fishery is faced with reduced harvest allowance for Pacific halibut under the IFQ program. Work in Alaska has shown that Pacific halibut bycatch can be reduced by the use of flexible grates in bottom trawl nets. A four seam net is required for proper grate installation but the selective flatfish trawl regulation (above) requires a two-seam trawl. The GMT has reviewed the situation and reported their findings, including four alternatives to addressing the issue (GMT 2011). One of the alternatives is to replace the selective flatfish trawl regulation with a four-seam small footrope trawl regulation requirement (for the area north of 40º10' N. lat). The proposal here is the same as the GMT alternative but without the four-seam element.

This proposal has potential negative biological impacts if catch of canary rockfish, an overfished species, should increase. Ultimately canary rockfish catch is limited by the available QP, however, there could be negative impacts for the fleet as a whole if the gear change resulted in disaster tows (tows with amounts of canary equal to a significant portion of the total shorebased fishery canary allocation). The selective flatfish trawl requirement was aimed at maintaining a nearshore flatfish trawl opportunity while reducing impacts to canary rockfish in the bottom trawl fishery rather than moving the shoreward boundary of the RCAs shoreward. An even greater concern now may be impacts to Pacific halibut, which could impede access to IFQ species allocations if vessel individual bycatch quota (IBQ) for halibut are reached. The potential impacts of the proposed change will be addressed if the Council decides to move forward with this recommendation.

**Issue 3: Fishing Across Management Lines.** This issue was not a high priority action item in the TRREC report, but the Council directed the workshop to scope the issue and see if something can be done about the situation. The situation is that under IFQ program regulations, vessels must land catches in the management area where they were caught before fishing in another management area. Some vessel owners report that the regulation is expensive to their operations, particularly those that fish out of ports in close proximity to a management line. The four IFQ management areas are (660.140 (c)(2)):

1. Between the US/Canada border and 40°10′N. lat.,
2. Between 40°10′ N. lat. and 36° N. lat.,
3. Between 36° N. lat. and 34°27′ N. lat., and
4. Between 34°27′ N. lat. and the US/Mexico border

The species management lines that correspond to the above areas are shown in Table 2. It shows that 12 of the 25 IFQ species or species groups are managed relative to on one of the above management lines.

Table 2: Management lines used for IFQ Species (50 CFR 660.140) 1/

| | |
|---|---|
| **Roundfish** | **Rockfish** |
| Lingcod. | Pacific ocean perch S. of 40°10′ |
| Pacific cod. | Widow rockfish. |
| Pacific whiting. | Canary rockfish. |
| Sablefish north of 36° N. lat. | Chilipepper rockfish S. of 40°10′ |
| Sablefish south of 36° N. lat. | Bocaccio S. of of 40°10′ |
| | Splitnose rockfish S. of 40°10′ |
| **Flatfish** | Yellowtail rockfish N. of 40°10′ |
| | Shortspine thornyhead N of 34°27′ N. lat. |
| Dover sole. | Shortspine thornyhead S of 34°27′ N. lat. |
| English sole. | Longspine thornyhead N of 34°27′ N. lat. |
| Petrale sole. | Cowcod S. of 40°10′ |
| Arrowtooth flounder. | Darkblotched rockfish |
| Starry flounder. | Yelloweye rockfish |
| Other Flatfish stock complex. | Minor Rockfish slope complex N. of 40°10′ |
| Pacific halibut (IBQ) N of 40°10′ | Minor Rockfish shelf complex S. of 40°10′ |
| | Minor Rockfish slope complex N. of 40°10′ |
| | Minor Rockfish shelf complex S. of 40°10′ |

1/ Species or species groups without north/south latitude designation are managed coastwide)

**Alternative 3a: Allow IFQ program vessels to move fixed gear across management lines.** This alternative would allow vessel owners to move fixed gear across management lines with groundfish on board the vessel after making an appropriate fishery declaration. Vessels that participate in the shorebased IFQ program may fish in only one management area during a trip (660.140 (c)(2)).

This means that vessel operators must offload their catches before fishing, or resetting their gear when fishing with fixed gear, in a different management area. IFQ program trawl vessels are allowed to fish fixed gear for IFQ species as per § 660.112 (b)(3) and declaring their intent before leaving port. Under current regulations if a fisher makes a fixed gear set in area A, they must land their fish before re-setting their gear in area B. Under the proposal here, they would be allowed to pull their gear in area A, reset it in area B and then land the fish caught in area A. The fisher would report the area where the fish were caught at time of landing. To fish across a management line as describe here, the fisher would first have to declare their intent before leaving port to check and move their gear. Thus a new declaration category will be required.

This recommendation does not allow for setting fixed gear in two (or more) management areas at the same time and delivery of the combined catches to a single port. This prohibition is mentioned because the location of catch from each management area cannot be determined when the catches are mixed. Such separation is important for species that are allocated based on management areas such as minor slope rockfish. Also, this recommendation does not address the issue of fishing across management lines using trawl gear. The workshop did not receive sufficient input on this latter issue to make a recommendation.

**Other Recommendations**

- Logbooks are not required for fixed gear fishing under the IFQ gear switching program. A federal action or actions by the coastal states would be required to implement such a program. This is an important action that needs to be moved forward.
- Electronic fishing monitoring technology could enhance enforcement monitoring of fishing activities especially when fixed and trawl gear are used on the same trip. This is another important action item that needs to be moved forward.
- The trawl permit length endorsement and associated permit transfer provisions are no longer needed as vessel capacity is no longer an issue under the IFQ program. However, there may be impacts to non-target species and to target species taken with fixed gear under gear switching that will need to be taken into account.

**References**

GMT. 2011. Groundfish Management Team report on preliminary management measures for 2013-14. Agenda Item E.9.b GMT report 2 November 2011. PFMC, Portland OR 97220. 17p. (http://www.pcouncil.org/wp-content/uploads/E9b_GMT_RPT2_NOV2011BB.pdf)

## APPENDIX A: Excerpt from November 2011 Groundfish Management Team Report: Allowance for Four-Seam Trawls Shoreward of the RCA

**(http://www.pcouncil.org/wp-content/uploads/E9b_GMT_RPT2_NOV2011BB.pdf)**

*Issue*: Allow the use of four-seam trawls shoreward of the RCA to facilitate the use of flexible grates for excluding Pacific halibut from trawl catches. A primary benefit of such a management is reduced catches of Pacific halibut and increase access to shelf flatfishes for the IFQ Program.

*Background*: Prior to 2005, small footrope trawls (and midwater trawls) were allowed shoreward of the RCA. There were no requirements regarding the number of panels (or seams), the breastline height (which approximates the maximum height of the headrope above the footrope), or the length of the headrope for bottom trawls fished shoreward of the RCA (Figure 1). The selective flatfish trawl became a requirement in 2005 north of $40_o$ 10' N latitude when trawling shoreward of the RCA. Modifications to the "typical" small footrope trawl were required for the development of the selective flatfish trawl (see Figure 1) and are described in Federal Pacific Coast Groundfish Regulations (Page 375; September 2, 2011):

(i) Selective flatfish trawl gear. Selective flatfish trawl gear is a type of small footrope trawl gear. The selective flatfish trawl net must be a two-seamed net with no more than two riblines, excluding the codend. The breastline may not be longer than 3 ft (0.92 m) in length. There may be no floats along the center third of the headrope or attached to the top panel except on the riblines. The footrope must be less than 105 ft (32.26 m) in length. The headrope must be not less than 30 percent longer than the footrope. An explanatory diagram of a selective flatfish trawl net is provided as Figure 1 of part 660, subpart D."

The purpose of this design was to reduce the catch of overfished rockfish species (e.g., canary rockfish), while providing access to a portion of the traditional shelf flatfish fishery (see 2005-2006 FEIS). The restricted breastline length ensured that the headrope height was approximately no more than 1 m above the footrope, and the required ratio of headrope length to footrope length provided a "cutback" headrope. Research in Oregon demonstrated that this low-rise trawl with a "cutback" headrope would maintain or increase flatfish catches while reducing catches of certain larger rockfish and roundfish species (including canary rockfish) and Pacific halibut relative to the most common four-seam trawls that were used by the U.S. west coast groundfish fleet at the time (King et al. 2004; Hannah et al. 2005). The reduced catches of rockfishes, other roundfishes, and Pacific halibut was thought to be facilitated by the low and "cutback" headrope because: (a) some fishes may move up and away from the bottom as they encounter the trawl footrope (e.g., Bublitz 1996; Rose 1996), and, (b) some fraction of certain "schooling" species may exceed 1 meter above the bottom as the trawl passes by (e.g., Pacific whiting and canary rockfish).

*Concern and Potential Solution*: Under the current IFQ program, many fishermen are concerned of exceeding their Pacific halibut IBQ before accessing their quota pounds (QP) for target species (see the presentation by Dr. John Gauvin, PFMC, Agenda Item I.7.c, Public Comment, Power Point Presentation, April, 2011). Since the inception of the IFQ Program, fishermen have been experimenting with sorting grates (rigid and flexible) that have been successfully used in Alaska trawl fisheries to reduce the catch of Pacific halibut (e.g., Rose and Gauvin 2000). These grates guide certain species (such as Pacific halibut) out of the trawl at fishing depth (through top or bottom escape panels) while allowing for the retention of species that are smaller and/or that exhibit different behaviors within trawls. Flexible grates are preferable to rigid grates because of ease of handling (e.g., see PFMC, Agenda Item I.7.c, Supplemental Public Comment Power Point, April 2011), and potentially safety concerns.

Although rigid grates may be effectively applied to both four- and two-seam trawls, flexible grates may be ineffective or problematic in two-seam trawls, which are required shoreward of the RCA. The water flow in the back end of a two-seam trawl (e.g., in the areas of the intermediate and codend) may be low, and consequently, these areas of the two-seam net may collapse on occasion during a tow. The result may be reduced halibut escapement or high loss of target species. The water flow throughout four-seam trawls may be higher than two-seam trawls which may result in higher success of flexible sorting grates for excluding Pacific halibut from the catch. Hence, two-seam trawls that are required shoreward of the RCA may not be suitable for the installation of flexible grates.

*Considerations for Further Analysis*: The GMT acknowledges that the limited Pacific halibut IBQ may be a significant constraint for individuals achieving their target species QP, and consequently, the commercial fishery reaching the ACL for many of the trawl-dominant species. Under Amendment 21, the maximum halibut IBQ allowed for the IFQ Program will be 279,570 lbs (round wt, legal + sublegal) until 2014, and 215,054 lbs (round wt, legal + sublegal) thereafter. These values for Pacific halibut IBQ represent a significant reduction to the annual halibut mortality demonstrated by the limited entry trawl fishery prior to the IFQ Program (e.g., approximately 459,000 to 633,000 lbs round weight for the years 2005 to 2009; Heery et al., 2010). Hence, measures may be required to reduce Pacific halibut catch and increase access to target species.

Further analysis of this potential management measure may be possible with low or moderate effort, depending on alternatives. Some considerations for analysis of this potential management measure will include: (a) potential for increased (or decreased) catch of overfished species, (b) improved access to target species, and (c) impact to the habitat (e.g., substrate). With these considerations in mind, potential alternatives that could be analyzed with low to moderate effort include:

- *No Action (Status Quo; Selective Flatfish Trawl)*

- *Alternative 1 (Four-Seam Selective Flatfish Trawl):* Allow four-seam trawls shoreward of the RCA, with all regulated specifications equal to the selective flatfish trawl except the number of seams (four instead of two).

- *Alternative 2 (Four-Seam Cutback Small Footrope Trawl):* Allow four-seam trawls shoreward of the RCA, with **cutback headrope** similar to the selective flatfish trawl. All other gear regulations currently in effect for small footrope trawls remain the same (e.g., small footrope, mesh size, chafing gear, etc). Headrope height is unrestricted.

- *Alternative 3 (Four-Seam Small Footrope Trawl):* Allow four-seam, small footrope trawls shoreward of the RCA. All current gear regulations shown for small footrope trawls would remain in place (e.g., headrope height and the headrope length:footrope length ratio are unrestricted).

- *Alternative 4 (Two-Seam Selective Flatfish Trawl Modified with Four-Seam Intermediate & Codend):* Allow existing two-seam selective flatfish trawl nets to be modified to include a four-seam intermediate and cod-end section.

Alternatives 1 – 3 progressively deviate from the selective flatfish trawl while maintaining all features of the small footrope trawl. Alternative 4 is a combination selective flatfish trawl (2-seam) that is modified to allow four-panel (seam) intermediate and codend that may better facilitate the installation of a flexible grate. Some potential impacts of these alternatives include:

• The alternatives may not significantly impact the habitat (e.g., substrate) relative to status quo because only small footrope trawls are included. The analysis would become more complex if alternatives included large footrope trawls due to their potential impact to the substrate shoreward of the RCA.

• Alternatives 1 – 4 allow four-seam trawls shoreward of the RCA, which will facilitate the use of flexible grates. This action may increase escapement of Pacific halibut from trawls at fishing depth relative to status quo, and subsequently increase access to target species QP.

• Although Alternative 1 may show similar catch rates for overfished species as Status Quo, this alternative would require the most significant modifications to four-seam small footrope trawls that fishermen currently own, and would therefore be most expensive for the fleet to implement. Cost to the fleet decreases with each alternative.
• Catch rates for target species may be significantly higher for alternatives 2 and 3 relative to status quo under equal conditions (i.e., fishing in the same area at the same time).

• Even though catch rates of overfished species may be relatively higher for alternatives 2 and 3 relative to status quo (under equal conditions), the IFQ Program requires 100% observer coverage, and fishermen are individually accountable for constraining catches within their Quota Pounds. This feature of the IFQ Program will likely result in fishermen adjusting their fishing methods to ensure that they remain within their Quota Pounds for overfished species (e.g., tow location and tow duration)

• Alternative 4 may show similar catch rates for overfished species as Status Quo, but would require fewer modifications to develop relative to Alternative 1. Alternative 4 might be a cost-effective solution that would enable fishermen to modify their two-seam selective flatfish trawl nets in a manner that is more compatible with flexible grate halibut excluder designs. This type of modification is common in Bering Sea flatfish trawl fisheries and has achieved successful results.

GMT Recommendation: The range of alternatives that provide for the use of Pacific halibut excluders (grates) could result in increased access to target species while minimizing catch of Pacific halibut, a significant benefit to the IFQ Program. The potential analysis described above could be completed with low to moderate effort since the overall impacts to groundfish would remain within the trawl allocation. That is, any changes to the harvest levels of the IFQ species will be accounted for by existing QPs. For non-IFQ species, changes to trip limits could be accommodated inseason if landings are projected to be greater than the trawl allocation. Further, as noted above, no changes to habitat are anticipated as a result of the proposed alternatives.

**References:**

Bublitz, C.G. 1996. Quantitative evaluation of flatfish behavior during capture by trawl gear. Fisheries Research 25:293-304.

Hannah, R.H., S.J. Parker, and T.V. Buell. 2005. Evaluation of a selective flatfish trawl and diel variation in rockfish catchability as bycatch reduction tools in the deepwater complex fishery off the U.S. west coast. North American Journal of Fisheries Management 25:581-593.

Heery, E, M.A. Bellman, and J. Majewski. 2010. Pacific halibut bycatch in the U.S. west coast groundfish fishery from 2002 through 2009. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112.

King, S.E., R.W.Hannah, S.J. Parker, K.M. Matteson, and S.A. Berkeley. 2004. Protecting rockfish through gear design: development of a selectivie flatfish trawl for the U.S. west coast bottom trawl fishery. Canadian Journal of Fisheries and Aquatic Sciences 61:487-496.

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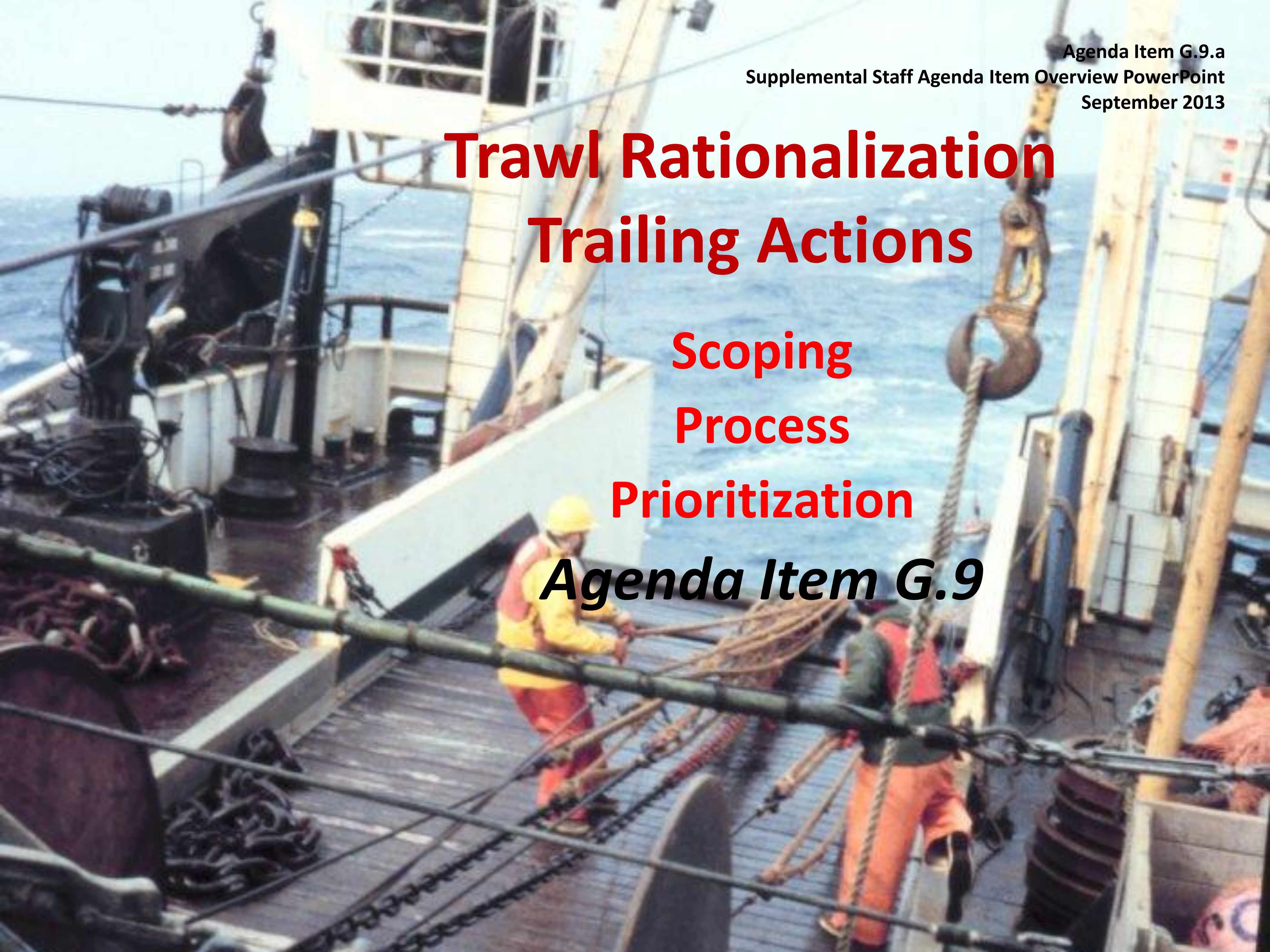
Rose, C.S. and J.R. Gauvin. 2000. Effectiveness of a rigid grate for excluding Pacific halibut, Hippoglossus stenolepis, from groundfish trawl catches. Marine Fisheries Review 62(2):61-66.



Agenda Item G.9.a
Supplemental Staff Agenda Item Overview PowerPoint
September 2013

# Trawl Rationalization Trailing Actions

## Scoping

## Process

## Prioritization

***Agenda Item G.9***

# Council Action

**Set priorities for upcoming trailing action cycle, including guidance on priorities for implementation of past actions.**

# Process the Council has Followed

Sept – Scoping Issues and Alternatives

Nov – Select Alternatives for Analysis

Mar – PPA

Apr – FPA

End of Yr – Implementation

# Previous Cycles

2010 and 2011 –

**September** – select initial list and priorities

**November** – re-prioritize list in context of workload assessment and selected issues and alternatives for analysis

2012 – Trailing Actions Displaced by Pacific Dawn

# Where Things Stand
# G.9.a, Attachment 1

Rules Still in Process ***– 4***

Implementation of Council Action Delayed ***– 4***

Council Consideration Delayed

- TRREC & Gear Workshop Issues (p. 6) ***– 11 (10)***
- Other Issues ***– 4 (3)***

Issues Identified in Council Discussions ***– 6***

Miscellaneous Staff Identified Items ***– 4***

Pacific Dawn II – Uncertain Outcome

The above are summarized on pp. 10-12.

# T-Flex Package

- **NMFS has proposed that the Council proceed under an action guided by a single purpose and need statement related to the goals of the trawl rationalization program**

- This package might cover a number of the issues identified by the TRREC and Gear Workshop (7 potential issues identified)

# Question for Cycles After 2013-2014

**Does the Council maintain**
**trawl rationalization trailing actions**

**or**

**merge them under**
**a general groundfish management**
**workload planning and agenda development item?**

# Process

Sept – Scoping Issues and Alternatives

Council Task: Set priorities

Nov – Select Alternatives for Analysis

Mar – PPA

Apr – FPA

End of Yr – Implementation

## INITIAL REVIEW OF PRE- AND POST-TRAWL RATIONALIZATION REGULATIONS

At the June 2013 Council meeting, NMFS proposed a review of pre and post trawl rationalization regulations for the Council's consideration in September (Agenda Item F.6.b, Supplemental NMFS Report, June 2013). As stated in June, NMFS is supportive of continuing the Council's efforts to revise the regulations and gain flexibility and efficiency in the program. In an effort to implement trawl trailing actions in an efficient manner, NMFS proposes a process where trawl program changes are considered more comprehensively with similar provisions analyzed and implemented together– rather than reviewing regulations one-by-one, each with its own analysis. Figure 1 shows the federal regulations subject to review to assess:

- The utility of particular regulations in addressing conservation and management priorities;
- Whether measures remaining from the old trip limit framework unnecessarily decrease flexibility, reduce efficiency, or increase regulatory complexity and, if so, how those measures might be amended.

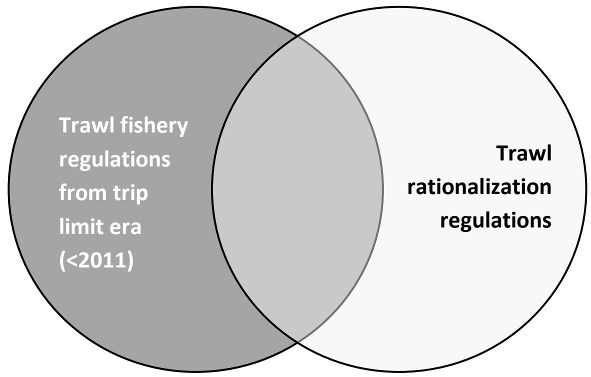



*Figure 1: Current federal trawl regulations subject to review for flexibility, efficiency, and complexity*

NMFS provides the following under scoping for future trawl trailing actions:

- A draft Purpose and Need statement for Council deliberation on an action to increase flexibility, improve efficiency, and reduce regulatory complexity.
- A summary of current trawl regulations that restrict the fishery to start the Council discussion on the scope of this action. In general, the summary of regulations would be organized by the following restrictions: how much fish can be caught, when fish can be caught, where fish can be caught, who can catch (and process) the fish, and what gear can be used to catch the fish.
- A list of corresponding Council recommendations not yet implemented, Trawl Rationalization Regulatory Evaluation Committee (TRREC) recommendations, and gear workshop report recommendations.

The intent of this regulatory review, and any potential action that results, is to refine Amendment 20 as appropriate, to remove unnecessary pre-trawl rationalization regulations, and to determine what revisions need to be done now, what revisions can accompany Amendment 24, and what revisions should wait until after the MSA required 5-year review (beginning in 2016). The expectation is that the Council could make preliminary and final recommendations in March and April of 2014, respectively, with the earliest potential effective date of January 1, 2015.

### *a. Draft Statement of the Purpose of and Need for Action:*

The purpose of this action is to provide more flexibility to the industry to allow for more efficient harvest of their individual allocations, which may result in reduced costs and increased revenues. The need for this action is to better use the individual accountability now in place for participants in the trawl rationalization program. Pre-trawl rationalization regulations that managed the fleet as a whole may need to be updated or may no longer be appropriate for managing the rationalized portion of the Pacific groundfish fishery. With the resource allocated to individuals or cooperatives, with 100 percent monitoring, and with individuals or cooperatives held accountable for the consequences of their decisions, participants would be allowed some additional flexibility in determining when and where to fish and with what gear.

*Background*:
Before implementation of the trawl rationalization program in 2011, regulations governing the groundfish trawl fleet delivering shoreside were built around monthly, bi-monthly, and per vessel trip limits and included a variety of restrictions on fishing practices including gear usage, area of catch, etc. The at-sea fleets (mothership and catcher-processor sectors) were managed primarily using a framework built around staggered season openings and closure on attainment of sector allocations. The trawl rationalization program replaced the need for some, but not all, of the trip limit structure in the regulations and modified regulations for the at-sea fleets. Some of the remaining pre-trawl rationalization regulations may be less efficient and effective under a catch share framework.

The goal of Amendment 20 and the trawl rationalization program was to "create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch" (Amendment 20 EIS, 2010). The program was designed, in part, to reduce fleet capacity and to economically rationalize the groundfish trawl fishery. The trawl fleet is expected to consolidate so that fewer vessels would participate in the fishery. With fewer vessels in the fishery, fishery managers expect increased efficiency in the utilization of fishery resources and lower levels of incidental catch. The program has already shown substantial reductions in annual fleet discard levels. In addition, the trawl fleet may be able to gain additional efficiencies and operational flexibility by removing or revising some pre-trawl rationalization regulations.

The intent of this review and any resulting action is to further the goals of Amendment 20 and the trawl rationalization program consistent with the conservation and management requirements of the MSA and other applicable laws. The review and any resulting action should particularly consider MSA National Standards 5 and 7. National Standard 5 requires the consideration of efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose. National Standard 7 states that conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

### *b. Review of current trawl rationalization program management restrictions & list of any corresponding Council, TRREC, Gear Workshop Report Recommendations*

This initial review of the current trawl rationalization program regulations broadly groups the regulations by management restrictions as follows: <u>how</u> much fish can be caught, <u>when</u> fish can be caught, <u>where</u> fish can be caught, <u>who</u> can catch (and process) the fish, and <u>what</u> gear can be used to catch the fish (Figure 1). The concept behind grouping the management restrictions in this way is to assist in understanding which aspects of fishery management are restricted, to assist in reviewing which restrictions may no longer be necessary given trawl rationalization, and to assist in analyzing revisions to or removal of certain restrictions.


**Figure 1**. Conceptual grouping of trawl program management restrictions

This initial review looks at management restrictions that affect the trawl rationalization program from federal regulations at 50 CFR part 660, subparts C (West Coast Groundfish Fisheries) and D (West Coast Groundfish – Limited Entry Trawl Fisheries). Items in *italics with grey background* would not be reviewed or revised under this action because they are not ripe for review under trawl rationalization program (see the following paragraph), are needed to implement limited access, or are needed to implement the conservation requirements of the MSA or Endangered Species Act. Items in **bold** could potentially be revised or removed consistent with the Purpose of and Need for this action. Where items have a pending Council, TRREC, or gear workshop recommendation, those recommendations are noted in the right-hand column. Items from the Council listed as pending are those on which the Council has taken its final action. The TRREC provided recommendations to the Council at its November 2011 meeting. The Council held a gear workshop in the summer of 2012 with a report provided to the Council in November 2012. This is a preliminary list for review and may not be exhaustive.

New regulations implementing the trawl rationalization program, including restrictions related to catch monitoring, catch reporting, and enforcement, are not considered ripe for review at this time and could be reviewed after the MSA 5-year catch share program review or, if appropriate, as part of electronic monitoring considerations or other Council trailing actions.

| *Management restrictions -*<br>*up for review* | ***Council/TRREC/Gear workshop recommendations*** | ***Management restrictions -***<br>*not up for review* |
|---|---|---|
| **WHO can catch and process fish?** | | |
| 1. **Sablefish at-sea processing exemption** | COUNCIL (Final APR 2012) – remove the sablefish at-sea processing exemption from the IFQ fishery. (Note: linked with #2) | *a. Limited entry permits (permit owners, vessels owners, and vessels registered to permit)*<br>*b. Gear endorsements*<br>*c. Vessel size endorsements*<br>*d. Sector endorsements (mothership catcher vessel (MS/CV), catcher processor (CP))*<br>*e. Quota share (QS) owners/permits*<br>*f. First receiver site licenses*<br>*g. Coop permits*<br>*h. At-sea processing exemptions: non-whiting*<br>*i. Restriction on being a CP and MS in the same year* |
| 2. **One limited entry permit per vessel** | COUNCIL (Final APR 2012) – allow limited entry fixed gear permit and trawl permit to be registered to the same vessel at the same time (Note: allowing multiple gears on a vessel is addressed separately) | |
| 3. **Number of vessel registration changes per year - permit transfers** | | |
| 4. **Processing fish waste at sea** | | |
| **WHAT gear can be used to catch the fish?** [1] | | |
| **Bottom trawl gear configuration** | | |
| 5. **Mesh size - minimum 4.5”** | GEAR WKSHP & TRREC - Reduce minimum mesh size for bottom trawl ½ inch to 4 inches. | |

[1] *FMP Objective 8*. Gear restrictions to minimize the necessity for other management measures will be used whenever practicable. Encourage development of practicable gear restrictions intended to reduce regulatory and/or economic discards through gear research regulated by exempted fishing permit (EFP).

| ***Management restrictions -*** *up for review* | ***Council/TRREC/Gear workshop recommendations*** | ***Management restrictions -*** *not up for review* |
|---|---|---|
| **6. Selective flatfish trawl gear (small footrope)**<br><br>Selective flatfish trawl gear, a type of small footrope trawl, must be a two-seamed net with no more than two riblines, excluding the codend. The breastline may not be longer than 3 ft in length. There may be no floats along the center third of the headrope or attached to the top panel except on the riblines. The footrope must be less than 105 ft in length. The headrope must be not less than 30 percent longer than the footrope. | See "WHERE" for more detail on selective flatfish:<br><br>GEAR WKSHP – Eliminate the selective flatfish trawl requirement and replace with small footrope (like south of 40°10')<br><br>TRREC – Eliminate the selective flatfish trawl requirement. Allow 4 seam nets so excluders can be used. | |
| **7. Footrope specifications**<br><br>Large footrope = >8", <19"<br>Small footrope = ≤8" | | |
| **8. Chafing gear**<br><br>last 50 meshes, 50% circumference, attachment method | | |
| **Midwater trawl gear configuration** | | |
| **9. Chafing gear** | COUNCIL (Final NOV 2012) – Top panel of codend must be uncovered (Note: Pending NMFS implementation in chafing gear rule 2014) | *j. Mesh size - minimum 3" for midwater*<br>k. *No roller or bobbins, bare sweeps* |
| **All trawl gear configuration** | | |
| **10. None Identified** | | *l. Codend - double-walled codend prohibited*<br>*m. Prohibition on beam-trawl* |

| ***Management restrictions -*** *up for review* | | ***Council/TRREC/Gear workshop recommendations*** | ***Management restrictions -*** *not up for review* |
|---|---|---|---|
| **Gear use** | | | |
| **11.** | **One type of trawl gear onboard per trip. Multiple fixed gear allowed onboard per trip. Can't have trawl and fixed gear onboard per trip.** | GEAR WKSHP & TRREC –<br>• allow multiple trawl gear types and midwater on the same trip<br>• allow multiple gear types, midwater, and fixed gear on the same trip | *n. Midwater trawl required for targeting primary season whiting*<br>*o. IFQ can use legal groundfish trawl or non-trawl (gear switching)* |
| **WHEN can fish be caught?** | | | |
| **12.** | **Primary whiting season (for vessels using midwater gear targeting whiting)** | COUNCIL (Final NOV 2012) – May 15 start date for IFQ whiting season. (Note: pending FMP amendatory language).<br>TRREC – consider possibilities for a year round whiting fishery (i.e. January 1 start date). | |
| **13.** | **Time of day - no night fishing for whiting south of 42°** | | |
| **WHERE can fish be caught?** | | | |
| **14.** | **RCAs - midwater gear in the trawl RCA only during whiting primary season** | GEAR WKSHP & TRREC – allow year-round midwater gear (for whiting and non-whiting) within and outside the trawl RCA north of 40º10' N. lat. (Note – this would not change whiting season date.) | *p. EFH Conservation Areas*<br>• *TRREC recommended allowing use of midwater gear in EFH conservation areas*<br>*q. Areas closed to whiting vessels*<br>• *Shoreward of 100 fm in Eureka*<br>• *Ocean salmon conservation zones* |

| *Management restrictions - up for review* | | *Council/TRREC/Gear workshop recommendations* | *Management restrictions - not up for review* |
|---|---|---|---|
| **15.** | **RCAs - selective flatfish trawl required shoreward of trawl RCA north of 40°10’** | GEAR WKSHP – Eliminate the selective flatfish trawl requirement and replace with small footrope (like south of 40°10’)<br><br>TRREC – Eliminate the selective flatfish trawl requirement. Allow 4 seam nets so excluders can be used. | • *Bycatch reduction areas* |
| **16.** | **IFQ management areas – not more than one on a trip**<br>• North of 40°10’<br>• 40°10’ -36°<br>• 36°-34°27’<br>• 34°27’ South | GEAR WKSHP & TRREC - Allow individual fishing quota (IFQ) vessels to move fixed gear across management lines. | |
| **HOW much fish can be caught?** | | | |
| **17.** | **IFQ species** | | *r. Harvest specifications*<br>*s. QS/vessel accumulation limits*<br>*t. Prohibited species/ESA species take limits* |
| **18.** | **Trip limit species** | | |
| **19.** | **Lingcod size limits** | | |
| **20.** | **Differential gear type trip limits** | | |
| **21.** | **Crossover provisions**<br>• cumulative limits which apply when moving between limited entry and open access<br>• prohibitions on moving between management areas with different trip limits, on a single trip | | |

# NATIONAL MARINE FISHERIES SERVICE REPORT ON THE ADAPTIVE MANAGEMENT PROGRAM FOR THE TRAWL RATIONALIZATION PROGRAM

The purpose of this report is to provide NMFS thoughts on the goals and objectives and structure of the Adaptive Management Program. At this point in the program's development, National Marine Fisheries Service (NMFS) would like Council input on the goals and objectives presented below. NMFS plans to bring a more refined analysis before the Council next spring along with the other trawl rationalization items.

In June 2009, the Council recommended as part of Amendment 20 to the Groundfish Fishery Management Plan (FMP) that NMFS establish the Adaptive Management Program (AMP). NMFS approved Amendment 20 and published the Program Components rule on December 15, 2010, which promulgated AMP in regulation (75 FR 78344), setting aside 10% of the non-whiting quota share (QS) to achieve several purposes.

The set aside of AMP QS was implemented to address the following objectives:

1) Community stability;
2) Processor stability;
3) Conservation;
4) Unintended/unforeseen consequences of IFQ management; or
5) Facilitating new entrants.

As we stated in our November 2012 supplemental NMFS report (see Agenda Item I.5.b, Supp NMFS Report) we believe the first two years of the trawl rationalization program have already shown significant conservation benefits, and therefore suggest the AMP be used to address other objectives, focusing on community/processor stability or new entrants. We also believe it would not be inappropriate for the Council's initial action on the AMP to be narrowly focused to ensure timely implementation. However, NMFS envisions this program living up to the stated purposes, and we do not believe a narrow initial implementation would limit future uses of the AMP. Instead, we envision that the AMP will evolve as the trawl rationalization program evolves.

*Alternatives*
Consistent with an initial narrow focus, two formulaic AMP alternatives are discussed: Vulnerable Communities and Principal Port. Similar alternatives were presented in analyses completed by the GMT and Council staff during the development of the trawl rationalization program. NMFS has refined them for this report focusing on several key considerations to minimize the complexity of the initial implementation of AMP. We focused on the program being an automatic action for NMFS each year, to use data that is already collected, to have no additional reporting requirements on harvesters or States, and with the goal of no Council or state actions required after the program is implemented. Although NMFS is focusing on more formulaic and automated actions now, this does not mean that NMFS believes that the AMP should always consist of formulaic and automated actions.

## 1. Vulnerable Communities

### Goals and objectives

*Goal:* The goal of this formula is to provide an incentive for vessels to land their catch in communities that the Council and NMFS determine to be at risk of losing significant landings during the early years of the TIQ program (GMT 2009). Vulnerable communities could be, but would not be limited to, those communities or subset of those communities listed as most vulnerable in the Trawl Rationalization Amendment 20 EIS, see Table 1 below.

*Objectives:* A program with this goal would distribute AMP QP to harvesters that made landings in specified vulnerable communities. Objectives could include preventing the loss of fishing-dependent businesses and related employment and tax revenues supporting port infrastructure.

*Eligibility to receive AMP and formula components:* Vessels that delivered into the most vulnerable ports, as determined by NMFS and the Council, during the previous year or a baseline period, would be eligible to receive AMP QP in the following year. Only non-whiting landings would count for this formula. How the allocation would be calculated and the minimum amount of landings required could include, but is not limited to, the following:

- AMP QP would be allocated to each vessel that delivered at least one landing into a vulnerable port
  - The vulnerable ports would be determined by NMFS and the Council before the start of the program.
  - QP would be distributed equally for each species among all vessels that made at least one landing into a vulnerable port.
- AMP QP would be allocated to each vessel that delivered a predetermined minimum number of landings into at least one vulnerable port.
  - The minimum number of landings and vulnerable ports would be determined by NMFS and the Council before the start of the program.
  - QP would be distributed equally for each species among all vessels that made the minimum number of landings into a vulnerable port.

### AMP QP transferability, duration, and eligibility

AMP QP will operate under the same regulations as non-AMP QP. Under this formula, eligibility would match requirements for QP and restrictions on transferability would follow current regulations.

Because this formula would be based on actions taken in the previous year or baseline period, it may be useful to align the allocation of AMP for more than one year at a time. For example, the qualifying period to receive AMP could be the two years prior to AMP implementation and would then be allocated for two years. This would reduce the complexity of a single year allocation because NMFS would not have to calculate and distribute AMP QP each year. It would also give recipients more certainty in making business decisions.

### Decision-making structure

The decision making structure under this formula enables NMFS to make the determination of AMP QP eligibility and substantially reduces or eliminates regular decision-making. Any entity that meets specific criteria established by the Council and NMFS, would automatically receive AMP quota, divided up among recipients according to a pre-set formula (CSWP 2009).

## 2. Principal Port

### Goals and objectives

*Goal*: The goal of this formula is to reduce potential delivery shifts by providing an incentive for harvest to continue delivering to their "principal port".

*Objectives*: A program with this goal would incentivize harvesters to land into the same ports year after year, with the objective of creating stability in coastwide landings or minimizing delivery shifts.

*Eligibility to receive AMP and formula components:* Vessels that maintained delivery into their principal port from the previous year or a predetermined baseline period, would receive AMP QP for that year or as mentioned above for two years. Principal port is defined as the port where a vessel made its largest overall tonnage of landings in a baseline year or baseline period. Landings would include only non-whiting landings.

The amount of AMP QP the vessel would receive after fulfilling the principal port requirement, could be based on, but is not limited to:

- Pro-rata to their percentage of coastwide landings in the previous year
- Pro-rata to their used and unused QP at the end of the previous year
- Pro-rata to their initial allocation for each species
- Divided equally among all vessels that maintained their principal port

### AMP QP transferability, duration, and eligibility

AMP QP will operate under the same regulations as non-AMP QP. Under this formula, eligibility would match requirements for QP and restrictions on transferability would follow current regulations.

Because this formula would be based on actions taken in the previous year or baseline period, it may be useful to align the allocation of AMP for more than one year at a time. For example, the qualifying period to receive AMP could be the two years prior to implementation and would then be allocated for two years. This would reduce the complexity in a single year allocation because NMFS would not have to calculate and distribute AMP QP each year. It would also give recipients more certainty in making business decisions.

### Decision-making structure

The decision making structure under this formula enables NMFS to make the determination of AMP QP eligibility and substantially reduces or eliminates regular decision-making. Any entity that meets specific criteria established by the Council and NMFS, would automatically receive AMP quota, divided up among recipients according to a pre-set formula (CSWP 2009).

## Monitoring and evaluation process, program review

Several different monitoring tools will be necessary for this program depending on the information NMFS and the Council want to track. If the program is based on a formula and the only information NMFS and the Council want to know each year is what AMP recipients qualified for AMP again no inseason tracking would be necessary. Also with a formula, if NMFS and the Council wanted to know how AMP was transferred and whether or not it was used by the original recipient, additional tracking would be required. Both kinds of tracking would help evaluate whether or not the program was incentivizing the behavior it was intended to, however tracking the how the AMP QP is transferred gives more detail and would require increased NMFS programming. Other types of monitoring may also be necessary.

Should the program transition to a more proposal-based system, increased monitoring would be necessary to see if the AMP QP was being use for the intended purposes.

Finally, NMFS anticipates periodic review of the overall AMP, with the Council, to decide if the goals and objectives are being met and whether those goals need to be changed.

## For the future:

The following is a list of items NMFS will address through further analysis on the program. However, we acknowledge this list does not contain all the details that need to be addressed before implementation.

- Approve goals and objectives and select formula
- Baseline years for AMP qualification. Considerations are the same for principal port and vulnerable communities formula
- Monitoring and evaluation process, program review
- Timing of AMP QP distribution each year
- Would AMP be exempt from vessel accumulation limits
- Does AMP count towards carryover

NMFS believes this program will evolve as the trawl rationalization program evolves. Therefore, the ideas presented in this report are not meant to exclude any changes to the program design in the future. Rather, NMFS looks forward to exploring new and innovative designs for the AMP.

### Tables

The following tables are provided to show the communities/ports and data that might be used in the design of AMP. No analysis has been completed at this time showing how many vessels would receive AMP QP under the principal port formula or which ports would be affected.

Table 1. Vulnerable communities from Trawl Rationalization EIS (Table 3-69).

| | **Dependence on Groundfish**[1] | **Lack of Resilience**[2] |
|---|---|---|
| Most vulnerable communities (medium dependence, least resilience) | | |
| **Neah Bay** | 2 | 5 |
| **Moss Landing** | 2 | 4 |
| Relatively lower dependence, but low resilience | | |
| **Ilwaco** | 1 | 3 |
| Relatively higher dependence, medium resilience | | |
| **Bellingham** | 3 | 2 |
| **Astoria** | 3 | 2 |
| **Coos Bay** | 3 | 2 |
| **Crescent City** | 3 | 2 |
| **Eureka** | 3 | 2 |
| **Fort Bragg** | 3 | 2 |
| Relatively higher dependence, higher resilience | | |
| **Newport** | 3 | 1 |
| **Morro Bay** | 3 | 1 |
| Medium dependence but higher resilience | | |
| **Westport** | 2 | 1 |
| Relatively lower dependence and relatively higher resilience | | |
| **Warrenton** | 1 | 1 |
| Higher dependence, but high resilience (not considered "vulnerable") | | |
| Brookings | 3 | 0 |
| San Francisco | 3 | 0 |
| Low dependence, high resilience (not considered "vulnerable") | | |
| Anacortes | 0 | 0 |
| Seattle | 1 | 0 |
| Hammond | 1 | 0 |
| Half Moon Bay | 1 | 0 |

Table 3 from NMFS Annual catch Report for the Pacific Coast Groundfish Shorebased IFQ Program in 2012 (Agenda Item D.2.a, April 2013). Annual landings and revenue, distributed by port group, for non-whiting trips (top) and directed whiting trips (bottom), in the Shorebased IFQ Program, for 2011 and 2012. Port groups are arranged by latitude. Columns labeled "percent" express either 2012 landings or revenue (corresponding to the column appearing to left) as a percent of 2011 values. Columns labeled "dist." show the distribution of annual landings or revenue among port groups (%).

| **Port group (non-whiting trips)** | **2011 landings** | **2012 landings** | **2011 dist.** | **2012 dist.** | **Land. difference** | **Land. percent** | **2011 revenue** | **2012 revenue** | **2011 dist.** | **2012 dist.** | **Rev. difference** | **Rev. percent** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bellingham, Blaine, Neah Bay, La Push | 1,185,687 | 1,500,658 | 3% | 4% | 314,971 | 127% | 816,996 | 977,857 | 2% | 3% | 160,861 | 120% |
| Westport | 162,774 | 494,278 | 0% | 1% | 331,504 | 304% | 450,500 | 680,484 | 1% | 2% | 229,984 | 151% |
| Ilwaco, Chinook | 2,882,683 | 2,809,640 | 7% | 7% | -73,043 | 97% | 3,051,630 | 1,700,006 | 9% | 6% | -1,351,624 | 56% |
| Other or unknown Washington ports | 130,220 | | 0% | 0% | -130,220 | 0% | 127,621 | | 0% | 0% | -127,621 | 0% |
| Astoria | 15,398,437 | 14,929,115 | 38% | 37% | -469,322 | 97% | 8,567,173 | 9,338,689 | 26% | 31% | 771,516 | 109% |
| Newport, Tillamook, Garibaldi | 2,759,574 | 3,590,916 | 7% | 9% | 831,342 | 130% | 4,538,783 | 4,935,313 | 14% | 16% | 396,530 | 109% |
| Charleston (Coos Bay), Winchester Bay | 4,665,899 | 4,744,945 | 11% | 12% | 79,046 | 102% | 3,187,748 | 3,171,837 | 10% | 10% | -15,911 | 100% |
| Brookings, Crescent City, Port Orford | 2,833,395 | 2,752,902 | 7% | 7% | -80,493 | 97% | 2,021,490 | 2,177,826 | 6% | 7% | 156,336 | 108% |
| Eureka | 4,671,640 | 4,159,850 | 12% | 10% | -511,790 | 89% | 3,355,484 | 2,753,363 | 10% | 9% | -602,120 | 82% |
| Fort Bragg | 2,897,221 | 2,623,714 | 7% | 6% | -273,507 | 91% | 2,570,326 | 1,916,710 | 8% | 6% | -653,616 | 75% |
| San Francisco, San Mateo, Oakland, Princeton (Half Moon Bay), Santa Cruz, Bodega Bay | 869,663 | 621,684 | 2% | 2% | -247,979 | 71% | 878,513 | 476,211 | 3% | 2% | -402,302 | 54% |
| Moss Landing, Monterey, Morro Bay, Avila, Santa Barbara | 2,152,997 | 2,664,560 | 5% | 7% | 511,563 | 124% | 3,369,670 | 2,324,466 | 10% | 8% | -1,045,203 | 69% |
| Sum | 40,610,190 | 40,892,262 | 100% | 100% | 282,072 | 101% | 32,935,934 | 30,452,763 | 100% | 100% | -2,483,170 | 92% |

[1] Number of times the city scored in the top one-third of commercial groundfish dependency indicators in the Quigley study

[2] Number of times the city scored in the top one-third (least resilient) of resiliency indicators in the Quigley study

**Agenda Item G.9.b**
**Supplemental NMFS PowerPoint**
**September 2013**

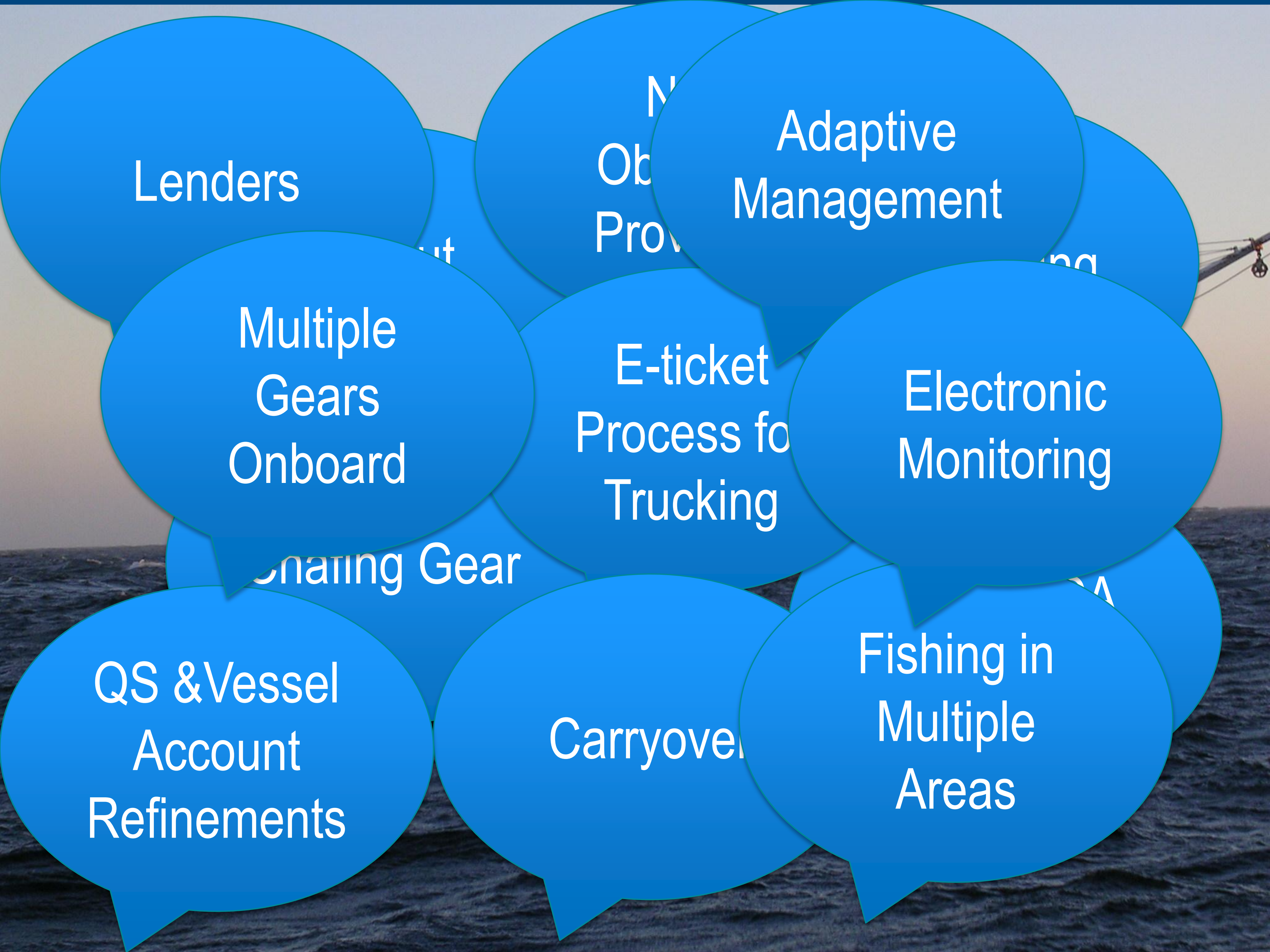
NOAA FISHERIES
Northwest Region

# Flexibility and Efficiency in Groundfish Trawl Regulations

Agenda Item G.9.b

NMFS Report 1

September 16, 2013


Lenders
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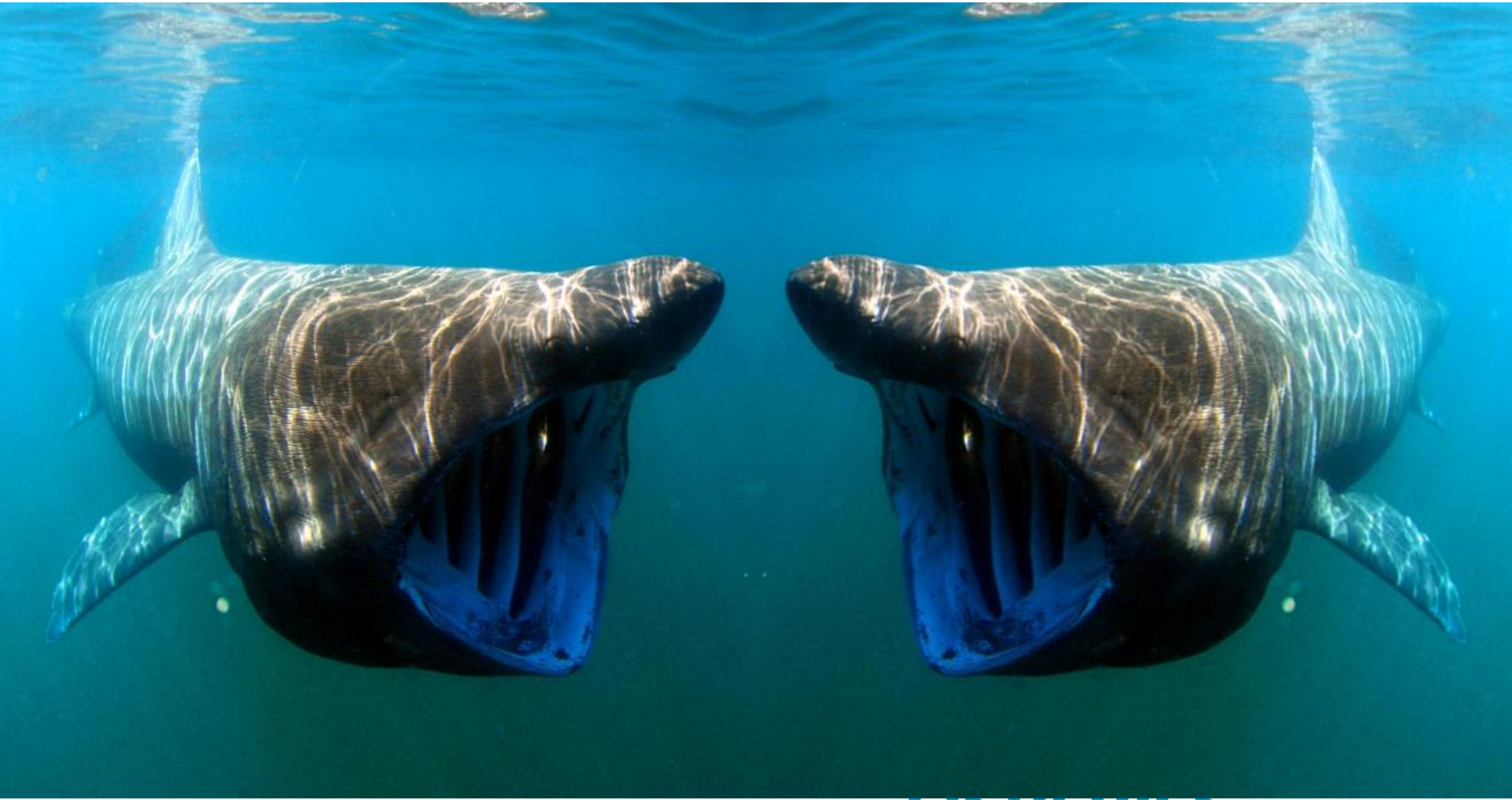
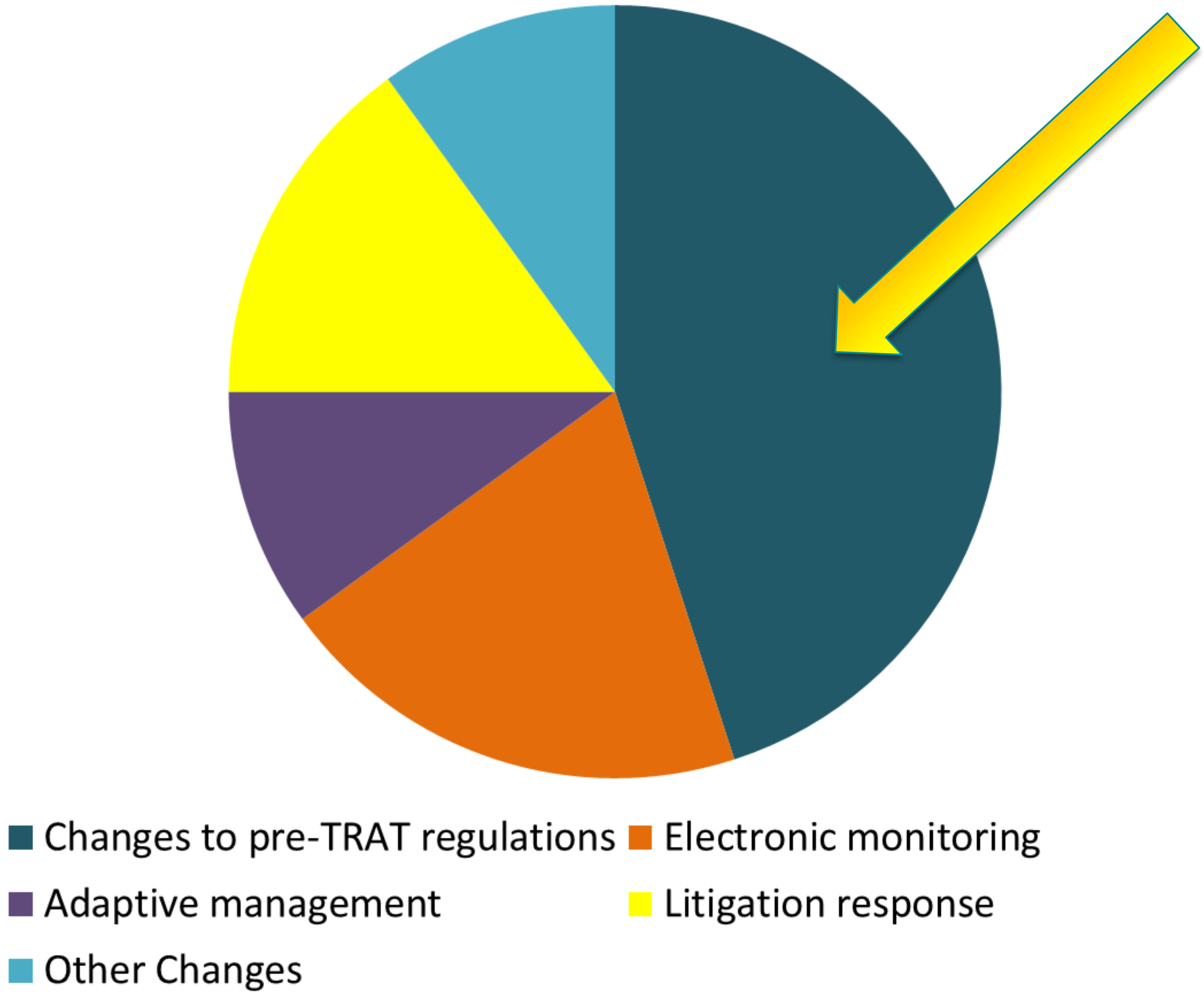
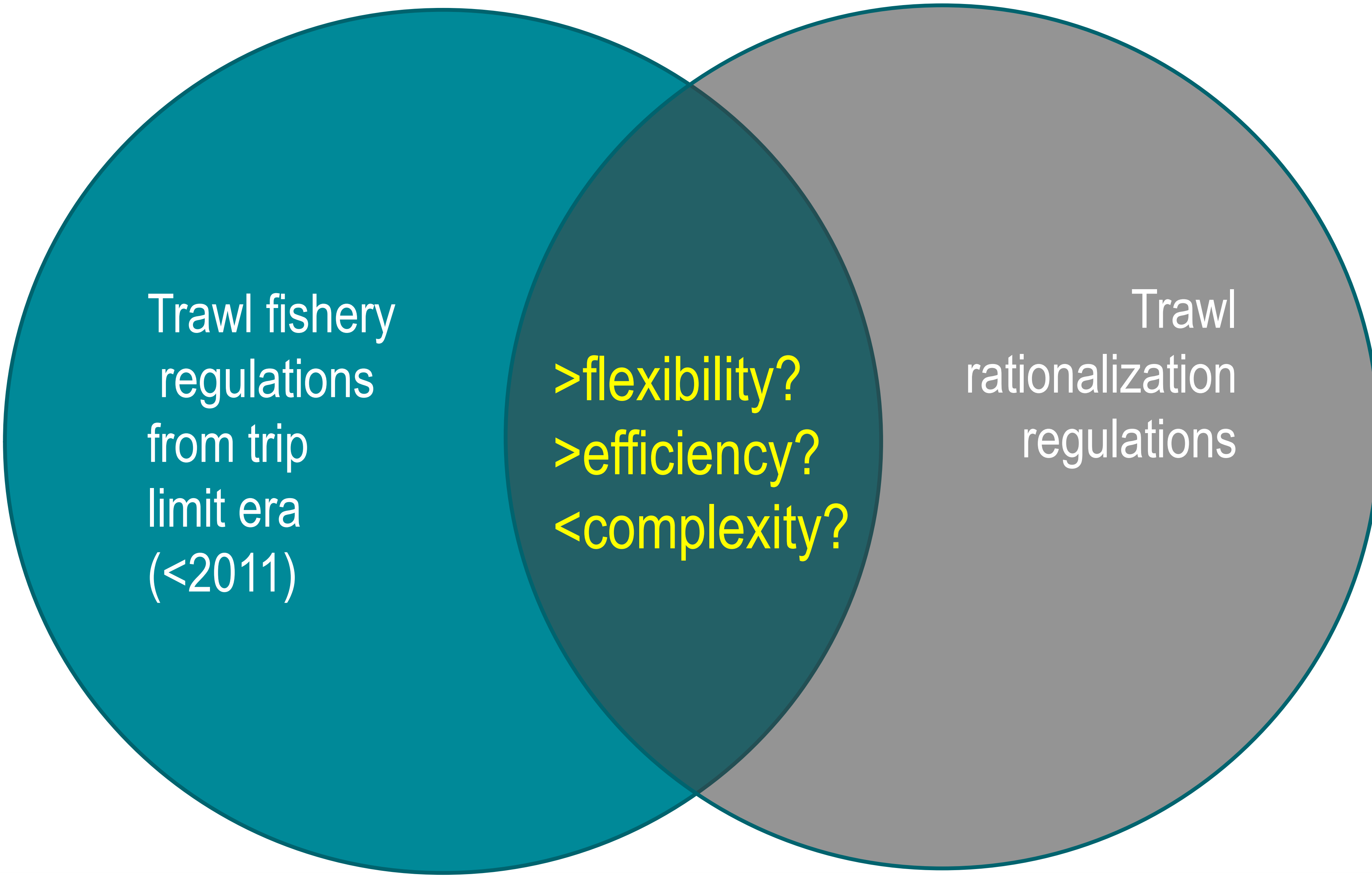
Fishing in Multiple Areas



FISHERIES

"…a formal and detailed review 5 years after the implementation of the program…" (MSA at §303A)


Changes to pre-TRAT regulations
Electronic monitoring
Adaptive management
Litigation response
Other Changes


Trawl fishery regulations from trip limit era (<2011)
>flexibility?
>efficiency?
<complexity?
Trawl rationalization regulations

MSA at National Standards: #5 "Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose."

Agenda Item D.2.c, Supplement GAP Report, April 2013

"…*The GAP believes that artifacts from previous management regime regulations are preventing higher attainment of some ACLs*…"

MSA at National Standards: #7 "Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication."

-Excerpt from open public comment at March 2013 Council meeting

*If we cannot figure out a way to reduce costs while at the same time extracting more value out of this fishery by eliminating redundant or irrelevant regulations, the benefits of the trawl program will be eroded.*

"The **purpose** of this action is to provide more flexibility to the industry to allow for more efficient harvest of their individual allocations, which may result in reduced costs and increased revenues.

The **need** for this action is to better use the individual accountability now in place for participants in the trawl rationalization program."

# TRAWL PROGRAM MANAGEMENT RESTRICTIONS

WHO
Can catch and process fish?

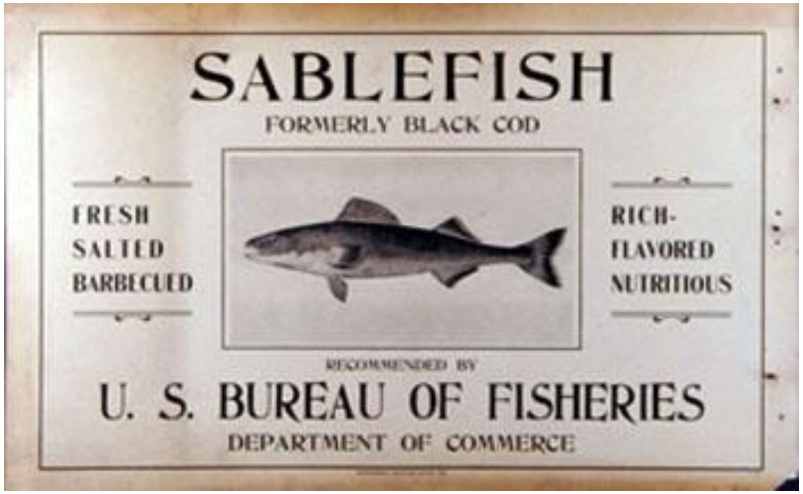
WHEN
Can fish be caught?

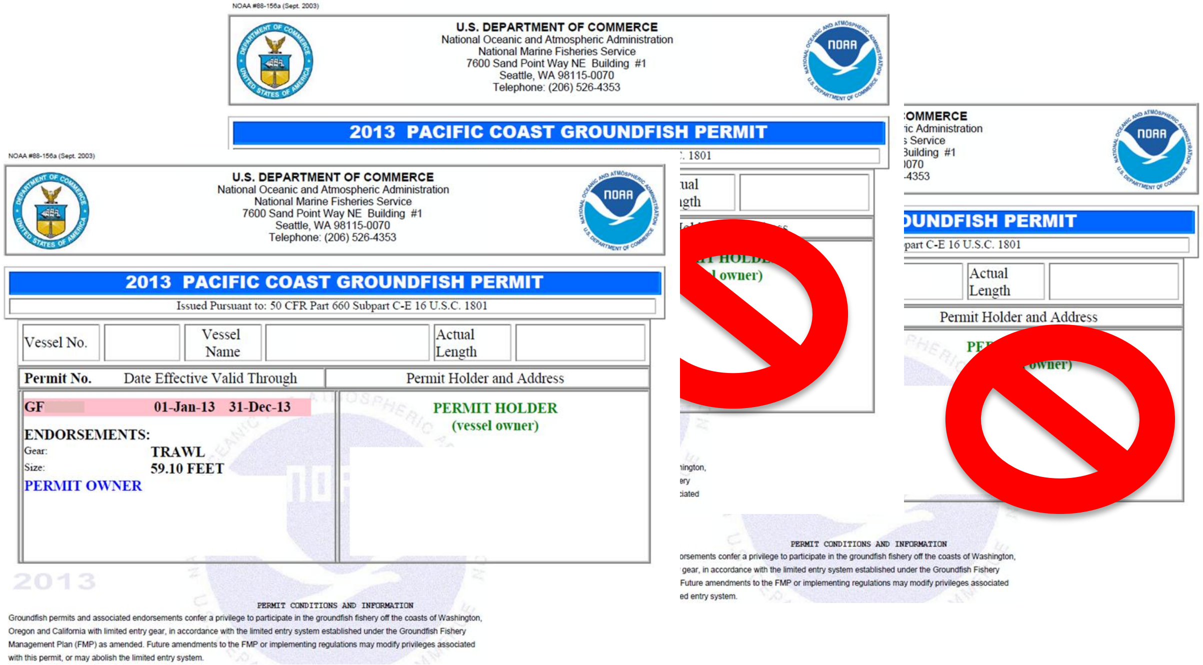
WHERE
Can fish be caught?

HOW
Much fish can be caught?

WHAT
Gear can be used to catch fish?

# WHO
# Can catch and process fish?



# WHAT
# Gear can be used to catch fish?

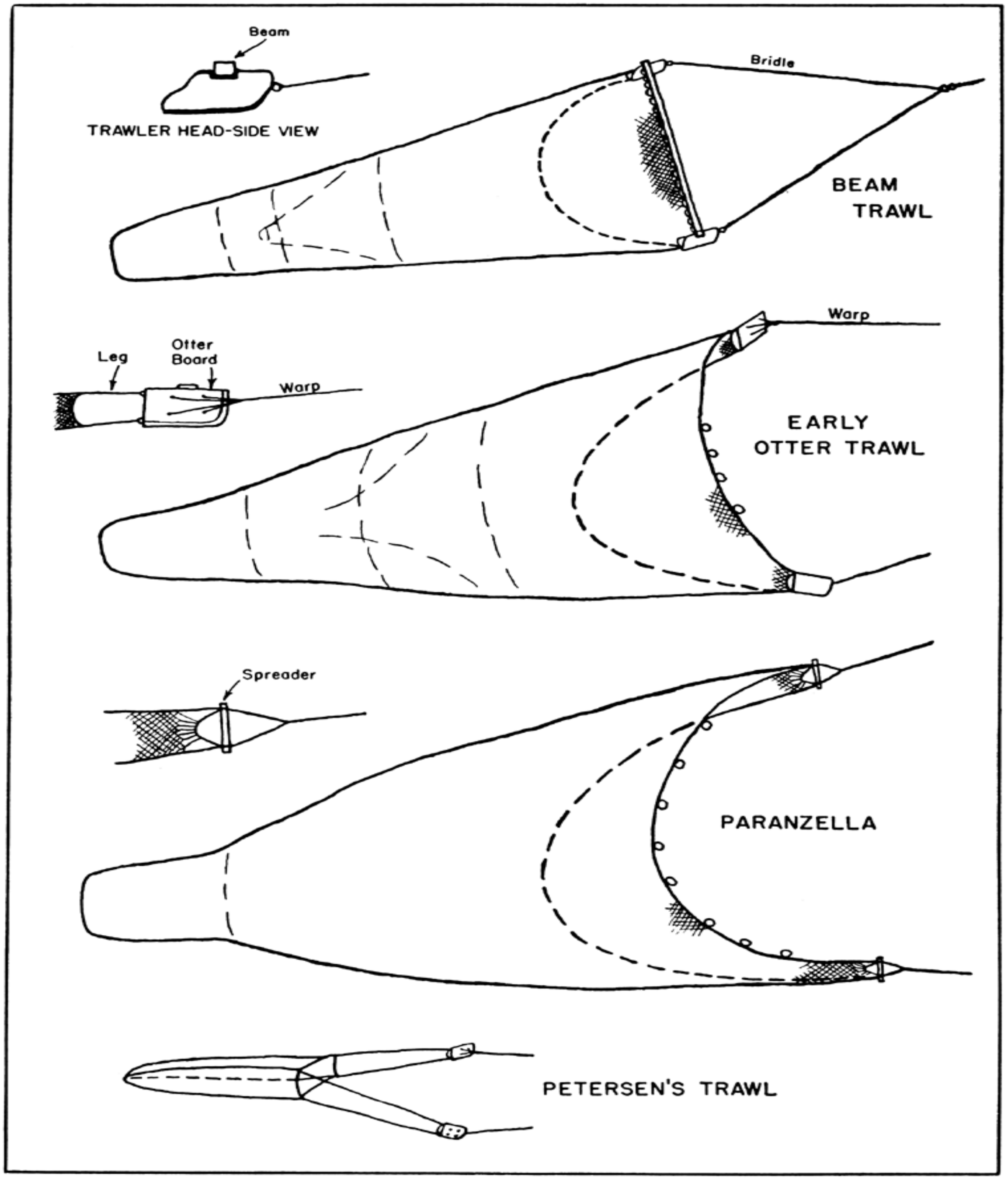
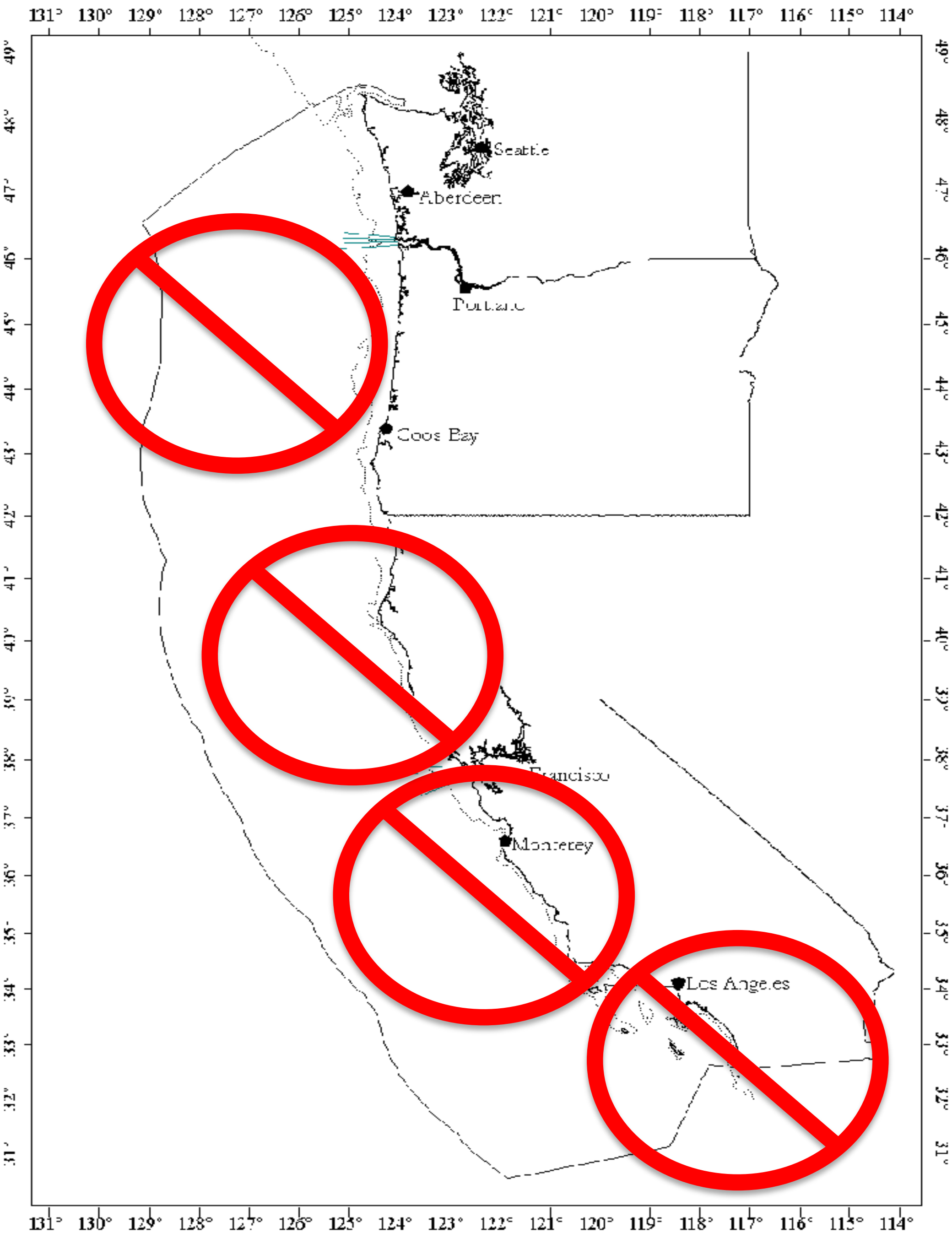
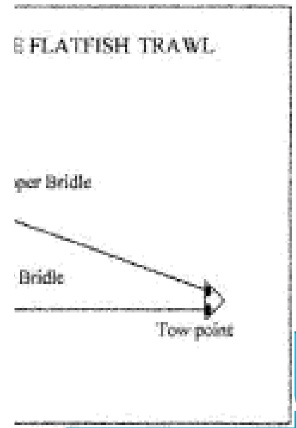
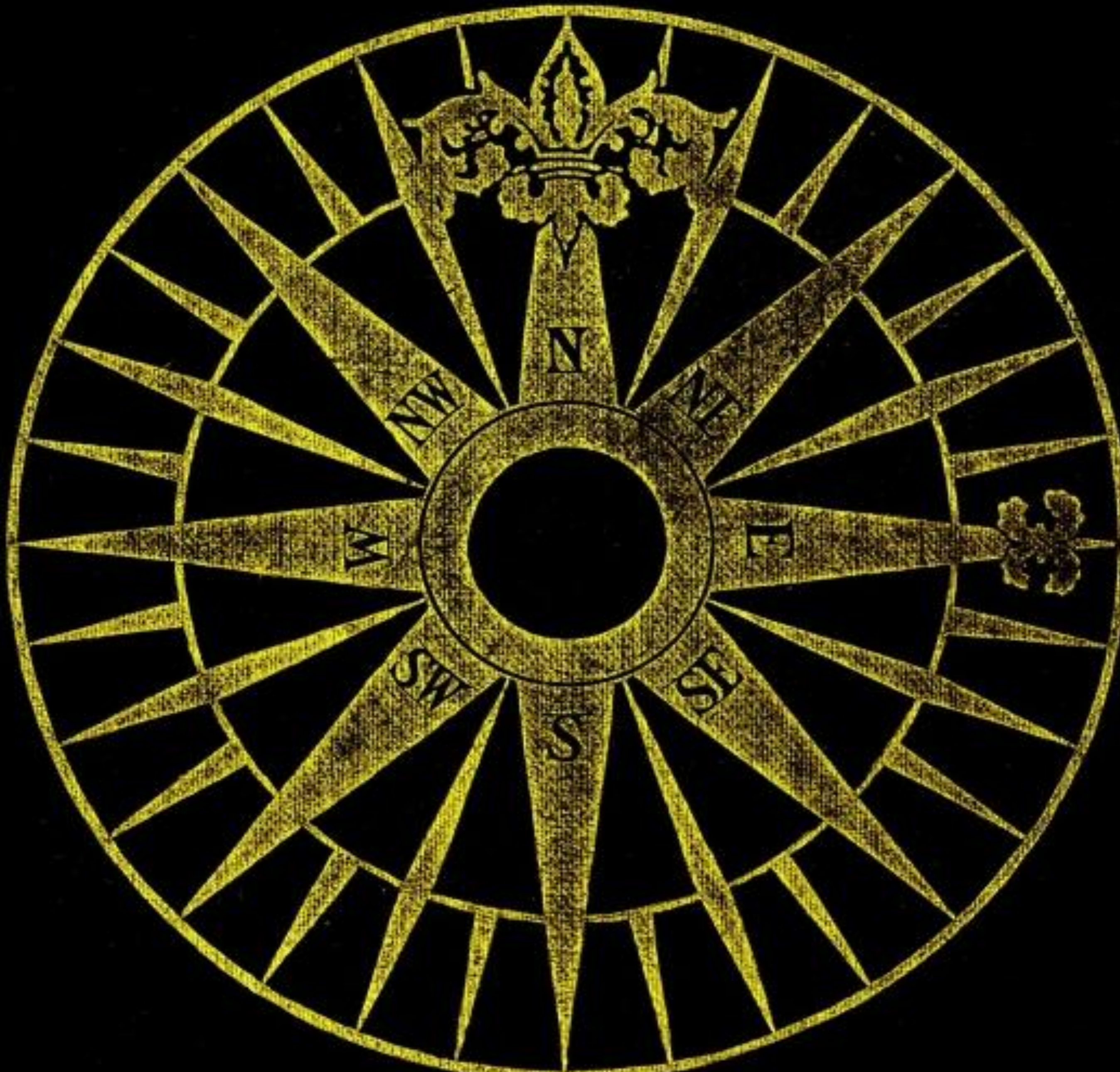



FIGURE 6. Diagram of the beam, otter and paranzella nets




WHERE
Can fish be caught?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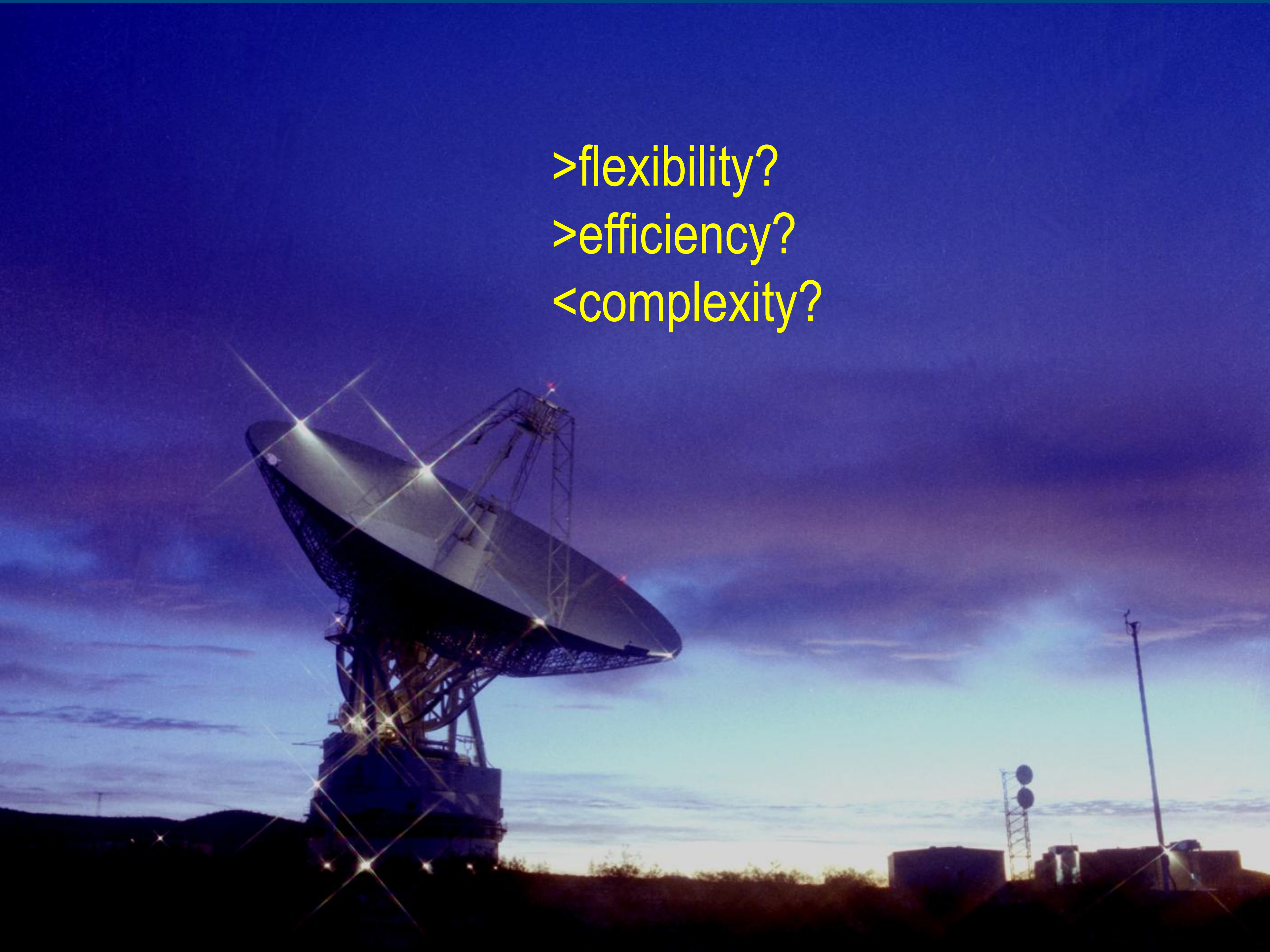

>flexibility?
>efficiency?
<complexity?

# Image credits – All NOAA images except:

- Ear – National Institute of Health
- Cupcakes – U.S. Department of State
- Goldstone Apple Valley Radio Telescope – NASA
- Diagram of beam, otter, and paranzella nets –CDFW
- Lingcod and ruler – ODFW

Agenda Item G.9.c
Supplemental GAP Report
September 2013

# GROUNDFISH ADVISORY SUBPANEL REPORT ON TRAWL RATIONALIZATION TRAILING ACTIONS SCOPING, PROCESS, AND PRIORITIZATION

The Groundfish Advisory Subpanel (GAP) heard a report from Mr. Jim Seger on trawl rationalization trailing actions process and prioritization, and Ms. Jamie Goen on the proposed Adaptive Management Program (AMP). and T-flex processes. The GAP offers the following comments and recommendations.

As an overarching comment, members of the GAP are increasingly frustrated with delays in implementing trailing actions already approved by the Council, while at the same time, NMFS continues to bring forward proposals for new work that will further delay critical improvements.

In developing our prioritization of trailing actions, the GAP tried to identify those actions that would have the greatest benefit to fishermen, processors, associated communities, and the trawl rationalization program overall. Specifically, the GAP prioritized those issues that 1) would provide additional opportunity to harvest available quota, 2) could reduce the cost burden on the fleet, and 3) could benefit the greatest number of participants. Based on those criteria, the GAP would like to see the Council prioritize the following issues:

| | |
|---|---|
| 1 | • Electronic monitoring |
| 2 | • Comprehensive RCA modifications<br>• Gear Issues<br>• Widow reallocation |
| 3 | • Whiting season start date |

## Electronic Monitoring

The GAP recognizes that electronic monitoring (EM) is moving forward as part of a separate action. However, the GAP wants to emphasize that EM development and implementation is the highest priority for stakeholders because we believe is has the potential to reduce costs and improve flexibility.

## Comprehensive RCA Modifications

Access to target stocks and the ability to catch target fish more efficiently could help offset increasing costs of participation in the trawl rationalization program. The GAP supports the comprehensive rockfish conservation area (RCA) modification concept put forward by Midwater Trawlers' Cooperative (MTC), Oregon Trawl Commission (OTC), Fishermen's Marketing Association (FMA), Coos Bay Trawlers Association, Environmental Defense (EDF), The Nature Conservancy (TNC), the California Risk Pool, and other partners to collaboratively develop a proposal for RCA modification, taking into account new information about overfished species hotspots and needs of the industry. One of the principal advantages of catch shares is that the accountability they provide can often replace less effective input controls. While the RCA was an effective tool for minimizing the catch of depleted species before the trawl rationalization program was implemented, hard caps and 100 percent monitoring now ensure that catch limits for the trawl sector will not be exceeded.

**Gear Issues**
Many pre-individual trawl quota (ITQ) regulations were based on the need to minimize rockfish catch under the trip limit management regime. With 100 percent monitoring and individual accountability, there are now more direct means to control rockfish catch. At the same time, many of the pre-ITQ regulations limit efficiency and some even hamper the ability to fish more cleanly (e.g. two-seam net requirement as part of selective flatfish trawl definition shoreward of the RCA).

**Widow reallocation**
Widow rockfish quota share was allocated to IFQ participants to provide for incidental catch of an overfished species. Now that widow rockfish is rebuilt, the GAP believes widow rockfish quota share should be reallocated to maximize economic revenue from the fishery. Specifically, it should be reallocated to allow for a target fishery for those who targeted it previously, while ensuring there are adequate amounts for bycatch needs in the whiting sector.

**Whiting season start date**
This action has been previously approved by the Council. The GAP believes NMFS should prioritize implementation of this issue to provide additional flexibility and opportunity to the whiting fleet. As we stated in our November 2012 statement, a start date of May 15 equalizes the opportunity of all whiting sectors, giving the whiting sector as a whole flexibility to best time harvest and processing to maximize net revenues. It will also simplify the regulatory structure. Ultimately, the GAP would prefer to move forward with a year-round season, but we recognize that such an action requires significant additional analysis. The proposed change is aimed at securing an interim opportunity.

The GAP views all other potential trailing actions to be of lower priority. While we don’t comment on all of the other potential trailing actions individually, we would like to provide the following comments on the AMP.

**Adaptive Management Program**
The GAP does not believe there has been any demonstrated need to implement the AMP. The greatest risk to fishermen, processors, and dependent communities has to do with program costs and inability to access available target species, for various reasons. The current NMFS AMP alternatives do nothing to solve those problems. Moreover, redirecting 10 percent of available quota may in fact cause more problems than it solves.

The GAP also believes that development of an AMP program would take significant Council and NMFS time and resources away from higher priority trailing amendments. In the meantime, the GAP would like to see AMP quota continue to be passed through to the fleet. The GAP believes the appropriate course of action is to wait until the five-year review to conduct an evaluation of problems that threaten the rationalization program overall, and a further assessment of whether the AMP could be a valuable tool in addressing those threats.

**T-flex Proposal**

The GAP strongly supports the proposed T-flex process to remove regulatory inefficiencies through a comprehensive assessment of pre-ITQ regulations that may no longer be necessary. As you'll note implicitly in all of the GAP priorities, the fishery is now dramatically different than it was pre-rationalization. One hundred percent observer coverage and individual accountability for all mortality have changed the game. We believe that NMFS proposed T-flex concepts recognizes this change and we would like to see it move forward expeditiously.

PFMC
09/15/13

# THE GROUNDFISH MANAGEMENT TEAM REPORT ON TRAILING ACTIONS SCOPING, PROCESS, AND PRIORITIZATION

The Groundfish Management Team (GMT) would like to thank Mr. Jim Seger and Ms. Jamie Goen for providing an overview of this agenda item. The GMT had a very limited time to discuss the issues under the trawl trailing actions agenda item. In the overview the GMT heard that there may be some consideration of maintaining the current trawl rationalization trailing actions process or merging it with a general groundfish management approach. The general groundfish management approach--being pursued under Amendment 24--would take a more holistic approach to all issues that come up in the groundfish fisheries. The GMT is supportive of anything that helps streamline processes, prevents duplication of efforts, and maximizes efficiencies.

PFMC
09/16/13

# Port Orford Ocean Resource Team

PO Box 679
444 Jackson St.
Port Orford, OR97465
P: 541.332.0627
F: 541.332.1170
info@oceanresourceteam.org
oceanresourceteam.org

August 21, 2013

MS. Dorothy Lowman, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384

RE: G.9 Trawl Rationalization Trailing Actions Scoping, Process, and Prioritization

Dear Ms. Lowman:

Our organization strongly supports the Council taking action to prioritize developing a plan for the Adaptive Management Pounds (AMP) set-aside in the next suite of trawl rationalization trailing actions. At this time, there is no program to manage the AMP. Our concern is that the longer we go without a plan, the less likely the Council is to bring the AMP back for the intended purpose.

When the Council decided to move ahead to implement the trawl rationalization program with no plan or program for AMP, we were concerned. However, the Council indicated a strong commitment to develop an AMP plan by did setting a date to have a program in place—January 2015. At that time, we trusted that Council members would follow through on their commitment to have a program in place and be ready to implement management of the AMP by January 2015. We understand that to meet the January 2015 implementation date the Council will need to begin work on the program immediately. We ask that you prioritize the work, and get started right away so the Council can follow through on your commitment to the public.

We trust that the Council will follow their intent to develop a program for the AMP that will mitigate unintended consequences from the trawl rationalization program and benefit fishing communities.

Our community has spent the past 2 years developing a Community Fishing Association. We have a strong business plan, community sustainability plan (as referenced in the Magnuson Act), bycatch and discard reduction plan, and seafood marketing program. As the Council moves forward to develop an AMP program, we would like to be included in any committee appointments or industry workshops.

Please take action at the September Council meeting to prioritize developing a management program for AMP.

Thank you,

Leesa Cobb

Leesa Cobb, Executive Director

# CONSEQUENCES

# On a collision course

From
U.S. Coast Guard
reports

One late June morning the skipper and sternman of a 43-foot fiberglass lobster boat were working about 20 miles from their northern New England home port until about 11:30 a.m. before heading north for home.

That same day, around midmorning, the skipper and sternman of a 34-foot lobster boat left the same port for their day's second trip to set 10 traps along a southerly course. They then headed east to set another string of traps.

On the northbound boat, the skipper manned the helm as the sternman napped, cruising at about 18 knots. The boat planed at cruising speed, requiring the skipper to stand to see over the bow.

The skipper sat on a stool near the helm to eat lunch. After motoring for 45 minutes, he stood up to scan for traffic and saw one vessel off his port bow that appeared to be setting traps about 1.5 to 3 nautical miles away. He sat back down to finish his lunch.

Across the bay the eastbound boat's sternman was preparing traps for the next set while the skipper manned the helm. At around 1:30 p.m., the sternman heard the diesel engine's supercharger whistle and felt the boat slow down as if it was taken out of gear. Looking over his shoulder, he saw the northbound boat bearing down.

The northbound boat's bow struck the eastbound boat's starboard side amidships. It ran across the eastbound boat's beam, crushing the wheelhouse and breaching the hull. The eastbound boat's sternman grabbed the northbound boat's trap rack and pulled himself aboard to avoid being tossed overboard.

The sinking boat's skipper was quickly spotted near the helm of his wheelhouse. The sternman on the 43-footer leapt into the water and retrieved the skipper, who was hauled aboard, unconscious.

The northbound vessel's skipper then called the local Coast Guard and notified them of the situation. He also called the harbormaster's office before steaming for his home port.

Ten minutes later, emergency medical personnel, the marine patrol and National Park Service rangers met the boat at the dock. Attempts to resuscitate the unconscious skipper were unsuccessful.


USCG

### Lessons learned

The northbound boat was the stand-on vessel, and the eastbound boat was the give-way vessel. Still, under Rule 8 of the International Regulations for Preventing Collisions at Sea, both boats were required to take action to avoid collision.

If you're near another vessel and are unsure of its intentions, contact them via VHF to bring attention to your boat and discuss collision avoidance strategy.

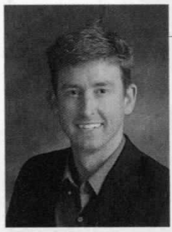
Don't assume the other vessel sees you. Even in perfect weather, use every means possible to detect other traffic, including radar.

Whatever your boat's size, you're bound by the navigation rules. Share the nautical road and fish safe! NF

*This article is based on U.S. Coast Guard reporting and is intended to bring safety issues to the attention of our readers. It is not intended to judge or reach conclusions regarding the ability or capacity of any person, living or dead, or any boat or piece of equipment.*

# DOCK TALK

# Next steps for West Coast catch shares



By Shems Jud

*Shems Jud is the Pacific deputy regional director of the Environmental Defense Fund's Oceans Program based in Portland, Ore.*

Perhaps the only thing more complicated than multispecies fishery management is multispecies fishery management reform, and the only thing harder than *that* is writing about it. *National Fisherman* is to be commended for its ongoing reporting about our nation's catch share programs, including the one we are involved with on the West Coast.

*NF*'s recent article on this fishery ("Catch shares by request," *NF* June 2013, p. 26) covered some of the good news resulting from groundfish catch share management — such as dramatically reduced discards and increased flexibility for fishermen — along with a few of the significant challenges that fishermen and policymakers still face.

Not surprisingly, those challenges boil down to fishing opportunity and profitability. In order for the conservation benefits of the program to be secured for the long term, fishermen need to prosper. That's why we are working to reduce cost burdens on the fleet and enable access to productive fishing grounds.

I've been involved with West Coast groundfish for six years, including serving on the Pacific Fishery Management Council's Groundfish Advisory Panel and Groundfish Allocation Committee. Here are EDF's priorities as we work alongside fishermen:

**Cost recovery & restructuring the buyback loan:** As *NF*'s reporting pointed out, NMFS plans to impose a maximum 3 percent cost-recovery fee on West Coast fishermen to administer the catch share program. Fortunately, based on public comment, NMFS recently decided to provide fishermen with a brief respite by delaying implementation until 2014. When cost-recovery is eventually imposed, however, it will come on top of a 5 percent ex-vessel fee fishermen now pay to cover the 2003 federal loan that funded the fleet-reducing boat and permit buyback. EDF advocates for restructuring the existing buyback loan (currently at a relatively high 6.97 percent fixed rate) and adjusting the cost-recovery fee to reduce the combined ex-vessel hit to no more than 5 percent of landed value. At a time when many fishermen measure profit margins in single digits, 5 percent of landed value is still significant, but 5 percent is better than 8 percent. House and Senate bills introduced in mid-July seek to refinance the loan to current market rates. Along with the trawl fleet, we wholeheartedly support these efforts.

**Reducing observer costs:** Most West Coast fishermen recognize the value of full accountability, but the costs of 100 percent observer coverage threaten to sink smaller operations. From a current effective level of roughly $200 (the day-rate paid by fishermen after the existing federal cost-share), the daily expense is expected by some industry observers to reach as much as $800 — just as the cost-share expires. For many fishermen, that number will not pencil out, and some may have no choice but to leave the fishery. That's why we're working with the council to develop a solution that maintains high levels of catch accountability at a dramatically reduced cost. We believe an appropriate blend of electronic monitoring and reporting — coupled with human observers on some vessels — can maintain 100 percent accountability without threatening the financial viability of fishing businesses.

**Fishing opportunity:** The Rockfish Conservation Area was established more than 10 years ago to minimize trawl catch of overfished species. With 100 percent observer coverage and hard bycatch caps under catch shares, however, we now have more direct ways to ensure catch limits for low-quota species. This has led to a call to open up closed fishing grounds, especially where fishermen believe they can fish "cleanly" for target stocks. The key to profitability is fishing opportunity, so EDF is working with a range of industry, NGO and agency partners on mapping and fieldwork projects to explore where the council might increase access to productive grounds without creating undue risk to the catch share or rebuilding programs.

Although the challenges described in *NF*'s reporting and expanded on here aren't the only ones trawlers face, they are the most immediately significant, and they must be overcome in order for the West Coast groundfish industry to recognize its remarkable potential. It will take a lot of work, but given the focus and goodwill demonstrated by stakeholders during the nearly decade-long process of developing and implementing this catch share program, I am confident that future reporting about West Coast groundfish will include more good news. **NF**

*Email Dock Talk submissions to jhathaway@divcom.com, or fax them to (207) 842-5603. Submissions should be approximately 600 words and include daytime phone number and Social Security number. Authors published in Dock Talk receive $150.*

Coos Bay Trawlers' Association

California Risk Pool
Fishermen's Associations

8/30/13

Mrs. Dorothy Lowman - Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

RE: Developing a comprehensive, collaborative proposal for reconfiguring the trawl Rockfish Conservation Area

Dear Chair Lowman,

Over the last ten years, the Rockfish Conservation Areas (RCAs) have been an important management strategy for minimizing the catch of depleted species and promoting their rebuilding. At the same time, it is also a coarse tool and may close some areas unnecessarily, especially in light of the catch share system's hard bycatch caps, observer coverage, and strong fishermen incentives to avoid species of concern. The creation of a catch share system for the trawl sector has provided a more direct means of controlling mortality and ensuring that Annual Catch Limits (ACLs) are not exceeded. One of the principal advantages of catch shares is that the accountability they provide can often replace less effective or direct input controls. Given this, there have been increasing calls for the removal or liberalization of the RCAs as part of post rationalization management.

Based on this rationale, the Oregon Trawl Commission, the California Risk Pool, the Midwater Trawlers Cooperative, Fishermen's Marketing Association, Coos Bay Trawlers, Environmental Defense Fund, and The Nature Conservancy are partnering over the coming year to develop a comprehensive proposal to reconfigure the trawl RCA. Our group does not necessarily believe that the RCAs should be opened up completely, but believes a thorough exploration of the possibilities is warranted. After a close look at the available data and taking into account the history and experience of harvesters, there may be hotspots or areas of high relief habitats that should remain protected. The challenge is to identify these areas and to balance the benefit of increased access to target stocks afforded by 100% accountability, with the risk of encountering species of concern and any potential threats to rebuilding goals.

We believe that strategic RCA reconfiguration needs to be done in a comprehensive, coast wide manner and our project partners will be engaged in developing an initial proposal for the Council and other members of the fleet and the public to consider. The extensive data layers developed as part of the Essential Fish Habitat (EFH) process are an excellent foundation to help identify critical areas. Most importantly, local fishermen knowledge and strong incentives to avoid species of concern and promote rebuilding will help us propose a set of openings and retained closures that will balance the various goals of effective management. We will strive to make development of this initial proposal as inclusive as possible.

We anticipate that we will submit the proposal for consideration in September 2014. Our hope is that at that time it can be included, along with remaining rulemaking priorities, for consideration during 2015 with potential implementation in January of 2016. We recognize and support that localized RCA liberalization may take place in the meantime, including the current proposal which passed successfully through the Council in June that would affect shoreward and seaward boundaries of the trawl RCA for period 6 in 2013 and all of 2014. At the same time we also believe that a systematic, coastwide approach will ultimately be the best means of balancing the goals of the program. If this potential pathway does not seem feasible given time, workload, or process constraints, we request Council guidance on alternatives under which such a proposal might be considered.

While this process will be focused on the trawl RCA, some of the members of our coalition from the California Risk Pool may also propose a separate, stand alone proposal for the non-trawl RCA for the area south of Cape Mendocino.

We appreciate the Council's consideration of this issue and thank you in advance for any guidance you may provide us in moving ahead. We look forward to working through the Council process on this critical aspect of the catch share program's implementation.

Sincerely,

Brad Pettinger
Executive Director
Oregon Trawl Commission

Michell Norvell
Project Manager
Fort Bragg Groundfish Association

Shems Jud
West Coast Deputy Director
Environmental Defense Fund

Lisa Damrosch
Executive Director
Half Moon Bay Groundfish Marketing Association

Michael Bell
Senior Marine Project Director
The Nature Conservancy

John Griesser
Executive Director
Central California Seafood Marketing Association-Morro Bay

Heather Mann
Executive Director
Midwater Trawlers Cooperative

Pete Leipzig
Executive Director
Fishermen's Marketing Association

Cc:
Will Stelle - West Coast Regional Administrator, NOAA Fisheries
Frank Lockhart - West Coast Regional Assistant Administrator, NOAA Fisheries
Jamie Goen - Catch Share Program Analyst, NOAA Fisheries
Dr. Don McIsaac - Executive Director, Pacific Fishery Management Council
John Devore - Staff, Pacific Fishery Management Council

# Adaptive Management Program Proposal

presented by

Ana Kujundzic

This presentation is derived from a joint work with Levis Kochin[1]. The proposal originated from Daniel Holland[2].

[1]*Associate Professor, Dept. of Economics, University of Washington, Seattle*
[2]*Conservation Biology Division, NOAA Fisheries NWFSC, Seattle*

# The Adaptive Management Program (AMP)

- Objectives:

1) Community stability
2) Processor stability
3) Conservation
4) Unintended/unforeseen consequences of ITQ management
5) Facilitating new entrants

# Current situation

- One of the unintended consequences of the ITQ program is stranded fish, which translates into revenue losses for the whole industry.
- AMP pounds could be used as a means to decrease strandings and thus increase revenue and financial stability as specified in AMP objectives.

Table 1. Species shown in red are valuable groundfish species for which attainment was lower in the U.S. than BC in 2012. *Sources:* Sean E. Matson, 2013. Department of Fisheries and Oceans Canada, 2012-2013.

| | U.S. non-whiting ITQ fishery | BC non-whiting ITQ fishery | | |
|---|---|---|---|---|
| Species (Coastwide) | 2012 Attainment | 2012 Attainment | 2012 U.S. Industry Revenue | 2012 U.S. Industry Revenue Loss |
| Arrowtooth flounder | 26.12% | 39.24% | $2,656,219 | $1,334,224 |
| Canary rockfish | 27.60% | 74.54% | $16,718 | $28,434 |
| Dover sole | 32.74% | 61.46% | $15,450,151 | $13,550,837 |
| English sole | 1.54% | 50.41% | $276,675 | $8,794,429 |
| Lingcod | 21.02% | 22.73% | $1,037,928 | $84,350 |
| Longspine thornyheads | 47.71% | 18.96% | $2,681,830 | -$1,615,976 |
| Pacific cod | 34.92% | 43.42% | $1,009,443 | $245,866 |
| Pacific ocean perch | 44.85% | 70.66% | $120,552 | $69,394 |
| Petrale sole | 100.28% | 98.72% | $4,749,129 | -$73,695 |
| Sablefish | 82.32% | 76.15% | $15,915,622 | -$1,192,301 |
| Shortspine thornyheads | 48.61% | 73.38% | $1,970,653 | $1,003,973 |
| Widow rockfish | 45.04% | 67.30% | $337,529 | $166,782 |
| Yelloweye rockfish | 5.74% | 91.14% | $80 | $1,185 |
| Yellowtail rockfish | 32.03% | 93.76% | $2,362,998 | $4,554,219 |
| Total | 30.84% | 53.61% | $48,585,527 | $26,951,721 |

# Dover sole and shortspine thornyheads

- ***Dover sole***:
- Landings
  35% decrease (2008–2012), 7% decrease (2011–2012)
- Ex-vessel price
  11% increase (2008–2012), 2% increase (2011–2012)
- Ex-vessel revenue
  28% decrease (2008–2012), 5% decrease (2011–2012)

- ***Shortspine thornyheads***:
- Landings
  49% decrease (2008–2012), 1% decrease (2011–2012)
- Ex-vessel price
  11% decrease (2008–2012), 8% increase (2011–2012)
- Ex-vessel revenue
  55% decrease (2008–2012), 6% increase (2011–2012)

Fig. 1. Dover sole landings and ex-vessel prices in CA, OR and WA during 2008-2012.
*Sources*: Sean E. Matson, 2013. PacFIN all W-O-C species report, 2008-2010 Commercial Landed Catch.

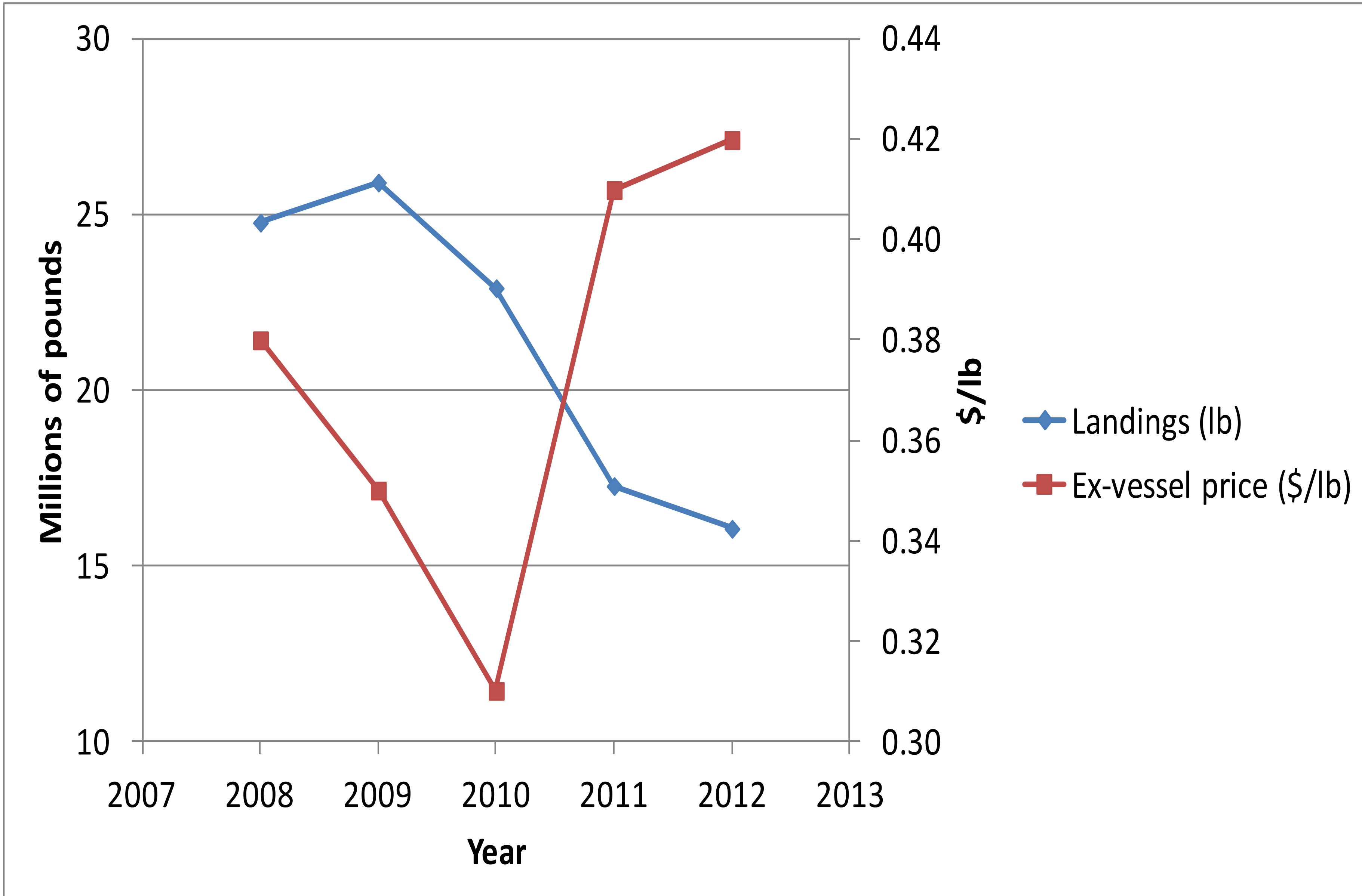
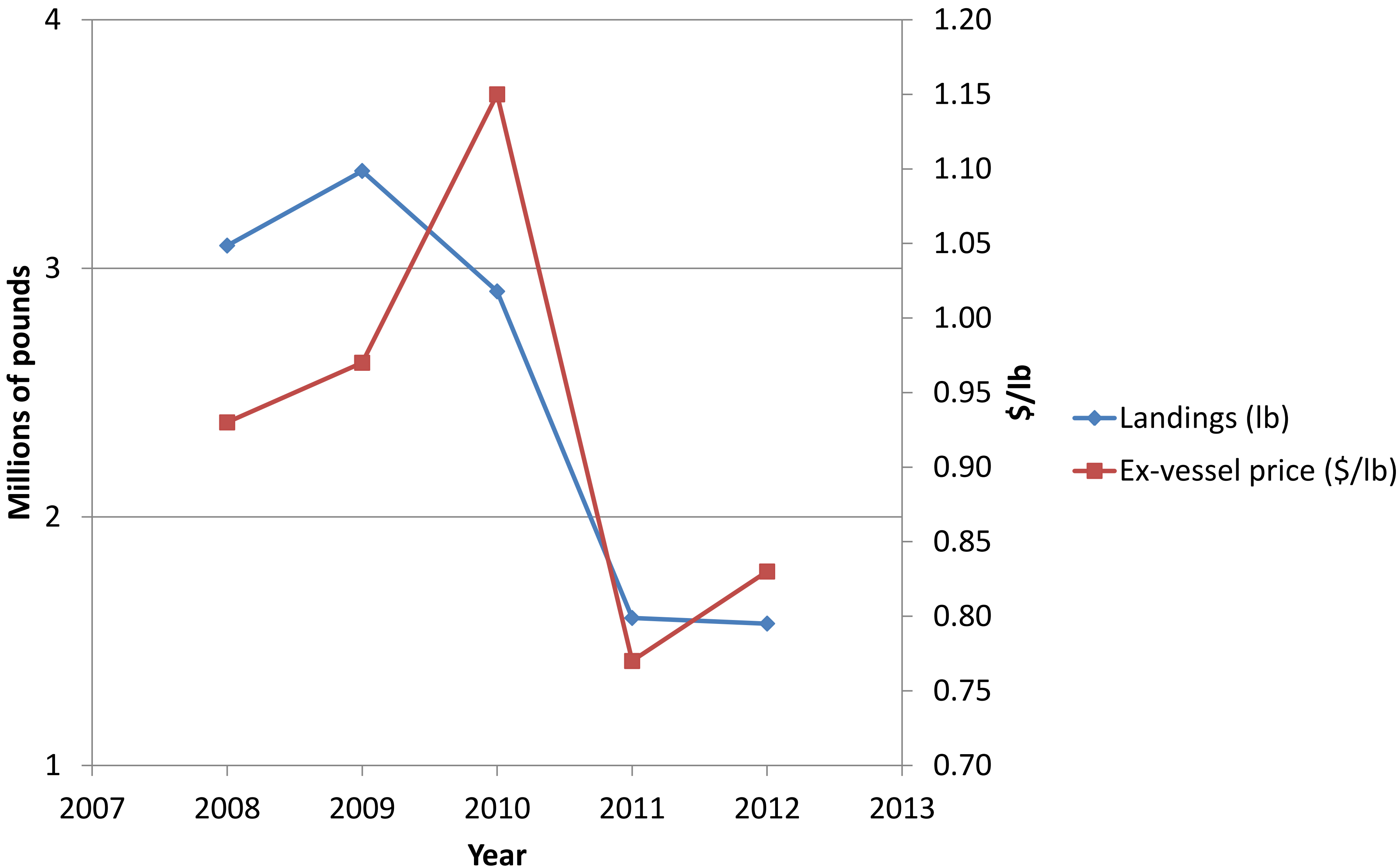


Fig. 2. Shortspine thornyheads landings and ex-vessel prices in CA, OR and WA during 2008-2012.
*Sources*: Sean E. Matson, 2013. PacFIN all W-O-C species report, 2008-2010 Commercial Landed Catch.



# “Deemed value” proposal to mitigate strandings problem

- Use AMP quota pounds to create a “deemed value” system.
- A fisherman would be charged a fee (deemed value) for landing fish for which he does not have sufficient quota pounds.
- A fisherman could get a refund of the deemed value if he later acquires quota pounds in order to balance the catch on which he previously paid deemed value.
- Deemed value rates can be set higher for some species and lower for others.
- The event of ACLs being exceeded is unlikely since landings that can be covered by deemed value would be limited to the AMP QS pool.

# Benefits of a deemed value system

- For the individual fisherman:
  - Allows him to keep fishing
  - Reduces his transaction costs of covering bycatch events
  - Reduces uncertainty and fear of a “lightning” tow
  - Provides some certainty over out-of-pocket costs

- For the quota market:
  - More flexibility for fishermen to balance incidental catch (efficiency)
  - The system would facilitate better reallocation of quota among the participants
  - More fishing opportunities for new entrants until they obtain quota pounds via market transactions

# In summary: Use AMP for Deemed value

- The strandings problem stems from relative catch rates, especially for jointly caught species (e.g. DTS complex, canary and yelloweye rockfish).
- Strandings are exacerbated by a thin quota market, addressed by the deemed value proposal.
- AMP objectives will more likely be met by having a more efficient quota market, making quota prices less volatile and quota pounds more liquid.
- Deemed value is effective when applied to species with low attainment rates.
- In combination with other changes (gear regulation and RCA modifications), deemed value should increase attainment rates and make the fishery more profitable.

# References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- Sean E. Matson 2013. Annual Catch report for the Pacific Coast Groundfish, Shorebased IFQ Program in 2012. National Marine Fisheries Service and NWR, Sustainable Fisheries Division.
- Department of Fisheries and Oceans Canada, 2012-2013 Groundfish Trawl Summary of Catch vs. Available Weight.

# Correspondence

For any further questions or concerns, please contact:


- akujundzic.1@gmail.com
- lakochin@u.washington.edu

# ELECTRONIC MONITORING SCOPING

In November 2012, the Council decided to hold a workshop on electronic monitoring (EM) as a step in the initial consideration of EM for the trawl catch share program (trawl rationalization). At its April, 2013 meeting the Council received the workshop report and decided to move forward with consideration of the possible use of EM. A set of regulatory objectives and a calendar for moving ahead were adopted; and, the Council decided the primary focus of integrating EM into the trawl catch share program would be to achieve the compliance monitoring required for individual accountability of catch and bycatch. Also at the April meeting, the Council tasked staff with developing a document on performance standards, and a set of recommendations for the 2013 EM field study was approved for forwarding to Pacific States Marine Fisheries Commission. In May 2013, funding was received to support the Council's consideration of EM. At its June meeting, the Council directed that Council staff modify the document on performance standards to focus on scoping for the September Council meeting (Agenda Item G.10.a, Attachment 1). The scoping document provides background regarding the scoping process to date, a draft purpose and need statement for EM development, as well as the goals and objectives and an update of the calendar adopted by the Council at its April meeting.

Also at its June, 2013 meeting, the Council established a Groundfish Electronic Monitoring (GEM) Policy Committee (GEMPC) to focus on the development of options for EM use in the trawl catch share program and a Groundfish Electronic Monitoring Technical Advisory Committee (GEMTAC) to advise the GEMPC. On August 20-21, 2013, both committees met to review the draft scoping document and discuss development of EM. The August GEMPC Report contains a draft set of Key Components for an EM Program as well as meeting notes (Agenda Item G.10.b, Supplemental GEMPC Report). Under this agenda item, the Council is scheduled to hold a public scoping session and provide further guidance to the GEM Committees on developing policy alternatives and analysis.

**Council Action:**

1. **Provide guidance to the GEM Committees for development of alternatives and impacts for consideration in the analysis.**
2. **Provide responses to recommendations and issues indentified in the GEMPC Report to the Council, as necessary.**
3. **Provide other guidance as necessary.**

Reference Materials:

1. Agenda Item G.10.a, Attachment 1: Information for Public Scoping of Electronic Monitoring in the Pacific Coast Limited Entry Trawl Groundfish Fishery.
2. Agenda Item G.10.b, Supplemental GEMPC Report: GEM Committees Report to Council.
3. Agenda Item G.10.c. Public Comment.

Agenda Order:

a. Agenda Item Overview — Brett Wiedoff
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action**: Provide guidance to Groundfish Electronic Monitoring Committees for development of draft alternatives and impact analyses.

PFMC
08/23/13

# INFORMATION FOR PUBLIC SCOPING OF ELECTRONIC MONITORING IN THE PACIFIC COAST LIMITED ENTRY TRAWL GROUNDFISH FISHERY

September, 2013

## Table of Contents

## ACRONYMS

| | |
|---|---|
| EM | Electronic Monitoring |
| GEM Committee | Groundfish Electronic Monitoring Committees |
| GEMPC | Groundfish Electronic Monitoring Policy Committee |
| GEM TAC | Groundfish Electronic Monitoring Technical Advisory Committee |
| IFQ | Individual Fishing Quota |
| NEPA | National Environmental Policy Act |
| MSA | Magnuson-Stevens Fishery Conservation and Management Act |
| QP | Quota Pounds |
| VMS | Vessel Monitoring System |

# 1.INTRODUCTION

In 2011, NMFS implemented a Council developed catch share program for the West Coast limited entry groundfish trawl fishery. The program requires that each vessel acquire quota pounds (QP) to cover its catch (including discards) of nearly all groundfish species.[1] Proper functioning of the program requires some form of at-sea monitoring to ensure that discards are enumerated for each vessel. The catch share program specified that this monitoring function be achieved through 100% at-sea observer coverage. The cost of this observer coverage is a burden on industry that is currently being born largely through government subsidies. Those subsidies are phasing out and there are concerns about the impacts that bearing a greater portion of the observer costs will have on industry. Electronic monitoring (EM) is being explored as a potential technically and economically viable substitute for the use of human observers in the function of compliance monitoring for the catch share program.

At the November 2012 Council meeting, the Council directed that an EM workshop be held. The announced purpose of the workshop was to develop the policy context and identify necessary elements for a thorough Magnuson-Stevens Act (MSA) process to consider possible regulatory changes providing for the use of EM in the West Coast groundfish trawl catch share program. If electronic monitoring is implemented, the current 100 percent catch observer coverage requirement could be changed. The workshop was held February, 2013, and the workshop report is provided in Appendix B.

The Council decided at the April, 2013 Council meeting to move forward with consideration of the possible use of EM for the trawl catch share program (trawl rationalization). At that time, the Council decided that the primary focus of integrating EM into the trawl catch share program would be to achieve the compliance monitoring required for individual accountability of catch and bycatch, as opposed to using EM to meet needs for biological data or other scientific information monitoring. A set of regulatory objectives and calendar from the February EM workshop report were adopted. Also, at the April meeting a set of recommendations on the 2013 EM field study was approved for forwarding to Pacific States Marine Fisheries Commission. A similar field study was conducted in 2012. Both studies focus on comparison of video and observer data.

At the June 2013 Council meeting, the Council established two EM committees to focus on the development of options for EM use in the trawl catch share program and the development of this scoping document. In August 2013 both the Groundfish Electronic Monitoring (GEM) Policy Committee (GEMPC) and the GEM Advisory Technical Committee began the process of furthering the Council scoping process.

[1] Exceptions were made for some species rarely caught in the trawl groundfish fishery.

## 1.1 Scoping Process for EM

### 1.1.1 Overview

Scoping is an early and open public process conducted in compliance with the National Environmental Policy Act (NEPA). Through public meetings of the Council, workshops and established committees comments are sought during the scoping process. Generally, discussions of the purpose and need for a proposed action are discussed along with goals and objectives throughout the Council deliberative process. This scoping process is intended to address program design issues, develop alternatives that should be considered, and discuss impacts (both negative and positive) of the alternatives that should be covered in an environmental analysis and other Council policy documents.

### 1.1.2 Timeline for Considering EM

The following is the process adopted by the Council and updated by Council staff for its deliberations on EM.

**Table 1. EM calendar scoping and regulatory process calendar.**

| Dates | Process Considerations |
|---|---|
| Summer 2013 | • Execute at-sea and shoreside field studies |
| Sept 2013 | • Scoping session on EM |
| Nov 2013 | • Consider initial results of NMFS/PSFMC 2013 field season[a/]<br>• Adopt alternatives for analysis. |
| June 2014 | • Consider full analysis of alternative.<br>• Select preliminary preferred alternative. |
| Sept 2014 | • Select final preferred alternative. |
| Sept 2014 through 2015 | • Secretarial approval process and implementation, including<br>○ regulation drafting and paperwork reduction act submissions,<br>○ securing contracts for video review,<br>○ commercial installation and testing, and<br>○ observer program adjustments. |

a/ Staff Note: based on the 2012 field season, significant results may not be available until the spring of 2014.

## 1.2 Background

### 1.2.1 Context for Electronic Monitoring Deliberations

Prior to the trawl rationalization program, the West Coast groundfish observer program monitored approximately 20 percent of the trips taken on groundfish trawl vessels. The trawl rationalization program relies on the monitoring of all trips. See pages E-16 and E-17 for the current language on electronic monitoring in Appendix E of the trawl rationalization program in the groundfish FMP. Modification of this language would occur through a regulatory amendment.

### 1.2.2 Why 100% Monitoring?

One hundred percent monitoring is required to provide for the individual accountability on which the program relies, to fully achieve the potential program benefits, and to prevent the complexity and challenging enforcement circumstances which would arise if some vessels were monitored and others were not. The trawl fishery is a multispecies fishery in which the allowable harvest levels for some stocks (potentially including overfished species) constrain total harvest. If a vessel were not monitored on a particular trip, the elimination of individual accountability would generate an incentive to alter fishing behavior and target stocks that are more difficult to catch without encountering high levels of constraining species. The trawl rationalization program has helped the fleet make tremendous gains in bycatch avoidance. During an unmonitored trip the incentive to avoid bycatch would be minimal. Alternative regulations would have to be developed for unmonitored trips, adding to regulatory complexity. Those regulations would have to assume high bycatch rates for constraining species in order to ensure that the trawl allocations not be exceeded. The assumption of such high bycatch rates would increase vessel operation costs (require the vessel to use more quota) and diminish quota potentially available for the remainder of the fleet. To provide more opportunity, different bycatch rates could be created for different harvest areas. However, this would increase regulatory complexity with a greater number of management lines and assumed bycatch rates, make the calculation of trip catch more complex and time consuming, and potentially burden enforcement with determination of whether any tows on the trip crossed into the high bycatch area. This example assumes that area of catch is the only parameter affecting high bycatch rates of constraining species. Other parameters such as the sonar signal on which fishermen set their gear and the configuration and manner in which the gear is fished may also affect bycatch rates. For example, halibut excluders might be disabled on unmonitored trips in order to increase CPUE. Finally, the Council is in the process of considering how to more fully achieve the potential benefits of the individual incentives provided by the trawl rationalization program by liberalizing a number of regulations governing trawl vessels (e.g. gear regulations). If some vessels were unmonitored, two sets of regulations might need to be maintained, one for monitored vessels the other for unmonitored vessels, further increasing regulatory complexity. For these reasons, 100 percent monitoring is required for effective function of the program.

### 1.2.3 Why Monitor With Observers?

Currently 100% monitoring is achieved through the use of observers on the vessels. The Council’s final action on trawl rationalization included a provision allowing vessel observes to be supplemented with cameras (one of the most common forms of electronic monitoring), but not allowing the use of cameras to completely fulfill the monitoring function. At the time the Council took final action, the program had already been in development for over five years and consideration of camera monitoring may have further delayed implementation. The trawl rationalization program entailed a tremendous change to the fishery and, while the change was expected to be positive, there was concern about the potential for unexpected consequences. Even though cameras had been successfully used to monitor the whiting fleet on an experimental basis, the incentives provided by individual accountability also create an incentive to avoid detection, which was not present during the development of the camera monitoring program for the whiting fishery. The West Coast Groundfish Observer Program was successfully monitoring about 20 percent of the trips and, thus providing a familiar tool. While the incentives to avoid detection could also lead to behaviors frustrating the observer's role, a human observer has more ability than a camera system to detect and respond to contingencies and collect information useful to modifying the monitoring program. Thus, the decision to not include cameras as an alternative to observes was made in the context of uncertainties about the performance of the overall program and cameras and potential delays in program implementation that may have resulted from a more careful considering of the camera options.

### 1.2.4 Why Monitor With EM?

The circumstances, under which electronic monitoring was originally rejected, have changed. Fishery managers have now had two years of experience under the program, which has provided a better understanding of how the fishery performs and how fishermen operate under the program. This has reduced some of the uncertainty about potential unintended consequences. Now, increasing information is becoming available on the performance of electronic monitoring and there is time to more carefully consider the utility of electronic monitoring relative to human observers. There are a number of needs that an alternative to monitoring with observers may address. First, for vessels, the need to pay for vessel observers is one of the most expensive compliance costs associated with participation in the trawl rationalization program. For the first years of the program, NMFS has subsidized observer costs to help the fleet though the period of adjusting to the new management system. Overall fleet profits, and consequently the price of quota, will be below what they might otherwise be if less expensive monitoring is available. Second, small vessels may be disproportionately affected by observer costs. Vessels are billed for observers on a per day basis, and because smaller vessels may have a lower total revenue per day at sea observer costs reduce vessel net revenue disproportionately more than for larger vessels. On this basis, over time it might be expected that quota will migrate to larger vessels and there will be fewer smaller vessels in the fleet—assuming small vessels do not have other countervailing advantages. Third, because of the overhead involved with maintain observer availability in small, somewhat isolated ports with relatively low demand for observers, at least one observer company has indicated that it may pull out of at least one of the small ports on the West Coast. In addition some observer companies may not be willing to provide observers for safety reasons. Thus, over time, smaller ports may be disadvantaged by the observer requirement, relative to larger ports. Fourth, if overall monitoring costs can be reduced (those borne by both private parties and the public), national net economic benefits may be increased. And finally, the observer fee system puts pressure on vessels to fish in unsafe conditions. Because vessels are billed on per day both for at-sea and for standby time, vessels may incur higher costs for standing down due to marginal weather conditions.

### 1.2.5 Trawl Catch Share Program Electronic Monitoring (EM) Workshop Report

The Pacific Fishery Management Council held a workshop on the potential use of electronic monitoring (EM) in the trawl fishery catch share program, February 25-27, 2013. The full report is available at: http://www.pcouncil.org/wp-content/uploads/D7b_EM_WKSHOP_RPT_APR2013BB.pdf)

During the EM workshop there was a discussion of the potential regulatory requirements for an EM system and the need for regulatory flexibility, both with respect to technologies employed and processes. The needed flexibility would allow private industry to develop efficient and effective monitoring system and to continue to innovate as new technologies become available over time. It was suggested that rather than being prescriptive, regulations should specify performance standards which must be met. This recommendation is in line with Executive Order 12899, which requires that each agency "identify and assess alternative forms of regulation and shall, to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt."

## 1.3 Purpose and Need for the Proposed Action

### 1.3.1 Draft Purpose and Need Statement (modified version of EM Workshop Report)

Since implementation of the Pacific coast trawl rationalization program, there is a continuous need to maintain the full functionality of the program, including individual accountability and adequate monitoring of the fisheries for compliance with existing regulations. The program currently utilizes 100 percent observer coverage, however; future costs to continue this level of coverage may not be economically feasible to fishery participants and managers, or provide operational flexibility for program participants. Therefore, there is a need to adequately monitor the program in an economical and flexible manner yet meet the goals and objectives of national policies and standards, the Pacific Groundfish FMP, and the catch share program.

NMFS and the Council identified that EM may be a viable option to monitor fisheries for compliance; therefore, the purpose of developing an EM program for the Pacific coast groundfish trawl fisheries is to meet the regulatory objectives identified by the Council at the June 2013 meeting (See section 1.4.1).

While considering policy adjustments to meet these needs, there is also a need to ensure continued collection of adequate scientific data on the fishery. The effect of any changes in observer coverage on the quantity and quality of other biological and habitat data will need to be considered during development of an EM program and appropriate adjustments made if EM is implemented.

## 1.4 Goals and Objectives

### 1.4.1 Council Recommended EM Regulatory Objectives

The regulatory objectives for this action pertain to catch share program compliance monitoring. As proposed by workshop participants from the EM Workshop Report and recommended by the Pacific Council at the June 2013 meeting, the regulatory objectives are to:

1. reduce total fleet monitoring costs to levels sustainable for the fleet and agency;
2. reduce observer costs for vessels that have a relatively lower total revenue;
3. maintain monitoring capabilities in small ports;
4. increase national net economic value generated by the fishery;
5. decrease incentives for fishing in unsafe conditions;
6. use the technology most suitable and cost effective for any particular function in the monitoring system; and
7. reduce the physical intrusiveness of the monitoring system by reducing observer presence;

while

8. maintaining current individual accountability for catch and preserving equitable distribution of monitoring coverage among members of the fleet,
9. supporting the collection of biological information necessary for managing the fishery, for stock assessments, and to meet other needs for scientific data, with no degradation relative to pre-trawl catch share program standards,[1]
10. taking into account agency budgets and abilities to support any new policy,
11. maintaining capabilities for ACL management (e.g. for non-quota species), and
12. following an implementation path most optimal for the fishery.

These regulatory objectives are for an action to develop an EM program for trawl catch share program compliance monitoring, not for the collection of scientific data. The first seven items in the above list are direct regulatory objectives, i.e. reasons for considering EM. Items eight through twelve in this list are considerations, i.e. the Council would not be undertaking this action in order to achieve items eight through twelve but rather in pursuing the first seven objectives will be bounded by items eight through twelve. These objectives do not displace the original objectives for the trawl catch share program (Amendment 20 objectives) or the groundfish FMP.

### 1.4.2 MSA and FMP Policy Goals and Objectives

This section contains the primary goals and objectives cited in the MSA and the groundfish FMP and related amendments.

### 1.4.3 NMFS Policy Directive

On May 3, 2013, NMFS released its Policy on Electronic Technologies and Fishery Dependent Data Collection to " adoption of electronic technology solutions in fishery-dependent data collection programs" (NMFS, 2013). A complete copy of this policy has been posted on the EM page of the Council web site (http://www.pcouncil.org/groundfish/trawl-catch-share-program-em/). The objective for this policy is stated as follows:

> It is the policy of the National Oceanic & Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NOAA Fisheries) to encourage the consideration of electronic technologies to complement and/or improve existing fishery-dependent data collection programs to achieve the most cost-effective and sustainable approach that ensures alignment of management goals, data needs, funding sources and regulations.

Appendix A contains the full policy directive and objectives.

### 1.4.4 MSA Management Standards

**Table 2. National Standards from the Section 301 of the MSA.**

| | |
|---|---|
| NS-1 | Conservation and management measures shall prevent overfishing while achieving,on a continuing basis, the optimum yield from each fishery for the United States fishing industry. |
| NS-2 | Conservation and management measures shall be based upon the best scientific information available. |
| NS-3 | To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination. |
| NS-4 | Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges. |
| NS-5 | Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose. |
| NS-6 | Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches. |
| NS-7 | Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication. |
| NS-8 | Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities by utilizing economic and social data that meet the requirements of paragraph (2), in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities. |
| NS-9 | Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. |
| NS-10 | Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea. |

### 1.4.4.1 Trawl Rationalization Goals and Objectives (Amendment 20)

**Table 3. Trawl Rationalization goals and objectives from Amendment 20.**

| | |
|---|---|
| Goal<br>*Create and implement a capacity rationalization plan that increases net economic benefits, creates individual economic stability, provides for full utilization of the trawl sector allocation, considers environmental impacts, and achieves individual accountability of catch and bycatch.* | |
| Objectives<br><br>The above goal is supported by the following objectives: | |
| 1. | Provide a mechanism for total catch accounting. |
| 2. | Provide for a viable, profitable, and efficient groundfish fishery. |
| 3. | Promote practices that reduce bycatch and discard mortality and minimize ecological impacts. |
| 4. | Increase operational flexibility. |
| 5. | Minimize adverse effects from an IFQ program on fishing communities and other fisheries to the extent practical. |
| 6. | Promote measurable economic and employment benefits through the seafood catching, processing, distribution elements, and support sectors of the industry. |
| 7. | Provide quality product for the consumer. |
| 8. | Increase safety in the fishery. |
| Constraints and Guiding Principles<br><br>The above goals and objectives should be achieved while the following occurs: | |
| 1. | Take into account the biological structure of the stocks including, but not limited to, populations and genetics. |
| 2. | Take into account the need to ensure that the total OYs and allowable biological catch (ABC) are not exceeded. |
| 3. | Minimize negative impacts resulting from localized concentrations of fishing effort. |
| 4. | Account for total groundfish mortality. |
| 5. | Avoid provisions where the primary intent is a change in marketing power balance between harvesting and processing sectors. |
| 6. | Avoid excessive quota concentration. |
| 7. | Provide efficient and effective monitoring and enforcement. |
| 8. | Design a responsive mechanism for program review, evaluation, and modification. |
| 9. | Take into account the management and administrative costs of implementing and oversee the IFQ or co-op program and complementary catch monitoring programs, as well as the limited state and Federal resources available. |

### 1.4.5 Pacific Groundfish FMP Goals and Objectives

#### 1.4.5.1 General FMP

**Table 4. Pacific Groundfish FMP Goals and Objectives**

| |
|---|
| Goal 1 - Conservation. Prevent overfishing and rebuild overfished stocks by managing for appropriate harvest levels and prevent, to the extent practicable, any net loss of the habitat of living marine resources. |
| Goal 2 - Economics. Maximize the value of the groundfish resource as a whole. |
| Goal 3 - Utilization. Within the constraints of overfished species rebuilding requirements, achieve the maximum biological yield of the overall groundfish fishery, promote year-round availability of quality seafood to the consumer, and promote recreational fishing opportunities. |
| **Objectives**. To accomplish these management goals, a number of objectives will be considered and followed as closely as practicable: |
| **Conservation**<br><br>Objective 1. Maintain an information flow on the status of the fishery and the fishery resource which allows for informed management decisions as the fishery occurs. |
| Objective 2. Adopt harvest specifications and management measures consistent with resource stewardship responsibilities for each groundfish species or species group. Achieve a level of harvest capacity in the fishery that is appropriate for a sustainable harvest and low discard rates, and which results in a fishery that is diverse, stable, and profitable. This reduced capacity should lead to more effective management for many other fishery problems. |
| Objective 3. For species or species groups that are overfished, develop a plan to rebuild the stock as soon as possible, taking into account the status and biology of the stock, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem. |
| Objective 4. Where conservation problems have been identified for non-groundfish species and the best scientific information shows that the groundfish fishery has a direct impact on the ability of that species to maintain its long-term reproductive health, the Council may consider establishing management measures to control the impacts of groundfish fishing on those species. Management measures may be imposed on the groundfish fishery to reduce fishing mortality of a non-groundfish species for documented conservation reasons. The action will be designed to minimize disruption of the groundfish fishery, in so far as consistent with the goal to minimize the bycatch of non-groundfish species, and will not preclude achievement of a quota, harvest guideline, or allocation of groundfish, if any, unless such action is required by other applicable law. |
| Objective 5. Describe and identify EFH, adverse impacts on EFH, and other actions to conserve and enhance EFH, and adopt management measures that minimize, to the extent practicable, adverse impacts from fishing on EFH. |
| **Economics**<br>Objective 6. Within the constraints of the conservation goals and objectives of the FMP, attempt to achieve the greatest possible net economic benefit to the nation from the managed fisheries. |
| Objective 7. Identify those sectors of the groundfish fishery for which it is beneficial to promote year-round marketing opportunities and establish management policies that extend those sectors fishing and marketing opportunities as long as practicable during the fishing year. |
| Objective 8. Gear restrictions to minimize the necessity for other management measures will be used whenever practicable. Encourage development of practicable gear restrictions intended to reduce regulatory and/or economic discards through gear research regulated by EFP. |

| |
|---|
| **Utilization**<br><br>Objective 9. Develop management measures and policies that foster and encourage full utilization (harvesting and processing), in accordance with conservation goals, of the Pacific Coast groundfish resources by domestic fisheries. |
| Objective 10. Recognize the multispecies nature of the fishery and establish a concept of managing by species and gear or by groups of interrelated species. |
| Objective 11. Develop management programs that reduce regulations-induced discard and/or which reduce economic incentives to discard fish. Develop management measures that minimize bycatch to the extent practicable and, to the extent that bycatch cannot be avoided, minimize the mortality of such bycatch. Promote and support monitoring programs to improve estimates of total fishing-related mortality and bycatch, as well as those to improve other information necessary to determine the extent to which it is practicable to reduce bycatch and bycatch mortality. |
| **Social Factors.**<br><br>Objective 12. When conservation actions are necessary to protect a stock or stock assemblage, attempt to develop management measures that will affect users equitably. |
| Objective 13. Minimize gear conflicts among resource users. |
| Objective 14. When considering alternative management measures to resolve an issue, choose the measure that best accomplishes the change with the least disruption of current domestic fishing practices, marketing procedures, and the environment. |
| Objective 15. Avoid unnecessary adverse impacts on small entities. |
| Objective 16. Consider the importance of groundfish resources to fishing communities, provide for the sustained participation of fishing communities, and minimize adverse economic impacts on fishing communities to the extent practicable. |
| Objective 17. Promote the safety of human life at sea. |

# 2. ELECTRIC MONITORING OPTIONS FOR CONSIDERATION

This section provides a summary of current considerations for EM developed by participants of the EM Workshop, February 2013:

2.1 Midwater Trawl for Catcher Vessels Delivering At-Sea
2.2 Midwater Trawl for Shoreside IFQ Deliveries
2.3 Vessels Participating in Trawl Rationalization Program Using Fixed Gear
2.4 Bottom Trawl Large and Small Footrope, including Flatfish Trawl

Some options are similar for each sector and noted where applicable.

## 2.1 Midwater Trawl for Catcher Vessels Delivering At-Sea

| Midwater Trawl for Catcher Vessels Delivering At-Sea |
|---|
| **Maximum Retention / Full Accountability Fishery:**<br>• Non selective discards only ("Non selective" discards are discards made without selecting for species – for example, as a result of bleeding a net.)<br>• Regardless of why or how the discard happened, the vessel will be held accountable for the discard and deductions will be debited from IFQ vessel accounts.<br><br>**Electronic Monitoring Plans (EMP):**<br>• Each camera system application will have elements unique to the vessel (similar to the catch monitor plan for first receiver site licenses)<br><br>**System Components:**<br>• Tamper Proof or Tamper Evident System, Secure/Watertight Data Storage, Digital Cameras, Encrypted Data, Sensors, Deck/Stern Lighting, Bridge Monitor, GPS, VMS, Geo Fencing, E-logbook, Maximum Retention, Video Analysis by Sustainable Fisheries Division (SFD) and Pacific States Marine Fisheries Commission (PSMFC).<br><br>**System Configuration:**<br>• Consistent with previous standards, i.e. EFP and PSMFC pilot.<br>• E logbook compatibility<br><br>**Data Analysis:**<br>• Responsibility of SFD/PSMFC<br>• Models to consider<br>(1) A system similar to the one used by Archipelago for the shoreside whiting fishery EFPs. This approach involved an analysis team reviewing all data |

| Midwater Trawl for Catcher Vessels Delivering At-Sea |
| --- |

or subsamples from all vessels from the time of first set to the vessel's return to port and is labor intensive. See Attachment 4 to Electronic Monitoring Workshop Report. [2]

(2) Others options?

**Regulation Considerations:**

- Time and Area Restrictions.
    - Option 1: Prohibit night fishing. Currently there is a limited prohibition on night fishing: "Vessels fishing in the Pacific whiting primary seasons for the Shorebased IFQ Program, MS Coop Program or C/P Coop Program shall not target Pacific whiting with midwater trawl gear in the fishery management area south of 42°00′ N. lat. between 0001 hours to one-half hour after official sunrise (local time)."(660.131(f))
    - Option 2: Allow night fishing, with adequate artificial lighting (NOTE: Viability of artificial lighting needs to be demonstrated. Some comment indicates that artificial light conditions may be superior to daylight for video monitoring).
- Use EM as implemented for Amendment 10 as template (see Attachment 4 and Attachment 5 to this report).
- Update equipment specs to reflect upgrades in the technology.
- Use specs approval process to update technology specifications in the future.
- Will need regulations or other administrative process to determine methodology for estimating discards, large and small, for deducting vessel accounts.
- Others?

**E-logbook:**

- Verification of randomly selected video against log book entries allows for audit procedure that reduces the need to review 100% of the video data
- Log Book is a self reporting component that along with camera establishes trust and verification of the data. State long books will need to be modified for reporting discards and expanded specifications.
- E-logbook needs to be compatible with camera, i.e. timestamp and GPS
- E-logbook will use state log book as template and convert format from paper to electronic, i.e. same approach used in e fish tickets
- Federal and state regulations will need to be addressed making groundfish log books a Federal Requirement.
- E-logbooks have a significant "value added" component to their development and implementation.

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[2] Software analysis model being developed and tested by Alaska Science Center to narrow video review to times when events occurring on the deck with potential species identification through software capable video imagery analysis. Because it is expected that this would require a minimum of 4 years to perfect, EM Workshop participants recommended that it not be included in options for consideration.

| Midwater Trawl for Catcher Vessels Delivering At-Sea |
| --- |
| **Biological Sampling**<br>• Presume the pre-IFQ NW Science Center sampling program will continue.<br>• Observers deployed on a percentage basis, with data extrapolated across the fleet.<br><br>Note: Compliance with monitoring requirements would apply only while a vessel is participating in the trawl catch share program. |

## 2.2 Midwater Trawl for Shoreside IFQ Deliveries

**[Covers both whiting targeting and other targeting with midwater gear (e.g. pelagic rockfish)]**

Same as for "Midwater Trawl for Catcher Vessels Delivering At-Sea" except

[no differences at this time]

## 2.3 Bottom Trawl Large and Small Footrope, including Flatfish Trawl

**Bottom Trawl Large and Small Footrope, including Flatfish Trawl**

Same as for "Midwater Trawl for Catcher Vessels Delivering At-Sea" except

- Maximum Retention / Full Accountability Fishery
  - Add a suboption to allow discard of small sized sablefish and lingcod.

- Data Analysis – additional comments
  - Cameras, to date have not proven adequate for species identification let alone length and weight calculations.
  - For trawl, passing under a camera using some type of measurement scale has proven feasible in some controlled experimental environments.
  - Could prove to be extremely labor intensive which increases the cost significantly.
  - Software analysis may provide mechanism for species identification and catch accounting, but years away from implementation

| Bottom Trawl Large and Small Footrope, including Flatfish Trawl |
|---|
| • Halibut viability measures may be needed:<br>  ○ Option 1. All halibut considered dead under the camera option.<br>  ○ Option 2. Long-term potential for developing a different type of halibut viability model (additional research required)<br>  ○ Option 3. Use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations.<br>  ○ Others options?<br>• **Going Forward:**<br>  ○ We need PSMFC cameras on bottom trawl vessels this summer! With no history on camera deployment on bottom trawl we are operating at a severe disadvantage.<br>  ○ One potential would be a species identification camera/software system deployed in the net itself (a potential application of the research being done by Alaska Science Center, but we are years away). |

## 2.4 Vessels Participating in Trawl catch share Program Using Fixed Gear

Same as for "Midwater Trawl for Catcher Vessels Delivering At-Sea" except

- May only need full retention on
  - Option 1: IFQ species,
  - Option 2: rockfish and sablefish – assuming that cameras can provide some basic species differentiation for other species.
  - SubOption (to combine with either Option 1 or 2): allow discard of small sized sablefish and lingcod.
- There are no fixed gear state logbooks from which to develop an E-logbook.
- Halibut viability measures may be needed:
  - Option 1. All halibut considered dead under the camera option.
  - Option 2. Long-term potential for developing a different type of halibut viability model (additional research required)
  - Option 3. Use the historical observer information to estimate a likely average halibut mortality rate by gear type and fishery and to update those estimates over time based on observer data from more recent observations.
  - Others options?

# 3. Types of Regulations: Prescriptive, Performance Standards, and Management Standards

Participants at the February 2013 Electronic Monitoring Workshop and Council members at the April 2013 Council meeting expressed interest in the consideration of performance standards. Performance standards are measures by which one determines the adequacy of a particular action. Rather than dictating the specific action to be taken to achieve a particular end, a performance standard is established and an activity is then evaluated against whether or not it meets that standard. Regulations that dictate how an end is to be achieved are generally termed “prescriptive.” Generally, regulations are not either solely prescriptive nor solely performance based but rather are on a continuum between.

Performance standards can be applied at different levels. A performance standard applied at the policy level could be used to evaluate whether or not a particular program is meeting its public policy objectives. The national standards are a type of policy performance standard which are operationalized through the development of criteria such as annual catch limits (ACLs) against which adequacy of fishery management measures can be measured. A performance standard applied at the regulatory level provides flexibility to the regulated entity to determine how it will meet the regulatory objective. For example, a bimonthly trip limit is a performance standard that provide flexibility to fishermen to determine how and when they will take their catch. Catch share programs are performance standard based programs that provide even broader flexibility. In the development of electronic monitoring regulations, performance based criteria might be used to provide fishermen with flexibility to develop and adopt new technologies. One of the most important features of a performance standards is clear criteria for evaluation and ability for timely evaluation of whether a particular entity is meeting the criteria.

In general, the flexibility provided by performance standards provide industry greater opportunity to minimize costs but does not provide an incentive for developing and adopting technologies or practices that exceed those standards. For example, a performance standard pertaining to video coverage and clarity would allow fishermen to take advantage of lower cost equipment that meets the standards, as the equipment becomes available. However, if fishermen are not responsible for the costs of video review there might not be a direct incentive for fishermen to develop vessel based and adopt practices or technologies that speed the video review that occurs later on shore.

Another type of regulation is the management standard. Management standards can be effective depending on the types of challenges they are intended to overcome and the level of management standard. At the lowest level, the standard is only intended to ensure that information deficits are overcome and an entity is only required to go through a planning process, without regard to adequacy of the plan developed and whether or not it is implemented.  At the higher end, an entity is required to go through a planning process, develop a plan that meets certain criteria, and submit to audits or other monitoring to ensure that the plan has been implemented.  The electronic monitoring plans (EMP) proposed in the strawmen electronic monitoring considerations would be a high level type of management standard regulation.

# 4. APPENDIX

## Appendix A
## *NATIONAL MARINE FISHERIES SERVICE POLICY DIRECTIVE 30-133, MAY 3, 2013*

Department of Commerce * National Oceanic & Atmospheric Administration * National Marine Fisheries Service

| | |
|---|---|
| ***NATIONAL MARINE FISHERIES SERVICE POLICY DIRECTIVE 30-133<br>MAY 3, 2013*** | |
| ***Administration and Operations*** | |
| ***POLICY ON ELECTRONIC TECHNOLOGIES AND<br>FISHERY-DEPENDENT DATA COLLECTION*** | |
| **NOTICE:** This publication is available at: http://www.nmfs.noaa.gov/directives/. | |
| **OPR:** F/OP<br>**Type of Issuance:** Initial | **Certified by:** F/OP (M. Holliday) |
| ***SUMMARY OF REVISIONS:*** | |

Introduction.

This policy provides guidance on the adoption of electronic technology solutions in fishery-dependent data collection programs. Electronic technologies include the use of vessel monitoring systems (VMS), electronic logbooks, video cameras for electronic monitoring (EM), and other technologies that provide EM and electronic reporting (ER). The policy also includes guidance on the funding for electronic technology use in fishery-dependent data collection programs.

Constraining budgets and increasing demands for data are driving the need to evaluate and improve existing fishery-dependent data collection programs, in particular with respect to cost-effectiveness, economies of scale and sharing of electronic technology solutions across regions. The demands for more precise, timelier, and more comprehensive fishery-dependent data continue to rise every year.

The implementation of fisheries management regulations that require near real-time monitoring of catch by species at the vessel level have challenged the methodological and budgetary limits of data collection methods such as self-reporting, on-board observers, and dockside monitoring. A policy and process to consider the adoption of electronic technology options can help ensure the agency's fishery-dependent data collection programs are cost- effective and sustainable.

Objective.

It is the policy of the National Oceanic & Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NOAA Fisheries) to encourage the consideration of electronic technologies to complement and/or improve existing fishery-dependent data collection programs to achieve the most cost-effective and sustainable approach that ensures alignment of management goals, data needs, funding sources and regulations. To achieve this:

1. NOAA Fisheries encourages the consideration of all electronic technology options to meet science, management, and compliance data needs.

2. Fishery-dependent data collection programs will be designed and periodically reviewed by NOAA Fisheries regions to ensure effective, efficient monitoring programs that meet industry and government needs, increase coordination between regions, and promote sharing of research, development and operational outcomes.

3. Fishery-dependent data collection programs may be comprised of a combination of methods and techniques including self-reporting, on-board observers, and dockside monitoring, as well as the use of electronic technologies including electronic reporting and video monitoring.

4. Where full retention regulations and associated dockside catch accounting measures are in place, NOAA Fisheries supports and encourages the evaluation/adoption of video cameras to meet monitoring and compliance needs in federally managed fisheries.

5. NOAA Fisheries encourages the use of electronic technologies that utilize open source code or standards that facilitate data integration and offer long-term cost savings rather than becoming dependent on proprietary software.

6. NOAA Fisheries, in consultation with the Councils and subject matter experts, will assemble guidance and best practices for use by Regional Offices, Councils and stakeholders when they consider electronic technology options. Implementation of electronic technologies in a fishery-dependent data collection program is subject to the Magnuson-Stevens Act and Council regulatory process, other relevant state and federal regulations, and the availability of funds.

7. No electronic technology-based fishery-dependent data collection program will be approved by NOAA if its provisions create an unfunded or unsustainable cost of implementation or operation contrary to applicable law or regulation. Funding of fishery-dependent data collection programs is expected to consider the entire range of funding authorities available under federal law, including those that allow collection of funds from industry.

8. Where cost-sharing of monitoring costs between the agency and industry is deemed appropriate and approved under applicable law and regulation, NOAA Fisheries will work with Councils and stakeholders to develop transition plans from present to future funding arrangements.

Authorities and Responsibilities.

This policy directive establishes the following authorities and responsibilities:

(1) The NOAA Fisheries Science Board and Regulatory Board are the Executive-level sponsors of the execution of this policy, including oversight of the development of guidance and best practices. Staff support to the Boards will be provided by the Offices of Policy, Sustainable Fisheries, and Science and Technology. Technical assistance will be provided by *ad hoc* working groups, NOAA Fisheries Headquarters (HQ), Region and Science Center subject matter experts, and other agency or contract resources as requested by the Science or Regulatory Board, subject to the availability of funds. Approval of guidance and best practices is subject to Leadership Council concurrence and Assistant Administrator approval.

(2) Regional Administrators and the Office of Sustainable Fisheries - Implementation of this policy will rely on Regional Offices (and the Office of Sustainable Fisheries with respect to Atlantic Highly Migratory Species) initiating consultations in FY 2013 with their respective Science Centers, Councils, States, Commissions, industry, and other stakeholders on the consideration and design, as appropriate, of fishery-dependent data collection programs that utilize electronic technologies for each Federal fishery.

Measuring Effectiveness.

(1) The consultations by the Regional Administrators and the Office of Sustainable Fisheries will be initiated in FY2013 with the goal of completing by the end of calendar year 2014 a schedule of where and how to adopt appropriate electronic technologies, if any, for all fishery management plans (FMPs).

The following metrics will be used to evaluate progress towards the implementation of this policy:

- The number of FMPs with defined fishery-dependent data collection monitoring goals.
- The number of FMPs reviewed to identify fisheries where the adoption of additional electronic technologies would be appropriate for achieving data needs.
- For fisheries where additional electronic technologies are identified as appropriate, the number of FMPs with electronic technologies incorporated into fishery-dependent data collection programs.

Status reviews of the metrics will take place twice a year by the Regulatory and Science Boards.

References.

Procedural directives will be issued to implement this policy as needed. This policy directive is supported by the glossary of terms listed in Attachment 1.
Signature and Date Line.

Sam D. Rauch III Date
Acting Assistant Administrator
National Marine Fisheries Service

**Attachment 1**
**GLOSSARY Terms**

***Electronic Technology(ies)*** – Any electronic tool used to support catch monitoring efforts both on shore and at sea, including electronic reporting (e.g., e-logbooks, tablets, and other input devices) and electronic monitoring (Vessel Monitoring Systems, electronic cameras, and sensors on-board fishing vessels).

***Electronic Monitoring (EM)*** – The use of technologies – such as vessel monitoring systems or video cameras – to passively monitor fishing operations through observing or tracking. Video monitoring is often referred to as EM.

***Electronic Reporting (ER)*** – The use of technologies – such as smart phones, computers and tablets – to record, transmit, receive, and store fishery data.

***Fishery-dependent Data Collection Program*** **-** Data collected in association with commercial, recreational or subsistence/customary fish harvesting or subsequent processing activities or operations, as opposed to data collected via means independent of fishing operations, such as from research vessel survey cruises or remote sensing devices.

***Full Retention*** – A type of fishery where total catch is retained and brought to shore, without discards. This is a generic definition, used in the Policy Directive for illustrative purposes only. There are multiple stages in the fishing process where intentional and unintentional discards can occur. Such variations (e.g., maximum retention, operational discards, prohibited species catch, etc.) require specific definition in each fishery for regulatory compliance and/or enforcement purposes.

# Appendix B

## *TRAWL CATCH SHARE PROGRAM*
## *ELECTRONIC MONITORING (EM) WORKSHOP REPORT*
## *Portland, Oregon*
## *February 25-27, 2013*

http://www.pcouncil.org/wp-content/uploads/D7b_EM_WKSHOP_RPT_APR2013BB.pdf

# ENFORCEMENT CONSULTANTS REPORT ON ELECTRONIC MONITORING SCOPING

The Enforcement Consultants (EC) has reviewed the documents associated with agenda item G.10 and has the following comments.

Electronic Monitoring is a high priority issue for the EC. We participated in the February Workshop and have two representatives on the Electronic Monitoring (EM) Technical Committee. Primary issues for us are the use of the cameras as a component to achieving compliance monitoring objectives, development of an electronic logbook, and expanded use of the Pacific States Marine Fisheries Commission (PSMFC) E-Fish Ticket program.

We have extensive experience in camera application within the whiting fishery, both at-sea and shoreside. Although we have limited direct experience with camera use in the fixed gear fishery, extensive use of cameras in fixed gear fisheries in Canada and the Nature Conservancy Program in Morro Bay, California leads us to believe cameras may be applicable as a replacement for human observers as well.

The PSMFC camera study has successfully placed cameras on three bottom trawl vessels this summer, with an anticipated six vessels coming on line this fall. We anxiously await the results of this study. Absent a definite outcome emerging from this study, the EC is not confident that camera deployment on bottom trawl vessels as a regulatory amendment can be achieved within the current 2016 implementation schedule. As a result, we believe the Council may want to revisit its projected implementation schedule to include consideration of a phased in approach with midwater trawl and fixed gear moving ahead of bottom trawl.

An electronic logbook could provide numerous benefits to science, management, industry and enforcement. The Risa Lynn case briefed earlier in the Council week further highlights the benefits and need for moving forward with development of an electronic logbook. While species information may be the primary desired data component, location and gear deployment information is also important and may be the more immediate need. As such, a data logger type system may be useful as an interim step towards implementation of a more robust electronic logbook.

Expansion of the PSMFC E-Fish Ticket Program takes advantage of an investment already made in EM. In addition to the Federal requirement that all trawl deliveries be reported on the electronic fish ticket, the State of Oregon allows the use of this electronic format for all commercial deliveries. We believe the Limited Entry Fixed Gear Sablefish Fishery is a prime candidate for said expansion as elaborated on under agenda item G.2.

PFMC
09/16/13

Agenda Item G.10.b
Supplemental GAP Report
September 2013

GROUNDFISH ADVISORY SUBPANEL REPORT ON
ELECTRONIC MONITORING SCOPING

The Groundfish Advisory Subpanel (GAP) received a report from Mr. Brett Wiedoff about scoping for electronic monitoring (EM) and the proceedings of the initial Groundfish Electronic Monitoring (GEM) Workgroup meeting. The GAP offers the following comments and recommendations.

Development and implementation of an electronic monitoring option for monitoring in the catch share program remains the GAP's highest priority. As highlighted in previous statements, the GAP believes that electronic monitoring offers significant potential to reduce monitoring costs while providing additional flexibility. With overall program costs continuing to rise and more and more fishermen noting missed trips or delays in trips due to observer scheduling issues, it is imperative that the Council develop and implement electronic monitoring in the near term.

The GAP believes that the discussions and scoping meetings on EM to date have been incredibly helpful, and feels like the time is right to capitalize on that momentum. The GAP requests that the Council encourage industry and other stakeholders to bring specific proposals for EM alternatives to the next Groundfish Electronic Monitoring (GEM) meeting in October to help flesh out a reasonable range of alternatives.

On a related matter, the GAP understands that substantial work was done in Amendment 10 with respect to how EM might be developed for the whiting fishery. However, the GEM Workgroup and interested stakeholders have not been able to get access to that document. We don't understand why we are being prevented from taking advantage of work that has already been done and would appreciate clarification on what the problem is. We recognize that the rule was never finalized, but we believe that the preliminary work contained in that document could help speed the process and reduce administrative burden.

PFMC
09/15/13

# SUMMARY OF GROUNDFISH ELECTRONIC MONITORING POLICY COMMITTEE REPORT
August 2013

**Report to the Council**
At its June, 2013 meeting, the Council established a Groundfish Electronic Monitoring (GEM) Policy Committee (GEM PC) to focus on the development of alternatives for EM use in the Pacific coast groundfish trawl rationalization program (including participants with a trawl permit that switch to fixed gear) and a Groundfish Electronic Monitoring Technical Advisory Committee (GEM TAC) to advise the GEM PC. On August 20-21, 2013, both committees met to discuss development of an EM program for the trawl rationalization program. Participants reviewed the fisheries monitoring roadmap and draft purpose and need statement for an EM program. The Committees also heard a presentation regarding EM monitoring, discussed the National Marine Fisheries Service Policy Directive on Electronic Technologies and Fishery-dependent Data Collection, reviewed options from the February EM workshop, and heard from the West Coast Observer Program (WCOP) regarding the development of draft definitions for catch and discard.

A synopsis of the GEM PC and GEM TAC first meeting is provided below. It includes a general outline of the discussion, the initial thoughts of the PC, and directions the PC expects to take as it continues to develop recommendations on EM alternatives. The EM program would cover catcher vessels in the both the shoreside individual fishing quota (IFQ) fishery and the mothership coop fishery. It is not intended to replace the observers on the mothership or the catcher/processor vessels. There are no specific recommendations for Council action or requests for Council guidance, however, any guidance or direction from the Council would be of value for the Committee's upcoming meeting, scheduled for October 15-16. A summary of the meeting and recommendations for further work by the Committees is provided after the synopsis.

**Synopsis**
The Committees met August 20-21, 2013 to discuss development of an EM program for fisheries operating under the trawl rationalization program. Since there are multiple ways to monitor fisheries with electronic equipment and there are common and unique operational characteristics to fishing activity under the trawl rationalization program, the Committees focused primarily on an overall approach to EM rather than application by gear type (See Section 3). A set of "Key Components" was developed to help guide development of EM and would be the building blocks to further create EM alternatives that are common and unique to each fishery.

An overall approach to an EM program and how the WCOP would mesh with the use of EM were discussed. The Committees recognize that some level of biological sampling is still needed in the fishery; however, EM would not be developed with an objective of meeting the need for biological information. At this time, there is uncertainty how the shoreside capabilities of the WCOP might support an EM program. For example, would an observer be used to verify catch and discard events that are documented in the video and logbooks? In order to move forward, the Committees assumed the WCGOP would continue to collect scientific data at some level of coverage under an EM program and that the fisheries would be monitored for regulatory compliance 100 percent of the time through a combination of EM and the continued use of industry funded observers.

Discussion also focused on how to accurately account for discards using EM. For example, is a video census needed (i.e., review all video to account for all discard) or can we rely on logbook discard numbers and verify logbook entries with video review sampling. The Committees recognize that there is risk involved when trying to account for rare events, such as catching one yelloweye rockfish, and whether EM can appropriately capture these events; however, these issues should not hinder continued development of an EM program as similar risks are present with human observer coverage as well.

Many industry participants believe that EM should be an option and not mandatory, and that participants would need to meet certain criteria to be eligible to use EM in lieu of carrying an industry funded observer. Some level of review of the EM video and sensor data would be necessary to monitor compliance in the fishery and ensure that those carrying cameras were doing so properly and responsibly. It might be possible to require increased video review for vessels that have irregularities in their EM and/or log records, and to require that the vessels pay for the additional review. In the extreme, a vessel could be required to only carry an industry funded observer. Such conditions for participation may provide a natural incentive for compliance. If an enforcement action became necessary, there would be a legal penalty for noncompliance.

The Committees provided comments on a draft purpose and need statement that has been has incorporated into the scoping document, which is in the Council briefing materials for this meeting (Agenda Item G.10.a Attachment 1, September 2013). The next meeting of the GEM Committees is scheduled for Oct 15-16, 2013 and will likely focus on further development of potential alternatives that are applicable to individual fisheries under the trawl rationalization program.

# MEETING SUMMARY



## 1. Attendance

GEM PC Attendees:

Bob Alverson - Individual fishing quota fixed gear representative
Geoff Bettencourt - Individual fishing quota fixed gear representative
Dave Hanson serving as Chair
Travis Hunter - Shoreside bottom trawl representative

Paul Kujala - Shoreside bottom trawl representative
Shems Jud - Conservation representative
Heather Mann - Shoreside mid-water trawl representative
Howard McElderry - Electronic monitoring provider
Brent Paine - At-sea whiting representative

GEM TAC Attendees:

Dan Chadwick - Washington Department of Fish and Wildlife
Dave Colpo - PSMFC
Dayna Matthews - NMFS Office of Law Enforcement
Mariam McCall - NOAA General Counsel
Jon McVeigh - NMFS Northwest Fisheries Science Center (partial by phone)
Robert Puccinelli - California Department of Fish and Wildlife
Maggie Sommer - Oregon Department of Fish and Wildlife

## 2. Draft Purpose and Need Statement

The Committees reviewed and suggested modifications to the draft purpose and need statement to ensure that operational flexibility is included as a major reason for considering development of EM for compliance monitoring, citing the lack of observer coverage in small ports and timely availability among other concerns. This draft purpose and need statement, as modified based on the committee recommendation, has been incorporated into the scoping document that is in the Council briefing materials under Agenda Item G.10.a Attachment 1, September 2013:

> "Since implementation of the Pacific coast trawl rationalization program, there is a continuous need to maintain the full functionality of the program, including individual accountability and adequate monitoring of the fisheries for compliance with existing regulations. The program currently utilizes 100 percent observer coverage; however, future costs to continue this level of coverage may not be economically feasible to fishery participants and managers, or provide operational flexibility for program participants. Therefore, there is a need to adequately monitor the program in an economical and flexible manner yet meet the goals and objectives of national policies and standards, the Pacific Groundfish Fishery Management Plan (FMP), and the trawl rationalization program.
>
> NMFS and the Council identified that EM may be a viable option to monitor fisheries for compliance; therefore, the purpose of developing an EM program for the Pacific coast groundfish trawl fisheries is to meet the regulatory objectives identified by the Council at the June 2013 meeting (See Section 2.1).
>
> While considering policy adjustments to meet these needs, there is also a need to ensure continued collection of adequate scientific data on the fishery. The effect of any changes in observer coverage on the quantity and quality of other biological and habitat data will need to be considered during development of an EM program and appropriate adjustments made if EM is implemented."

## 2.1 Council Recommended EM Regulatory Objectives

The following regulatory objectives pertain to compliance monitoring of the Pacific coast trawl rationalization program, as adopted by the Pacific Council at its April 2013 meeting. The regulatory objectives are to:

1. reduce total fleet monitoring costs to levels sustainable for the fleet and agency;
2. reduce observer costs for vessels that have a relatively lower total revenue;
3. maintain monitoring capabilities in small ports;
4. increase national net economic value generated by the fishery;
5. decrease incentives for fishing in unsafe conditions;
6. use the technology most suitable and cost effective for any particular function in the monitoring system; and
7. reduce the physical intrusiveness of the monitoring system by reducing observer presence;

While:

8. maintaining current individual accountability for catch and preserving equitable distribution of monitoring coverage among members of the fleet,
9. supporting the collection of biological information necessary for managing the fishery, for stock assessments, and to meet other needs for scientific data, with no degradation relative to pre-trawl catch share program standards,[1]
10. taking into account agency budgets and abilities to support any new policy,
11. maintaining capabilities for annual catch limit management (e.g. for non-quota species), and
12. following an implementation path most optimal for the fishery.

These regulatory objectives are for an action to develop an EM program for compliance monitoring, not for the collection of scientific data. The first seven items in the above list are direct regulatory objectives, i.e., reasons for considering EM. Items eight through twelve in this list are considerations, i.e., the Council would not be undertaking this action in order to achieve items eight through twelve but rather, in pursuing the first seven objectives, will be bounded by items eight through twelve. These objectives do not displace the original objectives for the trawl rationalization program (Amendment 20 objectives) or the Pacific groundfish FMP.

# 3. Key Components of an EM Program

## 3.1 Overall Approach

The Committees developed a general list of "Key Components" for an EM program to monitor for compliance. The identified key components could be applicable to each fishery sector under the trawl rationalization program. However, this list may be incomplete and will likely be developed further to meet the needs for compliance monitoring of each sector. Further discussion is needed to define "compliance monitoring" (i.e., monitor discards for IFQ and fishery quota management) and what elements of the trawl rationalization program need to be monitored. An EM system must be able to adequately capture the information managers require for enumerating managed species. Compliance monitoring requires ensuring that all catch is accounted for. Landings are accounted for by shoreside monitors (deliveries to motherships are accounted for by observers). Observers on catcher vessels currently account for discards and EM is being considered as an alternative approach for fulfilling this role. The Committees propose consideration of the following approaches to monitor discard in the trawl rationalization program.

### 3.1.1 Self-reporting and Audit Approach

The first option is to create a "self-reporting and audit" system. Under this approach, the harvester reports the catch in a logbook and the EM system is used to verify the logbook information. The EM system allows for auditing, on an event basis, of all fishing activities and in particular disposition of catch as evidenced by signs of discards. The events for analysis might be a trip, a haul/set, or some other subdivision of a trip for which it would be possible to cross check video against fishing logs and landings receipts. An accurate log of all fish discarded is critical to accurate accounting of all catch and to avoid conducting a high percentage of video review/verification of fishing events. All catch, either retained or discarded, is accurately recorded by species with estimated weight in the fishing logbooks by the fishermen. While retained catch estimates are recorded in the logbooks, the final retained catch amounts used for IFQ accounting come from the shoreside landing receipts and shoreside catch monitor reports. For example, video images would be captured on a hard drive and some percentage (e.g., X%) of all fishing events across all trips recorded on the hard drive would be randomly selected for review to verify discard events noted in the logbooks. If fishing events do not match then further review and verification may be necessary (up to 100 percent), possibly at the vessel's expense. See Section 3.7 for an example.

**Further Committee Work**: Review British Columbia Groundfish Trawl Pacific Hake At-Sea Monitoring Requirements to inform development of this type of system.

**Further Committee Work**: It would be useful to define compliance monitoring, and define some fishery specific terms for self-reporting, audit, catch, discard, maximum retention, full retention, selective and non-selective discards based on the WCOP definitions as applicable and when available. Next step is to look at definitions and how they relate to EM.

### 3.1.2 Video Census Approach

Under this approach all video would be reviewed to estimate total discard quantities and retention of select species. This information would be used to monitor shoreside IFQ and at sea coop discards.

### 3.1.3 Video Sampling for Expansion Approach

This approach would include estimating discards by the random viewing of some percentage (e.g., X%) of all fishing events across all trips on the vessel hard drive. This information would be expanded to estimate total discard, and used to monitor IFQs or the quota management system in place.

### 3.1.4 Spatial Management Alternative

This option could be applied to any of the above approaches. Under this option, fishing activity in areas that are likely to have lower bycatch could be monitored with EM rather than using observers. Vessels would declare their fishing area prior to departure and be required to follow the appropriate fishing protocols for that area.

## 3.2 Vessel Activities and Processes

### 3.2.1 Retention Alternatives

The species for which discard will be allowed for each fishery should be specified to determine how to monitor the fishery accurately and appropriately. So far, three options have been identified.

- i) Alternative 1-Maximize/Full retention fishery (similar to shoreside whiting exempted fishing permit program)
  - (1) Discard of Endangered Species Act (ESA) and Marine Mammal Protection Act (marine mammals, turtles, short-tailed albatross)
  - (2) Discard of Non-ESA (i.e., seabirds, halibut, crab, salmon)
  - (3) Non selective discards only (i.e., safety issue discard)
  - (4) Selective discards (i.e., unmarketable species)
- ii) Alternative 2 - Discard of non regulated species only
- iii) Alternative 3 - Allow selective IFQ or regulated species discards with adequate camera species identification and weight estimate of discard (e.g., cameras system for identification, length/weight measurements)
  - (1) Sub-option full retention of rockfish only

### 3.2.2 Obligations for verifying system operations (e.g., image quality and continuity)

Vessel operators will have responsibilities for monitoring the EM system on the vessel to ensure that equipment is operating properly with adequate image quality, continuity of images, etc.

### 3.2.3 Electronic Monitoring Plan Specifications

There is utility in requiring individual vessel EM Plans. It's likely that the GEM PC will recommend that individual vessel EM Plans be mandatory. Such plans would specify how the EM system will be configured on the vessel and the hardware to be used. It may include very specific information that relates to layout of vessel, number of cameras needed with placement specifications, screen shots of all camera views, types of sensors and sensor data capture, download/maintenance schedule, and process for emergency or back-up equipment use protocols. It may also include vessel obligations with respect to care and maintenance of the EM system, as well as any specific onboard catch handling protocols necessary for EM to accurately monitor fishing operations. It would connect the basic monitoring objectives to the output of the data and serve as a communication tool between vessel, regulatory authorities, those reviewing data, and field service personnel. It can be a "living document" so analysts or field service personnel can recommend changes or updates to the plan. The plan would be certified by NMFS (i.e., EM system and equipment) and be similar to the first receiver (FR) program in the shoreside IFQ fishery. Under this type of EM plan, enforcement action could be taken if vessels are not complying with specific requirements of the plan. Each individual plan may contain EM system characteristics and data transfer protocols that are general and applicable to all individual plans such as how, what and when data will be captured, stored, downloaded, and transferred for review.

**Recommendation for Further Committee Work**: Review what is being developed for the Alaska fisheries.

**Recommendation for Further Committee Work:** Review Archipelago Marine Research Ltd. monitoring plan example to lay out what the basic elements of an EM plan, then discuss at next meeting.

### 3.2.4 Vessel Hardware, Data Capture, and Data Maintenance Onboard

An overall approach or specification of the hardware/software and protocols for downloading/retrieving data may be necessary to capture the appropriate data. This could include:

a) An Electronic Monitoring Plan (See Section 3.2.3)
b) Specified or general EM system components
c) Data elements (e.g., global positioning system, winch monitors/sensors, etc.)
d) Download/maintenance schedule, and process for emergency or back-up equipment use protocols

### 3.2.5 Data Transfer Processes

The method for physical transfer of the data will need to be considered in order to fully assess the effectiveness, costs, and benefits of the system. Note: If new logbook requirements are created, the states and fishermen should be consulted to ensure that the new or revised logbooks capture all required data elements and are compatible with fishing vessel practices and electronics as much as possible.

Notes: If a self-reporting/audit methodology is used to cross check video events with logbook entries, it would be good for managers to consider the related data needs and potential efficiencies when changing or adding state logbook fields.

When data transfer processes are considered they will need to take into account:

a) Video and sensor data
b) Logbooks (electronic and paper)
c) Landings data
d) Possible methods for physical transfer of data (i.e., a through c above)
    i) different methods among sectors or fleets; (standardize if possible)
    ii) Vessel Monitoring System, Wifi, email, thumbdrive

### 3.2.6 Data Processing, Validation, and Analysis

EM data processing would likely involve analysis of EM sensor, video data, and electronic logs. The following is an outline of some of the considerations to be taken up under this topic.

a) Video review and log comparison (would need to develop a review process)
    i) Options for percent of video review (i.e, 10 percent of all trips are reviewed)
    ii) Protocols for additional video review when non-compliance issues arise
    iii) If audit methodology is used, may need to define audit units that match fishing logs units (i.e., fishing events). For some fisheries fishing events are not clearly defined to facilitate an audit).
    iv) Could use observer data from an EM trip to validate data collected (video and/or logbook) – on trips for which the biological observers overlap with EM.
    v) Use landings data as part of audit for video
    vi) Include sensor data in video to verify time and location of fishing events
b) Electronic logs processed by NMFS for quota pound accounting regarding discards
    i) Encourage the use of electronic logs to increase timely submission, lessen data entry errors
    ii) Be mindful that not all vessels will be capable of electronic logs or willing to change
c) Potential reviewers
    i) Sustainable Fisheries Division
    ii) Pacific States Marine Fisheries Commission
    iii) Independent contractor

**For Future Committee Consideration**: Should an observer be used to validate EM and logbook data?

## 3.3 Compliance Incentives and Enforcement Actions

The committee will deliberate further on compliance incentives and enforcement actions. Considerations include:

a) Participation requirements
    i) "Good standing" required for participation and/or continued participation
    ii) Create incentives to comply (management incentives vs. enforcement action)
    iii) Potential exemptions from compliance observer coverage based on standards of compliance (no special exemption from biological observer coverage)

b) Ways the Alaska coops model might be used to implement the program, e.g., self-imposed sanctions within a group or fleet

## 3.4 Organizational Structure and Cost Distributions

The committee will deliberate further on organizational structure and the distribution of costs including:

a) Cost distribution issues
   i. Who pays for equipment?
   ii. Who pays for video review (industry or government)?

## 3.5 EM Participation

Many industry participants believe that EM should be an option and not mandatory, and that participants would need to meet certain criteria to be eligible to use EM in lieu of carrying an industry funded observer. The committee will deliberate further on whether the use of EM will be optional or mandatory.

a) EM is voluntary
   i. Must be eligible
   ii. Must have plan to participate; (e.g., monthly, annual, quarterly plan, etc, as specified by NMFS or agreement between fisher and provider)
   iii. Declaration of EM or observed trip; enforcement must be in the loop
b) EM is mandatory

**For Future Committee Consideration:** Is an EM program a voluntary option for participants? Can set the rules up such that the only way to use EM is through a coop or can a non-coop EM option be specified.

## 3.6 Implementation

a) Consider a phased in approach that includes a pilot implementation of the program

## 3.7 Example for Self Reporting - Maximized retention fishery

The self reporting approach is discussed above in section 3.1.1. One Committee member provided an example for self-reporting. A self-reporting approach would be applicable to those fisheries under the trawl rationalization program including shoreside (trawl and non-trawl) and mothership sectors. As an example of that approach, a vessel that wants to carry an electronic monitoring system versus a human observer would need to meet certain criteria:

a) No selective discards
b) It must carry and complete a logbook reporting specific information including non-selective discard events (discards that do not take place on purpose)
c) It will carry a camera system set up to view all activity on the decks

d) The video taken by the camera will validate two things: that no selective discards occurred and an audit of discards being reported in the logbook
   i. if a discard is viewed on the tape but not reported by the fishermen – he has a violation (could be a fine, warning, to be determined). If it happens twice he no longer meets the criteria to carry a camera for a certain amount of time
   ii. if the video reveals discrepancies between what is being self reported and what occurs on the video he is in violation. The first time he receives an administrative warning. If it happens twice he no longer meets the criteria to carry a camera for a determined amount of time.

**Suboption for non-compliance with discard**– to avoid regulatory and enforcement delays and ensure swift responses, violations could be addressed through an industry coop structure.

## 3.8 Developing EM Cost Estimates

Cost is a major factor when considering the implementation and use of EM. Even if cost per day for EM is comparable or more expensive than observers, an EM program may provide the industry with the flexibility to choose which coverage is best for their business model. The Committees understand that full individual accountability of discard is critical, so either approach must achieve full IFQ accurate discard accounting for each fishing vessel. To begin developing cost estimates for an EM program, the following non-mutually exclusive cost factors to consider were discussed:

1) Review time
2) Coverage of reviews (i.e., 10 percent, 20 percent, 50 percent, or 100 percent of all trips)
3) Type of EM system needed (minimum components needed)
4) Cost of EM system (type of system, number of camera per boat, etc.)
5) Cost to maintain system
6) Servicing ports (per-vessel costs)
7) Fixed and variable costs
8) Labor and material estimates
9) Quantity of data to be collected

Servicing of EM can be separated into three categories:

1) Interaction/installation, ongoing service emergency service timelines for collection (monthly, quarterly when data is full)
2) Data services: looking at entire data set, analysis for extraction (sensor values, discard review protocols), audits, hard drive management
3) Administrative element: define end user functions/needs

**For Future Committee Consideration**: To analyze costs, one approach is to conceptualize a system, do a cost estimate, and then evaluate the impacts, costs, program needs, and potential tradeoffs for cost savings. The first step is to develop fleet profiles for each fishery as a base for activity with some assumptions about characteristics, activity, landings, discards, and seasonality. Then define general characteristics for a type of monitoring system that would meet the data needs. Next, map out time and space of fishery, choose a variety of sensors needed to monitor activity, choose a maximum number of cameras needed to monitor discard events, and put in a ball park cost figure for the necessary equipment. There are multiple issues with estimating labor costs (video review, installation, maintenance, etc); however, it's possible to use previous EM experience to inform development for those sectors that are lacking EM experience. After these initial steps are completed for each fishery, a cost analysis could be done to examine how to distribute costs, possible data loss, and potential tradeoffs for cost savings.

**Recommendation**: Staff and region work to start profiling fishery and identifying data needs.

## 4. Cost-Benefit Analysis

The costs and benefits of the EM should be evaluated not only to determine whether there will be an overall net benefit to participants and managers, but also to ensure that the benefit of each additional program requirement or feature outweighs the costs of the added feature.

## 5. General Committee Statement Regarding Development of EM

There are concerns about the ability for EM to capture and estimate discard events using decision rules similar to those currently employed by human observers. Different potential scenarios were discussed based on the region's definitions of discard and catch. The GEM PC believes EM can be an effective tool for estimating discards. The GEM Committees recognize that both observer and video review of discard events may be subjective. Developing a methodology for utilizing cameras for discard estimation is important and will require a thoughtful and thorough discussion but the GEM Committees do not believe it is an insurmountable barrier to developing and implementing an effective EM system.

## 6. Continued Development

As recommended by the Council in the June 2103 meeting:
Develop an initial scoping package that would include the strawman proposals contained in the EM Workshop reports as initial EM alternatives (splitting pot and longline as recommended in the Supplemental GAP Report), as well as an alternative of electronic monitoring participation agreements, the information resulting from the information requests in the report as available and an initial list of the issues and tradeoffs that will need to be addressed.

**Next meeting**: October 15-16, 2013: Continue to develop EM program options and alternatives based on Council recommendations.

PFMC
09/06/13
C/R

NOAA FISHERIES

# Electronic Technologies in Data Collection

## NOAA Fisheries science is world-class, providing trusted information to meet the varied needs of our partners and diverse stakeholders.

NOAA Fisheries launched a new initiative to evaluate emerging technologies for use in fishery-dependent data collections with the goal of providing timely, accurate, and cost-effective information. Smartphones, laptops, and tablets are common-place in society and hold great promise for better data, better decision-making, and better fishing. We are committed to working with the Councils, our data partners, and other stakeholders to develop a thoughtful approach to integration of emerging technologies into our data collections.

### A Regional Approach

In April 2013, NOAA Fisheries issued an Electronic Technology Policy Directive, supported by a series of white papers and draft best practice guidance, to encourage the evaluation and use of the latest monitoring and reporting technologies. **The policy calls on our regional offices to develop Regional Electronic Technology Implementation Plans** to identify, evaluate, and implement (where appropriate) new technologies to improve their fisheries data reporting and monitoring. Plans also will consider implementation costs, timelines, and evaluation criteria.

Although the Plans are regionally-focused, we will also seek solutions on a series of overarching challenges that span the different regions. Those already identified relate to:

- Law enforcement
- Confidentiality
- Information technology infrastructure needed for broad scale implementation
- Apples-to-apples cost comparisons costs for electronic technologies and observer programs
- Technology advances such as data storage and transfer; and image recognition
- Moving from pilot projects to full implementation (i.e. scalability).

We brought aboard George Lapointe, an expert consultant with extensive experience in fisheries management at the state and federal level, to assist in the development of the regional plans. He also will connect with existing data collection efforts such as the At-Sea Observer Program, Marine Recreational Information Program, and regional Fisheries Information Networks to share information and ensure program coordination.

### Built on a Foundation of Stakeholder Input

**George is conducting listening sessions with the range of partners and stakeholders to inform regional plan development.** Initial conversations focused on NOAA Fisheries staff, Councils, and Commissions to learn more about existing efforts, impediments and opportunities, and other regional issues. A next step will be to expand those conversations to include recreational and commercial fishermen, seafood processors, distributors, and retailers, NGOs, service providers, and other interested parties.

### Share Your Thoughts

We recently released a document, *Electronic Monitoring and Electronic Reporting: Guidance and Best Practices for Federally-Managed Fisheries*, to foster discussion among all fisheries stakeholders to identify, evaluate, and implement electronic reporting and monitoring technologies. Read and comment on the draft guidance at: http://www.nmfs.noaa.gov/op/outreach/18_em_er_discussion_draft.html. Comments are due by September 30.

Connect with your NOAA Fisheries Regional Office or send ideas and feedback to George Lapointe directly at: George@GeorgeLapointeConsulting.com or (207) 557-4970.

---------- Forwarded message ----------
From: **jnozicka** <jnozicka1@peoplepc.com>
Date: Thu, Aug 1, 2013 at 8:00 PM
Subject: Please help- F/V San Giovanni
To: will.stelle@noaa.gov
Cc: Frank.Lockhart@noaa.gov, Dmlowman@comcast.net, Donald.McIsaac@noaa.gov

Dear Board and Council members,

My name is Jiri Nozicka. I am the current operator of the F/V San Giovanni. The F/V San Giovanni( Fed# 244706) has been operating out of port of Monterey under the West Coast Trawl Catch Share Program since the programs launch in 2011. Until recently (May 2013) we have been using services of Alaskan Observers Inc. to comply with the programs 100% observer monitoring requirement. Last month our cooperation with the AOI have ceased and we have tried to contract another catch share observer provider for our fishing to continue. Much to our great surprise, we have learned that none of the listed providers(MRAG, Saltwater Inc., Sea-tech) are currently providing observer coverage not only for area of our coast, but in reality for most of the coast of California as well. Due to this shortage we are now being forced out of the Catch Share program entirely until at least next spring.

The F/V San Giovanni have been the only bottom trawl vessel operating out of Monterey`s Harbor for last 8 years and the only vessel providing local catches of groundfish for local markets and the only vessel working with the Royal Seafoods co. which has been so greatly affected by this problem, that it`s owners are considering shutting their operation completely. The Royal Seafood is the only licensed Catch Shares first receiver in Monterey.

The F/V San Giovanni have also worked for the North Coast Fisheries, where most of our catches were processed in last 5 years. Their operation is also being affected by our vessel not being able to bring our catches to them as well. As I learned from their representative, one of their another boats from Fort Brag had a very difficult time finding observers for many fishing trips trough last and this year. This problem is seems to getting bigger and I am afraid it can get worse.

I am writing this letter not only bring awareness to this arising problem, but I want to urge you and the council to make sensible changes to the current Catch Shares monitoring program to accommodate small operators and small ports like Monterey, or Fort Brag in their need to successfully participate in the groundfish fisheries in the short and long term. We fully understand and accept the need of the 100% data monitoring requirement for the success of the Catch Share program, but under current circumstances and conditions the status quo actually threatens the very existence and the future of our industry and its infrastructure in our and other similar ports and possibly the rest of California.

Our case is unfortunate result of multiple reasons accumulated in the past decade`s years. The complete restructuring of our markets infrastructure, multiple buybacks etc.. has led to dramatic decline in both boats and markets especially in our parts of the coast. The resulted very small number of vessels operating out of these ports do not provide enough activities to make coverage possible for these private enterprises, whom needs, and its only natural, to make a profit for their own existence. So this resulted in practically nonexistent observer provider competition in our area. Within just one year of the programs existence the AOI has become the only provider on our coast. This is very dangerous situation, which can very easily erupt in a disaster for our industry. Especially if we consider that the other companies are not really eager to cover our ports and then possibly loose money in the process.

Having said all this, I understand the challenge, that more flexible and small port and small operator friendlier monitoring system might be to developed and establish, but this might be the exact time to try to bring it in to existence. Our vessel have been currently scheduled to install a electronic monitoring equipment aboard, I understand that the Archipelago co. is really confident in accurate monitoring aboard of bottom trawl vessels. I also understand that council is considering an Experimental Fishing Permit for electronic monitoring aboard of bottom trawl vessels within the Catch Share program. I personally would like to ask you to consider faster action on implementing the Electronic monitoring and I would like to request that our boat will be selected to demonstrate how the electronic monitoring without the observer aboard can be successful in accurate monitoring of our fishing operation. I am very confident in our ability to provide good and reliable process aboard of our vessel, to make the monitoring process easy, accurate and reliable. We can assure you that we will provide the best service for this program, to ensure future success for our industry. At the same time I would like to encourage you to work on further improvement of the other aspects of the monitoring program. For instance allowing another companies participate in the program would probably improve situation as well. I would even consider licensing individual observers through NMFS. We have a lot of Graduates here in our area looking for work. It seems like a natural thing to help them get certified and work more closely with individual boats, since they will have places to live already and can have another jobs on the side and will get pay more per each trip. The same principle should be applied to the catch monitor positions, because even if we will have success in launching of the electronic monitoring, we will most likely face challenge in searching for the catch monitors for the offloading, unless there will also be cameras installed on the docks as well. But, if there is a certified graduate living in our area it should be readily easy to keep them busy or to contact them at call. I think that this area of the monitoring will also need special attention by the council to improve.

At last, I would like to thank you for your time and effort you and the council have already put in resolving this issue, but I would like to stress one more time how urgent this is for the very existence and the survival of our operations and jobs in our area. It would be very unfortunate, if more full time, year around fishing operations like ours as well as small ports like Monterey, would have to face the very hard choices of leaving the industry for a problems like this. We love to fish in our area and the way we do. We have been adjusting to the new management and we were becoming part of what you might call "boutique fisheries" on our coast. Most of us, who are left, do smaller volume fishing and are focusing on developing more direct and higher quality and value marketing. Our industry is changing and we need your help in matching the management and the monitoring system to the real situations and problems in our world that might differ from the areas in Oregon and Washington. I firmly believe, that this situation can bring the needed changes and it will actually help the industry in the long term. I would like to offer you my help and expertise in solving this issue for the better end. Please consider our plea, and our commitment.

Thank you

Sicerely

Jiri Nozicka
F/V San Giovanni
Monterey,CA
(831)324-3808 c
(831)393-4945 h

Moved by: Michele Culver/Richard Lincoln

I move that at their October meeting, the GEMs review the supplemental EC Report and discuss specifically the 2 recommendations of:

1. A "phased in approach" starting with midwater trawl and FG in the 1st phase; bottom trawl as a separate phase; and
2. A data logger system (e logbook) as a component of the EM program.

Also, for the GEMs to discuss:

1. How maximized retention could be feasible (i.e., provide specific alternatives for what could be discarded); and
2. With regard to allowing safety discards to explore limiting tow times to reduce the necessity of safety discards.

And, request the NWFSC to provide a report on how the WCGOP program may move forward with an EM program in place for midwater trawl, fixed gear, and potentially bottom trawl at the November meeting. Specific questions for the WCGOP are:

1. What level of coverage would be needed to meet biological sampling goals, particularly for rare species, such as yelloweye rockfish?
2. What level of coverage would be needed to assess halibut size and viability?

Motion carried unanimously.