NATIONAL MARINE FISHERIES SERVICE REPORT ON GROUNDFISH MANAGEMENT

Situation: The National Marine Fisheries Service (NMFS) will report on its regulatory and scientific activities relevant to groundfish fisheries. Specific items for discussion include an update on 2004 regulations, progress on the Vessel Monitoring System, approval and implementation of Amendment 16-1 and Amendment 16-2, notice of a control date and proposed rulemaking on an individual quota program for the limited entry trawl fishery, an update on the West Coast Groundfish Observer Program, reports on regional bycatch plans, and other issues of interest to the Council.

Council Task:

1. Discussion.

Reference Materials:

1. Exhibit E.1.a, Control Date Letter.
2. Exhibit E.1.a, Notice of Rulemaking and Control Date: *Federal Register* notice of control date and proposed rulemaking for trawl IQs.
3. Exhibit E.1.a, Amendment 16-1 Letter.
4. Exhibit E.1.a, Amendment 16-2 Letter.
5. Exhibit E.1.a, NMFS Vessel Monitoring System Report.
6. Exhibit E.1.c, NMFS Northwest Region Bycatch Report.
7. Exhibit E.1.c, NMFS Southwest Region Bycatch Report.
8. Exhibit E.1.e, Public Comment.

Agenda Order:

a. Regulatory Activities	Bill Robinson
b. Science Center Activities	Elizabeth Clarke
c. Regional Bycatch Plans	Yvonne de Reynier and Dan Viele
d. Reports and Comments of Advisory Bodies	
e. Public Comment	
f. Council Discussion	

PFMC
02/24/04

Exhibit E.1.a
Amendment 16-1 Letter
March 2004

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

RECEIVED
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Mr. Donald Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place
Portland, OR 97220

Dear Mr. Hansen:

By this letter, I am approving Amendment 16-1 to the Pacific Coast Groundfish Fishery Management Plan (FMP). As you know, Amendment 16-1 sets a process for and standards by which the Council will specify rebuilding plans for overfished groundfish stocks. Amendment 16-1 is intended to ensure that Pacific coast groundfish overfished species rebuilding plans meet the requirements of the Magnuson-Stevens Act, in particular National Standard 1 on overfishing and §304(e), which addresses rebuilding overfished fisheries. Amendment 16-1 is also intended to partially respond to a court order in Natural Resources Defense Council, Inc. v. Evans, 168 F. Supp. 2d 1149 (N.D. Cal 2001,) in which the court determined that Pacific Coast groundfish rebuilding plans must be in the form of FMPs, FMP amendments, or regulations. Amendment 16-1 also makes the Federal observer program mandatory, as required by the court's decision in Pacific Marine Conservation Council v. Evans, 200 F. Supp. 2d 1194 (N.D. Calif. 2002).

NMFS published a proposed rule to implement Amendment 16-1 on September 5, 2003 (68 FR 52732), and we expect to have the final rule effective in early 2004. Regulations implementing Amendment 16-1 will include a new Federal regulation at 50 CFR 660.370 that will be reserved for the overfished species' target years for rebuilding (T_{Target}) and the harvest control rule to be used to rebuild each stock. All other overfished species rebuilding parameters would remain in the FMP.

Section 304(e) of the Magnuson-Stevens Act provides that the Secretary of Commerce, acting through NMFS, shall review rebuilding plans contained in FMP amendments or regulations at routine intervals that may not exceed two years. Amendment 16-1 provides that species-specific standards for determining when progress has been adequate will be developed for each plan. To comply with this provision, NMFS asked (at the November 2003 Council meeting) that the Council's Scientific and Statistical Committee (SSC) start developing these standards. NMFS further suggests that the SSC consider developing these standards as part of the Stock Assessment Review (STAR) processes for overfished species stock assessments.

NMFS appreciates the Council's ongoing efforts to rebuild overfished groundfish species and to better formalize overfished species rebuilding plans within the FMP and Federal regulations.

Sincerely,
Steve P. Freese (for)

D. Robert Lohn
Regional Administrator

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

JAN 3 0 2004

Mr. Donald Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place
Portland, OR 97220

Dear Mr. Hansen:

By this letter. I am approving Amendment 16-2 to the Pacific Coast Groundfish Fishery Management Plan (FMP). As you know, Amendment 16-2 amends the FMP to include overfished species rebuilding plans for lingcod, canary rockfish, darkblotched rockfish, and Pacific ocean perch within the FMP.

Amendment 16-2 addresses the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) to protect and rebuild overfished species managed under a Federal FMP. Amendment 16-2 also responds to a court order in Natural Resources Defense Council, Inc. v. Evans, 168 F. Supp. 2d 1149 (N.D. Cal 2001,), in which NOAA Fisheries was ordered to provide Pacific Coast groundfish rebuilding plans as FMPs, FMP amendments, or regulations, per the Magnuson-Stevens Act. On October 27, 2003 the court ordered NMFS to approve rebuilding plans for lingcod, canary rockfish, darkblotched rockfish, and Pacific ocean perch by January 31, 2004.

NMFS published a proposed rule to implement Amendment 16-2 on December 5, 2003 (68 FR 67998) and we expect to have the final rule effective in early 2004. Regulations implementing Amendment 16-2 will codify two rebuilding parameters, the target year for rebuilding and the harvest control rule to be used to rebuild the stock. These parameters control the establishment of the annual or biennial optimum yield for each overfished species in Federal regulation. The target rebuilding year is the year in which there is a 50 percent likelihood that the stock will have been rebuilt with a given mortality rate. The harvest control rule expresses a given fishing mortality rate that is to be used over the course of rebuilding. All other overfished species rebuilding parameters will remain in the FMP. If, after a new stock assessment, the Council and NMFS conclude that these should be revised, the revision will be done through a notice and comment rulemaking, and the updated values codified in the CFR.

On November 14, 2003, I sent you a letter of approval for Amendment 16-1. In that letter, I reminded the Council that Amendment 16-1 requires the Council to set species-specific standards for determining when rebuilding progress has been adequate to meet rebuilding plan goals. At the Council's November 2003 meeting, NMFS asked that the Council's Scientific and Statistical Committee (SSC) start developing these standards. The Council will need to complete their review and adoption of these review standards for Amendment 16-2 species no later than its September 2005 meeting in order to ensure timely review of the rebuilding plans.

NMFS appreciates the Council's ongoing efforts to rebuild overfished groundfish species.

Sincerely,

for Joe Scordino

D. Robert Lohn
Regional Administrator

Exhibit E.1.a
Control Date Letter
March 2004

PACIFIC FISHERY MANAGEMENT COUNCIL

7700 NE Ambassador Place, Suite 200
Portland, Oregon 97220-1384

CHAIRMAN
Donald K. Hansen

EXECUTIVE DIRECTOR
Donald O. McIsaac

Telephone: 503-820-2280
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December 1, 2003

Mr. Robert Lohn, Regional Administrator
National Marine Fisheries Service, Northwest Region
Building 1, BIN C15700
7600 Sand Point Way NE
Seattle, WA 98115-0070

Dear Mr. Lohn:

At its November 2003 meeting, the Council adopted November 6, 2003 as a control date for individual quota programs pertaining to the groundfish trawl fishery. We ask that NMFS publish a *Federal Register* notice on this control date as soon as possible.

This control date would apply to any person potentially eligible for individual quota shares. The control date puts those persons on notice that the Council may decide to not count activities occurring after the control date toward determining a person's qualification for an initial allocation or determining the amount of initial allocation of quota shares. The Council is considering both individual fishing quotas and individual processing quotas for groundfish trawl catch. The control date may be applicable to either of these individual quota systems, if such systems are eventually recommended by the Council and adopted by NMFS. The Council could decide to proceed with individual fishing quotas but not individual processing quotas, to proceed with neither programs, or to proceed with both programs.

The primary purpose of the control date is to discourage speculative increases in fishing effort while the Council is deliberating on the IQ program. Deliberations on IQ programs may encourage increased effort if fishers hope that additional landings will qualify them for a greater share of the initial allocation. Such increases can deteriorate conditions in the fishery while the IQ program is being considered. Deterioration would occur through an increase in effort beyond that which would be economically rationale in the absence of the opportunity to qualify for greater quota shares. Additionally, discards could be increased in this multispecies fishery as fishers seek to maximize catch despite having reached limits on the species are necessary to make the trip economically viable. The increased effort would require increased restrictions, to the detriment of those not engaging in speculative fishing. To consider landings during the period of program development would open the possibility that fishers would be rewarded for this detrimental fishing at the expense of more responsible fishers. Additionally, consideration of landings during this period may not necessarily be consistent with allocation criteria. Economic dependence and historical involvement in the fishery are significant criteria on which initial allocation rules are often based. Landings made only on the speculative basis of qualifying for greater initial allocation do not reflect true economic dependence or involvement in the fishery.

Thank you for your attention to this matter.

Sincerely,

D. O. McIsaac, Ph.D.
Executive Director

JLS:rdd

c: Mr. Rod McInnis
Ms. Eileen Cooney

Vessel Monitoring System Report
Pacific Fisheries Management Council
February 20, 2004

Due to the over fished status of several Rockfish species the Pacific Fisheries Management Council (PFMC) developed a "Depth Based Management" strategy that is intended to minimize by catch of the affected species and eventually restore depleted stocks.

To this end, the PFMC established the Rockfish Conservation Area(s) (RCA), a narrow corridor in the Pacific Ocean stretching from Canada to Mexico, which is closed to specific fishing activity. The RCA is closed to both Limited Entry Permit bottom trawlers and Limited Entry Permit fixed gear vessels. Vessels can legally transit the RCA at any time and engage in fishing activities inside that area that are not prohibited by regulation.

To assist enforcement within the RCA the PFMC adopted and implemented the NOAA Fisheries Office for Law Enforcement's (OLE) Vessel Monitoring System (VMS). Given the RCA's immense geographical area, the PFMC believes that VMS will provide an improved enforcement capability over traditional surveillance activities such as vessel patrols or over flights.

The final rule implementing the adoption of a Vessel Monitoring System (VMS) for the Pacific Coast Groundfish Fishery became effective on January 1, 2004.

The rules summary states "NMFS issues a final rule to require vessels registered to Pacific Coast groundfish fishery limited entry permits to carry and use mobile vessel monitoring system (VMS) transceiver units while fishing in state or Federal waters off the coasts of Washington, Oregon and California. This action is necessary to monitor compliance with large-scale depth-based conservation areas that restrict fishing across much of the continental shelf."

As of January 2004, the NOAA Fisheries, Office for Law Enforcement is electronically monitoring Limited Entry Permit vessels fishing in State and Federal waters off the West Coast of the United States. Moreover, OLE has also implemented a call-in telephone declaration system for vessel owners to declare the gear type their vessel will be using while engaged in authorized fishing activity within the RCA.

Electronic monitoring of vessels through the OLE VMS is achieved through a five step process.

- Mobile Transceiver Units (MTU's) installed on fishing vessels derive their Latitude and Longitude position from Global Position Satellites (GPS).
- These GPS positions are then sent to an orbiting communications satellite.
- The communications satellite forwards the position report to a Land Earth Station (LES).
- The Land Earth Station (LES) forwards the position report to the OLE VMS.
- The OLE VMS processes the data received from the LES.

Mobile Transceiver Units (MTU's):
Vessel position reports are generated and delivered to a communications satellite via an MTU purchased by the vessel owner. Currently, there are four MTU's type approved by NOAA Fisheries, Office for Law Enforcement for the Pacific Coast Groundfish Fishery. The MTU Type Approval process ensures that approved units meet minimum technical requirements for accurate operations.

The four type approved units are;

Satellite Network	Manufacturer	Model Number
Inmarsat C	Thrane and Thrane	3022D-NMFS
Inmarsat C	Thrane and Thrane	3026-NMFS
Inmarsat D+	Satamatics	SAT 101 NMFS/PCG
Orbcomm	Stellar	2500G-NMFS

Communications Providers / Land Earth Stations:
Depending on the MTU purchased by the vessel owner, several communications providers are available to provide "air time." The "air time" component of VMS is comparable to the purchase of a cell phone, where the user purchases a cell phone (hardware) and minutes per month (air time). Similarly, the VMS system requires an MTU (hardware) and messages from the MTU (air time) that take the form of position reports or other message traffic such as email. The various communication providers sell "air time" in two ways, by the message, such as by position report, or by a monthly flat fee which provides a set amount of "air time."

The communications providers approved for the Pacific Coast Groundfish Fishery are;

Communication Provider	Satellite Network	MTU's
Telenor	Inmarsat C	TT3022D, TT3026
Xantic	Inmarsat C	TT3022D, TT3026
Satamatics	Inmarsat D+	SAT 101
Skymate Wireless	Orbcomm	Stellar 2500G

OLE VMS:

The final component of the Pacific Coast Groundfish VMS network is located in the OLE NW Division office in Seattle, Washington. The OLE VMS consists of the Smart Trac application software from Absolute Communications and, an Oracle database that stores vessel information and position reports.

The Smart Trac software consists of three components. The first component continuosly monitors all communication providers and downloads vessel position reports to the Oracle database. The second component enables automatic alerts to be created that report when pre-set criteria are met. The third component of Smart Trac enables vessel position reports to be viewed in a graphical map format. The graphical map format displays vessel positions in relationship to the Conservation Areas established for the Pacific Coast Groundfish Fishery.

Currently the OLE NW Division VMS has;

A. Number of activated Units: 203
B. Number of position reports: 160,000+

Declaration System

Running in tandem with the VMS system is the Pacific Coast Groundfish declaration system. The declaration system was established in conjunction with the VMS regulation to provide vessel owners with a method to declare their intentions to fish in a conservation area consistent with the requirements of the regulations, and to specify the gear type their vessel will be using. The Compliance Guide for the Pacific Coast Groundfish Fishery Vessel Monitoring Program states:

"Limited entry vessels with trawl endorsements, and open access or tribal vessels using trawl gear are required to send a declaration report before the vessel is used to fish in any trawl RCA or the CCAs in a manner that is consistent with the requirements of the conservation areas. Limited entry vessels with longline and pot endorsements, must send a declaration report before the vessel can be used to fish in any non-trawl RCA or the CCA's".

The declaration system is a complimentary tool to VMS and assists law enforcement personnel in determining if a fishing vessel is operating gear consistent with the conservation area.

The declaration categories for the Pacific Coast Groundfish Fishery are:

Gear Code	Description
10	Limited entry fixed gear
20	Limited entry midwater trawl gear
30	Limited entry bottom trawl gear
41	Pink shrimp or ridgeback prawn trawl gear
42	California halibut trawl gear
43	Sea cucumber trawl gear
50	Tribal trawl gear
60	Spot and ridgeback prawns non-trawl gear
61	Crab or lobster gear
62	Pacific Halibut gear
63	Salmon troll gear
64	California halibut gear
65	California Sheephead gear
66	Gear used to take species under the Highly Migratory Species FMP
67	Gear used to take species under the Coastal Pelagic Species FMP
68	Gear used to take species in the California gillnet complex
69	A gear that is not listed above

Declarations may also be made that allow vessels to be exempted from the VMS rule. The Exemption declarations are;

Exemption Code	Description
10	Haul out Exemption - When a vessel is continuously out of the water for more than 7 consecutive days.
20	Outside Areas Exemption - When the vessel will be operating outside of the EEZ off Washington, Oregon, or California formore than 7 consecutive days

To date, NW OLE has received 234 declarations reports. The predominant number of declaration reports have fallen into the following categories.

61- Crab or lobster gear

30- Limited entry bottom trawl gear

10- Limited entry fixed gear

Cases:

The NW Division of OLE is currently investigating potential fisheries violations with the assistance of VMS.

Future Projects:

The MTU's type approved for the Pacific Coast Groundfish Fishery are two way messaging capable, that is, the units are able to send and receive messages. Two way messaging capability will enables future fisheries projects to be undertaken in addition to vessel position reporting. Future projects may include;

Catch and Effort Reporting
At Sea Declarations via Email

Conclusion:

The Pacific Coast Groundfish VMS is online and operating as intended. The declaration system is working well in tandem with VMS.

to lowest, would be Alternative 4, Alternative 2, Alternative 3, Alternative 4a, the preferred alternative, and finally, Alternative 1. As expected, the highest number of fleet DAS (Alternative 4) would have the greatest potential to ensure that vessels harvest the TAC, but at the expense of possibly exceeding the TAC.

According to section 8.8 of the Red Crab Specifications document, Alternative 1 would be expected to generate the lowest level of landings and revenue because it allocates 35 fewer fleet DAS than the preferred alternative. On the other hand, Alternatives 2, 3, and 4 would allocate more fleet DAS than the preferred alternative; 81, 60, and 94 more fleet DAS, respectively. The additional allocated DAS would enable each vessel to take extra trips, and the economic benefits would be expected to increase compared to FY2003 with more DAS available, depending on which alternative is selected. But each of these other alternatives would be more likely to result in exceeding the TAC. The opting out of one red crab vessel, however, means that the remaining four vessels will have 195 DAS each instead of 156 under the preferred alternative. This increase in individual DAS significantly increases the landings and economic benefits for these vessels, compared to FY2003. In balancing the FMP objectives of providing the fleet with the greatest number of landings without exceeding the TAC, the preferred alternative is considered to be the best. Section 5.0 of the FMP includes more detailed economic impact analysis of DAS measures.

Authority: 16 USC 1801 *et seq.*

Dated: January 6, 2004.

Rebecca Lent,

Deputy Assistant Administrtaor for Regulatory Programs, National Marine Fisheries Service.

[FR Doc. 04–465 Filed 1–8–04; 8:45 am]

BILLING CODE 3510–22–S

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 660

[Docket No. 031230329–3329–01; I.D. 120903B]

RIN 0648–AR82

Fisheries Off West Coast States and in the Western Pacific; Pacific Coast Groundfish Fishery; Advance Notice of Proposed Rulemaking regarding a Trawl Individual Quota Program and to Establish a Control Date

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Advance notice of proposed rulemaking; notice of control date for the Pacific Coast groundfish fishery; request for comments.

SUMMARY: The Pacific Fishery Management Council (Council) is considering implementing an individual quota (IQ) program for the Pacific Coast groundfish limited entry trawl fishery off Washington, Oregon and California. The trawl IQ program would change management of harvest in the trawl fishery from a trip limit system with cumulative trip limits for every 2–month period to a quota system where each quota share could be harvested at any time during an open season. The trawl IQ program would increase fishermen's flexibility in making decisions on when and how much quota to fish. This document announces a control date of November 6, 2003, for the trawl IQ program. The control date for the trawl IQ program is intended to discourage increased fishing effort in the limited entry trawl fishery based on economic speculation while the Pacific Council develops and considers a trawl IQ program.

DATES: Comments may be submitted in writing by February 9, 2004.

ADDRESSES: Comments may be mailed to Don Hansen, Chairman, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220–1384.

FOR FURTHER INFORMATION CONTACT: The Pacific Fishery Management Council at 866–806–7204; or Bill Robinson at 206–526–6140; or Svein Fougner at 562–980–4000.

SUPPLEMENTARY INFORMATION: The Pacific Fishery Management Council (Pacific Council) established under section 302(a)(1)(F) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1852(a)(1)(F)) is considering implementing an individual quota (IQ) program for the Pacific Coast groundfish limited entry trawl fishery off Washington, Oregon and California. The Pacific Coast groundfish limited entry trawl fishery is managed under the Pacific Coast Groundfish Fishery Management Plan (FMP) approved on January 4, 1982 (47 FR 43964, October 5, 1982), as amended 15 times. Implementing regulations for the FMP and its amendments are codified at 50 CFR part 660, subpart G. Additional implementing regulations can be found in the specifications and management measures for the Pacific Coast groundfish fishery published in the **Federal Register**, as amended through inseason actions. If the Pacific Council recommends and NMFS adopts a trawl IQ program, the program would be implemented through a proposed and final rulemaking, and possibly an FMP amendment.

The trawl IQ program would change management of harvest in the trawl fishery from a trip limit system with cumulative trip limits per vessel for every 2 month period to a quota system where each quota share could be harvested at any time during an open season. The trawl IQ program would increase fishermen's flexibility in making decisions on when and how much quota to fish.

With the lapse of the moratorium on new individual fishing quotas (IFQs) in October 2002, the Regional Fishery Management Councils may propose new IFQs and the Secretary of Commerce will review them for consistency with the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), in particular section 303(d).

In advance of a rulemaking on the trawl IQ program, this document announces a control date of November 6, 2003, for the trawl IQ program. The control date for the trawl IQ program is intended to discourage increased fishing effort in the limited entry trawl fishery based on economic speculation while the Pacific Council develops and considers a trawl IQ program. This control date will apply to any person potentially eligible for IQ shares. Persons potentially eligible for IQ shares may include vessel owners, permit owners, vessel operators, and crew. The control date announces to the public that the Pacific Council may decide not to count activities occurring after the control date toward determining a person's qualification for an initial allocation or determining the amount of initial allocation of quota shares.

Groundfish landed from limited entry trawl vessels after November 6, 2003, may not be included in the catch history used to qualify for initial allocation in the trawl IQ program.

Implementation of any management measures for the fishery will require amendment of the regulations implementing the FMP and may also require amendment of the FMP itself. Any action will require Council development of a regulatory proposal with public input and a supporting analysis, NMFS approval, and publication of implementing regulations in the **Federal Register**. The Pacific Council has established an ad-hoc Groundfish Trawl Individual Quota Committee to make recommendations on the development of IQs in the groundfish fisheries. Meetings of this committee are open to the public. Interested parties are urged to contact the Pacific Council office to stay informed of the development of the planned regulations. Fishers are not guaranteed future participation in the groundfish fishery, regardless of their date of entry or level of participation in the fishery.

This advance notice of proposed rulemaking has been determined to be not significant for purposes of Executive Order 12866.

Authority: 16 U.S.C. 1801 *et seq.*

Dated: January 6, 2004.

Rebecca Lent,

Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.

[FR Doc. 04–464 Filed 1–8–04; 8:45 am]

BILLING CODE 3510–22–S

Exhibit E-1-a
Supplemental
Buyback Analysis

The Aftereffects of the Pacific Groundfish Limited Entry Trawl Buyback Program
A Preliminary Analysis.
NMFS NWR (March 09, 2005 Draft)

Executive Summary

On December 4, 2003, under the Pacific Groundfish Limited Entry Trawl Buyback Program (Buyback Program) NOAA Fisheries permanently retired 91 trawl vessels and their Pacific Groundfish limited entry trawl permits. (NOAA Fisheries had previously announced the purchase of 92 vessels and federal groundfish permits, but at the last moment rejected one purchase due to an invalid bid package.) Designed under specific instructions from U.S. Congress (Attachment 1), the Buyback Program reduced the number of trawl permits to 172, excluding the ten associated with the catcher-processor fleet. The 91 buyback vessels cannot fish anywhere in the world ever again.

The Buyback Program was designed with the following goals:

* Reduce capacity in the groundfish fishery
* Increase the remaining harvesters' productivity
* Financially stabilize the fishery
* Conserve and manage groundfish

As a result of the Buyback Program:

* The number of permits has been reduced by 35%
* Annual groundfish revenues per permit are expected to increase by 53%
* Capacity in terms of endorsed permit length for the fleet has been reduced by 34%
* The physical capacity rating of the fleet (points) has been reduced by 31%
* Some trip limits have been increased

Since October 1, 2003, the NMFS NWR has transferred 15 trawl permits to new owners. The NWR has also received signals about the potential transfer of another two permits. Some of these transfers are by Buyback Participants and others are by seafood processors. Many of these permits have been idle in recent years. Some reviewers of the Buyback Program have raised concerns about Buyback Program participants reentering the fishery by buying such permits. Others have asked NOAA Fisheries to set a control date and issue an advance notice of proposed rule making to address inactive or "lightly fished" latent permits to keep new capacity from reentering the fishery.

The Buyback Program also bought 121 state crab and shrimp permits. This analysis does not describe the effects of the Buyback Program on these fisheries because of insufficient information. As a result this analysis is incomplete and preliminary. Some of this information will not be available until June 2004 after the California crab permit renewal cycle is completed. NOAA Fisheries is seeking information from the states on what actions they are taking to permanently revoke the state permits purchased. NOAA Fisheries is also now working with the states on how best to collect the fees needed to repay the $36 million loan portion of the Buyback Program's $46 million cost. (Attachment 2 provides information about the Buyback loan and state crab and shrimp fisheries.).

To help discussions concerns latent permits in the groundfish fishery, this analysis describes some of the results of the Buyback Program. In particular, this paper provides details on the 172 trawl permits that remain in the fishery. As a means of focusing discussion, this analysis sets up two alternative definitions of "latent." One definition defines an active permit as one that has landed at least one pound of fish, every year, over a number of consecutive years. A second definition is based on a review of 2002 harvests by permit and arbitrarily defines a latent permit as one that has less than 50,000 lbs. associated with it in a single year. Applying these definitions and comparing these alternatives produces a range of 24 to 32 latent permits. For discussion permits this range is collapsed into a single estimate of 30 permits.

However, defining "latent" and taking any action on "latent" permits will depend on discussions between NOAA Fisheries and the Pacific Fishery Management Council. The current Pacific Groundfish FMP does not contain provisions for removing "latent" permits. In developing Amendment 6 to the FMP, the Pacific Fishery Management Council rejected "Use It or Lose it" rules for removing "latent" permits.

> "These provisions result in expiration of a permit if the holder fails to make a certain minimum amount of landings in a fishing year. This type of measure is counter productive to effort reduction policies and its use was therefore minimized in development of the license limitation alternative." (Amendment six, page 4-81)

One way to frame future discussions on this issue is to address the following question:

> The Pacific Groundfish Buyback Program has reduced the available pool of limited entry permits for vessels that deliver to shore plants and motherships from 263 permits to 172 permits. Before carrying out a trawl ITQ program, should NMFS and the Council take action to reduce the number of inactive permits?

The next section of the analysis reviews various conclusions, findings, and other issues related to groundfish permits and the term "latent." These are:

* The term "latent" has no official definition.
* Forty permits had no recorded groundfish landings in 2002 and 2003.
* Four permit owners did not fish their permits at all during the 1998 to 2003 period.
* The number of unfished permits increased significantly after the year 2000 mirroring the decline in groundfish.
* During 2002, 56 permits had harvest levels less than 50,000 lbs.
* Some Permits may not be fished because of strategic planning.
* The ITQ Control Date and rising permit prices are discouraging the sale of latent permits.
* Fifteen trawl permits have changed hands since October 1, 2003. Six had 2002 harvests. Nine did not.
* Knowing there is a control date on ITQ's why buy a permit?
* Activating some permits may be helpful to some fishing communities. How has the Buyback Program affected fishing communities?

This section is then followed by final section whereby the two alternatives are described, applied, and compared. This section projects:

* For 2004, after considering recent permit transfers and the potential for increased harvests of whiting, about 30 "latent" permits remain in the fishery.

<u>**Discussion and Findings**</u>:

The term "latent" has no official definition

The Magnuson-Stevens Act, the Pacific Groundfish Fishery Management Plan (FMP), or the academic literature do not define the term "latent." As a result, there are no guidelines for the analyst to use for measuring latency. Defining the term "latent" will depend on available data and on the goals and objectives for the fishery.

In defining the term "latent" it will be important to distinguish between two interrelated concepts: "latent permits" and "latent capacity." Most discussions about "latent permits" concern minimum landing requirements that must be met for the permit to remain valid. Other discussions concern "latent" capacity which is about how much unutilized fishing effort exists in the fishery. This analysis is addressed to the "latent" permit issue.

Many of the issues surrounding the term "latent" are discussed in the March 16, 2000 draft Report on Overcapitalization in the West Coast Groundfish Fishery developed by the Economic Subcommittee of the Pacific Fisheries Management Council's Scientific and Statistical Committee:

> Under Amendment 6 to the Groundfish FMP (PMFC 1992a) the Council established a limited entry program whereby vessels meeting minimum landings requirements (MLRs) for trawl, longline or fishpot gear during the window period July 1, 1984-August 1, 19888 could qualify for a transferable limited entry permit. Permit holders were allowed to use only those gears endorsed on their permits (i.e., those gears for which they met the MLRs) while participating in the limited entry fishery. While permits must be renewed annually, permit holders are not required to land any groundfish in order for the permit to remain valid. To discourage increases in harvest capacity associated with the transfer of permits from smaller to larger boats, non-permitted vessels desiring to enter the fishery are required to either purchase a permit from a similar-sized or larger vessel or to purchase a combination of permits from smaller vessels according to a conversion formula based on vessel length. Trip limits and trip frequency limits, which were already being used to restrict harvest rates on the major groundfish complexes, were also expected to reduce the incentive for " capital stuffiing"

The SSC Report went on to define the MLRs for trawlers and "Capital stuffing"

> MLRs during the window period varied by gear type as follows: trawl-9 landings of at least 500 pounds of non-whiting groundfish or 450 mt of non-whiting groundfish or 17 landings of at least 500 pounds of whiting or 3,750 mt of whiting:...
>
> "Capital stuffing" pertains to the technological innovations and fishing practices that allow fishermen to increase their share of the allowable harvest in the race for fish. As these innovations and practices become more widespread, the competitive advantage they initially provided tends to dissipate, leading to additional rounds of innovation and higher costs for the fleet as a whole without a commensurate increase in harvest.

The SSC Report discussed the linkage between harvest capacity and permits:

> Potential harvest capacity includes both unutilized (i.e., latent) and utilized capacity. Although limited entry has likely had the effect of "freezing" potential harvest capacity in the fishery at its 1994 level, the low MLRs used to qualify a permit virtually assured that a significant proportion of the potential harvest capacity initially admitted into the fishery consisted of latent capacity. Furthermore, the amount of time elapsed between the window period (i.e., the 1984-1988 period during which vessels would had to fish to qualify for a limited entry permit) and the year when limited entry was actually implemented (1994) increased the likelihood of permits being issued to vessels whose

Involvement in the groundfish fishery had waned by the time permits were actually issued.

Permit transferability per se has the advantage of flexibility, in that it allows the composition of the fishing fleet to adapt to changes in environmental, biological and economic conditions, and allows individual vessels to enter and exit in response to changes in their personal circumstances. However, since vessels are typically not interested in buying a permit unless they intend to use it and since marginally involved fishery participants (i.e., vessels comprising the latent capacity in the fishery) are typically the most willing to sell their permits, the presence of significant latent capacity almost inevitably assures the increase in realized fishing effort when permits are transferred. The establishment of an active whiting catcher-processor sector resulting from the transfer of permits from trawlers to catcher-processors reduced the amount of latent capacity in the trawl sector and did little to curtail the actual amount of fishing effort expended by trawlers. Transfers involving fixed gear vessels have likely resulted in increased fishing effort as well.

The SSC concludes its report requesting that the Council take deliberate action:

In other words, latent capacity is always available in the open access fishery and likely to remain high in the limited entry fishery, since permit holders are much more likely to retain their permits rather than allow them to lapse. Unless the Council takes deliberate action, a significant amount of capacity will remain in the groundfish fishery that can be mobilized at any sign of improved fishing opportunities. Given that fishing effort can easily outpace OYs even if the OYs were to increase to much higher levels, the current problems associated with low landings limits and short seasons will not go away unless latent capacity is permanently removed from the groundfish fishery.

In its Executive Memorandum to the Council, the SSC asserted that:

The Council should take immediate action to develop stringent capacity reduction programs, for all sectors of the West Coast groundfish fishery. Given the current moratorium on IFQs and the complexities of designing an IFQ system, IFQs are best viewed as a long term management strategy for West Coast groundfish. Other potential solutions include limited entry for the open access fishery and buyouts and/or permit stacking for the limited entry fishery should be explored immediately.

Forty permits had no recorded groundfish landings in 2002 and 2003.

Vessels that deliver to shore or to non-tribal motherships use these permits. Sometimes within a year or across years, two or more vessels use a given permit. We added preliminary PacFIN data for January-September 2003 to the Buyback Program Database which contains 199 -2002 fish ticket data. We then organized the data by permit and developed a simple rule to define a "fished" permit. A fished permit is one where at least one pound of groundfish landed or delivered during the time the permit was valid. Below, we analyze these permits based on total pounds landed or delivered in 2002. (This analysis describes the 172 trawl permits that remain in the fishery. It does not include permits combined with other permits in 1998 (5), 1999 (1) and in 2003 (1) or the 10 permits associated with the catcher-processor fleet.)

Remaining Limited Entry Trawl Permits

Year	1998	1999	2000	2001	2002	2003
Fished	154	158	152	140	133	132
Not fished	18	14	20	32	40	40
Total	172	172	172	172	172	172

(Excludes 10 permits associated with Factory Trawlers)

Four permit owners did not fish their permits at all during the 1998 to 2003 period.

Only four permits recorded no landings consecutively between 1998-2003.

Number of Unfished Permits by Consecutive Period

1998-2003	4
1999-2003	7
2000-2003	13
2001-2003	24
2002-2003	33
2003	40

The number of unfished permits increased significantly after the year 2000 mirroring the decline in groundfish harvests.

Harvests of all groundfish or whiting by the entire limited entry trawl fleet (excluding catcher processors and tribal trawlers) fell off significantly during the 2001-2003 period compared with the 1998-2000 period. Pacific whiting harvests have fallen off significantly in the last two years, matching the trends in unfished permits during these two years. During this later period, nine species of fish were declared overfished, including whiting. In response, the Pacific Council and NOAA Fisheries set up large area closures and other measures to protect these fish.

Groundfish Harvests 1000 Tons

Buyback and Non-Buyback Trawlers

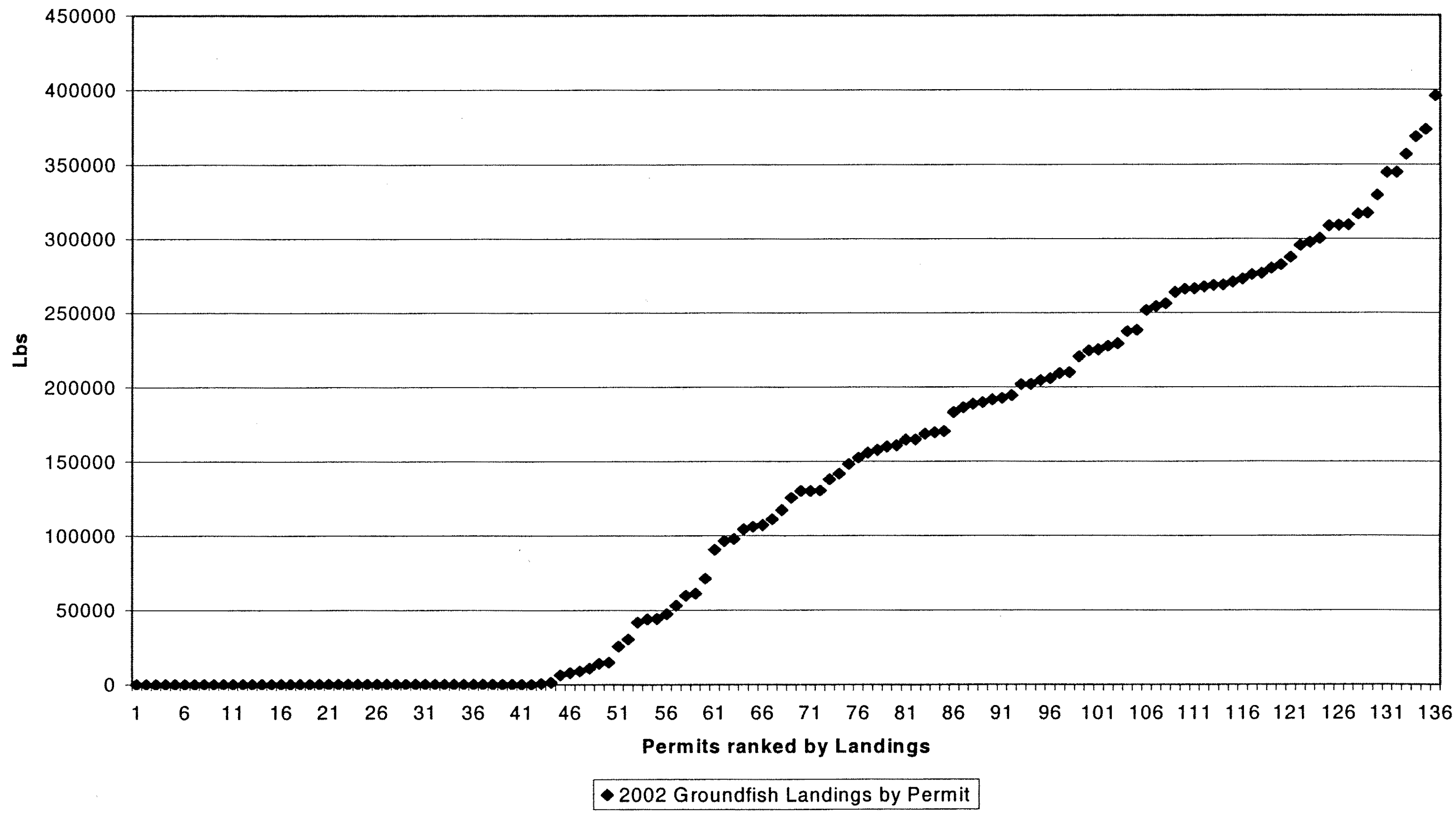
1000 metric Tons

	Non-Whiting Shore	Whiting Shore	Total Shore	Whiting Non-Tribal Mothership	Groundfish Total	Whiting Total
1994	46	80	126	93	219	173
1995	50	75	125	41	166	115
1996	52	85	137	47	184	132
1997	47	87	135	50	185	138
1998	34	91	125	50	175	140
1999	33	87	120	48	167	135
2000	29	89	117	47	164	136
2001	25	73	99	36	135	109
2002	25	46	71	27	98	72
2003	22	55	78	26	104	81

During 2002, 56 permits had harvest levels less than 50,000 lbs.

The graph below plots permits against landings. (To avoid the scale effects associated with Pacific whiting permits, the plot excludes permits with more than 400,000 lbs.) There are no obvious break points on which to base a definition of a latent permit.

2002 Landings by Permit; Permits with Landings less than 400,000 lbs



The table below classifies permits by groundfish harvest combining shoreside landings with non-tribal mothership deliveries. The owners of forty permits did not fish their permits in 2002. Thirty permits were not fished at all, and 10 permit owners fished species other than groundfish during the year (mainly crab and shrimp). Of the permits that were fished, ten permits had harvests ranging from one to 15,000 lbs. Finally, six permits had landings between 16,000 and 50,000 lbs.

2002 Harvests and Revenues for Remaining 172 Permits

Groundfish Range Low lbs	Harvest High lbs	Number of Permits	Groundfish Total Lbs	Groundfish Total Revenue	Groundfish Average lbs/permit	Groundfish Average $/permit	All Species Total Lbs	All Species Total Revenue
0	**0**	30	0	$0	0	$0	0	$0
0	**0**	10	0	$0	0	$0	719,695	$1,090,574
1	**15,000**	10	65,554	$41,422	6,555	$4,142	1,255,875	$685,242
16,000	**50,000**	6	233,843	$113,879	38,974	$18,980	1,610,520	$815,505
51,000	**100,000**	7	529,940	$319,852	75,706	$45,693	837,461	$742,562
101,000	**200,000**	29	4,440,717	$2,517,061	153,128	$86,795	10,416,529	$5,369,242
201,000	**400,000**	44	12,112,506	$6,703,388	275,284	$152,350	18,172,958	$10,567,037
401,000	**1,000,000**	6	3,889,682	$1,099,961	648,280	$183,327	4,055,289	$1,147,221
>1,000,000		30	152,446,116	$8,548,965	5,081,537	$284,966	154,794,826	$10,373,211
Totals		172	173,718,358	$19,344,528	1,009,990	$112,468	191,863,153	$30,790,594
All 2002 Permits		263	206,790,628	$32,106,888	786,276	$122,079	238,605,783	$49,219,394
Buyback Permits		91	33,072,270	$12,762,360	363,432	$140,246	46,742,630	$18,428,800

Some Permits may not be fished because of strategic planning.

Some of these permits may be unfished because of strategic planning by fishermen who keep their groundfish permits in case other fisheries they engage in decline. They may also be waiting for groundfish stocks to increase. For example, declining trends in the Pacific whiting fishery may account for 12 unfished permits used by the non-tribal mothership fleet. Projections for the 2004 whiting OY may return the whiting mothership to levels similar to those of 1998.

Motherships and their delivery vessels are typically closely tied. If the mothership chooses to remain in Alaska to process pollock, typically the allied delivery vessels do so too. Often, the delivery vessel fishes for Pacific groundfish using a permit owned by the mothership company.

Twenty-seven of the remaining 172 permits have been used as vessels engaging in the non-tribal mothership fishery over the period 1998 to 2003. Of these permits, eight were idle in 2003, 10 permits idle in 2002, and eight were idle in 2001. Over the period 1998 to 2003, annual non-tribal mothership harvests decreased from 50,000 tons to 26,000 tons. With the decline in harvests, the number of motherships taking part in the fishery also declined. In 1998, there were six motherships, whereas in 2003, there were only four. Starting in 2001, the mothership Golden Alaska stopped engaging in the fishery. Similarly, starting in 2002, the mothership Ocean Phoenix stopped taking part in the fishery.

In comparing the number of unique vessels (some vessels supply more than one mothership) over the period 1998 to 2003, it appears that 12 of the 40 unfished permits are unfished because of changes in the mothership whiting fishery. For perspective, during 1994, the first year of limited entry, there were nine major motherships employing 43 different delivery vessels to harvest 92,000 tons of Pacific whiting. Over the years 1998-2003, 31 different delivery vessels have participated in the fishery.

	Number of Delivery Vessels						
Motherships	1998	1999	2000	2001	2002	2003	
Arctic Fjord	7	3	5	4	5	4	
Arctic Storm	7	5	5	5	5	4	
Excellence	4	4	5	7	4	4	
Golden Alaska	4	4	4	0	0	0	
Ocean Phoenix	7	6	8	7	0	0	
Ocean Rover	2	3	2	3	2	2	
Unique JV	24	23	23	20	11	12	
New vessels that did not fish previously		2	3	1	0	1	31 different vessels
Mothership deliveries	49705	47580	46710	35658	26106	26102	

The ITQ Control Date and rising permit prices are discouraging the sale of latent permits.

On January 9, 2004, NOAA Fisheries published a November 6, 2003 control date notice for the Pacific groundfish fishery. The potential use of ITQ in the trawl fishery discourages the entry of new permit holders into the fishery and the sale of permits by existing permit holders. Current permit holders will be reluctant to sell their permits as they would be offering up their access to an IQ share. New permit holders that have entered the fishery may not see their new activities count toward the currently discussed trawl ITQ program. Currently discussed in the Pacific Council's ITQ Committee are ITQ allocation alternatives that would limit potential catch history periods to all or part of the 1994-2003 time period. Therefore any catch history developed after the November 6, 2003 ITQ Control Date will likely not count toward an ITQ share.

The Notice for the Pacific groundfish fishery (69FR1563), states the following:

> "The control date for the trawl IQ program is intended to discourage increased fishing effort in the limited entry trawl fishery based on economic speculation while the Pacific Council develops and considers a trawl IQ program. Persons potentially eligible for IQ shares may include vessel owners, permit owners, vessel operators and crew. The control date announces to the public that the Pacific Council may decide not to count activities occurring after the control date toward determining a person's qualification for an initial allocation or determining the amount of initial allocation of quota shares. Groundfish landed from limited entry trawl vessels after November 6, 2003 may not be included in the catch history used to qualify for initial allocation in the trawl IQ program."

The following table shows how the Buyback Program has affected permit prices. According to the "Permit News" section of the December 2003 *Fishermen's News*;

> "...The market for "A" trawl permits took off right after the buyback results were announced. Values have at least doubled, and prices are around $7000-$8000/pt."

The January 2004 issue of the *Fishermen's News* indicates how the control date on ITQ's is affecting the permit market:

> "Coastal "A" Trawl permits have become the hot item. With the buyback a done deal and participants set to receive funds any day now, there is all of a sudden a great deal of interest from people that are looking to get back in. There haven't been very many permits available, but some have sold. Prices have varied from around $7,000-$10,000/pt. The market is complicated somewhat by the potential for some sort of IFQ program in the future. Buyers want permits with history, but several of the permits that have been available have been inactive for the past few years."

The February 2003 issue of the *Fishermen's News* continues to report increasing prices but the market may be cooling down:

> "Coastal "A" trawl permits are still in demand, but the post-buyback furor has settled somewhat. A few permits are available, and look to spend around $10,000/pt."

Permit Prices-As reported by Dock Street Broker's (Seattle, Washington) "Permit News" Report:

	$/Point
January 1998	$6,000-$7,000
January 1999	$6,000-$6,500
January 2000	$5,000-$6,000
January 2001	$3,000-$4,000
January 2002	$2,000-$3,000
January 2003	$2,000-$3,000
February 2003	$2,000-$3,000
March 2003	$3,000-$3,000
April 2003	$3,000-$3,000
May 2003	$3,000-$3,000
June 2003	$3,000-$3,000
July 2003	$3,000-$3,000
August 2003	$3,000-$3,000
September 2003	$3,000-$3,000
October 2003	$3,000-$3,000
November 2003	$3,000-$3,000
December 2003	$7,000-$8,000
January 2004	$7,000-$10,000
February 2004	$6,000-$10,000
March 2004	$6,000-10,000

(*Fishermen's News,* various issues-dates are publication dates)

Listed as sold on the 02/02/04 edition of the www.permitmaster.com website was a 32-point trawl permit (80 feet) for $250,000 and on the www.dockstreetbrokers.com website a 10-point (50 feet) for $200,000. (This later offer appears contrary to the $7000-$8000 point estimate mentioned above.) Dockstreet Brokers sold a second permit for 52 feet (11 points) for $105,000 for an average of $9500 per point (02/11/2004 listing).

For someone to enter the fishery, he probably needs to buy a federal permit and a vessel. He probably also needs to buy some state permits to make the vessel profitable. The Buyback Program purchased 91 groundfish permits and vessels and 121 state permits for crab and shrimp. The median price paid out for a Buyback package was about $400,000. This implies that for a new entrant into the fishery, the costs of entering the fishery could be on the order of about $400,000.

The reference to "A" trawl is to distinguish the permit from a provisional "B" permit which no longer exists. The reference to points reflects the capacity rating scale associated with the permit. The capacity rating scale is a projection of capacity against vessel length. It is a nonlinear relationship

:

Length in Feet	Capacity (points)
33	3.50
40	5.66
50	9.88
60	15.59
70	22.92
80	32.00
90	42.96
100	55.90
110	70.94
120	88.18

This capacity rating schedule controls capacity in the fleet. To enter a new vessel into the fishery, the owner needs to buy (take out) a sufficient number of "points" through the purchase of existing permits so overall capacity in the fleet is not increased. Currently the major use of this schedule is used by fishermen who wish to lengthen their vessel and need to combine permits. As it bears on the cost on entering the fishery, the following example is illustrative.

> A vessel owner wants to increase his vessel by 10 feet. His vessel and associated Pacific groundfish permit are now 70 feet. A limited entry trawl permit with a 70-foot endorsement has a capacity rating of 23; a limited entry trawl permit with an 80-foot endorsement has a rating of 32 points. Therefore, the vessel owner needs to buy a permit of enough length to cover the nine points needed. To get the added length, the vessel owner may first consider buying the smallest permit in the fleet-33 feet. He rejects this permit as it would only provide 3.5 points. To get nine points he must purchase a 48-foot permit or greater. At $7,000 per point, this would imply that to lengthen his vessel, he would need to spend at least $63,000.

The average remaining permit has an endorsed length of 70 feet and a capacity rating of about 23 points. At current prices of $6,000 to $10,000 per point, the average permit is worth an estimated $138,000 to $230,000.

Permit Data-Endorsed Length:

Permit Endorsed Length (feet)	All Permits Number	Buyback Permits Number	Remaining Permits Number	% Reduction
33-40	5	0	5	0%
41-50	26	5	21	19%
51-60	73	32	41	44%
61-70	40	14	26	35%
71-80	71	33	38	46%
81-90	27	4	23	15%
91-100	7	1	6	14%
101-110	8	2	6	25%
111+	6	0	6	0%
Total	263	91	172	35%
Total Length Feet	18065	6089	11976	34%
Average	69	67	70	
Median	67	66	69	
Total "points"	6449	1984	4465	31%

Fifteen trawl permits have changed hands since October 1, 2003. Six had 2002 harvests. Nine did not.

Since October 1, 2003 and through March, 6, 2004, the NMFS NWR transferred 15 permits to new owners. Not all of the these permits were inactive. They have the following characteristics:

* 9 had no landings in 2002
* 6 had landings in 2002
* 3 had landings greater than 50,000 lbs.
* 5 Buyback participants purchased permits
* 8 permits were bought by buyback participants
* 3 permits were bought by non-buyback fishermen
* 5 permits were sold to seafood processors
* 1 permit was combined with another permit.

A Buyback Program participant has recently indicated to the NMFS NWR Permits Office that he may buy two permits and combine them. If this transaction is completed, 17 permits will have changed hands. Because of two permit combinations, the remaining number of permits will eventually be 170. Four of these 17 permits were associated with 2002 harvests greater than 50,000 lbs.

Knowing there is a control date on ITQ's why buy a permit?

* Processors who lost vessels may want to assure supply of fish to the processing plant. One processor lost all of his delivery vessels to the buyback.
* Processors may be buying permits to expand their market share.
* Permit holders who were ineligible to take part in the Buyback Program are willing to sell their permits because of increased prices.
* Some buyers may be speculating the Council will relax its rules on ITQs.
* Some buyers are buying permits to obtain potential ITQ history.
* Some buyers may calculate that it's profitable to buy a permit and fish it during the three to five years it may take to implement ITQs. In 2002, the average active permit (total =223) averaged $122,000 in groundfish revenues. If the 2002 groundfish fishery was carried out by the remaining 172 permits, the average groundfish revenue per permit would increase to about $187,000.

Activating some permits may be helpful to some fishing communities. How has the Buyback Program affected fishing communities?

To help answer this question, we developed the three tables shown below using 2002 ex-vessel revenue data and port data developed by Dr. Jim Hastie (NMFS NWC). The first table shows by port the change in the number of vessels because of the Buyback Program. The second and third tables show, respectively, by port groups, the share of groundfish revenues and all-species revenues associated with buyback vessels. All species revenues include groundfish, crab, shrimp, and all other species landed by groundfish trawlers under permits issued in 2002. Dr. Jim Hastie identified two primary groundfish ports for each permit-one associated with non-whiting groundfish landings and one for whiting landings. For this analysis, information on the two primary ports was combined into a single primary port. If whiting landings are greater than 40 percent of the permit's total revenues (all species), we assigned the whiting primary port to the permit. If whiting landings were less than 40 percent of the permit's total revenues, we assigned the non-whiting primary port to the permit. There were also two at-sea whiting permits that had no shoreside landings, and these were assigned to a state but not to a port.

The Buyback Program affected almost all the groundfish ports and their communities. Few ports were unaffected. The ports of Eureka and Bellingham were the most affected with Bellingham losing all of its vessels to the Buyback Program. As pointed out previously, 40 of the remaining 172 permits, were idle in 2002. As indicated in these tables, four of the 91 Buyback permits were also idle in 2002. In terms of 2002 groundfish ex-vessel revenues, Buyback Program vessels accounted for 40 percent of the $32 million of landed by all groundfish trawlers either on shore or delivered to non-tribal motherships. These vessels also account for a similar share percentage of the $49 million in all species revenues.

Affected communities can respond to the potential loss in revenue and income from the Buyback Program in several ways. First, the remaining vessels in the Port can expand their effort to replace the revenues associated with Buyback Program participants to the extent that trip limits allow. Second, active vessels can be hired away from other communities. Finally, a local processor or fisherman can buy and fish an inactive permit. Available information on permit transfers suggests that three of the permits will be used in the port of Bellingham.

Community Effects of the Buyback

Primary Port	State	2002 Active Vessels	Buyback Vessels	Remaining Vessels	Percent Reduction
Avila	CA	7	4	3	-57%
Bodega Bay	CA	2	1	1	-50%
Fort Bragg	CA	13	4	9	-31%
Crescent City	CA	16	14	2	-88%
Santa Cruz	CA	2	0	2	0%
Eureka	CA	23	14	9	-61%
Monterey	CA	4	0	4	0%
Moss Landing	CA	8	4	4	-50%
Morrow Bay	CA	2	0	2	0%
Princeton/Half Moon Bay	CA	11	1	10	-9%
San Francisco	CA	4	1	3	-25%
Astoria	OR	40	13	27	-33%
Brookings	OR	9	5	4	-56%
Coos Bay	OR	24	8	16	-33%
Florence	OR	1	0	1	0%
Newport	OR	25	6	19	-24%
Tillamook/Garibaldi	OR	1	0	1	0%
Portland/Seattle	OR/WA	2	0	2	0%
Bellingham Way	WA	4	4	0	-100%
Blaine	WA	4	1	3	-25%
Ilwaco	WA	1	0	1	0%
Port Angeles	WA	7	4	3	-57%
Wesport	WA	9	3	6	-33%
All Ports	WA	26	12	14	-46%
All Ports	OR	101	32	69	-32%
All Ports	CA	92	43	49	-47%
Permits with no groundfish landings		44	4	40	-9%
Totals	All	263	91	172	-35%

2002 Ex-vessel Groundfish Revenues

		Total All Vessels	Buyback Vessels	Remaining Vessels	Percent Reduction
Bodega Bay/Princeton-Half Moon Bay/San Francisco	CA	$2,129,512	$359,738	$1,769,774	-17%
Crescent City/Eureka/Fort Bragg	CA	$6,695,023	$3,892,475	$2,802,548	-58%
Santa Cruz/Monterey/Moss Landing	CA	$1,199,239	$396,258	$802,981	-33%
Avila/Morrow Bay	CA	$1,073,632	$686,430	$387,202	-64%
Brookings	OR	$841,148	$548,289	$292,859	-65%
Coos Bay/Florence	OR	$3,075,793	$1,111,435	$1,964,358	-36%
Newport/Mothership	OR	$5,038,353	$961,614	$4,076,739	-19%
Astoria/Tillamook	OR	$6,359,037	$2,247,633	$4,111,404	-35%
Bellingham Way/Blaine/Port Angeles	WA	$3,368,541	$2,082,658	$1,285,883	-62%
Ilwaco/Westport/Mothership	WA	$2,326,610	$475,830	$1,850,780	-20%
Total All Ports		$32,106,888	$12,762,360	$19,344,528	-40%
Total	CA	$11,097,406	$5,334,901	$5,762,505	-48%
Total	OR	$15,314,331	$4,868,971	$10,445,360	-32%
Total	WA	$5,695,151	$2,558,488	$3,136,663	-45%
Total All States		$32,106,888	$12,762,360	$19,344,528	-40%

2002 Ex-vessel All Species Revenues

		Total All Vessels	Buyback Vessels	Remaining Vessels	Percent Reduction
Bodega Bay/Princeton-Half Moon Bay/San Francisco	CA	$3,380,783	$519,712	$2,861,071	-15%
Crescent City/Eureka/Fort Bragg	CA	$8,960,672	$4,844,543	$4,116,129	-54%
Santa Cruz/Monterey/Moss Landing	CA	$1,561,241	$414,203	$1,147,038	-27%
Avila/Morrow Bay	CA	$1,688,695	$862,384	$826,311	-51%
Brookings	OR	$2,448,784	$1,324,372	$1,124,412	-54%
Coos Bay/Florence	OR	$6,595,785	$2,775,972	$3,819,813	-42%
Newport/Mothership	OR	$6,711,731	$1,478,007	$5,233,724	-22%
Astoria/Tillamook	OR	$9,339,371	$3,030,195	$6,309,176	-32%
Bellingham Way/Blaine/Port Angeles	WA	$3,570,446	$2,276,191	$1,294,255	-64%
Ilwaco/Westport/Mothership	WA	$3,871,312	$903,221	$2,968,091	-23%
Non-fish landings-1	??	$1,090,574	$0	$1,090,574	0%
Total All Ports		$49,219,394	$18,428,800	$30,790,594	-37%
Total	CA	$15,591,391	$6,640,842	$8,950,549	-43%
Total	OR	$25,095,671	$8,608,546	$16,487,125	-34%
Total	WA	$7,441,758	$3,179,412	$4,262,346	-43%
Non-fish landings-1	??	$1,090,574	$0	$1,090,574	
Total All States and Non-Fish landings		$49,219,394	$18,428,800	$30,790,594	-37%

Comparison of "Latent Permit" Alternatives and Projection

For 2004, after considering recent permit transfers and the potential for increased harvests of whiting, about 30 "latent" permits remain in the fishery.

Minimum landing requirements (MLR) used in selecting the first recipients of limited entry permits usually combine elements of time, (usually a number of years) and landings or deliveries (pounds landed or delivered). For example, the minimum landings requirement (MLR) used to qualify trawl vessels for the current limited entry system is the following:

> "The current owner of a vessel which met the MLRs between July 11, 1984 and August 1, 1988 (the window) may qualify for an "A" gear endorsement. The MLRs are as follows:
>
> Trawl: At least 9 days in which over 500 pounds of any groundfish species caught with groundfish trawl gear except Pacific whiting are landed or delivered or 450 mt of landings or deliveries of any groundfish species caught with groundfish trawl gear except Pacific whiting, or 17 days in which over 500 pounds of Pacific whiting caught with groundfish trawl gear are landed or delivered, or 3,750 mt of landings or deliveries of Pacific whiting caught with groundfish trawl gear." (Amendment 6, Pacific Groundfish FMP, p 2-3

"Latent" Definition-Alternative 1

Similarly, any definition of "latent" would typically have the same elements. Under a simple MLR of 1 pound a year, 40 permits were latent in 2002 and 2003, compared to the 20 or less latent permits during the 1998-2000 period. The increase in unfished permits is likely the result of declining trends in groundfish harvest, especially whiting harvest. In expanding this MLR to one that applies to consecutive years, four permits may be deemed "chronically latent" as they were not fished at all during 1998 to 2003. Twenty-four permits may be deemed latent as they were not fished at all during the entire 2000-2003 period. Finally, forty permits may be deemed "recently latent" as they were not fished in 2002. A slightly different set of forty permits was not fished in 2003. As this is a lenient MLR (needing only 1 pound of landing to in each of these three years to meet this requirement) and using the 2001-2003 time period, perhaps a lower bound on the number of latent permits is 24 permits.

Number of Unfished Permits by Consecutive Period

1998-2003	4
1999-2003	7
2000-2003	13
2001-2003	24
2002-2003	33
2003	40

"Latent" Definition Alternative 2

An alternative way of defining a latent permit is to define a latent permit as one where less than 50,000 lbs. were landed in a given year. This is an arbitrary choice based organizing permits according to the following categories of harvest based on 2002 data.

Groundfish Range Low lbs	Harvest High lbs	Number of Permits	Groundfish Total Lbs	Groundfish Total Revenue	Groundfish Average lbs/permit	Groundfish Average $/permit
0	**0**	30	0	$0	0	$0
0	**0**	10	0	$0	0	$0
1	**15,000**	10	65,554	$41,422	6,555	$4,142
16,000	**50,000**	6	233,843	$113,879	38,974	$18,980
51,000	**100,000**	7	529,940	$319,852	75,706	$45,693
101,000	**200,000**	29	4,440,717	$2,517,061	153,128	$86,795
201,000	**400,000**	44	12,112,506	$6,703,388	275,284	$152,350
401,000	**1,000,000**	6	3,889,682	$1,099,961	648,280	$183,327
>1,000,000		30	152,446,116	$8,548,965	5,081,537	$284,966
Totals		172	173,718,358	$19,344,528	1,009,990	$112,468

There were 40 permits with no recorded groundfish landings in 2002 and another 10 with harvests between 1 and 15,000 lbs. Another 6 permits had landing between 16,000 and 50,000 lbs. The decision was not to define as latent the 7 permits within the 51,000 to 100,000 lb. category. The average revenue per permit for permits in this category is significant - $75,706. Assuming a crew share of 39%, permits in this category earn enough to pay a crew member wages equivalent to that of a male living in Astoria, Oregon one of the key groundfish ports. (According to 2000 U.S. Census data, the median income for a household in Astoria is $33,011, and the median income for a family is $41,446. Males have a median income of $29,813 versus $22,121 for females. The per capita income for the city is $18,759.)

In 2002, 56 permits had associated harvests less than 50,000 lbs. Since October 1, 2003, 15 permits have changed hands with three having harvests greater than 50,000 lbs. in 2002. Therefore, under this definition, permit buyers collectively have bought 12 "latent" permits. Because they were purchased, we can expect that these permits will become active. The increase in the whiting resource is also expected to activate an additional 12 permits by existing owners for use in the mothership fishery. Subtracting these two sets of permits from the 56 permits, leaves an estimate of 32 latent permits. It is not clear if any of the 12 latent permits purchased will be used in the whiting mothership fishery. Therefore, as a buffer against a potential overlap between these two sets of permits, the two permits that may soon be purchased and combined are not factored into the estimate.

Alternative Comparison

Therefore comparing these two alternatives gives a sense there may be 24 to 32 latent permits in the fishery. In simpler terms, there may be "something on the order of" 30 latent permits remaining in the fishery. If these permits were removed, this would bring the fishery to 142 permits.

Appendix 1

Adapted from: Consolidated Appropriations Resolution 2003, Public Law 108-7
Division N--Emergency Relief and Offsets
Title V--Fisheries Disasters
(Page H.J. Res.2--539)

TITLE V--FISHERIES DISASTERS

Sec. 501. (a) Fisheries Disasters.--In addition to amounts appropriated or otherwise made available, $100,000,000 is appropriated to the Department of Commerce for fisheries disaster assistance. Not more than 5 percent of such funds may be used for administrative expenses, and no funds may be used for lobbying activities or representational expenses.

....

(c) Northeast and West Coast.--$10,000,000 shall be made to conduct a voluntary fishing capacity reduction program in the Northeast multispecies fishery and $10,000,000 shall be made available to conduct a voluntary fishing capacity reduction program in the West Coast groundfish fishery. Such sums shall supplement the voluntary capacity reduction program authorized for the fishery in section 211 of Public law 107-206 and be consistent with 312(b) of the Magnuson-Stevens Fishery Conservation and Management Act and the requirements relating to the capacity program in section 211 of Public Law 107-206 that shall--

(1) permanently revoke all fishery licenses, fishery permits, area and species endorsements and any other fishery privileges issued to a vessel or vessels (or to persons on the basis of their operation of that vessel or vessels) removed under the program; and

(2) ensure that vessels removed under the program are made permanently ineligible to participate in any fishery worldwide, and that the owners of such vessels will operate only under the United States flag or be scrapped as a reduction vessel pursuant to section 600.1011(c) of title 50, Code of Federal Regulations.

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Conference Report to Accompany H.J. Res. 2

Adapted from 108th Congress House Representatives, Report 108-10 (February 13 (legislative day, February 12), 2003): MAKING FURTHER CONTINUING APPROPRIATIONS FOR THE FISCAL YEAR 2003, AND FOR OTHER PURPOSES (page 70)

SEC. *212* . (a) The Secretary of Commerce shall implement a fishing capacity reduction program for the West Coast groundfish fishery pursuant to section 212 of P.L. 107-206 and 16 U.S.C. 1861a(b)-(e) except that: the program may apply to multiple fisheries, except that within 90 days after the date of enactment of this Act, the Secretary shall publish a public notice in the Federal Register and issue an invitation to bid for reduction payments that specifies the contractual terms and conditions under which bids shall be made and accepted under this section; except that: Section 144(d0(1)(K)(3) of title I, division B of P.L. 106-554 shall apply to the program implemented by this section.

(b) A reduction fishery is eligible for capacity reduction under the program implemented under this section; except that no vessel harvesting and processing whiting in the catcher-processors sector (section 19 660.323(a)(4)(A) of title 50, Code of Federal Regulations) may participate in any capacity reduction referendum or industry fee established under this section.

(c) A referendum on the industry fee system shall occur after bids have been submitted, and such bids have been accepted by the Secretary, as follows: members of the reduction fishery, and persons who have been issued Washington, Oregon, or California Dungeness crab and Pink shrimp permits, shall be eligible to vote in the referendum to approve an industry fee system; referendum votes cast in each fishery shall be weighted in proportion to the debt obligation of each fishery, as calculated in subsection (f) of this section; the industry fee system shall be approved if the referendum votes cast in favor of the proposed system constitute a simple majority of the participants voting; except that notwithstanding 5 U.S.C. 553 and 16 U.S.C. 1861a(e), the Secretary shall not prepare or publish proposed or final regulations for the implementation of the program under this section before the referendum is conducted.

(d) Nothing in this section shall be construed to prohibit the Pacific Fishery management Council from recommending, or the Secretary from approving, changes to any fishery management plan, in accordance with applicable law; or the Secretary from promulgating regulations (including regulations governing this program), after an industry fee system has been approved by the reduction fishery.

(e) The Secretary shall determine, and state in the public notice published under paragraph (a), all program implementation aspects the Secretary deems relevant

(f) Any bid submitted in response to the invitation to bid issued by the Secretary under this section shall be irrevocable; the Secretary shall use a bid acceptance procedure that ranks each bid in accordance with this paragraph and with additional criteria, if any, established by the

Secretary: for each bid from a qualified bidder that meets the bidding requirements in the public notice or the invitation to bid, the Secretary shall determine a bid score by dividing the bid's dollar amount by the average annual total ex-vessel dollar value of landings of Pacific groundfish, Dungeness crab, and Pink shrimp based on the 3 highest total annual revenues earned from such stocks that the bidder's reduction vessel landed during 1998, 1999, 2000, or 2001. For purposes of this paragraph, the term ``total annual revenue" means the revenue earned in a single year from such stocks. The Secretary shall accept each qualified bid in rank order of bid score from the lowest to the highest until acceptance of the next qualified bid with the next lowest bid score would cause the reduction cost to exceed the reduction loan's maximum amount. Acceptance of a bid by the Secretary shall create a binding reduction contract between the United States and the person whose bid is accepted, the performance of which shall be subject only to the conclusion of a successful referendum, except that a person whose bid is accepted by the Secretary under this section shall relinquish all permits in the reduction fishery and may Dungeness crab and Pink shrimp permits issued by Washington, Oregon, or California; except that the Secretary shall revoke the Pacific groundfish permit, as well as all Federal fishery licenses, fishery permits, area, and species endorsements, and any other fishery privileges issued to a vessel or vessels (or to persons on the basis of their operation or ownership of that vessel or vessels) removed under the program.

(g) The Secretary shall establish separate reduction loan sub-amounts and repayment fees for fish sellers in the reduction fishery and for fish sellers in each of the fee-share fisheries by dividing the total ex-vessel dollar value during the bid scoring period of all reduction vessel landings from the reduction fishery and from each of the fee-share fisheries by the total such value of all such landings for all such fisheries; and multiplying the reduction loan amount by each of the quotients resulting from each of the divisions above. Each of the resulting products shall be the reduction loan sub-amount for the reduction fishery and for each of the fee-share fisheries to which each of such products pertains; except that, each fish seller in the reduction fishery and in each of the fee-share fisheries shall pay the fees required by the reduction loan sub-amounts allocated to it under this paragraph; except that, the Secretary may enter into agreements with Washington, Oregon, and California to collect any fees established under this paragraph.

(h) Notwithstanding 46 U.S.C. App. 1279(b)(4), the reduction loan's term shall not be less than 30 years.

(i) It is the sense of the Congress that the States of Washington, Oregon, and California should revoke all relinquishment permits in each of the fee-share fisheries immediately after reduction payment, and otherwise to implement appropriate State fisheries management and conservation provisions in each of the fee-share fisheries that establishes a program that meets the requirements of 16 U.S.C. 141861a(b)(1)(B) as if it were applicable to fee-share fisheries.

(j) The term ``fee-share fishery" means a fishery, other than the reduction fishery, whose members are eligible to vote in a referendum for an industry fee system under paragraph (c). The term ``reduction fishery" means that portion of a fishery holding limited entry fishing permits endorsed for the operation of trawl gear and issued under the Federal Pacific Coast Groundfish Fishery Management Plan.

MAGNUSON ACT

SEC. 312. TRANSITION TO SUSTAINABLE FISHERIES[7] 16 U.S.C. 1861a

(a) FISHERIES DISASTER RELIEF.--

(1) At the discretion of the Secretary or at the request of the Governor of an affected State or a fishing community, the Secretary shall determine whether there is a commercial fishery failure due to a fishery resource disaster as a result of--

(A) natural causes;

(B) man-made causes beyond the control of fishery managers to mitigate through conservation and management measures; or

(C) undetermined causes.

(2) Upon the determination under paragraph (1) that there is a commercial fishery failure, the Secretary is authorized to make sums available to be used by the affected State, fishing community, or by the Secretary in cooperation with the affected State or fishing community for assessing the economic and social effects of the commercial fishery failure, or any activity that the Secretary determines is appropriate to restore the fishery or prevent a similar failure in the future and to assist a fishing community affected by such failure. Before making funds available for an activity authorized under this section, the Secretary shall make a determination that such activity will not expand the size or scope of the commercial fishery failure in that fishery or
into other fisheries or other geographic regions.

(3) The Federal share of the cost of any activity carried out under the authority of this subsection shall not exceed 75 percent of the cost of that activity.

(4) There are authorized to be appropriated to the Secretary such sums as are necessary for each of the fiscal years 1996, 1997, 1998, and 1999.

(b) FISHING CAPACITY REDUCTION PROGRAM.--

(1) The Secretary, at the request of the appropriate Council for fisheries under the authority of such Council, or the Governor of a State for fisheries under State authority, may conduct a fishing capacity reduction program (referred to in this section as the 'program') in a fishery if the Secretary determines that the program--

(A) is necessary to prevent or end overfishing, rebuild stocks of fish, or achieve measurable and significant improvements in the conservation and management of the fishery;

(B) is consistent with the Federal or State fishery management plan or program in effect for such fishery, as appropriate, and that the fishery management plan--

(i) will prevent the replacement of fishing capacity removed by the program through a moratorium on new entrants, restrictions on vessel upgrades, and other effort control measures, taking into account the full potential fishing capacity of the fleet; and
(ii) establishes a specified or target total allowable catch or other measures that trigger closure of the fishery or adjustments to reduce catch; and

(C) is cost-effective and capable of repaying any debt obligation incurred under section 1111 of title XI of the Merchant Marine Act, 1936.

(2) The objective of the program shall be to obtain the maximum sustained reduction in fishing capacity at the least cost and in a minimum period of time. To achieve that objective, the Secretary is authorized to pay--

(A) the owner of a fishing vessel, if such vessel is (i) scrapped, or (ii) through the Secretary of the department in which the Coast Guard is operating, subjected to title restrictions that permanently prohibit and effectively prevent its use in fishing, and if the permit authorizing the participation of the vessel in the fishery is surrendered for permanent revocation and the owner relinquishes any claim associated with the vessel and permit that could qualify such owner for any present or future limited access system permit in the fishery for which the program is established; or

(B) the holder of a permit authorizing participation in the fishery, if such permit is surrendered for permanent revocation, and such holder relinquishes any claim associated with the permit and vessel used to harvest fishery resources under the permit that could qualify such holder for any present or future limited access system permit in the fishery for which the program was established.

(3) Participation in the program shall be voluntary, but the Secretary shall ensure compliance by all who do participate.

(4) The Secretary shall consult, as appropriate, with Councils, Federal agencies, State and regional authorities, affected fishing communities, participants in the fishery, conservation organizations, and other interested parties throughout the development and implementation of any program under this section.

(c) PROGRAM FUNDING.--

(1) The program may be funded by any combination of amounts--

(A) available under clause (iv) of section 2(b)(1)(A) of the Act of August 11, 1939 (15 U.S.C.

713c-3(b)(1)(A); the Saltonstall-Kennedy Act);

(B) appropriated for the purposes of this section;

(C) provided by an industry fee system established under subsection (d) and in accordance with section 1111 of title XI of the Merchant Marine Act, 1936; or

(D) provided from any State or other public sources or private or non-profit organizations.

(2) All funds for the program, including any fees established under subsection (d), shall be paid into the fishing capacity reduction fund established under section 1111 of title XI of the Merchant Marine Act, 1936.

(d) INDUSTRY FEE SYSTEM.--

(1) (A) If an industry fee system is necessary to fund the program, the Secretary, at the request of the appropriate Council, may conduct a referendum on such system. Prior to the referendum, the Secretary, in consultation with the Council, shall--

(i) identify, to the extent practicable, and notify all permit or vessel owners who would be affected by the program; and
(ii) make available to such owners information about the industry fee system describing the schedule, procedures, and eligibility requirements for the referendum, the proposed program, and the amount and duration and any other terms and conditions of the proposed fee system.

(B) The industry fee system shall be considered approved if the referendum votes which are cast in favor of the proposed system constitute a two-thirds majority of the participants voting.

(2) Notwithstanding section 304(d) and consistent with an approved industry fee system, the Secretary is authorized to establish such a system to fund the program and repay debt obligations incurred pursuant to section 1111 of title XI of the Merchant Marine Act, 1936. The fees for a program established under this section shall--

(A) be determined by the Secretary and adjusted from time to time as the Secretary considers necessary to ensure theavailability of sufficient funds to repay such debt obligations;

(B) not exceed 5 percent of the ex-vessel value of all fish harvested from the fishery for which the program is established;

(C) be deducted by the first ex-vessel fish purchaser from the proceeds otherwise payable to the seller and accounted for andforwarded by such fish purchasers to the Secretary in such manner as the Secretary may establish; and

(D) be in effect only until such time as the debt obligation has been fully paid.

(e) IMPLEMENTATION PLAN.--

(1) The Secretary, in consultation with the appropriate Council or State and other interested parties, shall prepare and publish in the Federal Register for a 60-day public comment period an implementation plan, including proposed regulations, for each program. The implementation plan shall--

(A) define criteria for determining types and numbers of vessels which are eligible for participation in the program taking into account characteristics of the fishery, the requirements of applicable fishery management plans, the needs of fishing communities, and the need to minimize program costs; and

(B) establish procedures for program participation (such as submission of owner bid under an auction system or fair market-value assessment) including any terms and conditions for participation which the Secretary deems to be reasonably necessary to meet the goals of the program.

(2) During the 60-day public comment period--

(A) the Secretary shall conduct a public hearing in each State affected by the program; and

(B) the appropriate Council or State shall submit its comments and recommendations, if any, regarding the plan and regulations.

(3) Within 45 days after the close of the public comment period, the Secretary, in consultation with the appropriate Council or State, shall analyze the public comment received and publish in the Federal Register a final implementation plan for the program and regulations for its implementation. The Secretary may not adopt a final implementation plan involving industry fees or debt obligation unless an industry fee system has been approved by a referendum under this section.

Attachment 2 September 30, 2003

Dear Groundfish Referendum Voter:

I enclose a ballot for your vote in the Pacific Coast groundfish buyback referendum. Our records indicate that you're the holder or owner of record of the fishing permit specified on the enclosed ballot, and this qualifies you to one vote.

The referendum determines whether voters approve or disapprove the post-buyback landing fees necessary to repay a $36 million buyback loan financing about 78% of the buyback's $46 million maximum cost (a $10 million appropriation pays for the remainder).

Please note carefully:

- ***You may not submit your vote to us before October 15, 2003.***

- ***For your vote to be effective, you must complete the enclosed ballot and return it to us in the enclosed envelope in time for us to receive it not later than October 29, 2003.***

You may return the completed ballot to us by U.S. mail, overnight delivery, or any other method you choose. Whatever method you choose, please put the ballot in the enclosed envelope.

If you have more than one permit qualifying you to vote, you'll receive an additional ballot for each additional permit. We'll *separately* mail you one ballot for each permit qualifying you to vote. You're qualified to vote once for each of your groundfish trawl permits and once again for each of your California, Oregon, or Washington Dungeness crab or pink shrimp permits. We'll weight each vote as the table in item number twelve below indicates.

For further details about the referendum and related matters, please see the letter I sent you on July 30, 2003.

The remainder of this letter concerns the buyback bidding results, which may effect how you want to vote. The following summarizes the bidding results:

(1) How many bids in what amount did we receive?

108 bids totaling $59,786,471.

(2) How many bids in what amount may we accept?

We may accept the lowest scoring bids until accepting the next lowest scoring bid would cause the buyback to exceed its maximum $46 million cost. Consequently, there are 92 acceptable bids for

$45,752,471.

(3) How many vessels do the acceptable bids cause to be permanently removed from all fishing?

92 vessels.

(4) How many fishing permits do the acceptable bids cause to be relinquished, how many are in the seven fee paying fisheries, and what percentage of the total existing permits is this?

240 permits will be relinquished. 213 of these permits involve the seven fisheries subject to repaying the buyback loan (the other 27 involved other Federal fisheries other). The 213 permits are distributed among the seven fisheries fee paying fisheries as follows:

FISHERY	PERMITS IN EACH FISHERY		
	NUMBER	NUMBER RELINQUISHE D	PERCENTAGE OF TOTAL EXISTING
Groundfish[1]	263	92	34.98%
CA crab	632	23	3.64%
CA shrimp	77	31	40.26%
OR crab	443	10	2.26%
OR shrimp	185	40	21.62%
WA crab	232	3	1.29%
WA shrimp	109	14	12.84%
Total	1,941	213	-

(5) During the four years from 1998 through 2001, what was the *average*, annual, ex-vessel value of fish landed in each of the seven fisheries by the 92 vessels and 213 permits in the acceptable bids, and what percentage of the total value in each fishery is this?

FISHERY	*AVERAGE* ANNUAL VALUE IN EACH FISHERY

[1] CA, OR, and WA trawl fishery, excluding whiting catcher/processors (which were unqualified to bid).

	VALUE REMOVED	FISHERY'S TOTAL VALUE	PERCENTAGE OF TOTAL VALUE REMOVED
Groundfish:			
• *Excluding* whiting	$15,561,899	$33,800,713	46.04%
• *Including* whiting	$15,972,354	$43,799,118	36.47%
CA crab	$1,302,847	$14,955,003	8.71%
CA shrimp	$376,288	$1,267,120	29.70%
OR crab	$763,259	$19,657,008	3.88%
OR shrimp	$1,243,970	$7,628,189	16.31%
WA crab	$206,185	$18,228,037	1.13%
WA shrimp	$144,777	$1,374,177	10.54%
Total	$20,009,680	-	-

(6) *Prospectively*, what portion of a nearly $36 million buyback loan would each of the seven fisheries repay, and what percentage of the projected post-buyback landing value in each fishery would the *initial* loan repayment fee be?

FISHERY	LOAN PORTION	LANDING FEE PERCENTAGE
Groundfish	$28,538,743	5.00%
CA crab	$2,327,872	1.28%
CA shrimp	$672,336	4.35%
OR crab	$1,363,760	0.57%
OR shrimp	$2,222,675	2.39%
WA crab	$368,403	0.17%
WA shrimp	$258,682	1.54%
Total	$35,752,471	-

(7) *All other things being equal*, what's the relationship in each of the seven fisheries between the annual loan repayment expense and the extra average ex-vessel landing value *potentially*

available each year to post-buyback vessels in each fishery?

FISHERY	TOTAL ANNUAL *EXPENSE* OF REPAYING LOAN	EXTRA *AVERAGE* ANNUAL *EX-VESSEL LANDING VALUE* AVAILABLE TO POST-BUYBACK VESSELS	EXTRA *LANDING VALUE* PER EACH $1.00 OF LOAN *EXPENSE*
Groundfish	$2,340,853	$15,972,354	$6.82
CA crab	$190,941	$1,302,847	$6.82
CA shrimp	$55,147	$376,288	$6.82
OR crab	$111,861	$763,259	$6.82
OR shrimp	$182,312	$1,243,970	$6.82
WA crab	$30,218	$206,185	$6.82
WA shrimp	$21,218	$144,777	$6.82
Total	$2,932,550	$20,009,680	$6.82

(8) What's the *average* effect for each post-buyback permit holder?

All other things being equal, the bidding results mean greater ex-vessel revenues for fewer post-buyback permit owners. Using the *average* annual ex-vessel landing value in each of the seven fisheries from 1998 through 2001, the following tables illustrate the buyback's *potential* effect in each of the fisheries:

	GROUNDFISH		
	BEFORE BUYBACK	AFTER BUYBACK	NET DIFFERENCE
Number of permits	263	171	92 less
Average, annual, total ex-vessel gross revenue	$43.8 million	$43.8 million	none
Average per permit	$166,536	$256,135	$89,599 more
Minus 5% Fee	-	$12,807	$12,807

Net *average per permit*	-	$243,328	$76,792 more

	CA CRAB		
	BEFORE BUYBACK	AFTER BUYBACK	NET DIFFERENCE
Number of permits	632	609	23 less
Average, annual, total ex-vessel gross revenue	$15.0 million	$15.0 million	none
Average per permit	$23,663	$24,556	$893 more
Minus 1.28% Fee	-	$314	$314
Net *average per permit*	-	$24,242	$579 more

	CA SHRIMP		
	BEFORE BUYBACK	AFTER BUYBACK	NET DIFFERENCE
Number of permits	77	31	46 less
Average, annual, total ex-vessel gross revenue	$1.27 million	$1.27 million	none
Average per permit	$16,456	$27,546	$11,090 more
Minus 4.35% Fee	-	$1,198	$1,198
Net *average per permit*	-	$26,348	$9,892 more

	OR CRAB		
	BEFORE BUYBACK	AFTER BUYBACK	NET DIFFERENCE
Number of permits	443	433	10 less

Average, annual, total ex-vessel gross revenue	$19.7 million	$19.7 million	none
Average per permit	$44,372	$45,397	$1,025 more
Minus 0.57% Fee	-	$259	$259
Net *average per permit*	-	$45,138	$766 more

	OR SHRIMP		
	BEFORE BUYBACK	**AFTER BUYBACK**	**NET DIFFERENCE**
Number of permits	185	145	40 less
Average, annual, total ex-vessel gross revenue	$7.6 million	$7.6 million	none
Average per permit	$41,234	$52,608	$11,374 more
Minus 2.39% Fee	-	$1,257	$1,257
Net *average per permit*	-	$51,351	$10,117 more

	WA CRAB		
	BEFORE BUYBACK	**AFTER BUYBACK**	**NET DIFFERENCE**
Number of permits	232	229	3 less
Average, annual, total ex-vessel gross revenue	$18.2 million	$18.2 million	none
Average per permit	$78,569	$79,598	$1,029 more
Minus 0.17% Fee	-	$135	$135
Net *average per permit*	-	$79,463	$894 more

	WA SHRIMP		

	BEFORE BUYBACK	AFTER BUYBACK	NET DIFFERENCE
Number of permits	109	95	14 less
Average, annual, total ex-vessel gross revenue	\$1.38 million	\$1.38 million	none
Average per permit	\$12,607	\$14,465	\$1,858 more
Minus 1.54% Fee	-	\$223	\$223
Net *average per permit*	-	\$14,242	\$1,635 more

(9) What's the practical effect?
If (a) each \$1 spent on buyback loan repayment fees results in \$6.82 of extra gross operating revenue and (b) the operating cost of producing the extra revenue doesn't increase, the practical effect would be \$5.82 earned for each \$1 spent. The fixed operating costs (for example, debt service and insurance) should remain the same with or without the buyback. Consequently, any potential increase in operating costs needed to produce the extra gross revenue should be limited to variable operating costs, and the degree to which this may reduce the \$5.82 gain may vary among permit holders and fisheries.

(10) Will the buyback loan repayment fees be tax deductible?

We believe the landing fees each post-buyback harvester pays will be deductible as an expense of doing business, but this is an Internal Revenue Service determination.

(11) Will the fee rates decrease in the future?

The thirty-year buyback loan is a *fixed* principal amount at a *fixed* interest rate, and ex-vessel prices will presumably inflate over the next 30 years. *All other things being equal*, if ex-vessel prices inflate over time, the fee rates will become a smaller percentage of landing values.

(12) How will we weight votes from each of the seven fisheries?

FISHERY	TOTAL EX-VESSEL VALUE, DURING 4 YEARS FROM 1998-2001, OF CAPACITY WHICH BUYBACK REMOVES		
	EACH OF 7 FISHERIES (DIVIDEND)	DIVIDED BY *ALL 7* FISHERIES (DIVISOR)	EQUALS WEIGHTING PERCENTAGE FOR *EACH OF 7* FISHERIES
Groundfish	\$63,889,417	\$80,038,721	79.82%

CA crab	$5,211,386	same	6.51%
CA shrimp	$1,505,152	same	1.88%
OR crab	$3,053,036	same	3.82%
OR shrimp	$4,975,881	same	6.22%
WA crab	$824,741	same	1.03%
WA shrimp	$579,108	same	0.72%
Total	$80,038,721	same	100.00%

This concludes the buyback bidding summary.

After October 29, 2003 *(the last day for our receipts of votes)*, we will notify all bidders and voters of the referendum results and publish a reduction payment tender notice in the Federal Register as soon as we possibly can.

Please note the following two corrections to the table on page No. 5 of my July 30, 2003, letter about the referendum:

- In the second column's heading, "2003" should be "2001", and
- The table should have indicated that the ex-vessel values in the second and third columns are those of the accepted bidders' buyback vessels.

Please do not hesitate to contact us, at the following numbers and addresses, if you need further referendum or buyback information of any kind:

PERSON	NUMBERS/ADDRESS	
	TELEPHONE (301) 713-2390	E-MAIL ADDRESS
Mike Sturtevant	Extension 212	michael.a.sturtevant@noaa.gov
Shawn Barry	Extension 186	shawn.barry@noaa.gov
Mike Grable	Extension 185	michael.grable@noaa.gov

We look forward to receiving your referendum ballot not later than October 29, 2003.

Sincerely,

Michael L. Grable, Chief
Financial Services Division

ENCLOSURE (one ballot for one permit)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

MAR - 4 2004

RECEIVED
MAR 4 2004
PFMC

Mr. Donald Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place
Portland, OR 97220

Dear ~~Mr.~~ Don Hansen:

NOAA Fisheries published an advance notice of proposed rulemaking (ANPR) and establishment of a control date of November 6, 2003 for the trawl individual quota (IQ) program (69 FR 1563, January 9, 2004) which excluded any references to processor quotas, either through an individual processor quota (IPQ) program or the ability of processors to own shares of IQ. The control date announces to the public that the Pacific Fishery Management Council (Council) may decide not to count activities occurring after the control date toward determining a person's qualification for an initial allocation or determining the amount of initial allocation of quota shares. As you'll recall, the Council, at its November 2003, meeting, adopted a control date of November 6, 2003 after reviewing a report by the Ad Hoc Trawl IQ Committee. The Council recommendation included a consideration of both individual fishing quota and IPQ for the groundfish trawl fishery and noted that the control date should apply to both of these IQ programs, in case the Council recommends, and legislation authorizes such IQ programs in the future.

NOAA Fisheries removed all references to processor quotas in the *Federal Register* notice on the control date because the Magnuson-Stevens Fishery Conservation and Management Act (MSA) does not authorize or address the use of IPQs. Further, section 804 of the Consolidated Appropriations Act of 2004 (Public Law 108-199), passed on January 23, 2004, states that "A Council or the Secretary may not consider or establish any program to allocate or issue an individual processing quota or processor share in any fishery of the United States other than the crab fisheries of the Bering Sea and Aleutian Islands." Although this provision had not been enacted in the appropriations language at the time the ANPR was published, it had been adopted by the House of Representatives and in conference, and it was anticipated that it would be included if any appropriations Bill were enacted in January.

I am aware that the Council is anxious to begin working on a NEPA document in support of a proposed groundfish trawl IQ program. Given the current status of IPQ programs described in the prior paragraph, the Council should not include any consideration of IPQ programs in NEPA documents in support of harvesting IQ programs.

However, the ANPR and control date notice does not preclude the Council from developing an IQ program that allows processors to own quota or includes other provisions that take into account the needs of fishing communities, including processors. NOAA Fisheries is committed to working with the Council to make progress on IQ program formulation and analysis.

Sincerely,

Bob Lohn

D. Robert Lohn
Regional Administrator

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Mr. Donald Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place
Portland, OR 97220

RECEIVED
MAR - 8 2004
PFMC

Dear Mr. Hansen:

Exempted fishing permits (EFPs) will continue to be used to support a full retention fishery and sampling program in the shorebased sector of the Pacific whiting fishery in 2004. The issuance of EFPs allows vessels to delay sorting of groundfish catch in excess of cumulative trip limits and allows the retention of prohibited species until offloading. Because whiting deteriorates rapidly, it needs to be handled quickly and immediately chilled to maintain the quality. As a result, on most whiting vessels the catch is dumped directly or near directly into the hold, making it difficult to effectively sort the catch. Delaying sorting until offloading allows samplers located at the processing facilities to collect incidental catch data for total catch estimates while allowing whiting quality to be maintained. Without an EFP, groundfish regulations at 50 CFR 660.306 (b) require vessels to sort their prohibited species catch and return them to sea as soon as practicable with minimum injury. Similarly, regulations at 50 CFR 660.306 (f) prohibit the retention of groundfish in excess of the published trip limits.

At this time, NMFS is in the process of developing federal regulations to support activities that have historically occurred under the EFPs and are otherwise illegal. It is our intent to have regulations supporting these provisions in effect before the start of the 2005 primary season for the shorebased sector.

At this time, I would like to inform you of a change in how EFP activities will be monitored in 2004. All EFP participants will be required to carry video cameras for monitoring full retention at sea. It is NMFS intention to provide funding for these cameras. However, because the service contracts needed to support video monitoring may not be in place by June 15, 2004, the start primary season north of 42° N. latitude, EFP participants will be required to carry cameras as soon as they become available. Roughly half a day per vessel will be required for installation. Information gathered from video cameras will be used to assess the effectiveness of video monitoring the shorebased whiting fishery as well as in other full retention monitoring programs.

Sincerely,

William L. Robinson
Assistant Administrator for
Sustainable Fisheries

2003 PACIFIC WHITING FISHERY
FOR NON-TRIBAL MOTHERSHIPS AND CATCHER/PROCESSORS
(Based on Preliminary Observer Data)

TABLE 1. SUMMARY - CUMULATIVE NON-TRIBAL CATCH OF ALL SPECIES

Groundfish	Retention (mt)	Discard (mt)	Total (mt)
Pacific whiting	66,746.18	489.60	67,235.78
Rockfish	51.36	15.15	66.52
Flatfish	8.17	2.45	10.62
All other groundfish	18.01	14.01	32.02
TOTAL	66,823.72	521.21	67,344.94
Prohibited Species		Number of fish	
Halibut		199	
Salmon		2,872	

TABLE 2. NON-TRIBAL ROCKFISH CATCH AND RATIO BY AREA (in metric tons)

ROCKFISH	VANCOUVER - 670			COLUMBIA - 710			EUREKA - 720			TOTAL WOC		
	Ret	Dis	Tot	Ret	Dis	Tot	Ret	Dis	Tot	Ret	Dis	Tot
Bocaccio	0.03	0.00	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.06	0.00	0.06
Other rockfish	0.06	0.00	0.06	22.68	2.80	25.48	0.02	3.49	3.51	22.76	6.29	29.05
POP	0.07	0.00	0.07	0.68	0.13	0.81	0.01	4.26	4.27	0.76	4.39	5.16
Thornyhead	0.03	0.00	0.03	14.37	1.24	15.61	0.00	0.02	0.02	14.40	1.26	15.65
Canary	0.01	0.00	0.01	0.13	0.07	0.20	0.01	0.03	0.04	0.15	0.10	0.26
Yellowtail	1.31	0.00	1.31	0.42	0.57	0.99	0.01	0.01	0.02	1.74	0.58	2.32
Widow	0.01	0.00	0.01	10.49	0.90	11.39	0.12	0.73	0.85	10.62	1.63	12.25
Chili-pepper	0.00	0.00	0.00	0.46	0.79	1.25	0.01	0.00	0.01	0.47	0.79	1.26
Shortbelly	0.00	0.00	0.00	0.42	0.09	0.51	0.00	0.00	0.00	0.42	0.09	0.51
TOTAL ROCKFISH	1.52	0.00	1.52	49.68	6.59	56.27	0.18	8.54	8.72	51.38	15.13	66.52
TOTAL WHITING	816	0	816	60,545	445	60,990	5,385	44	5,429	66,746	490	67,236
[illegible]kfish [illegible]iting (mt/mt)	0.0019			0.0009			0.0016			0.0010		

* Joint venture 11-year average coastwide was 0.007.
Slight discrepancies occur due to rounding.

TABLE 3. NON-TRIBAL SALMON CATCH AND RATIO BY AREA

	VANCOUVER - 670	COLUMBIA - 710	EUREKA - 720*	TOTAL
Chinook (no.)	0	1,811	837	2,648
Other salmon (no.)	13	204	7	224
TOTAL salmon (no.)	13	2,015	844	2,872
Whiting (mt)	816	60,990	5,429	67,236
No. chinook/mt whiting	0.0000	0.0297	0.1542	0.0394
JV average 1981-90 (# all sal/mt whiting)	0.16	0.09	0.15	0.11**

* At-sea processing could occur only north of 42°; JV could operate down to 39°.
** Monterey area north of 39° rate was 0.03 salmon per mt whiting.

TABLE 4. CATCH BY NON-TRIBAL MOTHERSHIPS AND CATCHER/PROCESSORS

SPECIES	MOTHERSHIP					CATCHER/PROCESSOR					TOTAL WOC
	RETAIN (mt)	(%)	DISCARD (mt)	(%)	TOTAL (mt)	RETAIN (mt)	(%)	DISCARD (mt)	(%)	TOTAL (mt)	
Whiting	25,707	99	314	1	26,021	41,039	100	175	0	41,214	67,236
Rockfish	0.89	26	2.58	74	3.47	50.47	80	12.56	20	63.03	66.52
Flatfish	0.01	4	0.22	96	0.23	8.16	79	2.22	21	10.38	10.62
*All other groundfish	0.09	4	2.47	96	2.56	17.91	61	11.55	39	29.46	32.02
TOTAL	25,708	99	319	1	26,027	41,116	100	201	0	41,317	67,345
SALMON				%	No.				%	No.	
Chinook				91.1	2,078				96.4	570	2,648
Other				8.9	203				3.6	21	224
Total				100	2,280				100	591	2,872
No.chinook/mt whiting					0.0798					0.0138	0.0393

Slight discrepancies occur due to rounding.

TABLE 5. CATCH OF ROCKFISH BY NON-TRIBAL MOTHERSHIPS AND CATCHER/PROCESSORS (metric tons)

ROCKFISH SPECIES	MOTHERSHIP	CATCHER/PROCESSOR	TOTAL
Bocaccio	0.00	0.06	0.06
Other rockfish	0.69	28.36	29.05
POP	0.11	5.04	5.16
Thornyheads	0.15	15.50	15.65
Canary rockfish	0.08	0.17	0.26
Yellowtail rockfish	0.57	1.75	2.32
Widow rockfish	0.69	11.56	12.25
Chilipepper rockfish	1.15	0.11	1.26
Shortbelly rockfish	0.02	0.48	0.51
TOTAL ROCKFISH	3.47	63.03	66.52
Mt whiting	26,021	41,214	67,235
Mt rockfish/mt whiting	0.0001	0.0015	0.0010

Slight discrepancies occur due to rounding.

Table 6. 1995-2002 PACIFIC WHITING NON-TRIBAL AT-SEA PROCESSING VESSELS (NMFS Observer Data)

	COMMON NAME	WEIGHT (mt) 1996	1997	1998	1999	2000	2001	2002	2003
R	Pacific whiting	112776.1	121172.2	120452.	115259.1	114655.0	94450.6	62934.7	67235.8
O	Pacific cod	0.00	0.01	0.00	0.04	0.19	0.00	0.00	0.25
U	Lingcod	0.07	0.14	0.11	0.06	0.41	0.66	0.27	0.49
N	Jack mackerel	60.19	13.18	229.14	Moved to coastal pelagics FMP in 1999				
D	Sablefish	6.57	0.81	27.83	2.10	47.13	21.50	21.02	16.95
F	Arrowtooth	0.57	0.16	1.04	3.21	8.61	3.76	2.17	2.86
L	Dover sole	0.09	0.00	0.01	0.00	0.27	1.53	0.65	0.85
A	English sole	0.01	0.00	0.00	0.02	0.22	0.10	0.11	0.02
T	Petrale sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F	Rex sole	0.22	0.04	0.36	0.02	5.54	18.32	11.51	6.71
I	Rock sole	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
S	Starry flounder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H	All other flatfish	0.00	0.05	0.01	0.01	1.32	7.05	0.15	0.18
R	Bocaccio	0.15	0.21	1.21	0.32	2.65	0.29	0.19	0.06
O	Canary rockfish	1.22	1.81	2.72	1.22	1.42	1.61	2.41	0.26
C	Chilipepper	0.00	0.01	0.01	0.54	4.83	3.57	4.90	1.26
K	Pacific oc. perch	5.99	3.28	21.28	14.15	9.61	19.74	3.62	5.16
F	Shortbelly	6.15	0.76	0.02	0.00	0.86	27.33	0.60	0.51
I	Thornyhead	1.93	0.46	2.51	0.02	19.07	15.21	11.91	15.65
S	Widow rockfish	266.57	207.21	292.76	148.95	220.62	168.91	135.60	12.25
H	Yellowtail	630.95	290.15	376.98	684.13	555.56	124.99	14.28	2.32
	Other rockfish spp	35.5	81.56	62.36	33.15	120.34	78.22	23.67	29.05
	Other groundfish 2/	98.30	217.27	218.07	254.05	92.46	89.18	38.82	14.33
	TOTAL GROUNDFISH	113,891	121,989	121,689	116,401	115,746	95,033	63,207	67,345
N	Pacific mackerel	244.34	54.15	458.78	1.47	15.52	47.29	0.04	0.00
O	Jack mackerel 3/				53.84	52.98	107.43	6.85	12.38
N	Pacific sardine	0.37	0.31	1.94	0.18	0.06	0.23	0.01	0.00

PROHIBITED SPECIES	1996	1997	1998	1999	2000	2001	2002	2003
Chinook Salmon	1,446	1,398	1,477	4,391	6,260	2,568	1,679	2,648
Other Salmon 4/	279	924	27	802	115	770	173	224
TOTAL SALMON	1,725	2,322	1,504	5,193	6,375	3,338	1,852	2,872
Percent Chinook Salmon	83.8	60.2	98.2	84.6	98.2	76.9	90.7	92.2
No. Chinook/MT whiting	0.0128	0.0115	0.0123	0.0381	0.0546	0.0272	0.0267	0.0394
Pacific Halibut	42	9	7	47	211	74	59	199

1/ Defined as sharks, skates, kelp greenling, cabezon, ratfish, morids, and grenadiers.
2/ Non-groundfish species that are incidental to the whiting fishery, but which are not prohibited.
3/ Managed under Pacific Coast groundfish FMP until 1999 when it was moved to the coastal pelagic species FMP.
4/ [illegible] 1995, approximately 1,575 were pink salmon.
Sl[illegible] discrepancies occur due to rounding.

2003 PACIFIC WHITING FISHERY SUMMARY, ALL SECTORS

SPECIES	TRIBAL						NON-TRIBAL MOTHER-SHIPS		CATCHER/ PROCESSORS		SHORE-BASED PROCESSORS			TOTAL WOC	
	MOTHERSHIP		SHORE BASED		ALL						EFP only		non-EFP		
	mt	Rate	mt	Rate	mt	Rate	mt	Rate	mt	Rate	mt	Rate	mt	mt	Rate
Whiting Allocation					25,000		29,088		41,208		50,904			146,200 1/	
WHITING	19,375		4,079		23,454		26,021		41,214		51,196		135	142,020	
Yellowtail Rockfish	34.08	0.0018	1.79	0.0004	35.87	0.0015	0.57	---	1.75	---	48.7	0.0010		86.89	0.0006
Widow Rockfish	2.16	0.0001	0.04	---	2.20	0.0001	0.69	---	11.56	0.0002	8.97	0.0002		23.42	0.0002
Canary Rockfish	0.67	---	0.02	---	0.69	---	0.08	---	0.17	---	0.11	---		1.05	0.0000
Darkblotched Rockfish	0.02	---	0.00	---	0.02	---	0.10	---	4.21	0.0001	0.26	---		4.59	0.0000
POP	1.08	---	0.10	---	1.18	---	0.11	---	5.05	0.0001	0.30	---		6.64	0.0000
Lingcod	0.05	---	0.00	---	0.05	0.0001	0.09	---	0.40	---	0.41	---		0.95	0.0000
All other groundfish	260.68		3.87		264.57		4.62		79.74		56.25			405.18	
TOTAL GROUNDFISH	19,673		4,085		23,758		26,027		41,317		51,311		135	142,548	
Percent over/under Whiting Allocation					-6.2%		-10.5%		-0.2%		0.8%			-2.9%	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate		Number	Rate
Chinook	3,430	0.1770	9	0.0021	3,439	0.1466	2,078	0.0798	570	0.0138	425	0.0083		6,512	0.0459
Non-Chinook (including salmon unident.)	3,952		7		3,959		203		21						

Data sources: All data is total catch (retained plus discarded catch). The at-sea Catcher/processor and mothership data is from the NorPac data base. Shore-based data is from Oregon Department of Fish and Wildlife 2003 shore-based sampling summary, and the tribal shore-based catch was provided by the Makah fisheries office

1/ This value is the sum of the commercial OY of 121,200 plus the tribal OY of 25,000

Northwest Region Current Bycatch Priorities and Implementation Plan National Marine Fisheries Service

[NOTE: This is a public, working document that will be revised in the future as additional bycatch minimization opportunities occur.]

National Marine Fisheries Service, Northwest Region
7600 Sand Point Way, NE
Seattle, WA 98115

November 2003

Table of Contents

1.0 Introduction

In 1998, the National Marine Fisheries Service (NMFS or NOAA Fisheries) produced *Managing the Nation's Bycatch*, which provided a series of national goals for monitoring and managing bycatch. In addition to these national goals, *Managing the Nation's Bycatch* also specified regional goals for monitoring and managing bycatch and for keeping the public informed about and involved in the bycatch management process. For the fifth anniversary of *Managing the Nation's Bycatch*, the agency decided to evaluate its progress to date on meeting national and regional goals for bycatch monitoring and management. These national and regional goals were spurred by National Standard 9 of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act):

> *"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."*

Throughout 2003, NMFS has been working through a series of evaluative steps, articulated in the *NOAA Fisheries National Bycatch Strategy* (NMFS, 2003). The third step in the NMFS process for evaluating and improving its bycatch management program is for the NMFS regional offices to develop plans to improve regional implementation bycatch monitoring and management. These regional implementation plans are intended to implement National Standard 9, as it was articulated in *Managing the Nation's Bycatch:*

> *"The fundamental national goal of NMFS bycatch-related activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided."*

In *Managing the Nation's Bycatch,* NMFS defined "bycatch" as "discarded catch of any living marine resource, plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear. NMFS developed this expanded definition of bycatch so that its bycatch management measures would reflect the agency's responsibilities under a variety of laws: the Magnuson-Stevens Act, the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), the Migratory Bird Treaty Act (MBTA) and the Pacific Halibut Act. In reviewing and updating *Managing the Nation's Bycatch*, these regional implementation plans are intended to address the agency's bycatch minimization responsibilities under this suite of laws.

1.1 Northwest Region Fishery Management Responsibilities: Federal fisheries off the West Coast are managed by the NMFS Northwest and Southwest Regional Offices, in cooperation with the Pacific Fishery Management Council (Pacific Council), the states of California, Oregon, and Washington, Indian tribes with treaty rights to fish for federally managed fish, and interested members of the public. West Coast fisheries target salmon, bottomfish, highly migratory species such as tunas, pelagic schooling species such as anchovy, sardines and squid, as well as shellfish like shrimp and crab. These fisheries are harvested using a variety of gear types (trawls, seines, pots, hook and line, etc.) that produced about 338,000 metric tons (mt) of harvest during 2002, and had an ex-vessel value of approximately $229 million (PacFIN 2003).

NMFS' Northwest Region is responsible for working with the Pacific Council to implement its Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP), Pacific Coast Salmon FMP (Salmon FMP), and Pacific Halibut Catch Sharing Plan. This regional bycatch goal implementation plan will focus on fisheries targeting those three species or species groups and their effects on both targeted and protected species.

Groundfish: Over 80 species of groundfish are included in the Pacific Coast Groundfish FMP. Species groups managed under the Groundfish FMP include rockfish, roundfish (such as sablefish and whiting), flatfish (soles and flounders), sharks, skates, and other species. A variety of gear types are used to fish for groundfish, including trawl, hook-and-line, pot, and net gears. The primary economic management objective for West Coast groundfish is to provide a continuous, year-round flow of fresh fish to markets to produce a variety of benefits, including promoting continuous employment in coastal communities. However, fleet overcapitalization, increased effort, and either declining or stable total allowable catch have forced managers to significantly slow catch rates to spread the catch of each species or species complex for which there is a specified optimum yield (OY) over the entire year. The Pacific Council uses trip-landing limits as the vehicle to slow the catch rates. Because almost all species managed by trip limits are harvested in a multispecies mixture with other trip-limit species, vessels are forced to discard species once the trip limit for that species is reached, while the vessel continues to fish on the trip limit for other species. As trip limits become more restrictive and as more species come under trip-limit management, regulatory discards increase. Most species are managed under two-month cumulative trip-landing limits. Trip limit induced discards also can occur when fishermen continue to harvest other species when the OY of a single species is reached and further landings of that species are prohibited. Vessels discard groundfish at sea for many reasons, including discards made to comply with regulatory constraints and discards made because a portion of the catch is economically undesirable.

Salmon: Pacific salmon support important commercial, recreational, and tribal fisheries in the states of Washington, Oregon, California, and Idaho. Of the five species of Pacific salmon, Coho and Chinook are of primary importance to Pacific Council fisheries. In addition, pink salmon are abundant in alternate (odd-numbered) years in waters off of the state of Washington. Commercial, recreational, and tribal fishermen harvest salmon from the Pacific Ocean, Puget Sound, estuaries, and rivers along spawning migration routes using trolling gear, seines, gill nets, and hook-and-line. Although several specific populations of salmon have declined over the last century due to freshwater habitat degradation, excessive harvests, and hydropower activities, there have been recent increases in overall abundance of harvestable salmon due to more favorable ocean conditions.

The Salmon FMP requires the Pacific Council to manage fisheries consistent with standards developed by the NMFS regarding actions necessary to protect species listed under the ESA. Since 1989, NMFS has listed 26 evolutionarily significant units (ESU) of salmon and steelhead under the ESA. As the listings have occurred, NMFS has initiated formal section 7 consultations and issued biological opinions that consider the impacts to listed salmonid species, and some salmonid species proposed for listing, resulting from proposed implementation of the Salmon FMP, or in some cases, from proposed implementation of the annual management measures. NMFS has also reinitiated consultation on certain ESUs when new information has become available on the status of the stocks or on the impacts of the Salmon FMP on the stocks. Some biological opinions have concluded that implementation of the Salmon FMP is not likely to jeopardize the continued existence of certain listed ESUs. Other biological opinions have found the Salmon FMP is likely to jeopardize certain listed ESUs, and have identified reasonable and prudent alternatives (consultation standards) that would avoid the likelihood of jeopardizing the continued existence of the ESU under consideration. Currently 12 coho and chinook salmon ESUs listed under the ESA are considered of most concern as bycatch in the fisheries under the Salmon FMP. Sockeye and chum salmon and steelhead species are not typically caught in large numbers in ocean salmon fisheries, therefore impacts to the 14 remaining listed ESUs is very small. There are no pink salmon stocks listed under the ESA.

The Federally managed ocean salmon fisheries are divided into commercial troll and recreational fisheries. Both groups use hook-and-line gear. Inside-water commercial fisheries, which are managed by the states and treaty tribes and are thus not elsewhere discussed in this report, use gill nets and purse seines. Bycatch in the ocean commercial troll and recreational salmon fisheries has three major components. The first is the catch and discard of salmon species which can legally be kept, but which are below the size limit. The second is the catch and discard of salmon species, either coastwide or by management area, where the retention of some but not all species of salmon is allowed. This type of bycatch can occur, for example, when the quota for one species has been reached, but catch of another is still allowed, or where complete non-retention of a depressed or listed stock is required. The third type of bycatch mortality occurs in mark selective fisheries, where only hatchery raised salmon identified by an external mark (usually an adipose fin clip) can be retained and all other salmon of the same species (generally wild stocks) must be released.

In addition to salmon bycatch within the salmon fisheries, the salmon fisheries also incidentally take non-salmon species, including some overfished groundfish species. However, bycatch of fish other than salmon in the salmon fisheries is generally very limited, and there are regulations that allow for retention of most groundfish species and limited numbers of Pacific halibut that are caught incidentally while salmon fishing.

"Bycatch" for the purposes of Salmon FMP defined as: fish caught in an ocean salmon fishery which are not sold or kept for personal use and includes economic discards, regulatory discards, and fishery mortality due to an encounter with fishing gear that does not result in capture of fish. Bycatch does not include any fish that legally are retained in a fishery and kept for personal, tribal, or cultural use, or that enter commerce through sale, barter, or trade. In addition, under the provisions of the Magnuson-Stevens Act, bycatch does not include targeted salmon released alive under a recreational catch-and-release fishery management program. Under the Salmon FMP, the primary bycatch that occurs is bycatch of salmon species. Therefore, the Pacific Council's conservation and management measures seek to minimize salmon bycatch and bycatch mortality (drop off and hooking mortality) to the greatest extent practical in all ocean fisheries. When bycatch cannot be avoided, priority is given to conservation and management measures that seek to minimize bycatch mortality and ensure the extended survival of such fish. These measures are developed in consideration of the biological and ecological impacts to the affected species, the social and economic impacts to the fishing industry and associated communities, and the impacts upon the fishing, management, and enforcement practices currently employed in ocean salmon fisheries.

During the salmon preseason planning process, management options are assessed for effects on the amount and type of salmon bycatch and bycatch mortality. Estimates of salmon bycatch and incidental mortalities associated with salmon fisheries are included in the modeling assessment of total fishery impact and assigned to the stock or stock complex projected to be impacted by the proposed management measure. The resultant fishery impact assessment reports for the ocean salmon fisheries specify the amount of salmon bycatch and bycatch mortality associated with each accompanying management option. The final analysis of Pacific Council-adopted management measures contains an assessment of the total salmon bycatch and bycatch mortality for Pacific Council salmon fisheries, and includes a comparison with the previous year's total bycatch and bycatch mortality levels.

Halibut: Pacific halibut is managed by the International Pacific Halibut Commission (IPHC,) a bilateral commission in which the U.S. cooperates with Canada to set Pacific halibut harvest levels in the Bering Sea and Gulf of Alaska, as well as off the Canadian and U.S. West Coasts. Off the U.S. West Coast, the Pacific Council's Catch Sharing Plan sets general principles for halibut management, which are then implemented by the state, tribal, and federal governments. The tribal commercial fisheries, tribal ceremonial and subsistence fisheries, the recreational fisheries, and the non-tribal commercial fisheries for halibut are all managed to ensure that halibut is taken under regulations that allow retention of other species caught in common with halibut. Halibut stocks are healthy and Northwest Region's primary bycatch concern with respect to halibut is the bycatch of halibut in groundfish and shrimp trawl fisheries. With the recent development of the West Coast Groundfish Observer Program, NMFS has notably improved its information on halibut bycatch in the groundfish trawl fishery. The agency's model for halibut bycatch in the groundfish trawl fisheries shows a sharp drop in halibut bycatch, 64% lower in 2002 than in 2001. This drop is likely due to two factors: incorporation of recent observer data into the model rather than reliance on early-1990s fisheries data and a decrease in on-the-grounds trawl hours in recent years associated with overall groundfish declines.

Because halibut management is directed by an international commission, and because regional management focuses on integrating halibut catch into fisheries for other co-occurring species, this regional plan will not further address halibut except as it might occur as bycatch in fisheries directed on species other than halibut.

Marine Mammals: The waters off Washington, Oregon, and California (WOC) support a wide variety of marine mammals. Approximately thirty species, including seals and sea lions, sea otters, and whales, dolphins, and porpoise, occur within the EEZ. Many marine mammal species seasonally migrate through Pacific Coast waters, while others are year round residents.

Species Listed as Endangered Under the ESA
Sperm whale (*Physeter macrocephalus*),
Humpback whale (*Megaptera novaeangliae*),
Blue whale (*Balaenoptera musculus*), and
Fin whale (*Balaenoptera physalus*).

Species Listed as Threatened Under the ESA
Steller sea lion (*Eumetopias jubatus*)Eastern Stock,
Guadalupe fur seal (*Arctocephalus townsendi*), and
Southern sea otter (*Enhydra lutris*) California Stock.

Species Listed as Depleted under the MMPA
Northern fur seal (*Callorhinus ursinus*) Eastern Pacific Stock and

Under the MMPA on the West Coast, NMFS is responsible for the management of cetaceans and pinnipeds, while the U.S. Fish and Wildlife Service (FWS) manages sea otters. Stock assessment reports review new information every year for strategic stocks (those whose human-caused mortality and injury exceeds the potential biological removal (PBR)) and every three years for non-strategic stocks. Marine mammals whose abundance falls below the optimum sustainable population (OSP) are listed as "depleted" according to the MMPA.

Fisheries that interact with species listed as depleted, threatened, or endangered may be subject to management restrictions under the MMPA and ESA. NMFS publishes an annual list of fisheries in the Federal Register separating commercial fisheries into one of three categories, based on the level of serious injury and mortality of marine mammals occurring incidentally in that fishery. The categorization of a fishery in the list of fisheries determines whether participants in that fishery are subject to certain provisions of the MMPA, such as registration, observer coverage, and take reduction plan requirements. The WOC groundfish fisheries are in Category III, indicating a remote likelihood of, or no known serious injuries or mortalities, to marine mammals.

Seabirds: The highly productive California Current System, an eastern boundary current that stretches from Baja Mexico to southern British Columbia, supports more than two million breeding seabirds and at least twice that number of migrant visitors. Tyler et al. (1993) reviewed seabird distribution and abundance in relation to oceanographic processes in the California Current System and found that over 100 species have been recorded within the EEZ including: albatross, shearwaters, petrels, storm-petrels, cormorants, pelicans, gulls, terns and alcids (murres, murrelets, guillemots, auklets and puffins). In addition to these "classic" seabird, millions of other birds are seasonally abundant in this oceanic habitat including: waterfowl,

Species Listed as Endangered Under the ESA

Short-tail albatross (*Phoebastria albatrus*),
California brown pelican (*Pelecanus occidentalis*),
and
California least tern (*Sterna antillarum browni*).

waterbirds (loons and grebes), and shorebirds (phalaropes).

The FWS is the primary Federal agency responsible for seabird conservation and management. Under the Magnuson-Stevens Act, NMFS is required to ensure fishery management actions comply with other laws designed to protect seabirds. NMFS is also required to consult with FWS if fishery management plan actions may affect seabird species listed as endangered or threatened.

Sea Turtles: Sea turtles are highly migratory and four of the six species found in U.S. waters have been sighted off the Pacific Coast. Little is known about the interactions between sea turtles and West Coast commercial fisheries. The directed fishing for sea turtles in WOC groundfish fisheries is prohibited, because of their ESA listings, but the incidental take of sea turtles by trawl gear may occur. The management and conservation of sea turtles is shared between NMFS and FWS.

Species Listed as Endangered Under the ESA
Green turtle (*Chelonia mydas*),
Leatherback turtle (*Dermochelys coriacea*), and
Olive ridely turtle (*Lepidochelys olivacea*).

Species Listed as Threatened Under the ESA

1.2 Structure of the Regional Bycatch Goal Implementation Plan: Regional bycatch goal implementation plans are intended to provide information on both bycatch management and bycatch monitoring. In addition to National Standard 9 and the national goal for NMFS bycatch-related activities, NMFS work on bycatch issues must address the requirement of the Magnuson-Stevens Act at §303 *Contents of Fishery Management Plans* at (a)(11), which requires that FMPs:

> *"Establish a standardized reporting methodology to assess the amount and types of bycatch occurring in the fishery, and include conservation and management measures that, to the extent practicable and in the following priority – (A) minimize bycatch; and (B) minimize the mortality of bycatch which cannot be avoided."*

In this section, the Magnuson-Stevens Act is recognizing one of the most basic challenges of bycatch management: the agency must be able to estimate how much bycatch is occurring if it is to meet the national goal of minimizing bycatch to the extent practicable. This regional bycatch goal implementation plan will address bycatch monitoring and bycatch management in the following sections.

2.0 Bycatch Reporting Methodologies – in which the Plan will discuss Science Center efforts to standardize and enhance West Coast bycatch reporting methodologies

3.0 Bycatch Research Needs – in which the Plan will prioritize Science Center/Region bycatch-related research needs, such as gear modification and monitoring technology and methods.

4.0 Bycatch Management Measures – in which the Plan will discuss potential new bycatch management measures for West Coast fisheries within the Region's management responsibilities.

5.0 Education and Outreach Efforts – in which the Plan will describe Region/Science Center initiatives to make the public aware of bycatch issues and to involve the public in development of bycatch-reducing technologies.

2.0 Bycatch Reporting Methodologies

Several different agencies collect data used for West Coast bycatch management. NMFS is responsible for collecting and analyzing the majority of these data. However, the states and the Pacific States Marine Fisheries Commission play key supporting roles in collection of indispensable ancillary data. As this a regional plan, other agencies' roles must be considered in NMFS' planning for monitoring and reducing bycatch.

Generally speaking, any fishery may face a range of bycatch issues, including: marine mammal takes, sea turtles takes, takes of threatened or endangered non-marine mammal species, and/or interception of overfished fish species. Bycatch issues for nine federally-managed West Coast marine fisheries are discussed within this document. Five of the fisheries target groundfish: at-sea hake/whiting, shoreside hake/whiting, bottom trawl, fixed gear (limited entry fixed gear and open access nontrawl) and recreational. In addition to these groundfish fisheries, there are commercial and recreational fisheries for Pacific salmon as well as commercial and recreational fisheries for Pacific halibut. There are no standardized methodologies or data collection for the West Coast salmon fisheries as a collective whole. Any initiative to create a bycatch observation program would cost in the millions of dollars, and would be complicated by cross-jurisdictional issues of state, tribal, and treaty fisheries that also take place in areas adjacent to the Pacific ocean salmon fisheries. As mentioned above, Pacific halibut is managed by the IPHC, but NMFS' state and tribal science partners collect data on halibut fisheries.

From preliminary data, the most pressing bycatch concerns in the West Coast fisheries are likely ESA-listed salmon and overfished groundfish species. The Center has focused monitoring efforts on the fisheries that have the largest rate of bycatch for salmon and overfished groundfish species. While there have been documented takes of some marine mammals and seabirds, the take of marine mammals is less than the potential biological removal (PBR) level for the species taken (all nine fisheries are Category III) and no listed or endangered seabird or marine mammal species have been documented as being taken in any of the fisheries. However, self-reporting methods used for these species are likely to be biased, as fishers have incentives to under-report encounters with species that may limit fishing access or quotas. In addition, while it is mandatory for Category III vessels to report mortalities or injuries of marine mammals to the NMFS Office of Protected Resources via a mailed form, reporting of seabird takes is strictly voluntary. Therefore, baseline reporting methods should be maintained in order to monitor any increase or decrease in the level of incidence. For fisheries with other reporting methods beyond self-reporting, the bycatch of marine mammals and seabirds may be conducted simultaneously with data for other more immediate bycatch concerns in these fisheries. As an example, observers collecting overfished groundfish species bycatch data from a commercial trawl fleet can also gather incidences of marine mammal and seabird takes.

2.1 Fishery Independent Surveys: Currently, the Science Center has four groundfish surveys: a continental shelf/slope bottom trawl survey, a pilot pot survey for sablefish, a pilot fixed gear survey for bocaccio and the joint US/Canada Pacific hake survey. The surveys use standardized gear to characterize the distribution, abundance and biology of species encountered by the fishery. The bottom trawl and hake surveys are coastwide and detailed data such as size and age composition and maturity levels are collected from targeted species to determine trends in the population. The pilot pot and fixed gear surveys are limited to geographic areas of concern for the species they are surveying (i.e. the pot survey for sablefish takes place off Oregon and the fixed gear survey for bocaccio takes place off Southern California.) While these surveys are deployed, data is collected simultaneously from as many species as possible, some which may be used for bycatch monitoring. Survey operations procedures including verifying net warp lengths before and after surveys, an operations manual with survey components outlined, etc. is in development for each of the Science Center's surveys. The associated annual costs for these fishery independent surveys are approximately $5,000K.

2.2 Fishery Dependent Sampling Methods: Fishery dependent sampling methods include commercial fishery landings/sales receipts ("fish tickets"), trawl logbooks, port sampling and recreational sampling. For the commercial fisheries, each state is responsible for carrying out fish ticket, logbook, catch reporting and port sampling responsibilities. Logbook and fish ticket data is combined with observer program data to assess total bycatch on a fleet-wide basis. Recreational fisheries are assessed via the Recreational Fisheries Information Network (RecFIN,) a comprehensive program coordinating federal and state activities for purposes of providing standardized catch and effort trend data on a broad geographic basis. A Vessel Monitoring System (VMS) is expected to be in use for the 2004 fishery. The position data collected via this system could be correlated with other data to assess how bycatch may be further reduced. The associated annual costs for these methods are difficult to assess and multiple agencies will be involved at different levels.

2.3 Observer and Monitoring Programs: Two distinct observer programs are coordinated at the Science Center: the At-sea Hake Observer Program and the West Coast Groundfish Observer Program. As discussed above, NMFS' immediate bycatch management concerns are the incidental take of salmon and overfished groundfish species. Sampling methodologies employed by the observer programs reflect these priorities. Although the incidental take of protected non-fish species (i.e., marine mammals, seabirds, and sea turtles) is rare in these fisheries, the observer programs make sampling for them a priority when they are encountered.

The Science Center focuses its monitoring efforts on the fisheries that have the largest incidental take of salmon and groundfish species and plans to expand into other fisheries as resources permit. The specific sampling design employed by the programs differ based on goals to be achieved, but they are adequately standardized to combine catch and bycatch data from the two programs. Bycatch and catch data from these programs are also comparable to NMFS observer program data for other regions, which allows monitoring for the cumulative effect of fisheries on species that travel into other NMFS regional areas, i.e. sea turtles, marine mammals and seabirds.

The Science Center's two programs deploy observers on vessels in three of the nine West Coast fisheries (at-sea hake, groundfish bottom trawl, non-trawl gear groundfish). The fisheries they cover are distinct in fleet composition, gear used, target species and time fished. The data collected is used in combination with state-collected logbook and fish ticket information to estimate the bycatch in the these West Coast fisheries.

At-sea Hake Observer Program: This program deploys two observers on the each at-sea hake processor. Begun during the 1970's by the Alaska Fisheries Science Center (AFSC,) this program is one of nation's longest running observer programs. Observers collect information on total catch, species composition of the catch (including any protected resources and seabirds), age structure data from several species and the fishery's interactions with species of concern. Observer total catch estimates are accessed on a daily basis by the Northwest Region for in-season fishery management. This fishery is a major source of salmon bycatch on the coast. Under the Biological Opinion on the effects of the groundfish fisheries on endangered and threatened salmon stocks, the at-sea hake fishery is anticipated to take up to 11,000 chinook salmon per season as bycatch. With close to 100% of the hauls in the fishery sampled, the program closely monitors the number of chinook taken. The majority of the annual cost of the deploying the observers is paid for by industry. The cost of training, in-season support and debriefing observers is supported by NMFS. Currently the annual cost of the program is approximately $535K ($500K paid for by industry).

West Coast Groundfish Observer Program: The program began deploying observers on groundfish vessels in August 2001. The focus of this program is to collect total catch and discard data (including protected resources and seabirds) from commercial groundfish trawl and non-trawl gear (longline, pot, etc.) vessels. Observers in this program collect species composition of the discard and data on target fisheries interactions with species of concern. This program is collecting data on one of the largest unknowns on the coast – the amount of groundfish discard by the bottom trawl and non-trawl fleets. As these fleets land the majority of catch in mixed species fisheries, they are likely the main source of bycatch of overfished groundfish on the West Coast. The observer program's data is already being used in a bycatch model that guides West Coast groundfish fisheries management.

This observer program initially targeted the trawl and non-trawl limited entry fleets for observer coverage. Next, the program plans to expand its data collection efforts to assess catch and bycatch in those open access fisheries that target groundfish. The program currently collects data from the open access fleet operating off California, but may expand to also cover open access vessels operating off Oregon in 2004, pending revisions to state regulations. Few vessels land open access groundfish into Washington ports and this fleet and has been covered on a limited basis. Beyond these groundfish-targeting fisheries, there are several state-managed fisheries that incidentally take and land or discard groundfish. The observer program hopes to also deploy observers on these fleets to determine the extent of the bycatch in non-groundfish fisheries. The associated annual costs for these programs is approximately $3,730K.

The collection of bycatch data in the salmon fisheries is limited, and what little data is collected is regionally based and not consistent along the Pacific coast. Currently Washington State has an observer program that collects all bycatch data in the recreational salmon fisheries, the program has been running since 1999. Washington also had observers on some commercial salmon vessels in 2003. California also has been collecting some bycatch data in their recreational salmon fisheries in the last few years, however this was limited to only salmon bycatch. Washington and Oregon also have been monitoring the mark rates in mark selective fisheries, though there has not been consistent reporting of this information.

2.4 Other Monitoring Programs: Some of the remaining fisheries could be monitored for bycatch by methods more cost-effective and less labor-intensive than observer programs. The Regional office is currently scoping alternatives to monitor the shoreside whiting fishery. This fleet uses similar pelagic trawl nets to catch whiting delivered to shoreside plants. Unlike the at-sea processors, the catch and bycatch of these vessels is sampled by port samplers as they land their fish for processing. However, to confirm that all catch is landed, a monitoring program is preferable over a self-reporting system. Monitoring alternatives include developing an Electronic Monitoring System (EMS) that collects video images with associated time and positional data. The images can be analyzed to confirm that all catch is being landed and the estimates of bycatch from port sampler data is accurate. NMFS has tested some of these techniques on groundfish vessels.

3.0 Bycatch Research Needs

3.1 Groundfish: In 2000, the Center developed a groundfish research plan with input from scientists, constituents and other interested parties. The plan's research priorities have focused on collecting data from portions of the fisheries that were previously data-poor. The Science Center has greatly expanded its research capability in the last two years to address these data-collection priorities by: expanding the West Coast bottom trawl survey, creating a research group focused on science for ecosystem management, establishing a pot survey for sablefish and a fixed gear survey for bocaccio, expanding the hake/whiting acoustical survey and establishing an observer program. These priorities are expansive and include investigations into the different components of the coastwide fisheries system. For the purpose of this bycatch plan, we will address fishery specific bycatch research needs.

At-sea Hake Observer Program Staff Funding. The At-sea Hake Observer Program addresses the bycatch monitoring concerns of the at-sea fishery. However, this program has been run without designated funding since its inception and the staffing costs are paid from base funds. In addition, the AFSC still aids the program in supplying observer's sampling gear, data transmission software capability and database support. Without their support and some designated funding, the Science Center will be hard-pressed to maintain the program. If AFSC is able to continue its aid, the Science Center would need $25K annually of staff funding and is seeking that funding. If AFSC were to withdraw its support from this program, the Science Center would need an additional $150 in annual funding for program support.

Monitoring Program for Shoreside Whiting. As mentioned above, alternative monitoring programs for the shoreside whiting fishery are being analyzed. The scoping analysis, including the associated implementation costs for alternatives is expected to be completed in the near future. The program design could include partial industry funding, but funding for associated NMFS staffing costs, data analysis and oversight will also be necessary. Cost unknown.

Groundfish Observer Program Coverage Expansion. The West Coast Groundfish Observer Program is funded for collecting data from both the limited entry bottom trawl and fixed gear fisheries year-round. These fleet components that account for the overall majority of the catch are being covered at approximately 10%. Coverage of a higher percentage of the fleet would require more resources. However, the observer program is also expanding its coverage to the open access fleet. Vessels in this fleet are more problematic for coverage due to their smaller size (including kayaks and skiffs) and high mobility (boats can be trailered from port to port). The program has established partial coverage of the California portion of the fleet, and expects to be partially covering the other large portion of the fleet in Oregon. Other state fishery vessels that take groundfish as bycatch are also a concern. The program is exploring expansion into some of these fisheries that are likely taking groundfish as bycatch. Additional data processing and analysis staff would be needed for these expansions. Cost is approximately $1,500K to significantly increase coverage percentage and/or $500K for each additional ancillary fleet.

Gear Modifications. In the summer of 2003, the Science Center was involved with an Exempted Fishing Permit that tests a modified bottom trawl net. The Oregon Department Fish and Wildlife tested the gear last summer and verified that it reduced the bycatch of roundfish when targeting flatfish stocks. The Science Center deployed observers on the vessels participating in the EFP to sample catch. The net (referred to as flatfish net, cut-back net, upside-down trawl, pineapple trawl) has gained popularity with members of the fleet as it reduces the bycatch crews have to sort through. Preliminary results of this EFP suggest that continued research into net modifications may yield highly cost-effective techniques for bycatch reduction. Cost unknown.

Seabird Abundance Study. The impact of seabird bycatch in these fisheries is difficult to assess. The available observer data do not indicate a problem in gross seabird takes. However, a single take of an ESA-listed seabird species, such as the short-tailed albatross, would be of major concern. Expanding observer programs for rarely occurring bycatch 'events' could be cost-prohibitive. Studies to determine seabird abundance and distribution around fishing vessels is the first step to determining whether seabird/ fisheries interactions are an issue in NWR-managed fisheries. The information can be collected on vessels chartered for this purpose as well as aboard commercial vessels. A similar study conducted in the North Pacific by SeaGrant cost approximately $50K.

Integrated Data System. The current GIS of bottom habitat information is now complete. Additional layers including ecosystem, social and biological data will be added over the coming years as it they become available. This database will help assess where annual bycatch hot spots are located and the effects of shifting the fishery out of those areas. Data is currently being collected for these layers by scientists in the Science Center and will be augmented each year. Cost unknown.

Monitoring Program for Pacific Halibut. Bycatch in this fishery is likely to be similar to other non-trawl fisheries that the observer program currently covers. The commercial halibut fishery is a series of three to six short, 12 hour openers per year. The observer program does not cover the Pacific halibut fishery due to the vagueness of the authority of NMFS to require coverage on those vessels and the fishery's size. An option being discussed in the Council is combining the halibut fishery with the non-trawl gear groundfish fishery. This combination would give clear authority for observer coverage. If the halibut fishery remains autonomous from the non-trawl gear groundfish fishery, the observer program will need to expand its coverage into this fishery to collect bycatch data on at least a baseline level. Cost $0K to $4K.

Fishery Dependent Surveys. The RecFIN program is currently being modified to provide more timely and accurate information for management purposes, particularly for overfished groundfish species. Given current budgetary limitations, these modifications, along with existing on-going efforts to improve recreational data collection, should improve the ability to assess bycatch issues in the West Coast recreational fisheries. Cost unknown.

3.2 Salmon:

Hooking Mortality Rate Estimates for Both Recreational and Commercial Fisheries. The current structure of estimating mortality in the salmon fisheries is not as precise as it could be. There has been some recent research in this area, however there are only a few stocks on the Pacific coast that have reliable mortality estimates. This limits fishery manager's options in the management of the various salmon fisheries. Increasing the confidence of the mortality rate estimates would allow managers to have more flexibility in structuring fisheries to protect weak stocks. Cost $500,000 to $10,000,000, depending on the scope and spatial scale.

Coded Wire Tags (CWT) and Adipose Fin Clips - Hatchery Coho and Chinook Mass Marking. Currently the vast majority hatchery coho on the West Coast are adipose fin clipped. Limited numbers of hatchery chinook on the West Coast are mass marked with adipose fin clips: the majority of Puget Sound hatchery chinook and approximately a third of the hatchery stocks in the Columbia River Basin. Generally, 3-5% of marked hatchery coho and chinook releases have CWT. To increase the mark rate of hatchery fish would allow for increased use of selective fisheries for coho, and could establish selective fisheries for chinook; however, implementing such a program would coast several million dollars. To improve CWT recovery and fishery sampling, the states would need to increase sampling of inside sport fisheries (e.g. Puget Sound and California,) at an annual cost of about $1-2 million annually. In addition, about 25 hand wands per state (75 wands) would be needed to detect and recover CWTs after mass marking is completed, at a cost of about $10,000 for each wand. Mark selective fisheries cause substantial problems with continuing to use the CWT system to estimate fishery impacts on ESA listed stocks. Research is needed to find innovative ways of 'fixing' the problems. Possible solutions are DNA analysis, PITT tags, otolith marking, thermal marks, and greatly increased sampling efforts. Currently NMFS is in the early stages of convening a technical workshop to explore methods.

Estimation of Stock Composition of Salmon Bycatch in the Salmon Fisheries. Currently there are no estimates on the stock composition of salmon bycatch. A non-lethal means of sampling, such as microsatellite DNA analysis, needs to be developed. Also, further research into acquiring finer resolution of DNA analysis is needed (population level identification vs. regional identification). Cost unknown.

Escapement and Production Data Gaps (CA, OR, ID, PS, WA coastal stocks). Currently there are many salmon stocks that do not have any monitoring or sampling for escapement and production. Escapement and production data is baseline information that is critical for adequately managing salmon stocks, and in formulating estimates of salmon bycatch and its longterm effects. States need increased funding to support sampling of escapements and production of salmon from West Coast rivers and streams. Cost unknown.

Selective Gear Studies. Fishing spreads per boat, hooks, and other potential methods and gear modifications need to be investigated to reduce bycatch in the salmon fisheries. In addition, technologies such as live holding boxes with oxygenated water should be studied. This technology has been used in the commercial tangle-net fishery in the lower Columbia River in recent years, and shows some indication that mortality of released salmon is decreased. An investigation on whether this technology is feasible in the commercial and charter boat fleet should be completed. Cost unknown.

Observer Program for Commercial Vessels and Charter Boats. There is observation of fishing and bycatch in the recreational salmon fishery, however it is limited and does not cover the entire coast. There is currently no observation of bycatch in the commercial salmon fisheries. An observation program would give accurate data on bycatch, and would support the other research priorities listed above. Possible methods are Vessel Monitoring Systems, video, and observers on the boats and dockside. Cost unknown.

3.3 Protected Non-Fish Species: Because interactions between marine mammals, seabirds, sea turtles and groundfish fisheries managed by the NWR are rare, there are no observer programs solely designated to monitor for their bycatch. However, the observer programs do collect protected species incidental catch baseline data and data on sightings of protected non-fish species and seabirds in addition to their other duties. Groundfish observers are instructed in the species identification of protected non-fish species and are provided with dichotomous keys to aid with the identification of drowned specimens. Incidental take data can be used to monitor the effects of groundfish fisheries on protected non-fish species. Additionally, interaction and sighting data aid scientists in determining the temporal/spatial nature of protected non-fish species and can be used to predict fishery interactions.

4.0 Bycatch Management Measures

4.1 Groundfish: The greatest challenge facing West Coast groundfish fisheries management is the need to constrain the direct and incidental catch of overfished groundfish species to levels that facilitate timely rebuilding, while providing fisheries access to more abundant groundfish stocks. Nine groundfish species have been declared overfished since the passage of the Sustainable Fisheries Act: bocaccio, canary rockfish, cowcod, darkblotched rockfish, lingcod, Pacific ocean perch (POP,) Pacific whiting, widow rockfish, and yelloweye rockfish. All of these species tend to be found mixed with a wide variety of other, more abundant species, and all of the overfished species except POP and darkblotched rockfish are continental shelf species. In spite of having been declared overfished, Pacific whiting is a relatively abundant stock and is the only overfished groundfish species for which there is a directed fishery. The other eight overfished groundfish species either may not be taken or retained at all, or may only be retained when taken incidentally in fisheries targeting associated healthier stocks. Incidental take of overfished species has been managed through a variety of efforts, from restrictions on the types of gears used to large-scale area closures known as Rockfish Conservation Areas.

Northwest Region is developing a programmatic environmental impact statement (EIS) to review bycatch management in the West Coast groundfish fisheries. This programmatic EIS is intended to provide the Council with a road map for its future groundfish management efforts, to ensure that groundfish management programs address and reduce bycatch of groundfish and non-groundfish species in the groundfish fisheries. Program alternatives for bycatch reduction in this EIS include:

- Implement effort reduction measures to reduce the number of vessels participating in the groundfish trawl fleet so that the number of participants is ultimately one-half of the number of current participants (220-250 vessels). The programmatic EIS assumes that reducing the trawl fleet by one-half will allow the Council to continue to use its current trip limit management program and to raise the trip limits within that program.

- Eliminate the current policy of maintaining a year-round fishery, introducing short fishing seasons that allow higher trip limits within each short season than are currently available in the six two-month cumulative periods.

- Establish sector-specific catch limits for overfished groundfish species, such that each fishery sector would be permitted to fish as long as that sector keeps its catch of overfished species below limits for those species. This program alternative would require intensive monitoring to ensure compliance.

- Establish vessel-specific catch limits for overfished and other groundfish species, such that each vessel would be permitted to fish as long as that vessel keeps its catch below limits for those species. This program alternative would also require intensive monitoring to ensure compliance.

- Establish long-term closed areas where overfished groundfish and other sensitive species are most likely to be encountered; establish individual vessel catch limits for various groundfish species, and prohibit discarding of designated species.

NMFS plans to submit the Draft EIS to the Environmental Protection Agency (EPA) for review in January 2004. The EPA will then publish a Notice of Availability (NOA) on the Draft EIS and request comments from the public on NMFS's behalf. The public comment period on the Draft EIS will be held from the January publication (NOA) through mid-April. Following receipt of comments from the public and the Council, NMFS plans to make the Final EIS available to the public in June 2004.

In addition to this program-level EIS, NMFS and the Council will be dealing with bycatch on a more direct basis in several arenas. Through the 2004 specifications and management measures process, NMFS will introduce a series of management measures for the groundfish fisheries that are specifically intended to minimize total catch of overfished species to levels that will facilitate rebuilding of those species. Management measures include continued implementation of the Rockfish Conservation Areas, season closures in both recreational and commercial fisheries, landings limits for more abundant species constrained based on co-occurrence rates with overfished species, and other measures. Monitoring in the groundfish fishery will also increase in 2004 with the implementation of a final rule for a vessel monitoring system (VMS) program.

Beyond immediate fishery management measures, the biggest roadblock to bycatch management in the West Coast groundfish fisheries is overcapacity. Most sectors of the fishery were overcapitalized before the agency implemented broad-scale closures and reductions to protect overfished species. With overfished species protection setting the framework for groundfish management, the notably lower harvest levels relative to the number of vessels in the fishery has resulted in even greater levels of overcapacity. At its September 2003 meeting, the Council decided to explore an individual fishing quota program for the limited entry groundfish trawl fishery and to review the need for a license limitation program in the open access groundfish fisheries. If NMFS and the Council are able to get groundfish fishing capacity to levels more appropriate to available harvest, they will be better able craft bycatch management programs that both minimize bycatch and allow vessels to operate profitably.

The current biological opinion on ESA listed salmon for the West Coast groundfish fisheries was completed on December 15, 1999. When new information becomes available, NOAA Fisheries reviews that information in relation to the most recent biological opinion, and then makes an assessment whether reinitiation of consultation is needed. In January 2004, the Science Center plans to make observer data for the second year (September 2002-August 2003) of the West Coast observer program available to the public and for use in reviewing bycatch in groundfish fisheries. Following the release of this observer data, NWR will review salmon bycatch information from the 2002 and 2003 observer seasons and determine whether the 1999 biological opinion needs to be reinitiated.

4.2 Salmon: There are no new management measures that are available presently, however modification of the current regime of management options (see the Pacific Coast Salmon Plan; www.pcouncil.org/salmon/salfmp.html) could be structured differently to reduce bycatch. Examples are: innovative use of time/area closures; innovative use of gear restrictions, e.g. troll lines per boat and lures that target species salmon species; eliminate mooching (drifting with the ocean currents using baited lures) in California recreational fisheries because mooching has a high hooking mortality for salmon that are released; modify size limits, i.e. eliminating the minimum size limit in the recreational fishery would eliminate the release of undersized fish; increase enforcement presence and fines; and eliminate selective fisheries. The most effective long-term approach would be a uniform enforcement presence coastwide, with heavy fines for infractions of the salmon fishery regulations. Currently the states and USCG enforce the regulations in ocean salmon fisheries. Recent budget cuts for state fishery management agencies, and homeland security duties for the USCG have weakened the enforcement presence on the coast. To maximize the effect of these regulations, enforcement must be present and infractions prosecuted.

4.3 Protected Non-Fish Species: There are no management measures presently implemented to specifically reduce the bycatch of protected non-fish species because groundfish fisheries managed by the NWR are thought to have minimal interactions with protected non-fish species. For example, the NWR groundfish fisheries are in MMPA Category III, indicating a remote likelihood of, or no known serious injuries or mortalities, to marine mammals. Sea turtles are rare in areas where groundfish fisheries are prosecuted and the incidental take of a sea turtle has not been documented in any groundfish fishery managed by the NWR. While seabirds have been observed feeding offal and following fishing vessels, few incidental takes of seabirds in groundfish fisheries managed by the NWR have been documented. As more information about the spatial and temporal overlap of groundfish fisheries and protected non-fish species along the Pacific Coast is gathered, a more comprehensive understanding of protected species/fishery interactions is possible and management measures may be implemented to mitigate the effects of NWR groundfish fisheries if necessary.

NMFS is taking action, with the U.S. Fish and Wildlife Service (FWS) to improve the federal government's understanding of fisheries interactions with seabirds. The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing, or possessing migratory birds is unlawful. In addition to the MBTA, an Executive Order, Responsibilities of Federal Agencies to Protect Migratory Birds, (EO 13186) directs Federal agencies to negotiate Memoranda of Understanding with the U.S. Fish and Wildlife Service (FWS) that would obligate agencies to evaluate the impact on migratory birds as part of any NEPA process. In 2002 and 2003, the FWS and NMFS have been working together to draft a Memorandum of Understanding concerning seabirds. The following seabirds have been listed by the FWS as "birds of conservation concern:" Black-footed albatross (*Phoebastria nigripes*); Ashy storm-petrel (*Oceanodroma homochroa*); Gull-billed tern (*Sterna nilotica*); Elegant tern (*Sterna elegans*); Arctic Tern (*Sterna paradisaea*); Black skimmer (*Rynchops niger*); Xantus's murrelet (*Synthliboramphus hypoleucus*), and; Cassin's auklet (*Ptychoramphus aleuticus*).

Under the Magnuson-Stevens Act, NMFS must ensure fishery management actions comply with other laws designed to protect seabirds. NMFS is also required to consult with FWS if fishery management plan actions may affect seabird species listed as endangered or threatened. Taken together, these laws and directives underscore the need to consider impacts to seabirds in decision making and consider ways to reduce potential impacts of the proposed action. In February 2001, NMFS adopted a National Plan of Action (NPOA) to Reduce the Incidental Take of Seabirds in Longline Fisheries. This NPOA contains guidelines that are applicable to relevant groundfish fisheries and would require seabird incidental catch mitigation if a significant problem is found to exist. During the first two years of NPOA implementation, NMFS regions were tasked with assessing the incidental take of seabirds in longline fisheries. In the limited entry groundfish longline fleet off the coast of Washington, Oregon, and California during September 2001 - October 2002, there were no incidental seabird takes documented by West Coast Groundfish Observers. In 2004, NWR plans to draft a Biological Assessment of the effects of the West Coast groundfish and halibut fisheries on short-tail albatross to meet the agency's obligations under the ESA.

5.0 Education and Outreach Efforts

5.1 NMFS Communications with the Public: NMFS Northwest Region education and outreach program uses several approaches to inform the public and the media on a variety of fishery management concerns.

The NWR regularly employs many communications tactics and resources to reach out to the public and the media and to educate members of the public on fishery issues. These projects are intended to be useful to the general public, the fishing public (commercial and recreational, non-government organizations, other government agencies, academia, etc. The following activities *are intended to educate the public about what the agency is doing about those issues, and how people can assist with those efforts:*

- Using Northwest Region Website to provide easy access to information by posting news, various materials, updates and appropriate links.
- Distribution of news releases on significant activities.
- Distribution of media advisories/radio public service announcements to remind people of issues/programs and to solicit input on them.
- Distribution of e-mail notices, requests for input, reminders and updates.
- Scheduling and executing media editorial boards to educate media leadership and provide agency points of view.
- Soliciting appropriate entities to include NWR information on their Websites and link to the NWR's section on them.
- Identifying, supporting and participating in appropriate subject-related panels, seminars and conferences.
- Participation in related industry exhibitions such as FishExpo, recreational fishing, boat shows.
- Participation in related public events and festivals such as environmental fairs, salmon homecomings, city celebrations.
- Holding meetings/workshops to provide information and solicit input; for the general public or with targeted invitations.

NMFS information specific to commercial and recreational fisheries management and regulations is distributed via a variety of mediums.

- Groundfish fisheries information is distributed in regular mailings to the groundfish fleet, via fax, via a website (http://www.nwr.noaa.gov/1sustfsh/gdfsh01.htm,) and via an internet news list (westcoastgroundfish@noaa.gov).
- Salmon fisheries information is distributed via mail in an annual regulations package, via several telephone hotlines, and via a website (http://www.nwr.noaa.gov/1sustfsh/salmon01.htm.)
- Halibut fisheries information is distributed via mail to the halibut fleet, via a telephone hotline, and via a website (http://www.nwr.noaa.gov/1sustfsh/halbut01.htm.)
- Seabird information, including albatross identification guides, information on ESA listed species and species of conservation concern, and seabird deterrent information, has been distributed via mail to halibut fishers. Albatross identification guides are distributed to the groundfish fleet via the West Coast Observer Program. NMFS NWR plans to develop a webpage to disseminate seabird information in 2004.

The Region also meets quarterly with California fisheries managers to discuss marine resource management issues that cross federal and state jurisdictions. Other salmon fishery related meetings include the North of Cape Falcon Forum, US v. Oregon fisheries, and US-Canada Pacific Salmon Treaty fisheries. In 2003, the Region began meeting with fisheries managers from the Washington treaty tribes (Makah, Quileute, Hoh, Quinault) and from Washington State to also discuss cross-jurisdictional groundfish management issues.

The Science Center's website (http://www.nwfsc.noaa.gov/index.cfm) provides information on all of their research programs, including those focusing on groundfish and salmon harvest activities:

- Groundfish – Fisheries Resource Analysis and Monitoring Division: (http://www.nwfsc.noaa.gov/research/divisions/fram/index.cfm)
- Salmon – Resource Enhancement and Utilization Technologies Division: (http://www.nwfsc.noaa.gov/research/divisions/reut/index.cfm)

In addition to these research program websites, the Science Center sponsors an industry-formed website (http://www.fishresearchwest.org/) to communicate with the public about cooperative research issues. This website explains how the fishing and marine-interest public can get involved with the government in collaborative research projects, posts opportunities for involvement in collaborative research for fishing vessels and non-fishing partners, and solicits grants and contracts for fisheries research. The Center also participates in a discussion group that occurs quarterly in Oregon with state agencies, industry, university and federal scientists to discuss research priorities and issues, including bycatch issues.

Additional potential NWR communications resources to educate members of the public about bycatch, what the agency is doing to minimize bycatch and bycatch mortality, and how people can assist with those efforts:

- Design and produce color regional bycatch poster and brochure; estimated cost $6,000.
- Produce a video bycatch public service announcement; estimated cost $14,000.

Additional potential NWR communications tactics to reach out to members of the public about bycatch issues:

- Distribute bycatch posters and brochures to marinas, yacht and kayak clubs, sailing and rowing schools, aquaria, maritime centers, Washington State Ferries, state offices of environmental education; estimated cost $1,200.
- Provide brochures to appropriate trade shows, festivals, fairs, etc.; estimated cost $400.
- Reproduce video bycatch public service announcement and distribute to regional television stations; estimated cost $1,000.

5.2 Bycatch Reporting for the Public: Bycatch-related regulations are distributed as part of the general public information distribution processes described above for all fisheries regulations. Information from the West Coast Groundfish Observer Program is reported on an annual basis and is distributed on the Science Center's website as well as by paper copies on request. The Observer Program also reports on its activities to the Pacific Council at each of the Council's meetings. For the at-sea whiting fisheries, bycatch data is provided to fishery participants as inseason reports, so that they know where their bycatch levels fall relative to allowable levels. The at-sea whiting fleet also maintains a within-fleet satellite information system that allows them to track areas where bycatch of non-whiting species is relatively higher in real time so that vessels may avoid those areas to reduce their bycatch of protected species (salmon, halibut, Dungeness crab) and overfished groundfish species.

In addition to these bycatch data reports, the Center has developed a bycatch model that estimates amounts of overfished groundfish species taken in groundfish and other fisheries targeting more abundant stocks. This model was developed in 2001 for use in 2002 fisheries management and has since been refined with information from the Observer Program. In January 2003, NMFS sponsored a meeting of the Pacific Council's Scientific and Statistical Committee to review the bycatch model and make model-improvement suggestions. The model is discussed and explained in public Council-related fora and in *Federal Register* notices implementing the groundfish fishery specifications and management measures.

5.3 Partnering with the Public on Bycatch-Related Research: NMFS has been working with the States and the public to develop and implement Exempted Fishing Permit (EFP) programs that develop alternative gear designs to reduce bycatch. EFPs provide a process for testing innovative fishing gears and strategies to substantiate methods for prosecuting sustainable and risk-averse fishing opportunities. In 2002 and 2003, the following bycatch-related EFPS were approved for West Coast research:

- August 2003: California flatfish EFP for small footrope trawl vessels using an experimental net design intended to reduce incidental catch of rockfish.
- April 2003: Oregon EFP for experimental trawl gear for flatfish fisheries, intended to test a net design that would reduce incidental catch of rockfish.
- January 2003: Washington EFPs for trawl pollock, trawl arrowtooth flounder, and longline spiny dogfish, intended to document bycatch rates of overfished species by vessels operating under observed, bycatch cap fishing constraints.
- September 2002: California flatfish EFP for small footrope trawl vessels using an experimental net design intended to reduce incidental catch of rockfish.
- July 2002: California EFP for vertical hook-and-line gear, intended to test incidental canary rockfish bycatch rates for fishing directed at nearshore and shelf rockfish complexes.
- May 2002: Washington EFPs for trawl arrowtooth flounder and trawl yellowtail rockfish, intended to document bycatch rates of overfished species by vessels operating under observed, bycatch cap fishing constraints.

NMFS also either participates in or approves scientific research fishing that involves West Coast marine resources. Scientific research permits (SRPs) are issued for NOAA/NMFS research and letters of acknowledgment (LOAs) are issued to other government agencies and/or universities conducting scientific research fishing. Under the Magnuson-Stevens Act, scientific research fishing does not include gear development research, however, many of the recently issued SRPs and LOAs address species co-occurrence ratios, survival rates of discarded fish, and other bycatch-related issues.

In 2002 and 2003, SRPs were issued for the following projects:

- Assessing the effects of environmental and capture processes on the behavior and mortality of important bycatch species,
- U.S./Canada echo integration trawl and oceanographic survey assessing the Pacific whiting population,
- Survey to assess the pre-recruit Pacific whiting population,
- Trawl survey to assess groundfish populations along the continental shelf and slope,
- Fixed gear survey to assess groundfish populations in the California Bight,
- Fixed gear survey to assess the Pacific Coast sablefish population, and
- Assessing species-specific groundfish habitat requirements.

In 2002 and 2003, LOAs were issued for the following projects:

- Development of a selective bottom trawl to reduce bycatch in the flatfish fishery,
- Development of a selective pot to reduce bycatch in the flatfish fishery,
- Assessing benthic condition of the continental shelf,
- Fixed gear survey to assess the Pacific halibut population off Washington and Oregon,
- Assessing rockfish populations in a rocky reef environment, and
- Assessing rockfish habitat utilization along the continental shelf off Oregon.
- Chinook Technical Committee LOA funded projects on encounter rates (Makah, and WDFW), and the coastwide DNA standardized baseline development project.
- Tangle net test research by WDFW in the Columbia River and Willapa Bay.

The primary foci of a cooperative research program with industry should be the development of bycatch reduction gear and investigation of methods to provide economic incentives to reduce bycatch. This would require a significant expansion of the Center's existing Cooperative Research Program. Cost is approximately $1,500K.

6.0 Literature Cited

Tyler, W.B., K.T. Briggs, D.B. Lewis, and R.G. Ford. 1993. Seabird distribution and abundance in relation to oceanographic processes in the California Current System. In The status, ecology, and conservation of marine birds of the North Pacific. K. Vemeer, K.T. Briggs, K.H. Morgan, and D. Siegel-Causey, Eds. Can. Wildl. Serv. Spec. Publ., Ottawa, pp. 48- 60.

Northwest Region Current Bycatch Priorities and Implementation Plan Summary

Monitoring

Priorities for FY04:

- Integrate 2002-2003 WCGOP data into groundfish bycatch model
- Convert at-sea whiting fishery observer program from voluntary participation to mandatory participation (proposed rule published on September 10, 2003, 68 FR 53334)

Priorities for FY05:

- Implement mandatory catch monitoring program for shore-based whiting fishery, possibly with camera or other technological observation systems
- Explore expanding the vessel monitoring system program to cover commercial open access and fleets that target groundfish

Research

Priorities for FY04:

- NMFS will convene a technical workshop to explore ways to solve problems with continuing to use the CWT system to estimate fishery impacts on ESA listed stocks while increasing the use of mark selective fisheries
- Expand observer program coverage to assess bycatch in open access fleet

Priorities for FY05:

The "Research Needs" section, above, is essentially a wish list. The changes that would help to decrease the bycatch of non-target salmon species and listed salmon ESUs would increase the precision of salmon bycatch estimates in the array of West Coast salmon fisheries. Portions of the projects listed under groundfish research needs will be part of the Science Center's ongoing research priorities. NMFS would have to increase funding to existing research and monitoring programs to meet bycatch research needs for salmon, groundfish, and halibut fisheries and on fisheries interactions with protected species.

Management

Priorities for FY04:

- Complete programmatic bycatch EIS for West Coast groundfish fisheries
- Revise non-trawl/fixed gear 2004 groundfish landings limits based on early-2004 analysis of 2002-2003 WCGOP data
- Determine whether Biological Opinion on effects of West Coast groundfish fishery on listed salmon species needs to be reinitiated
- Draft Biological Assessment on effects of West Coast groundfish and halibut fisheries on short-tailed albatross

Priorities for FY05:

- Explore capacity reduction programs in groundfish trawl and open access sectors

Education/Outreach

Priories for FY04:

- Develop seabirds and fisheries interaction website for NWR
- Continue to work with the Pacific Council on development of its communications plan

Priorities for FY05

Unknown

Southwest Region Current Bycatch Priorities and Implementation Plan

[NOTE: This is a public, working document that will be revised in the future as additional bycatch minimization opportunities occur.]

SOUTHWEST REGION
NATIONAL MARINE FISHERIES SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE WASHINGTON, D.C.

NOVEMBER 28, 2003

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I. INTRODUCTION

The National Bycatch Strategy

On March 11, 2003, the National Marine Fisheries Service (NMFS) initiated a six-part National Bycatch Strategy developed in response to a petition for rulemaking, in which the petitioner asserted that NMFS was not complying with its statutory obligations to monitor and minimize bycatch. The first component of the announced Strategy is a comprehensive review of the agencies progress toward meeting the National Bycatch Goal, which had been described in a 1998 report entitled *Managing the Nations Bycatch* (NMFS 1998). The second component of the Strategy is the development of a national approach to a standardized bycatch reporting methodology, as required by the Sustainable Fisheries Act. This approach is set out in *Evaluating Bycatch: a National Approach to Standardized Bycatch Monitoring Programs* (NMFS 2003), which concluded that at-sea observation (observers or digital observation) provides the best mechanism to obtain reliable and accurate bycatch estimates. The third component, to which the present document contributes, consists of implementing the national bycatch goal through regional implementation plans.

The National Goals for Regulating Bycatch

NMFS' responsibilities for reducing bycatch are mandated by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and the Migratory Bird Treaty Act (MBTA). The National Bycatch Goal consists of the statutory requirements related to bycatch contained in these Acts. The National Bycatch Goal defines bycatch as the discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear (NMFS 1998). This definition is somewhat more expansive than that found in the MSA and is intended to allow consideration of the effects of all fishing related mortality associated with U.S. fisheries.

The MSA provides the following direction with respect to controlling the amount of fish that are discarded in the course of fishing operations in U.S. fisheries: 1) fishery management plans must establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery; 2) conservation and management measures shall, to the extent practicable, minimize bycatch and to the extent bycatch cannot be avoided, minimize the mortality of such bycatch; and 3) fishery management plans must assess the type and amount of fish caught and released alive during recreational fishing under catch and release fishery management programs and the mortality of such fish, and include conservation and management measures that, to the extent practicable, minimize mortality and ensure survival of such fish.

The standard set by the MSA for bycatch reduction is "to the extent practicable". NMFS has suggested that "to the extent practicable" should be understood in terms of net benefits to the nation: "From a National perspective, there is too much bycatch mortality in a fishery if a reduction in bycatch mortality would increase the overall net benefit of that fishery to the Nation through alternative uses of the bycatch species. . . . In many cases, it may be possible but not practicable to eliminate all bycatch and bycatch mortality." The MSA, however, offers no such unusual definition of the word "practicable". The direction to minimize bycatch where practicable and minimize bycatch mortality where bycatch is unavoidable recognizes that bycatch can have significant negative impacts on marine ecosystems and that those effects must be limited to sustainable levels; but it also acknowledges that bycatch is unavoidable and must be tolerated to some extent if fishery resources are to exploited.

The ESA requires that the incidental take of species listed as threatened or endangered under the Act be limited to the extent that the take is not likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of critical habitat. “Take” is defined broadly by the ESA to include harass, harm, pursue, hunt, shoot, wound, kill, trap. capture, or collect, or attempt to engage in any such conduct. If a threatened or endangered species occurs as bycatch in a fishery, then NMFS may issue an Incidental Take Statement that specifies the impact of any incidental taking, as well as Reasonable and Prudent measures, and terms and conditions to implement the measures, necessary to minimize the impacts.

The MMPA requires that commercial fisheries reduce incidental mortality and serious injury of marine mammals to insignificant levels approaching a zero mortality and serious injury rate. It further requires NMFS to develop and implement Take Reduction Plans to assist in the recovery or prevent the depletion of certain “strategic” stocks of marine mammals. The MMPA requires that NMFS classify each U.S. fishery according to whether there is a frequent (Category I), occasional (Category II), or remote (Category III) likelihood of incidental mortality and serious injury to marine mammals. Participants in Category I or II fisheries are required to register with NMFS, take on board an observer if requested by NMFS to do so, and to comply with all applicable Take Reduction Plan regulations.

The MBTA establishes a federal prohibition on the taking of certain migratory birds, unless permitted by regulations; NMFS monitors and reports the bycatch of these and other seabirds. Several seabird species, such as the marbled murrelet and short-tailed albatross, are also protected under the ESA. If listed seabirds are taken by federally regulated fisheries, NMFS must consult with the U.S. Fish and Wildlife Service, in order to obtain an Incidental Take Permit.

II. SOUTHWEST REGIONAL FISHERIES

This plan addresses bycatch associated with federally managed fisheries for which the Southwest Region has primary responsibility for developing regulatory measures under authority of the MSA, the MMPA or the ESA. Those fisheries are the Coastal Pelagic Species Fishery managed under the Coastal Pelagic Fishery Management Plan, the California and Oregon Drift Gillnet Fishery, managed under the ESA and MMPA, and the Large Vessel Tuna Purse Seine Fishery in the Eastern Tropical Pacific Ocean, managed under the MMPA[1].

A proposed FMP for U.S. West Coast Fisheries for Highly Migratory Species, developed by the Pacific Fishery

[1] Two other California fisheries are also not included in this plan because they are not actively regulated by NMFS. The angel shark/halibut set gillnet (>3.5 in. mesh) fishery, which operates off southern and central California, is a Category I fishery in the MMPA List of Fisheries because the average estimated mortality and serious injury of the Monterey Bay stock of harbor porpoise exceeds 50 percent of the PBR level. In September 2002, the California Department of Fish and Game issued permanent regulations prohibiting set gillnet fishing in ocean waters that are 60 fathoms or less in depth in central California, from Point Reyes to Point Arguello, citing concerns over the incidental take of seabirds and sea otters. California also prohibits this fishery from operating within 3 miles of land south of Pt. Conception. NMFS will continue to monitor this fishery, but also expects that this closure will result in a significant reduction in effort in this fishery off central California, and subsequently, in incidental mortality and serious injury or harbor porpoise. The yellowtail, barracuda, white seabass, and tuna drift gillnet fishery (mesh size >3.5 in and < 14 in.) was added to the 2003 MMPA List of Fisheries as a Category II fishery based on the fishery's similarity to other drift gillnet fisheries, and therefore, its potential to entangle marine mammals. California Department of Fish and Game logbook and landings data for 1991-2001 indicate that there are approximately 24 vessels that operate in this fishery. Vessels in this fishery set at the surface, using drift gillnets of up to 6,000 feet long. NMFS does not currently have observer data on the mortality or serious injury of marine mammals incidental to this fishery. However, in July 2002, NMFS began placing observers on some vessels in this fishery to better assess its potential to entangle marine mammals. Based on information collected by observers, NMFS will reassess the categorization of this fishery and evaluate whether incidental mortality and serious injury needs to be addressed through a Take Reduction Plan.

Management Council, is presently under NMFS review. The final FMP implemented by NMFS will comply fully with the various statutory mandates governing bycatch, as well as meet all of the agency goals with respect to reducing bycatch. Therefore, those fisheries covered by the draft FMP are not covered here, except for the two over which NMFS already exercises regulatory authority: the California and Oregon Drift Gillnet fishery and the large scale tuna purse seine fishery in the ETP. Other than a brief description of the draft FMP below, this plan does not cover the following west coast highly migratory species fisheries: recreational, pelagic longline, small vessel tuna purse seine, harpoon, and albacore troll.

NMFS has advised the Pacific Council that certain aspects of the draft FMP are not likely to be implemented because of concerns about the bycatch of sea turtles. In anticipation of the likely partial disapproval of the HMS FMP, NMFS is developing a companion rule under authority of the ESA to ensure that the west coast longline fishery is not likely to jeopardize the continued existence of sea turtles. NMFS expects to publish the two final rules simultaneously on or about February 19, 2004.

NMFS will conduct an ESA section 7 consultation on the effects of implementing the proposed FMP and a biological opinion resulting from that consultation will be issued prior to a decision to approve, disapprove, or partially approve the HMS FMP or to issue any other regulations to manage the West coast longline fishery under the ESA

Coastal Pelagic Species

The coastal pelagic species (CPS) fishery targets northern anchovy, jack mackerel, market squid, Pacific sardine, and Pacific mackerel. Two of the species, Pacific sardine and Pacific mackerel, are actively managed, that is, harvest guidelines are calculated based on current biomass estimates of each resource. Three species, northern anchovy, jack mackerel and market squid, are monitored only; no current biomass estimates are made. CPS finfish landed by the roundhaul fleet (fishing primarily with purse seine or lampara nets) are sold as relatively high volume, low value products (e.g., Pacific mackerel canned for pet food, Pacific sardine frozen and shipped to Australia to feed penned tuna, and Northern anchovy reduced to meal and oil). Other vessels target CPS finfish in small quantities, typically selling their landings to specialty markets for relatively high prices. These include live bait vessels in California, Oregon and Washington; roundhaul vessels that take Northern anchovy which are sold as dead bait to recreational anglers; and roundhaul and other mostly small vessels that target CPS finfish (particularly Pacific mackerel and Pacific sardine) for sale in local fresh fish markets or canneries. In addition to fishing for CPS, some vessels also fish for Pacific bonito, bluefin tuna, and Pacific herring.

Market squid frequently ranks as California's largest fishery both by tonnage and value. Management authority for the fishery rests with the State and a Market Squid Fishery Management Plan is currently under development by the State. Among the goals of the plan are to ensure proper utilization and the avoidance of bycatch in the market squid fishery as well as wastage of market squid in other fisheries.

California and Oregon Drift Gillnet Fishery

The California and Oregon Drift Gillnet (DGN) fishery targets swordfish and thresher shark. The fishery developed off southern California in the late 1970s as a shark fishery and expanded with the increased catch of swordfish. The fishery is regulated by the State of California under a limited entry system. It was classified by

NMFS as a Category I fishery under the MMPA as a result of interactions with marine mammals, some of which are listed under the ESA, and became the subject of a Take Reduction Plan in 1997. In 2000, NMFS, determined that the fishery was likely to jeopardize the continued existence of leatherback and loggerhead turtles in the Pacific. NMFS subsequently implemented fishery time-area closures under ESA regulations to reduce the takes of leatherback and loggerhead turtles. In 2003, NMFS re-classified this fishery as a Category II fishery based on reductions in takes of marine mammals.

Large Vessel Tuna Purse Seine Fishery

The eastern tropical Pacific (ETP) tuna fisheries, concentrated between 20° N and 20° S latitudes, are dominated by purse seiners targeting yellowfin and skipjack tuna; other gears include longline and pole-and-line. From 1970 to 1980, U.S. participation in the fishery expanded, but during the 1980s a progressive relocation of the U.S. fleet to the central western Pacific occurred. The purse-seine fishery operates year round, exhibiting little seasonality in catch. Large U.S. purse seine vessels (greater than 400 short tons carrying capacity) fish for tuna in the ETP under jurisdiction of the Inter-American Tropical Tuna Commission (IATTC) and are governed by the Agreement on the International Dolphin Conservation Program (AIDCP).

Proposed FMP for U.S. West Coast Fisheries for Highly Migratory Species

On June 18, 2003 the Pacific Fishery Management Council adopted a proposed Fishery Management Plan (FMP) for U.S. West Coast Fisheries for Highly Migratory Species. The proposed FMP covers a number of commercial and recreational fisheries for highly migratory species, including surface hook and line, drift gillnet, harpoon, pelagic longline, purse seine and recreational fisheries. The FMP was transmitted to NMFS on October 31, 2003, and NMFS is in the process of reviewing the plan to determine whether it is consistent with the requirements of the MSA, ESA, MMPA and other applicable law. A critical element of NMFS' review and approval of the proposed FMP will be a determination of whether it establishes a standardized reporting methodology to assess the amount and type of bycatch occurring in each fishery; and whether the conservation and management measures minimize bycatch, and, to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. An ESA section 7 consultation on the effects of implementing the plan on listed species, such as sea turtles and albatross, is part of the review process.

The proposed FMP authorizes NMFS to require that vessels carry observers, and requires observer programs initially for the longline, surface hook-and-line, small purse seine, and commercial passenger fishing vessel fisheries. Initial observer sampling plans for these fisheries are to be completed by NMFS within 60 days of FMP implementation. The SWR, in co-ordination with F/ST-NOP, has identified the following amounts for FY04 observer coverage of three west coast HMS fisheries: California-based pelagic longline ($200,000); small purse seine targeting tunas and selected CPS ($75,000); and the hook-and-line albacore fishery ($100,000).

III. CRITERIA FOR IDENTIFYING VULNERABILITY OF DISCARD SPECIES TO ADVERSE IMPACTS

1. Quantitative assessment of bycatch mortality on the incidentally caught species Assessing the impact of fishing on species that are subject to bycatch or non-landed mortality, as a result of being discarded for regulatory or economic reasons, is in principle no different than assessing the affects of fishing on the target species. If sufficient information is available on fecundity, growth, age-specific rates of natural mortality, and mortality rates associated with discard in the fishery, an estimate of the mortality rate associated with

maximum sustained yield can be made and compared with that resulting from bycatch mortality. For many discarded species, however, such data are not available. In some cases there are insufficient data even to evaluate trends in abundance.

2. Status of the incidentally caught species In the absence of data that allow direct assessment of the effects of bycatch mortality on the reproductive potential of a population, other criteria must be used to determine the severity of the impacts on discarded species. If the species subject to discard mortality are classified as overfished under MSA, or listed as threatened or endangered under the ESA, or enjoys special protections under other statues, such as the MMPA or MBTA, then efforts to reduce bycatch mortality should receive a high priority.

3. High incidence of bycatch in a fishery Species that occur as bycatch as a large proportion of the catch in a fishery may be a management concern depending on the mortality rates associated with bycatch and the status of the incidentally caught species.

IV. Species of Concern in Southwest Regional Fisheries

The following marine resources have been identified as vulnerable as a result of their status or potentially vulnerable due to high rates of bycatch.

Sea Turtles All sea turtles that occur in U.S. Pacific waters are listed as either endangered or threatened under the ESA, and, with the exceptions of olive ridleys and Hawaiian green turtles, are in decline. Sea turtles are taken as bycatch in the large vessel tuna purse seine fishery and the DGN fishery. While the numbers of turtles that are taken in these fisheries are small, the precarious status of the populations, in particular leatherback and loggerhead turtles, makes the populations sensitive even to the small numbers of takes associated with Southwest Regional fisheries. These species have continued to decline in the Pacific basin; both populations have decreased by an order of magnitude over the last two decades. Thus, any fishery-associated mortality, no matter how low, will have negative impacts on the populations. Mitigation measures have been specified for sea turtles in the DGN fishery and the high seas pelagic longline fishery in the West Coast HMS FMP, now under NMFS review.

Dolphins, Whales and Other Marine Mammals Several species of dolphins are taken as bycatch in the large vessel tuna purse seine fishery, three of which are recognized as depleted under the MMPA: the northeastern offshore spotted dolphin, eastern spinner dolphin and the coastal spotted dolphin. The biological status of the coastal spotted dolphin is unclear and information to re-evaluate this stock is limited. The currently depleted populations of both northeastern offshore spotted dolphins and eastern spinner dolphins are not increasing at the rate expected based on the low rate of reported mortalities from the fishery since 1991. The DGN fishery takes Pacific white-sided dolphin, Risso’s dolphin, long-beaked and short-beaked common dolphin, and northern right-whale dolphin, and has a history of interactions with fin whales, sperm whales, gray whales, and short-finned pilot whales.

Salmon Sixteen populations of west coast salmon are listed as threatened or endangered under the ESA. Many other populations, particularly those supported by hatchery production, are abundant and support substantial directed salmon fisheries, which are regulated to protect listed stocks. When the Coastal Pelagic Fishery for sardine began to develop off Oregon and Washington, concern was expressed regarding the potential bycatch of salmon, especially in the fishery just off the mouth of the Columbia River. Pilot observer programs were initiated by the States of Washington and Oregon to document the level of salmon bycatch in their sardine fisheries.

Groundfish Nine groundfish species have been declared overfished by NMFS: bocaccio, canary rockfish, cowcod, darkblotched rockfish, lingcod, Pacific ocean perch, Pacific whiting, and yelloweye rockfish. Rockfish have been reported as bycatch in CPS fisheries and the DGN fishery.

Seabirds Seabirds occasionally interact with, and are taken by, the DGN and large vessel purse seine fisheries. No mitigation measures are presently in place for SWR fisheries, but have been specified for the high seas pelagic longline fishery in the West Coast HMS FMP, now under NMFS review.

Molas Common mola is the finfish most frequently discarded in the DGN fishery. In the calendar year 2001 fishery, 2,525 molas were observed discarded and 2,618 fish retained including 393 swordfish, 363 thresher shark and 1,279 tunas. Twenty-one percent of the 2001 effort was observed. The effect of these captures on the mola population is unknown; over 95% of molas observed captured in the DGN fishery are returned to the ocean alive. However additional research on the effects of capture on individuals and the population is appropriate given the apparently high rates of interaction with the fishery.

Blue and shortfin mako shark Blue shark is the second most common fin fish discarded in the DGN fishery. Unlike molas, most blue sharks are returned to the ocean dead. Relative abundance trends for common thresher, shortfin mako and blue shark in the DGN fishery have been investigated using data from fisher bridge logs, onboard observer records, and an NMFS fishery-independent relative abundance survey. Preliminary results indicate that local thresher shark stocks may be rebuilding after being overfished during the 1980s. Trends in relative abundance of shortfin mako and blue sharks show a slightly decreasing trend in abundance along with decreased fish size in the catch over the same period but the extent to which this has been influenced by shifts in environmental conditions and fish distributions is not known.

Invertebrates Large numbers of small pelagic invertebrates, such as salps, are captured and discarded by the DGN fishery. For example observer records suggest that during the 2001 fishery, as many as 100,000 pelagic tunicates were entangled. The effects of these removals, either on the invertebrate populations or on species which feed on gelatinous macro- plankton, such as sea turtles, is unknown.

V. IDENTIFICATION OF BYCATCH PROBLEMS

Coastal Pelagic Species

CPS vessels fish with encircling nets, targeting a specific school and the most common incidental catch in the CPS fishery is another CPS species. Few measures have been proposed to minimize bycatch (e.g. the use of grates to cover openings of holds through which fish are pumped). In California, limited amounts of information are available from at-sea observations. The bulk of bycatch data is derived from port sampling and suggests a very low incidence of bycatch (PFMC, 2003). When the sardine fishery was initiated off Washington and Oregon, the states implemented observer programs specifically to assess bycatch. The precision and accuracy of these data have not been assessed; however the reported levels of bycatch support the view that bycatch of vulnerable species is not significant. For example, the bycatch of salmon observed in the

Washington and Oregon sardine fishery in 2002 amounted to 1,800 fish, an insignificant amount compared to the landed catch of chinook and coho in the 2002 ocean salmon fisheries, which exceeded 400,000 fish off Washington and Oregon.

California and Oregon Drift Gillnet Fishery

Gillnets are efficient, non-selective gear and the bycatch of non-target species such as common mola, blue shark, skipjack tuna and mackerel in the DGN fishery is high. Between 1997 and 2001 observed landings of 5,300 swordfish were accompanied by the discard of 31,700 fish (excluding invertebrates), including 14,700 mola, 9,200 blue shark, 2,100 skipjack tuna, and 1,600 albacore tuna. Ninety-five percent of the molas were released alive and the majority of the tuna that was caught was landed. The fishery also takes marine mammals and sea turtles. Since 1980, with the exception of a few years, either the California Department of Fish and Game or NMFS have conducted an observer program to collect data on the bycatch of protected species. The DGN fishery is subject to the Pacific Offshore Cetacean Take Reduction Plan, implemented in 1997 to address incidental takes of beaked whales, pilot whales, pygmy sperm whales, sperm whales, and humpback whales. The Take Reduction Plan, which required the use of pingers, 36 feet net extenders, and mandatory skipper education workshops, reduced marine mammal entanglements by an order of magnitude in its first two years of implementation. The DGN fishery also takes Pacific white-sided dolphin, Risso's dolphin long-beaked and short-beaked common dolphin, and northern right-whale dolphin. The mortality rates of these species is less than 5% of the Potential Biological Removal (PBR) level, with the exception of northern right-whale dolphin, fin whales, and sperm whales for which the average mortality rates from 1998 to 2002 were 12%, 17.6% and 55.6% of PBRs, respectively.

In 2000, NMFS determined that the DGN fishery, operating under the Take Reduction Plan, will have a negligible impact on listed marine mammals. Takes of marine mammals in the DGN fishery have declined since implementation of the Take Reduction Plan, and as a result, in 2003, NMFS recategorized the DGN fishery from Category I to Category II on the MMPA List of Fisheries. The short-term goal of the Take Reduction Plan, to reduce mortality and serious injury of marine mammals to less than their PBR level, has been met for this fishery. NMFS is in the process of promulgating regulations that will provide guidelines about how to evaluate whether the long-term goal of a Take Reduction Plan, referred to as the Zero Mortality Rate Goal, has been met. Whether or not this fishery has met the goal will be assessed after a final decision is made.

In 2000, NMFS conducted an ESA section 7 consultation of the DGN fishery and evaluated the incidental take of listed sea turtles and marine mammals by the fishery. The opinion found that the operation of the fishery was likely to jeopardize the existence of leatherback and loggerhead sea turtle populations, and specified reasonable and prudent alternatives (RPAs) under which the fishery could operate. To comply with the RPAs, NMFS implemented time-area closures under the ESA for both species. To protect leatherback turtles, NMFS prohibited fishing with drift gillnets from August 15 through November 15 in U.S. waters in Monterey Bay, California and vicinity, north to the 45˚ N lat. intersection of the Oregon coast. To protect loggerhead turtles, NMFS prohibited fishing with drift gillnets from August 15-31 and January 1-31 in U.S. waters off southern California, south of Point Conception and west to the 120˚ W long., when the Assistant Administrator for Fisheries publishes a notice that El Niño conditions exist. NMFS is in the process of publishing a final rule that would change the loggerhead closure period from August 15-31 and January 1-31 to the months of June, July, and August during El Niño years. The take rates of leatherback turtles in the DGN fishery have been reduced, at least in part, due to the time-area closure. There has not been an El Niño year closure since implementation of the loggerhead closure, so no data are currently available to evaluate whether that closure is effective at reducing loggerhead takes.

The bycatch of seabirds is well documented for the DGN fishery. Management measures in effect for the DGN fishery greatly reduce the likelihood of interactions with albatross, pelicans or other sea birds.

Large Vessel Tuna Purse Seine Fishery

The U.S. policy regarding the bycatch of marine mammals was in large part defined by the purse seine fishery for tuna in the ETP. In the 1960s the practice of setting nets around dolphins to harvest tuna swimming below was developed in the ETP. From 1970 to 1980 the purse seine fishery expanded, dominated by the United States. Annual dolphin mortality was listed at over 350,000. In 1972, Congress ratified the MMPA, primarily due to the public reaction to the high levels of dolphin mortality associated with the ETP tuna fishery. During the 1980s, a progressive relocation of the U.S. fleet to the Central Western Pacific occurred. In 1980, the U.S. fleet consisted of 126 seiners, 25 bait boats and 4 jig boats with a combined capacity of 118,000 mt. By 1994, only 4 U.S. flag seiners were active in the ETP with a combined carrying capacity of less than 6,000 mt.

Mexico and Ecuador are now the dominant participants in the fishery. A small number of large U.S. purse seine vessels continues to fish the ETP. Since 1998, U.S. flag vessels have accounted for less than 4% of the catch of tunas. In 2001, 5 large U.S. tuna purse seine vessels participated in the fishery out of a total of 140 vessels. The IATTC reports annual estimates of fin fish and dolphin mortality by species and stock, as well as standard errors associated with the estimates for all vessel classes. No U.S. vessels currently fish on dolphins. All large U.S. vessels carry observers while fishing and the accuracy and precision of bycatch estimates is accordingly high. Since 1986, the total mortality of dolphins in the large vessel tuna purse seine fishery has been reduced 98% from about 132,000 in 1986 to less than 2,000 in 2000. The U.S. fleet accounts for less than 4% of the current total effort in the fishery.

While U.S. participation in the fishery has declined significantly, the bycatch of dolphins in the ETP tuna fishery remains a controversial issue (e.g. the recent redefinition of the “Dolphin Safe” designation). NMFS continues its efforts, through its support of the IATTC and international agreements, to reduce bycatch by U.S. and foreign flag vessels.

Bycatch of sea turtles has been documented in the ETP large vessel purse seine fishery (NMFS 1999). NMFS has promulgated regulations dealing with bycatch reduction in the purse seine fisheries and conducted a Section 7 consultation on the regulations. They included provisions requiring immediate release of sea turtles entangled in purse seine gear and special handling and release techniques for sea turtles that are brought on board injured or comatose.

The IATTC defines bycatch as fish other than commercially-important tunas, which are discarded dead at sea while “discards” are defined as commercially important tunas which are discarded dead at sea. The discard rate of juvenile tuna has increased in the ETP fishery as a result of a shift in fishing strategies from dolphin sets to log and school fishing. The vast majority of bycatch and discards comes from sets on floating objects. The AIDCP identifies avoiding the bycatch and discard of juvenile tuna as a goal in ensuring the long-term sustainability of tuna stocks. In 2001, IATTC member nations initiated a full catch retention program to require all large purse-seine vessels to first retain on board and then land all bigeye, skipjack, and yellowfin tuna caught, except fish considered unfit for human consumption for reasons other than size. The full catch retention program is intended to better document bycatch and act as an incentive for large vessels to avoid bycatch because of the economic penalty associated with having to land fish of little value. At the IATTC Working Group on Bycatch meeting in June 2002, there was a report that incomplete logbook reporting and dumping of fish, in spite of the resolution, were jeopardizing the program. The IATTC resolved in 2003 to continue with efforts to improve compliance and effectiveness in 2003 and 2004.

Parties to the IATTC have acknowledged that the current level of fishing capacity of 219,000 m^3 is in excess of the optimal level required to efficiently harvest tuna in the ETP, and have agreed to develop and implement a plan to achieve a target level of 158,000 m^3 of fishing capacity. If capacity reduction were realized and also resulted in reductions in fishing effort, associated bycatch levels would also be reduced.

VI. STRATEGIES FOR REDUCING IMPACTS

This section considers possible new bycatch management measures that should be considered on a fishery-by-fishery basis, including consideration of international and enforcement issues as necessary.

Coastal Pelagic Fishery

Amendment 9 of the CPS Fishery Management Plan recommended evaluation of the use of grates to cover openings of holds through which fish are pumped to allow release of larger fish. Oregon requires that a grate must be in place to sort out larger fish. The use of grates should also be evaluated for use in California and Washington and required if demonstrated to reduce the mortality resulting from bycatch. The cost of grates is minimal, approximately $100 per unit.

Drift Gillnet Fishery

NMFS has required a variety of modifications in the DGN fishery to reduce the bycatch rates of marine mammals, including the use of pingers, 36 feet net extenders, and mandatory skipper education workshops. In addition, NMFS has implemented significant time-area closures to reduce the bycatch of sea turtles. NMFS has determined that bycatch associated with the DGN fishery is consistent with the requirements of the ESA and MMPA. Gear modification measures were put in place as part of NMFS Take Reduction Team recommendations to reduce the take of marine mammals. Mesh sizes greater than 14 inches, 36 foot suspenders to sink the net, and pingers to drive off animals have shown good results in reducing the take of marine mammals. The gear modifications have also reduced the bycatch (discarded dead) of striped marlin, skipjack tuna, blue shark and common mola. However, they have increased the bycatch (discarded dead) of albacore. Tests for the statistical significance of these differences have not been conducted. Time/area closures have been developed for the DGN fishery by the states to protect juvenile and adult sharks, thus reducing the bycatch of these species by reducing economic discards. Time/area closures also exist to protect sea turtles and since the closures reduce effort, they tend to reduce the overall bycatch of other fish. Under state law in California, nets can only be set 2 hours before sunset and must be out of the water two hours after sunrise, to reduce the discard of striped marlin, which cannot be landed commercially.

Large Vessel Tuna Purse Seine Fishery in the Eastern Tropical Pacific

No new management measures or gear modification have been identified that would further reduce bycatch of juvenile tunas or protected species by large U.S. vessels fishing in the ETP purse seine tuna fishery. NMFS should continue its efforts, through its support of the IATTC and international agreements, to reduce the bycatch of protected species and juvenile tunas by U.S. and foreign flag vessels (see recommendations for research). NMFS should continue implementing the requirements of the 1999 biological opinion on the fishery as regulated by the MMPA.

VII. STANDARDIZATION AND ENHANCEMENT OF BYCATCH REPORTING METHODOLOGIES

Coastal Pelagic Species

In 1999, Amendment 8 to the Northern Anchovy Fishery Management Plan was partially approved by the Secretary of Commerce. The portions of Amendment 8 approved by the Secretary added four species to the plan, implemented limited entry to prevent overcapitalization, and changed the name of the plan to the Coastal Pelagic Species Fishery Management Plan. Other provisions were not approved, in part because they did not conform to National Standard 9 of the MSA. Specifically, Amendment 8 did not contain a standardized reporting methodology to assess the amount and type of bycatch in the CPS fishery and did not explain whether additional management measures to minimize bycatch and the mortality of unavoidable bycatch were practicable. Amendment 9 to the FMP was developed in response to NMFS' partial disapproval of Amendment 8.

Amendment 9 addressed NMFS' partial disapproval by recommending 1) that state agencies, federal agencies, and tribes develop an observer program for new fisheries for CPS north of Pigeon Point, California; 2) that state agencies, federal agencies, and tribes develop programs to monitor and record CPS bycatch at the docks; 3) evaluation of the use of grates to cover openings of holds through which fish are pumped to allow release of larger fish; and 4) that federal regulations implementing the FMP include authorization for placing observers on CPS fishing vessels. The first two recommendations described efforts already undertaken by state agencies.

Amendment 9 did not specify a standardized reporting methodology to assess the amount and type of bycatch in the CPS fishery. Rather, it recommended that state, federal, and tribal agencies develop programs (including at-sea observation) for monitoring and recording bycatch, and it summarized the state's approaches for monitoring bycatch and require that bycatch data derived from these efforts be reported in the annual Stock Assessment and Evaluation Report. NMFS approved Amendment 9 and implemented regulations providing NMFS with the authority to place NMFS certified observers aboard fishing vessels operating in the coastal pelagic species fishery in circumstances where other data collection methods were deemed insufficient for management of the fishery. Beginning in 2000, Oregon and Washington implemented observer programs for their emerging sardine fisheries. California has continued its port sampling program that assesses bycatch in CPS fisheries and requires logbooks for the squid fishery, but not for other CPS fisheries.

The available information on bycatch in the CPS fisheries, including observer and port sampling data, does not indicate that bycatch is a significant problem. Reported bycatch consists primarily of other CPS species (much of which is landed), salmon off Washington and Oregon but at very low levels relative to the catch in salmon fisheries, and small numbers of barracuda, herring, blue shark, and thresher shark. By catch for the fishery is reported annually in the Stock Assessment and Evaluation Report, but reporting methodologies are not standardized among the three state agencies. This is not unexpected since the sardine fisheries off Washington and Oregon have only emerged in the past few years. In California, the port sampling program records observed bycatch as presence/absence evaluations; the actual amounts of bycatch are not quantified. Additional at-sea-observer data for California fisheries would be useful in quantifying and characterizing bycatch that may not be identified in the port sampling process, particularly in sectors of the fishery where sorting can occur at sea.

Recommendations: The CPS FMP should be amended to explicitly establish a standardized reporting methodology to assess the amount and type of bycatch occurring in all sectors of the fishery. The standardized methodology established by the FMP should be capable of reporting the precision and accuracy of bycatch estimates. A pilot at-sea-observer program in California to supplement and confirm the bycatch assessments derived from dock-side sampling conducted by the State of California should be a component of a standardized reporting methodology.

California/Oregon Drift Gillnet Fishery

The categorization of the DGN fishery under the MMPA provides NMFS with the authority to require participants to carry observers. The fishery was observed at relatively low rates, beginning in 1990. The 1997 Take Reduction Plan recommended an observer coverage rate of 20%, and since 1999, the fishery has been observed at a 20% rate or more, providing reliable estimates of bycatch of all vertebrate species. Reports of estimated marine mammal and sea turtle bycatch in this fishery are prepared annually by the Southwest Fisheries Science Center and reviewed by the Pacific Scientific Review Group, an external scientific peer-review panel convened in accordance with Section 117 of the MMPA. The reports currently contain estimates of precision associated with the estimates of marine mammal takes, but not for turtles or fish species. The Southwest Region produces annual summaries of observer data detailing landed and discarded catch in the fishery and makes them available on the internet. Protected Resources provides base marine mammal funding of $410,000 annually for observing the fishery.

The drift gillnet fishery for swordfish and sharks is one of the fisheries covered by the proposed FMP for West Coast Highly Migratory Species. In reviewing the proposed FMP, NMFS will determine the adequacy of the standardized reporting methodology to assess the amount and type of bycatch contained in the proposed FMP.

With the exception of green turtles and olive ridley turtles, sea turtle populations in the Pacific show no signs of recovering. NMFS should make every effort to ensure that the protective measures the agency requires are supported by the best information available. While the bycatch of species which are neither protected or commercially valuable is relatively high in the DGN fishery (e.g. common mola and blue shark) there is no evidence that the levels of bycatch are having a substantial negative effect on the populations. Estimates of precision are not available for measures of finfish and sea turtle bycatch in the fishery.

Recommendations: The Reasonable and Prudent Alternative of the current NMFS Biological Opinion on the DGN fishery should continue to be implemented, as well as the 1997 Take Reduction Plan. Observer coverage should be maintained at 20%. The SWFSC should prepare reports which include estimates of the total bycatch of finfish in the DGN fishery, as well as estimates of precision associated with measures of sea turtle and finfish bycatch. The preferred alternative for DGN management measures proposed in the HMS FMP should be implemented. Specifically, close all EEZ waters off Washington to drift gillnet fishers to protect the common thresher shark, sea turtles and marine mammals. Fishing is currently allowed in waters off the Columbia River, if fish are landed in Oregon or California. Establish an inshore boundary offshore Oregon, defined by a series of waypoints (rather than the 100 fm curve or a mileage offshore as is currently used off Oregon), inshore of which, swordfish gillnetting would not be allowed, to reduce the take of reproductively valuable thresher sharks and other bycatch species. It is estimated that implementation of this action would reduce the take of thresher sharks in the DGN fishery off Oregon by 84%.

Large Vessel Tuna Purse Seine Fishery in the Eastern Tropical Pacific

A small number (5 in 2001) of large U.S. purse seine vessels continues to fish the ETP under jurisdiction of international agreements (IATTC and AIDCP). Since 1998, U.S. flag vessels have accounted for less than 4% of the catch of tunas by the fishery and no U.S. vessels currently fish on dolphins. The IATTC reports annual estimates of fin fish and dolphin mortality by species and stock, as well as standard errors associated with the estimates for all vessel classes. Bycatch associated with the operation of U.S. vessels is not reported independently; that data is presumably available on request form the IATTC. Because observer coverage of U.S. vessels is 100%, the accuracy and precision of bycatch estimates is high.

Recommendation: NMFS should continue its efforts, through its support of the IATTC and international agreements, to ensure that bycatch by U.S. and foreign flag vessels is accurately reported. NMFS should obtain and evaluate annual summaries of bycatch associated with U.S. vessels.

VIII. CURRENT BYCATCH RELATED RESEARCH

Efforts to Reduce Sea Turtle - Fishery Interactions

1. Between 2002 and 2003, SWFSC deployed 8 satellite transmitters on loggerhead turtles along the Pacific coast of the Baja California Peninsula. Understanding movements of loggerhead turtles near Baja will help determine their normal movement and habitat use patterns as well as those during anomalous SST conditions such as El Niño.

2. SWFSC has deployed SDR transmitters (location via satellite, dive depth, time at depth) on a total of 8 loggerhead turtles captured in the California-based longline fishery. These deployments will shed light on post-hooking mortality rates and identify patterns of movement subsequent to hooking.

3. SWFSC is currently satellite tracking 3 loggerhead turtles that were released off the coast of Peru in 2003. In addition to location, satellite tags were equipped with a depth monitor to collect information on dive depth and dive duration. Elucidating the dive patterns of loggerhead in more southern portions of the Eastern Pacific will contribute to our overall understanding of their dive patterns throughout the Pacific.

4. Between 2000 and 2003 SWFSC has had an ongoing leatherback research program designed to monitory leatherback movements and dive behavior via satellite telemetry. To date, 18 transmitters have been deployed on leatherbacks in Monterey Bay, California, and 30 deployed on leatherbacks at their nesting beaches located in the Western Pacific (Papua and Papua New Guinea).

5. Since 2002, SWFSC has worked closely with the Chilean government on a study investigating the effect of hook type on sea turtle bycatch rates (a study modeled after the circle hook experiment in the Northeast Distant Waters area, a statistical reporting zone in the Western Atlantic Ocean). SWFSC has provided funding and assistance with experimental design. We anticipate this research effort will continue through the 2004 longline season in Chile.

6. A study by NOAA / JIMAR researchers investigating sea turtle hearing has been ongoing at the Honolulu Laboratory since 2000. Preliminary results of this research indicate that green turtles have a very narrow hearing range (100-200Hz) that does not allow them to sense the sound emissions from pingers currently used on driftnets. Although these data are for green turtles, it is likely that similar narrow hearing ranges are possessed by loggerhead turtles as well as leatherback turtles.

7. Research defining core nursery areas for the common thresher shark, to avoid bycatch of juveniles, which are not in market demand because of their small size, in commercial fisheries. Also need to identify pupping and core nursery areas of thresher and mako sharks. Areas where pregnant females and newborns congregate may be vulnerable to fishing.

8. Telemetry studies of pelagic sharks to determine migratory routes, within-region habitat use, and vertical day-night swimming behavior for use in developing bycatch avoidance techniques.

9. Telemetry and archival studies of *Mola mola* utilizing temperature and depth-sensing acoustic transmitters to characterize diel patterns of movement, diving behavior and environmental and oceanographic preferences of this species (non-NOAA research). Such studies may be useful in devising measures to reduce bycatch of the ocean sunfish in drift gillnets.

IX. FUTURE RESEARCH RECOMMENDATIONS

1. Determine the effects of removals by U.S. fishing vessels of adult and sub-adult leatherback and loggerhead turtles on the reproductive capacity of the respective populations in the Pacific Ocean.

2. Explore whether there are frequencies or ranges of frequencies that are more effective in deterring marine mammal entanglement than that currently used in pingers. If so, the next step would be to encourage the incorporation of this acoustic characteristic into pingers that are purchased by the fleet as replacements for their current pingers.

3. Study post-hooking and post-entanglement mortality rates in loggerhead and leatherback turtles that were incidentally captured in longline and driftnet fisheries. This information can help determine acceptable turtle-fisheries interaction rates, and reveal spatial and temporal variation in survivorship among turtles.

4. Establish the degree of fisheries-related sea turtle mortality in coastal marine habitats of Latin and South America

5. Explore options for providing NMFS Enforcement with the means for unobtrusive monitoring of pinger compliance at sea e.g. hydrophones.

6. Characterize the migratory pathways of leatherback and loggerhead turtles in the Pacific Ocean, especially during El Niño years. Determination of these pathways could identify important opportunities for avoiding fishery interactions.

7. Determine the effects of mitigation measures, such as funding and support of conservation, education, and protection programs aimed at protecting nesting females, their eggs, and nesting beach habitat, relative to the effects of fishery removals of adults and sub-adults.

8. Continue research on the effects of purse seine encirclement on dolphin populations in the ETP.

9. Determine the effects of removals by U.S. fishing operations on Pacific populations of blue and short fin mako shark.

10. Determine post release mortality rates associated with gill net capture and the effects on west coast mola populations.

11. Develop technology, such as sorting grids, for releasing juvenile tunas in the purse seine fishery. Develop technologies and assess feasibility for the identification of species and size composition in schools of tuna prior to setting.

12. Conduct quantification and trend studies of finfish bycatch in the DGN fishery. Characterize size composition of fish bycatch species in DGN fishery; currently lengths are not taken of many species.

13. Review the efficiency of DGN sampling rate (observer coverage) for estimating DGN finfish and other non-turtle and marine mammal bycatch to determine whether enough samples being collected given the variability.

14. Characterize habitat and spatial and temporal dynamics of different life stages of various bycatch species, so avoidance techniques or possible area closures could be developed

15. Conduct a feasibility study on implementing Performance Standards. This system would reward fishers for decreasing their bycatch and/or bycatch mortality. Under a program using performance standards, goals could be set to reduce bycatch, (as an example 10% of the current bycatch of a particular species) and fishers who meet the goal would be rewarded with some incentive (an example might be additional time on the water). The same could apply for a reduction in bycatch mortality. Under such a program, incentives could be offered for both reducing bycatch and bycatch mortality. The system would require extensive study before being applied. The objectives and rewards for achieving goals would need to be identified, rules would have to be implemented by the Council, and observers would need to be employed to evaluate the success of the program as logbooks would not provide reliable data.

16. Conduct temporal and spatial gear restriction studies. Research into how the variables of setting time of day, area, or depth of gear affects various bycatch species, for use in development of bycatch avoidance techniques. Restricting the time that gear might be in the water could be used to prevent bycatch of many species.

17. In addition to conducting studies of the socio economic effects of effort reduction programs, the effects on bycatch should also be considered. Restricting effort in the fishery by its very nature serves to reduce overall bycatch. Effort reduction through limited entry and permit reduction already exist at the state level for the swordfish-shark DGN fishery. California and Oregon limit the number of permits. California also has a program to reduce permits through attrition. The Pacific Council is currently examining limited entry options for the California-based high seas longline fishery, which will soon come under federal/Council jurisdiction.

XVIII. EDUCATION AND OUTREACH EFFORTS

Current Efforts The SWR takes advantage of a variety of communication resources to inform and educate the public on fishery issues. The goal of the public outreach program in the SWR is to promote public acceptance of decisions made or supported by NOAA. Much of the effort of our Public Affairs Officer, Web Page Administrator and Public Outreach Committee is directed towards building our capacity to advance science and environmental literacy in partnership with public and private organizations. Current and past education and outreach activity by the SWR specifically directed at reducing bycatch include the following:

Drift Gillnet Fishery

The Pacific Offshore Cetacean Take Reduction Team meets annually to evaluate the effectiveness of marine mammal take reduction measures such as net depth requirements, pingers, issuance of new DGN permits, and skipper workshops. The Team makes annual recommendations to SWR regarding necessary changes to existing take reduction measures and additional management measures and research needs. Industry feedback on existing management measures is solicited through representatives on the Team and through skipper workshops. Since 1997, the Southwest Region has hosted 33 skipper workshops. The SWR website provides summaries of the annual total catch and final disposition, by species, of all fish, marine mammals, sea turtles, and seabirds observed caught in the DGN fishery since 1990.

Large Scale Tuna Purse Seine Fishery

The SWR works closely with industry and non-governmental organizations in the implementation of management measures for the large tuna purse seine fishery and is in regular communication these groups regarding bycatch issues. The SWR also discusses bycatch and other issues directly with fishermen at skipper workshops.

SWFSC Outreach Activities

SWFSC personnel have been involved with outreach through capacity building efforts outside of the United States at both the governmental and non-governmental organization level. A summary of the outreach activities undertaken in 2003 follows.

In January 2003, researchers worked with a Guatemalan non-governmental organization to develop a long-term study investigating the foraging ecology, population abundance, and habitat use of green turtles (*Chelonia mydas*) in coastal waters of Guatemala.

In February 2003, SWFSC worked with the Charles Darwin Research Station in the Galapagos Islands, Ecuador to develop a research program designed to study foraging behavior and population ecology of sea turtles in nearshore waters, and determine the post-nesting migratory pathways of green turtles as they depart this archipelago. This information will lead to a better understanding of the susceptibility of this population to interactions with pelagic fisheries.

In June 2003, SWFSC participated in a capacity building exercise with community leaders in Sonora, Mexico to develop a sea turtle monitoring program in the eastern Gulf of California, Mexico.

In September 2003, SWFSC partnered with the Peruvian Government to conduct observer training workshops at the port cities of Ilo, Moro Sama, and Lima. The particular fisheries targeted in this educational program included artisanal longline and driftnet fisheries as well as industrial purse seine fishery. A subsequent visit by SWFSC staff to Peru is planned for February 2005.

Currently SWFSC is drafting a formalized Letter of Agreement with the Instituto del Mar del Perú (Government fisheries agency) regarding marine turtles of the Pacific, and is also drafting a separate agreement with MINAE (Costa Rica's Minister of the Environment) regarding sea turtle nesting beach protection and fisheries bycatch reduction.

Recommendations for Future Education and Outreach Efforts Related to Reducing Bycatch

1. Increase efforts to educate the public about changes in the dolphin-safe designation for canned tuna, and NMFS' finding that the tuna purse seine industry practice of encircling dolphins to catch tuna has no significant adverse impact on dolphin populations in the ETP. The goal of the campaign would be 1) to improve public understanding of the multilateral tracking and verification system administered by NMFS to certify and verify tuna caught in the ETP consistent with the AIDCP and without mortality or serious injury to dolphins; and 2) promote public confidence that dolphins are being protected when Americans purchase tuna with the dolphin-safe label.

2. Support formation and activities of the newly proposed Scientific Advisory Board to the IATTC. The functions of the Board include modifying current purse-seine technology to make it less likely to cause dolphin mortality and seeking alternative means of capturing large yellowfin tuna. Other possible program of work for the Scientific Advisory Board proposed by IATTC are: the prevalence and significance of cow-calf separation; stress effects; review of currently available estimates of abundance for dolphin stocks; ecosystem effects; mortality estimates; life history studies; stock assessment of coastal spotted dolphins; population modeling; developments in gear technology and fishing techniques to improve dolphin release; capture of mature tunas not in association with dolphins; and any other research the Board believes is important to enhance the Agreement.

3. Continue skipper workshops for new entrants to the DGN fishery. Educational seminars should be developed that augment workshops to instruct fishers on how to further reduce certain finfish (non-protected species) bycatch or bycatch mortality. Currently the workshop focus is on avoiding interactions with marine mammals and sea turtles, although discussion of avoiding blue sharks does take place. Future workshops should be expanded to include more information on avoiding bycatch of various fishes and invertebrates and on decreasing bycatch mortality, if such information exists.

4. Continue skipper workshops for participants in the large vessel ETP purse seine fishery.

5. Develop and conduct skipper workshops as needed for west coast HMS fisheries; e.g. surface hook-and-line fishery and small purse seine fishery.

REFERENCES

National Marine Fisheries Service (NMFS). 1998. Managing the Nations Bycatch Progarms, Activities, and Recommendations for the National Marine Fisheries Service.

NMFS. 1999. NMFS Biological Opinion on the interim final rule for the continued authorization of the United States tuna purse seine fishery in the eastern tropical Pacific Ocean under the Marine Mammal Protection Act and the Tuna Conventions Act as revised by the International Dolphin Conservation Program Act. December 8, 1999.

NMFS. 2003. Evaluating Bycatch: a National Approach to Standardized Bycatch Monitoring Programs

Pacific Fishery Management Council (PFMC). 2003. Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Accepted Biological Catches Stock Assessment and Fishery Evaluation 2003.

Pacific Fishery Management Council (PFMC). 2003. Fishery Management Plan and Environmental Impact Statement for U.S. West Coast Fisheries for Highly Migratory Species.

NOAA Fisheries National Bycatch Strategy

Northwest and Southwest

Regional Bycatch Plans

Definition of Bycatch (NMFS 1998)

The discarded catch of any living marine resource

PLUS

retained incidental catch

AND

unobserved mortality due to a direct encounter with fishing gear

This definition includes marine mammals (**MMPA**), endangered species (**ESA**), seabirds (**MBTA**), and fisheries resources (**MSA**).

National Bycatch Goal:

"The fundamental national goal of NMFS bycatch-related activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided."

** From "Managing the Nation's Bycatch," NMFS 1998, derived from Magnuson-Stevens Act, National Standard 9.

“To the Extent Practicable” according to Congress

- Term recognizes that bycatch can occur in any fishery, and that complete avoidance of mortality is impossible.
- Councils should make reasonable efforts in their FMPs to prevent bycatch and minimize its mortality.
- National Standard 9 not intended to allocate catch between gear groups, nor to impose costs on fishermen and processors that cannot be reasonably met.

** From 9/17/96 *Congressional Record* on the Sustainable Fisheries Act.

National Bycatch Strategy Includes:

- Regional Bycatch Plans
- "Evaluating Bycatch: A National Approach to Standardized Bycatch Monitoring Programs"
- "NOAA Fisheries Objectives, Protocol, and Recommended Precision Goals for Standardized Bycatch Reporting Methodologies"

http://www.nmfs.noaa.gov/bycatch.htm for above documents and further information

Implementing the National Bycatch Strategy

- Assess progress toward meeting the National Bycatch Goal and regional bycatch recommendations from *"Managing the Nation's Bycatch"*
- Develop a national approach to a standardized bycatch reporting methodology
- Draft regional bycatch goal implementation plans
- Education and outreach to develop cooperative bycatch reduction efforts
- Reduce bycatch of internationally-managed species through existing multi-national partnerships
- Identify funding requirements to support the national bycatch strategy

Regional Bycatch Plans

Northwest

- Groundfish – Federally managed
- Salmon – Federally managed marine fisheries

Southwest

- Coastal Pelagic Species – Federally managed
- CA/OR drift gillnet fishery (ESA/MMPA)
- Tuna purse seine, eastern tropical Pacific (MMPA)

Northwest Regional Plan Addresses:

- Bycatch Reporting Methodologies: at-sea surveys, observer programs, pilot shoreside and electronic monitoring alternatives.
- Bycatch Research Needs: expanded monitoring programs, gear selectivity tests, seabird abundance, hooking mortality rates, expanded coded wire tag program

Northwest Regional Plan Addresses, II:

- Bycatch Management Measures:
  - Groundfish - finalize groundfish bycatch EIS, refine conservation areas, reduce capacity, update Biological Opinion on groundfish fisheries
  - Salmon - time/area closures, gear restrictions, review mooching and size limits
- Education and Outreach Efforts: websites, email lists, bycatch data reports, EFPs for gear research, SRPs/LOAs for bycatch mortality

Northwest Near-Term Bycatch Priorities:

- Monitoring: Integrate 2002-2003 WCGOP data into bycatch model; Convert at-sea whiting observer program from voluntary to mandatory
- Research: Technical workshop on coded wire tagging and mark selective fisheries; Expand groundfish observer coverage to open access fleet
- Management: Complete bycatch EIS; Incorporate non-trawl bycatch data into 2004 inseason management; Assess need for Biological Opinion update; Biological Assessment for short-tailed albatross
- Education/Outreach: Develop seabird interaction website; Work with PFMC on its communications plan

Southwest Regional Plan Addresses:

- Vulnerability of Discarded Species
  - Quantitative assessment of mortality rates
  - Status of the incidentally caught species
  - High incidence of bycatch in a fishery
- Species of Concern
  - Marine Mammals
  - Sea Turtles
  - Listed Salmon
  - Sunfish, Blue and Mako Sharks

Southwest Regional Plan Addresses:

- Identification of Bycatch Problems
  - Coastal Pelagic Species
    - Available data suggests low levels of bycatch
  - Drift Gillnet Fishery
    - Implementation of TRP and the requirements NMFS' biological opinions have substantially reduced the bycatch of sea turtles and marine mammals.

Southwest Near-Term Bycatch Priorities:

- Monitoring:
  - CPS FMP should establish a standardized reporting methodology, capable of reporting the precision and accuracy of estimates of bycatch occurring in all sectors of the fishery.
  - Pilot observer program in California to confirm dock-side evaluations of bycatch levels.

Southwest Near-Term Bycatch Priorities:

- Management:
  - With the implementation of the HMS FMP, the SWR must work with the Southwest Fisheries Science Center and states to develop sampling designs within 6 months for observer programs and other activities to ensure that bycatch estimates will be available with adequate precision and accuracy.
  - NMFS should continue to promote bycatch assessment and reduction through the IATTC and other international programs.

Southwest Near-Term Bycatch Priorities:

- Research:
  - Effects of US fishing in the Pacific on reproductive capacity of leatherback and loggerhead turtles.
  - Post-hooking and post-entanglement mortality rates of leatherback and loggerhead turtles.
  - Effects of US fishing in the Pacific on reproductive capacity of molas, blue, and shortfin mako sharks.
  - Evaluate use of grates to cover openings of holds in CPS fisheries

Next Steps

Science

- Increased NMFS investment in monitoring, gear research, bycatch mortality studies, etc.
- Completion of NMFS nation-wide review of statistical accuracy of sampling programs

Management

- Council feedback on and/or recommendations for NWR and SWR plans
- Council-NMFS dialogue on bringing plan recommendation into FMP implementation

Exhibit E.1.e
Public Comment
March 2004

West Coast Seafood Processors Association
1618 SW 1st Ave., Suite 318, Portland, OR 97201
503-227-5076 / 503-227-0237 (fax)
email: seafood@attglobal.net

Serving the shore based seafood processing industry in California, Oregon and Washington

January 26, 2004

RECEIVED
JAN 27 2004
PFMC

Mr. Don Hansen
Chairman
Pacific Fishery Management Council
7700 NE Ambassador Place
Suite 200
Portland, OR 97220-1384

Dear Don:

The following comments on behalf of the West Coast Seafood Processors Association (WCSPA) are in response to the Advanced Notice of Proposed Rulemaking regarding a Trawl Individual Quota Program and Control Date, published in the January 9, 2004, *Federal Register*. WCSPA members process the majority of the Pacific groundfish landed on-shore in Washington, Oregon and California and thus will be directly affected by any individual quota program.

The recommendation for a November 6, 2003, control date was made by the Pacific Fishery Management Council at its most recent meeting. However, the *Federal Register* notice does not accurately describe the Council's recommendation: the Council voted to establish the control date for all participants in the fishery, which includes processors. Inexplicably, the *Federal Register* notice limits the applicability of the control date to "vessel owners, permit owners, vessel operators, and crew." The applicability of the control rule needs to be expanded to include "owners or operators of processing facilities that engage in processing Pacific groundfish." This addition will more correctly reflect the recommendation agreed to by the Council and will ensure the same orderly process for determining how processing shares or permits are distributed when the Council decides to include them in the individual quota system.

Sincerely,

Rod Moore
Executive Director

Pacific Marine Conservation Council

© Ray Troll 2003

February 9, 2004

Don Hansen, Chairman
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, OR 97220-1384

Re: Advance notice of proposed rulemaking; notice of control date for the Pacific Coast groundfish fishery

Dear Mr. Hansen,

Thank you for the opportunity to comment on the establishment of a November 6, 2003, control date regarding the possible development of individual fishing quota (IFQ) systems in the groundfish fishery. Pacific Marine Conservation Council (PMCC) is very concerned about the possible adverse impacts to commercial and recreational fisheries from the institution of IFQs without adequate protective standards. PMCC is also apprehensive about that moving forward with a trawl IFQ, along the lines discussed by the Pacific Fishery Management Council's (Council) Ad Hoc Trawl IFQ Committee, could have negative consequences for the diversity and integrity of historic fishing communities.

- **Establishment of a control date should cover the entire groundfish fishery.**

It is understandable, and likely prudent, to establish a control date to avoid economic speculation, especially since the Council has encouraged some expectation through the actions of the Ad Hoc Trawl IFQ Committee. However, this should in no way imply an endorsement of any particular IFQ proposal. This control date should not even be limited to a gear endorsement, such as trawl, but should extend to the entire groundfish fishery. Limiting alternatives prior to any formal public scoping would be improper.

- **A comprehensive programmatic environment impact statement is required for the groundfish fishery.**

The Pacific Coast groundfish fishery has undergone several major changes during the past few years. The small footrope restriction was instituted in an attempt to reduce catch of overfished species on the continental shelf. Nine species of groundfish were declared overfished and plans for rebuilding these populations are, after fits and starts, in various stages of development. The Council has made unprecedented use of spatial management in closing large areas of the continental shelf to specific gear effort. And 92 limited entry trawl permits were recently removed from the fishery at a cost of $46 million.

These changes in themselves require a step back and complete analysis of their individual and cumulative impacts. Before taking the extreme step of serious consideration of IFQ systems, it is necessary to look at the fishery as a whole, in a comprehensive manner. Participants in all related recreational and commercial fisheries, and the public at large, deserve a clear exposition of alternatives for future management of the groundfish fishery. This compels a formal and open public process. Prior to any further Council efforts related to IFQs, the Council

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and NOAA Fisheries should complete an up-to-date comprehensive programmatic environmental impact statement.

- **Establishing an IFQ control date should not obviate the need to deal with latent trawl permits.**

Legislation authorizing the trawl permit buyback did not address the possibility of permits with little or no recent associated landings becoming available to increase fleet capacity. NOAA Fisheries and the Council should deal with these latent permits, and promulgate rules to limit the possibility of activation of these permits. Failure to take such action could undermine the effectiveness of the buyback.

It would be a mistake to assume that investment in latent permits will be discouraged simply because a control date is established, and calculation of catch history (in allocating quota) is thereby limited to the time before that date. There should be no assumption that catch history will drive initial allocation of quota, even if IFQs are established. Quota might be distributed equally by permit, by vessel length, by royalty auction, by community or through a number of mechanisms that would not depend primarily on catch history. To presume otherwise is to preordain parts of a National Environmental Policy Act process that has yet to commence.

- **A Council-sponsored and funded committee should include an adequate range of stakeholder representation.**

The Ad Hoc Trawl IFQ Committee presently includes no representatives of recreational fisheries, nor of the fixed gear or open access groundfish fleet. All these fisheries would be affected if a trawl IFQ was instituted, replacing 2-month cumulative trip limits and certain other status quo management measures. Local and period-specific bycatch issues might be significant, for example. In addition, this committee has no one representing the interests of fisheries such as salmon or Dungeness crab. The wealth generated through groundfish quota distribution could capitalize businesses to expand their efforts into other regional fisheries, perhaps resulting in new over-capacity problems. There is also only a single conservation seat on the committee, chosen I assume because of their organization's support for rights-based management.

While it remains PMCC's position that a programmatic EIS is essential prior to working out any IFQ system, if the Council wishes to have a committee discussing IFQs then representatives of affected fisheries, coastal communities, and conservation groups that urge caution in IFQ development should be present.

- **IFQ systems should conform to basic, reasonable standards.**

IFQs may play some role in future fisheries, but PMCC holds that any system developed must meet basic standards to protect fishing businesses, coastal communities, and the public interest. IFQs must not in any way be construed to be property rights; rather, they are fishing privileges to be granted for a duration not to exceed seven years. There must be strict limits on accumulation of quota shares and fair and equitable initial allocation of shares. There needs to be a mechanism for independent review of the systems. As an IFQ program is developed, management should seek to preserve the full range of historical participation in the fishery, rather than simply favoring the most efficient operations. In addition, fishermen participating in the groundfish fishery should have the opportunity to vote, by two-thirds margins, whether to develop or approve an IFQ system. Unfortunately, what we've seen from the Council's Ad Hoc Trawl IFQ Committee does not conform to most of these standards.

Thank you for considering our comments. If you have any questions please call me at (503) 440-3211.

Respectfully submitted,

Peter Huhtala
Senior Policy Director

Exhibit E.2
Situation Summary
March 2004

LINGCOD AND CABEZON STOCK ASSESSMENTS FOR 2005-2006

Situation: New stock assessments were prepared last year for lingcod coastwide and the portion of the cabezon stock occurring in waters off California. These assessments were considered by the Council in November 2003 for use during the 2005-2006 management period. However, the SSC did not recommend adoption of these assessments until models were revised with additional input data and modified assumptions. Specifically, the Scientific and Statistical Committee (SSC) took issue with the specifications for a parameter in the lingcod model that set recruitment variability and the lack of available 1947-1959 California commercial passenger fishing vessel (CPFV) logbook data in the cabezon model. The Council, therefore, postponed adoption of these assessments with the expectation they would be revised and reviewed by the SSC by the March 2004 Council meeting.

Both assessments have since been revised and reviewed by the SSC's Groundfish Subcommittee during a February 25 teleconference. The full SSC is scheduled to review these assessments in March and report to the Council under this agendum. The Council task is to consider approving these revised assessments after receiving the advice of the SSC and other advisory bodies. Once approved, these assessments will provide the basis for refining the range of harvest specifications analyzed and the preferred harvest specifications for these species. These decisions are scheduled for Council action in April.

The original assessments and Stock Assessment Review (STAR) Panel reports that were provided last November are included in electronic format on a CD. Additional material from the Stock Assessment Teams addressing the SSC's concerns are provided as attachments to this agendum.

Council Task:

1. Adopt new stock assessments for lingcod and cabezon.

Reference Materials:

1. Exhibit E.2.a, Attachment 1: CD copy of assessments and STAR Panel reports:
   - Assessment of Lingcod (*Ophiodon elongatus*) for the Pacific Fishery Management Council in 2003
   - Lingcod STAR Panel Meeting Report, September 2003
   - Status and Future Prospects for the Cabezon (*Scorpaenichthys marmoratus*) as Assessed in 2003
   - Cabezon STAR Panel Meeting Report, September 2003
2. Exhibit E.2.a, Attachment 2: Addendum to “Assessment of Lingcod (*Ophiodon elongatus*) for the Pacific Fishery Management Council in 2003."
3. Exhibit E.2.a, Attachment 3: Cabezon Addendum - “SSC Requests from the November PFMC Meeting.”

Agenda Order:

a. Agendum Overview — John DeVore
b. Reports and Comments of Advisory Bodies
c. Public Comment
d. **Council Action:** Approve Stock Assessments

PFMC
02/24/04

Assessment of Lingcod
(*Ophiodon elongatus*)

for the

Pacific Fishery Management Council

in 2003

by

Thomas H. Jagielo[1], Farron R. Wallace[2], and Yuk Wing Cheng[1]

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October 2003

Executive Summary

Stock

This assessment applies to lingcod (*Ophiodon elongatus*) in the full Pacific Fishery Management Council (PFMC) management zone (the US-Vancouver, Columbia, Eureka, Monterey, and Conception INPFC areas). Separate assessment models were constructed to describe population trends in the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

Catches

Commercial Landings

Commercial lingcod catch history in California waters is available beginning 1916 (personal communication Brenda Erwin, PSMFC) and averaged 428 mt between 1916 and 1955. Commercial lingcod landings in Oregon were first reported in 1950 (Mark Freeman, personal communication) and averaged 264 mt between 1950 and 1953. Washington commercial lingcod landings were first reported in 1937 (anonymous, 1956, WDFW report) and averaged 106 mt until 1955.

Catch data were compiled from agency reports and personal communication for all years preceding 1981. The PacFIN database was queried for catch information in subsequent years. Landings peaked in 1985 at 3,129 mt in northern waters (Columbia and Vancouver INPFC areas) and in 1974 at 1,735 mt in southern waters (Eureka, Monterey and Conception INPFC Areas). Commercial fishery restrictions under lingcod rebuilding management (1998-present) dropped catches to an annual average below 135 mt in both northern and southern waters in recent years.

Over the last two decades, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (62%) coast. In recent years (1998-2002), commercial fishery restrictions constrained the trawl portion of the catch to 54% and 45% for the northern and southern coast, respectively. In 2002, coastwide commercial landings totaled 223 mt and were distributed as follows by INPFC area: U.S.-Vancouver 63 mt (22%), Columbia 52 mt (30%), Eureka 63 mt (27%), Monterey 35 mt (16%), Conception 10 mt (5%).

Recreational Landings

Recreational fishers in California have targeted lingcod since the early 1940's and catch averaged 65.3 mt annually between 1947-1954. Recreational lingcod catch information is not available until 1977 for Oregon waters. Removals averaged 52.3 mt annually between 1977 and 1979. Recreational lingcod catch in Washington was first estimated in 1967 to be 25.3 mt, and annual catch estimates have been provided since 1975.

Recreational catch estimates were extracted from the RecFIN database for years 1980–1989 and 1993 to present for California waters. California recreational catch estimates for all other years were compiled previously in the 2000 lingcod assessment (Jagielo et al., 2000). Oregon recreational catch data were provided by ODFW (Don Bodenmiller, personal communication). Washington recreational catch data were obtained from the WDFW Ocean Sampling Program.

Recreational catch in southern waters has declined dramatically since catch peaked in 1980 at 2,226 mt. In contrast, recreational catch in northern waters peaked at 236 mt in 1994; 127 mt was landed in 2002.

Historically, recreational landings have comprised a larger proportion of the total landings for the southern area, compared to the northern area. In recent years, the recreational portion of the total landings has increased substantially in both the southern and northern areas. In 2002, recreational fisheries harvested 83% of the total lingcod catch in the south and 52% in the north.

Data and Assessment

Present Modeling Approach and Assessment Program

The present assessment updates the previous coastwide assessment (Jagielo et al. 2000) and is implemented in Coleraine using the executable code COLERA20.EXE (Hilborn et al. 2000). Coleraine is a statistical catch-at-age model programmed in AD Model Builder with a Microsoft Excel user interface and has been used for New Zealand assessments including blue whiting, ling, elephant fish, orange roughy and black oreo; in 2000 for Icelandic cod; and recently on the U.S. west coast for sablefish (Hilborn et al. 2001).

In Coleraine, recruitments are assumed to follow a Beverton-Holt spawner recruit curve with a lognormal penalty function for recruitment deviates (Hilborn et al. 2000, section 1.2.3). The parameters are: average recruitment in the unfished state (R_0), steepness (*h*) - the fraction of recruitment obtained at 20% of virgin spawning biomass, and the standard deviation of annual recruitment residuals (Hilborn et al. 2000). In this stock assessment, the initial age composition was determined by assuming that the population was in equilibrium with a fixed, sex specific exploitation rate - U_{init}. (Hilborn et al. 2000, section 1.2.2).

As in the previous assessment, separate age structured models were constructed to analyze stock dynamics for the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

The LCN model incorporated the following likelihood components, which are described mathematically in Hilborn et al.(2000). Input data sources are specified by Table number in the body of the 2003 assessment document which follows:

1) Commercial Catch-At-Age: 1979-2002 (Table 7).
2) Recreational Catch-At-Age: 1980, 1986-2002 (Table 8).
3) Commercial Catch-At-Length: 1975-1978 (Table 11).
4) Recreational Catch-At-Length: 1981-1983 (Table 11).
5) NMFS Trawl Survey Catch-At-Age: 1992, 1995, 1998 and 2001 (Table 9).
6) NMFS Trawl Survey Catch-At-Length: 1986 and 1989 (Table 10)
7) WDFW Tag Survey Catch-At-Age: 1994-1997 (Table 9).
8) WDFW Tag Survey Catch-At-Length: 1986-1993 (Table 10).
9) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
10) WDFW Tag Survey Abundance (Numbers of Fish): 1986-1992 (Table 19).
11) Trawl Fishery Logbook CPUE Index: Washington and Oregon lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1976-1997 (Table 21).

The LCS model incorporated the following likelihood components:

1) Commercial Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
2) Recreational Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
3) NMFS Trawl Survey Catch-At-Age: 1995, 1998 and 2001 (Table 12).
4) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
5) Trawl Fishery Logbook CPUE Index: Oregon and California lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1978-1997 (Table 22).

Unresolved Problems and Major Uncertainties

Uncertainty regarding stock status is higher for the southern area relative to the northern area, primarily because historical data from the southern area were sparse relative to the northern area. The time series of fishery age data available for the southern (LCS) model is short and samples sizes are small, resulting in a shorter time series of estimated recruitments relative to the northern area. More assumptions about the early recruitments in the LCS time series were required, which resulted in greater uncertainty in the estimation of assessment parameters and stock productivity for the southern area. Age data for the NMFS trawl survey were sparse for both regions, but particularly for the southern region. Assumptions about fixed selectivity for this index of abundance were required for the LCS model.

Management-implemented minimum size limits have resulted in limiting the utility of fishery information for estimation of recent stock recruitment in both regions, and fishery trip limits have compromised the utility of recent fishery CPUE data as viable indices of abundance.

Management Reference Points

Comparison of the spawning stock estimates for 2002 with the estimates of virgin spawning stock size under the asymptotic fishery selectivity model assumption indicate that the recent coastwide spawning population size is approximately 25% of virgin levels (Table ES1). Under the domed fishery selectivity model assumption, the estimate of depletion was similar at 24%. By contrast, the model estimates of F_{45} differed between the asymptotic ($F_{45} = 0.12$) vs. domed

($F_{45} = 0.18$) cases, indicating higher productivity under the domed fishery selectivity assumption. Consequently, projected yields under the domed fishery selectivity model assumption tend to be higher than under the asymptotic fishery selectivity model assumption (Table ES2).

When compared to the domed fishery selectivity model, the asymptotic fishery selectivity model is generally more consistent with the assumptions made in the previous lingcod stock assessment (Jagielo et al. 2000) and rebuilding analysis (Jagielo and Hastie 2001). (In the 2000 lingcod stock assessment, all fisheries were assumed to be asymptotic, with the exception for male fishery selectivity in the northern area, which was allowed to be dome shaped.) Estimates of F_{45} for the 2003 asymptotic model (0.12-north, 0.12-south) are similar to the estimates of F_{45} from the 2000 assessment (0.12-north, 0.14-south), with a slightly higher value for the south.

Spawning Stock Biomass

For the asymptotic fishery selectivity model, Coleraine estimates of the coastwide female spawning stock biomass declined from 22,918 mt in 1973 to 1,942 mt in 1994, and subsequently increased to 10,776 in 2003 (Figure ES1-Top). The trend over time was similar for the northern and southern areas. Female spawning biomass depletion (B_0/B_t) ranged from 0.53 in 1973 to a low of 0.05 in 1994, and subsequently increased to 0.25 in 2003.

For the dome shaped fishery selectivity model, Coleraine estimates of the coastwide female spawning stock biomass declined from 31,682 mt in 1973 to 1,897 mt in 1994, and subsequently increased to 10,665 mt in 2003 (Figure ES2-Top). Female spawning biomass depletion (B_0/B_t) ranged from 0.67 in 1973 to a low of 0.04 in 1994 and subsequently increased to 0.23 in 2003 (Figure ES2-Bottom). Estimated depletion was somewhat greater for the northern area compared to the southern area in the early part of the time series.

It should be noted that the Coleraine estimate of depletion can differ from the estimate obtained from the rebuilding analysis (Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Recruitment

For the asymptotic fishery selectivity model, estimated recruitment was higher in the early part of the time series and relatively low by comparison through the 1990's. From 1973-1985, coastwide recruitment averaged 3,173 (thousand age 1 fish). From 1986-2002, coastwide recruitment averaged 2,832 (thousand age 1 fish). For the dome shaped fishery selectivity model, coastwide recruitment averaged 3,527 (thousand age 1 fish) from 1973-1985; from 1986-2002, coastwide recruitment averaged 2,869 (thousand age 1 fish).

Exploitation Status

Under coastwide rebuilding management, the asymptotic fishery selectivity model estimates of exploitation rate (catch/available biomass) in the northern area averaged 0.03 (commercial fishery) and 0.02 (recreational fishery) in recent years (1998-2002). In the southern area exploitation rates averaged 0.03 (commercial fishery) and 0.11 (recreational fishery) for the same period. Estimates from the dome shaped fishery selectivity model for the same time period were 0.03 (commercial-north), 0.03 (recreational-north), 0.07 (commercial-south) and 0.13 (recreational-south).

Management Performance

The first lingcod ABC's based on a quantitative assessment were implemented in 1995. A comparison of reported landings and ABC values shows good correspondence through 2001, when landings were typically at or below the target ABC values (Figure ES3). In 2002, landings exceeded the coastwide ABC by 17% and the coastwide OY was exceeded by 51%. Harvest in excess of the OY can be attributed in part to the northern California recreational fishery; RecFIN catch estimates increased from 140mt in 2001 to 430 mt in 2002.

Forecasts and Decision Table

Six rebuilding analysis projections were produced using separate sets of information derived from the present stock assessment (Appendix II). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. The population projections were configured to begin in 2002 with rebuilding scheduled to occur by the start of 2009 (year 10 from the original rebuilding start year of 1999).

The projected coastwide yields for 2004-2008 under both the asymptotic and domed fishery selectivity assumptions are constrained by the ABC rule, for values of $P < 0.6$ (Table ES2). Coastwide ABC yield for 2004-2008 ranges from 1,820 mt to 2,053 mt for the asymptotic fishery selection model, compared to 2,141 mt to 2,123 mt for the domed fishery selectivity model.

Recommendations: Research and Data Collection Needs

Emphasis should be placed on improving fishery age structure sampling size and geographical coverage in both regions. More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment. In the southern region, the CPFV observer project CPUE data should be analyzed (on a reef-specific basis) using a General Linear Model (GLM) analysis, for evaluation as an index of abundance. Coastwide enumeration of at-sea discards (e.g. by an on-board observer program) is needed to properly account for total fishery mortality.

Table ES1. Management reference points derived from the 2003 lingcod stock assessment (Jagielo et al. 2003). Alternative models included the assumption of asymptotic vs. domed fishery selectivity. Under each assumption, rebuilding projection input files were constructed for 1) coastwide (northern and southern model data pooled) and 2) northern and southern area model data separately.

	Asymptotic Fishery Selectivity			Domed Fishery Selectivity		
	Coastwide	Northern	Southern	Coastwide	Northern	Southern
FMSY proxy	0.121	0.124	0.122	0.184	0.165	0.190
FMSY SPR / SPR(F=0)	0.45	0.45	0.45	0.45	0.45	0.45
Virgin SPR	12.41	13.27	11.20	11.77	13.27	11.20
Virgin Spawning Output (mt)	36967	19434	16969	37115	19518	18848
Target Spawning Output (mt)	14787	7774	6788	14846	7807	7539
Current (2002) Spawning Output (mt)	9160	5410	3751	8931	5679	3253
Depletion ($SpBio_{2002}/SpBio_{Virgin}$)	0.25	0.28	0.22	0.24	0.29	0.17
Spawning Output (ydecl) (mt)	4203	2226	1972	4077	2464	1608

Table ES2. Projected yield (mt) under model assumptions of asymptotic vs. domed fishery selectivity. Yields are shown for probability of recovery values ranging from P=0.5 to P=0.9, and for the 40-10 and ABC rules.

Model	Year	P= .5	P= .6	P= .7	P= .8	P= .9	Yr=Tmid	F=0	40-10 Rule	ABC Rule
Coastwide Asymptotic	**2004**	1843	1799	1750	1693	1631	1767	0	1429	1820
	2005	1947	1906	1859	1805	1744	1875	0	1753	1926
	2006	2006	1968	1924	1873	1816	1939	0	1970	1986
	2007	2043	2008	1967	1920	1866	1981	0	2085	2025
	2008	2069	2037	1999	1955	1904	2012	0	2102	2053
North Asymptotic	**2004**	1342	1328	1305	1285	1255	1339	0	1050	1109
	2005	1359	1346	1326	1309	1281	1356	0	1156	1149
	2006	1354	1343	1326	1311	1287	1352	0	1174	1168
	2007	1331	1322	1307	1294	1273	1330	0	1172	1168
	2008	1312	1304	1291	1279	1261	1311	0	1170	1166
South Asymptotic	**2004**	686	660	626	594	547	650	0	492	759
	2005	752	725	692	659	610	715	0	664	823
	2006	794	768	736	704	655	759	0	800	862
	2007	830	805	774	742	694	796	0	898	894
	2008	859	836	805	775	728	827	0	961	920
Coastwide Domed	**2004**	2058	2009	1962	1905	1838	2032	0	1616	2041
	2005	2135	2089	2045	1992	1930	2111	0	1966	2118
	2006	2138	2098	2058	2010	1953	2117	0	2137	2124
	2007	2139	2102	2066	2022	1969	2120	0	2182	2126
	2008	2135	2101	2067	2025	1976	2117	0	2167	2123
North Domed	**2004**	1512	1496	1478	1462	1440	1509	0	1164	1185
	2005	1477	1464	1449	1435	1416	1475	0	1198	1195
	2006	1438	1427	1414	1403	1387	1436	0	1194	1192
	2007	1376	1366	1355	1346	1332	1374	0	1165	1163
	2008	1339	1330	1320	1312	1300	1337	0	1148	1146
South Domed	**2004**	600	571	538	502	455	603	0	421	803
	2005	658	629	595	557	509	661	0	618	858
	2006	687	659	626	588	540	690	0	764	877
	2007	711	683	650	613	564	714	0	860	893
	2008	736	708	676	639	589	738	0	924	911

Figure ES1. Female spawning biomass (top) and depletion (bottom) estimated under the assumption of asymptotic fishery selectivity.

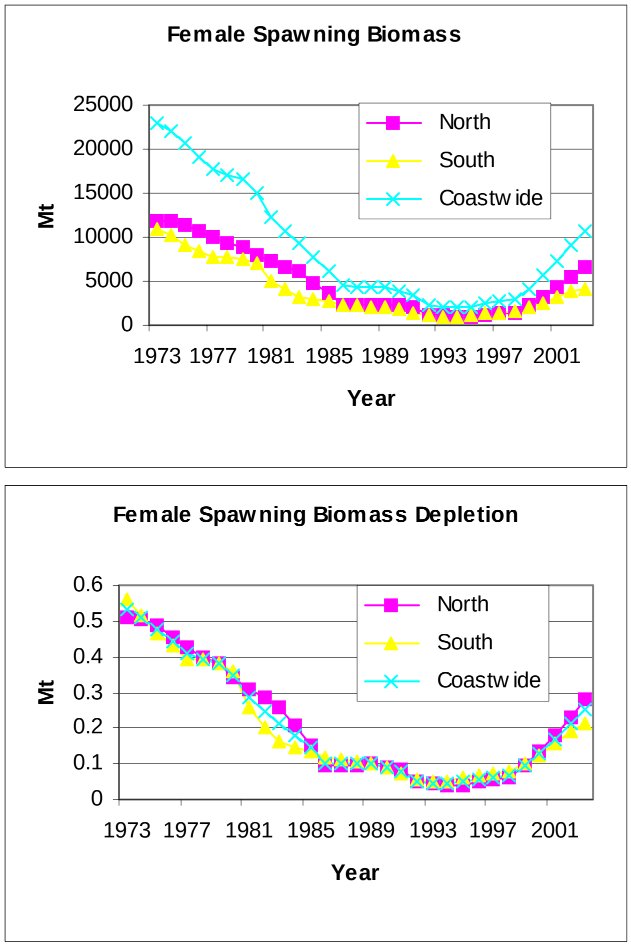
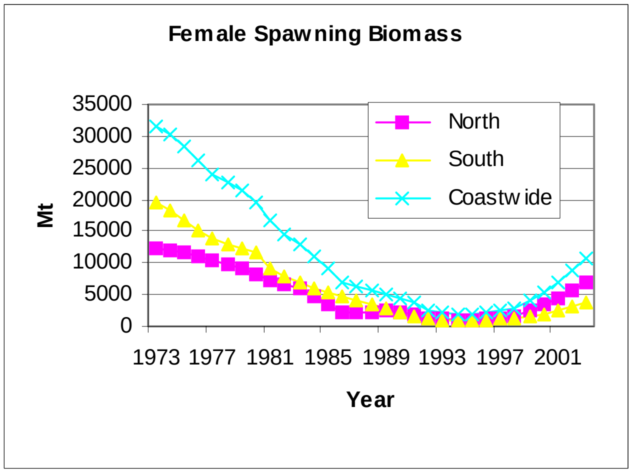


Figure ES2. Female spawning biomass (top) and depletion (bottom) estimated under the assumption of dome shaped fishery selectivity.



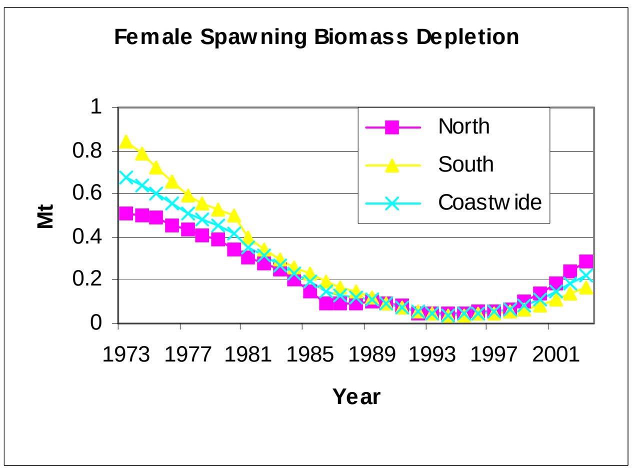
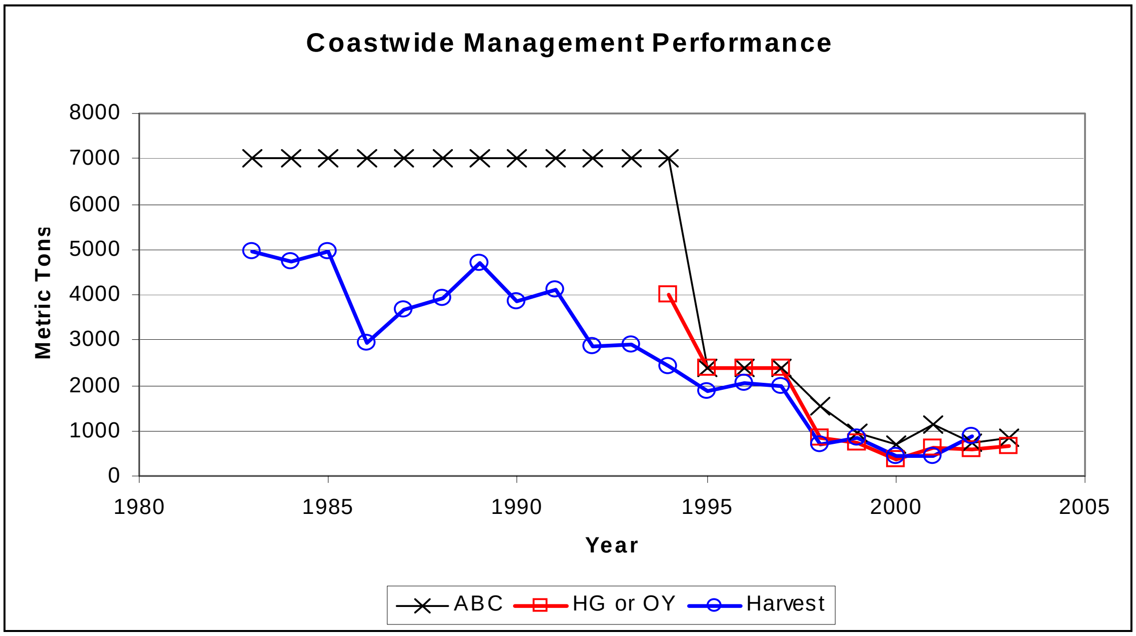


Figure ES3. Comparison of lingcod ABC, OY and landings (mt) between 1983 and 2003.



Introduction

Stock Structure and management Units

This document provides an updated coastwide assessment of the lingcod population in 2003 for the full PFMC management zone. Evidence from genetics analysis (Jagielo et al. 1996) and tagging studies (Cass et al. 1990, Jagielo 1995, Jagielo 1999a) suggest that the fish found within this entire area are of one intermingling stock unit. However, because of regional differences in data sources and data availability, the assessment was divided into two separately modeled units: Lingcod-North (LCN) and Lingcod-South (LCS), as it was in the previous assessment (Jagielo et al. 2000) (Figure 1). A study currently underway by WDFW indicates that there are significant differences in growth in lingcod found in southern Eureka, Monterey and Conception INPFC Areas), and northern coastal waters (Columbia and Vancouver INPFC areas). Based on this evidence, we continue to support and provide a separate assessment for southern and northern areas.

Life History

Lingcod (*Ophiodon elongatus*) are top order predators of the family *Hexagrammidae*. The species ranges from Kodiak Island in the Gulf of Alaska to Baja California, and its center of abundance is near British Columbia and Washington (Hart 1973). An analysis of genetic variation indicates that lingcod are genetically similar throughout the range (Jagielo et al. 1996). Among the *Hexagrammidae*, the genus *Ophiodon* is ecologically intermediate between the more littoral genera *Hexagrammos*, *Agrammus*, and *Oxylebius* and the more pelagic *Pleurogrammus* (Rutenberg 1962). Lingcod are demersal on the continental shelf, most abundant in waters less than 200 m deep, and patchily distributed among areas of hard bottom and rocky relief (Smith and Forrester 1973; Jagielo 1988). Lingcod are considered non-migratory, though some tagged individuals have moved exceptional distances and indirect evidence suggests a seasonal onshore movement associated with spawning (Jagielo 1995, 1999). Larval lingcod hatch in late winter and become epipelagic. When about 3 months old, juveniles settle on sandy bottom near eelgrass or kelp beds. By age 1 or 2, lingcod move into rocky habitats similar to those occupied by adults, but shallower. Fishery and survey data indicate that male lingcod tend to be more abundant than females in shallow waters, and the size of both sexes increases with depth (Jagielo 1994). In late fall, male lingcod aggregate and become territorial in areas suitable for spawning. Mature females are rarely seen at the spawning grounds and it is assumed that they move into spawning areas for only a brief time to deposit eggs. Following egg nest deposition, males assume a guardian role through the period of hatch-out. Hatch out is typically complete by April in Washington but has been reported as early as January and as late as June throughout the species range (Jagielo 1994). A more detailed review of lingcod life history can be found in Jagielo (1994), Adams and Hardwick (1992), and Cass et al. (1990).

History of the fishery

Lingcod have been a target of commercial fisheries since the early 1900’s in California (CDFG Reports), and since the late 1930’s in Oregon (Unpublished, ODFW Report, 1950) and Washington (Anonymous WDF Report, 1955) waters (Table 4). Recreational fishers have targeted lingcod since the 1920’s in California. A modest recreational fishery (less than 20 mt annually) has taken place in Washington and Oregon since at least the 1970’s.

Management

History

From 1983 through 1994, a coastwide ABC of 7,000 mt was in effect with the INPFC area components: US Vancouver (1000 mt), Columbia (4,000 mt), Eureka (500 mt), Monterey (1,100 mt) and Conception (400 mt) (Table 1). In 1994 a coastwide harvest guideline (HG) of 4,000 mt was established. Following an assessment for the northern area (Jagielo 1994), the coastwide ABC and Harvest Guideline were reduced for 1995 through 1997 to 2,400 mt with separate ABC's for the US Vancouver-Columbia (1,300 mt), Eureka (300 mt), Monterey (700 mt), and Conception (100 mt) areas. In 1998, following an updated assessment for the northern area (Jagielo et al.1997), the coastwide ABC was reduced to 1,532 mt with a Harvest Guideline of 838 mt. Separate ABC's by area were: Vancouver (including a portion of Canadian waters)-Columbia (1,021 mt), Eureka (139 mt), Monterey (325 mt), and Conception (46 mt). For 1999, the Council established a coastwide ABC of 960 mt and a Harvest Guideline of 730 mt, with area specific ABC's of US Vancouver-Columbia (450 mt), Eureka (139 mt), Monterey (325 mt), and Conception (46 mt). Following a new assessment for the southern area (Adams et al.1999) and a rebuilding analysis (Jagielo 1999b), the coastwide ABC for 2000 was reduced to 700 mt which included area values of US Vancouver-Columbia (450 mt) and Eureka-Monterey-Conception (250 mt). Subsequently, a coastwide stock assessment (Jagielo et al. 2000) provided a northern ABC was of 610 mt and a southern ABC of 509 mt. Based on a revised rebuilding analysis (Jagielo and Hastie 2001) the 2001-coastwide lingcod OY was set at 611 mt, which is the harvest level derived from a constant exploitation rate that was expected to have a 60-percent probability of rebuilding the stock to B_{msy} within 9 years. The coastwide lingcod OY was similarly set at 577 mt in 2002 and 651 mt in 2003.

Regulations

A history of lingcod commercial trawl trip limits is summarized in Table 2. No trip limits were in effect prior to 1995, and trip limits have become increasingly restrictive since then as annual harvest guidelines have decreased.

A history of PFMC enacted recreational size and bag limits is summarized in Table 3. In California, a 5 fish bag limit was enacted in 1980 followed by a 22 inch size limit in 1981. These regulations remained in effect for 17 years. In March 1998, the bag limit was reduced from 5 to 3 fish and concurrently the size limit was increased to 24 inches. The bag limit was lowered again from 3 fish to 2 fish with in January 1999. In January 2000, the size limit increased from 24 to 26 in. and a seasonal closure (January through February) was implemented from the U.S.-Mexico border north to Lopez Point (36 deg 00 min N., Monterey County), and for March through April from Lopez Point north to Cape Mendocino (40 deg 10 min N., Humboldt County) The bag limit remained at 2 fish. A gear restriction was also enacted at this time limiting the number of hooks to 3, although this was primarily directed toward rockfish effort.

Performance

The first lingcod ABC's based on a quantitative assessment were implemented in 1995. A comparison of reported landings and ABC values shows good correspondence through 2001, when landings were typically at or below the target ABC values (Figure 2). In 2002, landings exceeded the coastwide ABC by 17% and the coastwide OY was exceeded by 51%. Harvest in excess of the OY can be attributed in part to the northern California recreational fishery; RecFIN catch estimates increased from 140mt in 2001 to 430 mt in 2002.

DATA

Catch

Commercial Landings

Commercial lingcod catch history in California waters is available beginning 1916 (personal communication Brenda Erwin, PSMFC) and averaged 428 mt between 1916 and 1955 (Table 4). Commercial lingcod landings in Oregon were first reported in 1950 (Mark Freeman, personal communication) and averaged 264 mt between 1950 and 1953. Washington commercial lingcod landings were first reported in 1937 (anonymous, 1956, WDFW report) and averaged 106 mt until 1955.

Catch data were compiled from agency reports and personal communication for all years preceding 1981. The PacFIN database was queried for catch information in subsequent years and catch detail is presented by gear and INPFC area in Table 6.

Commercial landings peaked in 1985 at 3,129 mt in northern waters (Columbia and Vancouver INPFC areas) and in 1974 at 1,735 mt in southern waters (Eureka, Monterey and Conception INPFC Areas)(Table 5). Average catch between 1990-1997 declined 40 % and 35% since the 1980's in northern and southern waters, respectively. Under rebuilding management, commercial fishery restrictions in recent years (1998-present) reduced catches to an annual average of less the 135 mt in both northern and southern waters (Figure 3).

Over the last two decades, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (62%) coast (Table 6). In recent years (1998-2002), commercial fishery restrictions constrained the trawl portion of the catch to 54% and 45% for the northern and southern coast, respectively. In 2002, coastwide commercial landings totaled 223 mt and were distributed as follows by INPFC area: U.S.-Vancouver 63 mt (22%), Columbia 52 mt (30%), Eureka 63 mt (27%), Monterey 35 mt (16%), Conception 10 mt (5%).

Recreational Landings

Recreational fishers in California have targeted lingcod since the early 1940's. Catch averaged 65.3 mt annually between 1947-1954 (Leet et al., 1992). Recreational lingcod catch information is not available until 1977 for Oregon waters and averaged 52.3 mt annually between 1977 and 1979. Recreational lingcod catch in Washington was first estimated in 1967 to be 25.3 mt and annual catch estimates have been provided since 1975.

Recreational catch estimates were extracted from the RecFIN database for years 1980–1989 and 1993 to present for California waters. California recreational catch estimates for all other years were compiled in the 2000 lingcod assessment (Jagielo et al., 2000). Oregon recreational catch data were provided by ODFW (Don Bodenmiller personal communication). The recreational catch in Washington was provided by the WDFW Ocean Sampling Program.

Recreational catch in southern waters has declined since catch peaked in 1980 at 2,226 mt (Table 5, Figure 4). In contrast, recreational catch in northern waters peaked at 236 mt in 1994. In 2002, 127 mt was landed.

Historically, recreational landings have comprised a larger proportion of the total landings for the southern area, compared to the northern area. In recent years, the recreational portion of the total landings has increased substantially in both the southern and northern areas. In 2002 recreational fisheries harvested 83% of the total lingcod catch in the south and 52% in the north (Figure 5).

Discard

There are three sources of discard information for lingcod. These include the federal Marine Recreational Fisheries Statistical Survey (MRFSS), and both the Washington Department of Fish and Wildlife (WDFW) and the NMFS West-Coast Groundfish Observer Programs. MRFSS have collected B1 (reported by angler to be dead) and B2 (reported by angler to be alive) catches since 1980. Estimates of lingcod discarded alive have increased substantially in response to 1) management changes in 1998 (the size limit increased from 22 to 24 inches), and 2) a seasonal closure in California waters beginning in 2000 (Table 6a). It is interesting to note that estimates of fish discarded dead have decreased over time. Estimated live lingcod discarded in southern California was 306,000 fish in 2002. This compares to a total landed catch of 25,000 fish. WDFW began collecting discard information from the recreational fishery in 2002 and estimated that 57% of the catch was discarded. WDFW does not collect information on the portion of the catch discarded live or dead.

Based on an earlier study (Ricky, WDFW unpublished report), the PFMC Groundfish Management Team used a 20% inflation factor to adjust landed catch to account for unobserved lingcod mortality (personal communication, PFMC) in the commercial fishery beginning in 2002. Data collected by the Groundfish Observer program in 2001-2002 estimated that the percent discard of total observed catch was 78.8%. Because lingcod lack a swim bladder, it is likely that there is a relatively good survival rate for these fish.

Age and Size Composition

Age composition data from the northern area is summarized for the commercial fishery in Table 7. These data were derived by weighting the raw age frequencies from each WDFW vessel sample by the total landed weight of lingcod from that vessel. The recreational fishery age composition data, compiled from WDFW and ODFW recreational fishery samples, are summarized in Table 8. Age compositions derived from samples taken on board the NMFS Triennial Trawl shelf survey and age compositions obtained from sub-samples of lingcod taken for aging as part of the WDFW Cape Flattery Tag survey are summarized in Table 9. Survey and fishery size composition data (cm) used in the northern model, with associated sample sizes, are summarized by data source in Tables 10 and 11, respectively.

Age composition data and sample size information for the southern area are summarized for the commercial and recreational fisheries, and the NMFS Triennial Trawl shelf survey in Table 12.

Natural Mortality, Length, Weight, and Maturity at Age

Vectors of length, weight, and maturity-at-age by sex are summarized for the northern area in Table 13. Parameter estimates for these relationships, and natural mortality estimates used in the LCN model are summarized in Table 14. Comparable information for the southern area is summarized in Tables 16 and 17. Figure 6 shows the fit of female and male LCS and LCN lingcod to the von Bertalanffy growth equation.

Abundance Indices

NMFS Triennial Shelf Trawl Survey

Survey estimates of biomass (metric tons) and the associated coefficients of variation (CV's) from the triennial survey for 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998 and 2001 are summarized in Table 18. The total sum of lingcod abundance estimates from the US Vancouver and Columbia area for all depth strata (55-183 m, 184-366 m and 367-500 m) was incorporated into the LCN model. The total sum of the Eureka and Monterey biomass estimates for each year and depth strata was used in the LCS model. Geographic distribution of lingcod biomass (kg/ha) for all tow catch data is displayed in Figures 7, 8 and 9 for coastwide, northern and southern areas, respectively.

Biomass estimates have been revised using a filtered dataset that excluded "water hauls". A complete description of the tow analysis and identification procedures of "water hauls" can be found in AFSC Processed Report 2001-03 (Zimmermann et al., 2001). Generally, lingcod biomass estimates from the filtered dataset increased with one exception. The 1980 Columbia INPFC lingcod biomass estimate was reduced from 8,699 mt to 3,219 mt, a difference of 5,480 mt (Table 18 and Figure 10). The difference resulted from a single large lingcod tow that was identified as a "water haul" and excluded from the dataset.

WDFW Cape Flattery Tag Survey

Annually, from 1986-1992, WDFW sampled lingcod from an established survey area in a consistent manner using bottomfish troll (dingle bar) hook and line gear. This sampling was initiated for the purpose of capturing fish for release as part of a multiple-year mark-recapture experimental design (Jagielo 1991, 1995). From 1986-1992, estimates of lingcod abundance in the Cape Flattery survey area were derived using external tags (Table 19). Voluntary tag returns from the recreational lingcod fishery at Neah Bay, Washington were used as the method for obtaining tag recaptures. Annual sampling with bottomfish troll gear continued beyond 1992 to extend the length composition time series, which had shown value as a recruitment index for previous lingcod stock assessments (Jagielo 1994, Jagielo et al.1997, Jagielo et al. 2000).

Trawl Fishery Logbook Catch-Per-Unit-Effort (CPUE) Index

Similar to the 2000 assessment, two independently estimated trawl fishery CPUE indices were incorporated into the northern and southern assessment models. These indices have been revised since the 2000 assessment. The new indices were constructed from Washington, Oregon and California trawl fishery logbook and fish ticket data dating back to 1976 (Table 20). Skipper's tow-by-tow estimates of retained catch were reconciled with fish ticket data (landing receipts). The adjusted catch and the skipper's estimate of tow duration was used to compute lingcod CPUE (lbs/hour)(Figures 11-14).

Following data verification and screening, a total of 474,946 tows in the southern area and 490,971 tows in the northern area were used in the analysis. Because of significant changes in management beginning in 1998 both the northern and southern time series were truncated after 1997. Furthermore, the 1976 and 1977 tow data from the southern area were deemed of insufficient sample size and were dropped from the time series used in the assessment model.

Tow-by-tow catch rates (CPUE) were fitted in a two-stage model process using Delta-Lognormal GLM procedure to predict abundance indices across the time series for each area. The model included a year, month, depth, and location (PFMC area) effect. A bootstrap procedure was used to estimate the standard errors of the year by year index values. The STAT Team determined and the Star Panel concurred that the bootstrap estimates of standard errors were unrealistically low and opted to use an assumed annual CV of 0.20 in both the southern and northern index.

The revised northern trawl logbook index trend used in the present assessment model corresponds well with the logbook index trend used in the 2000 stock assessment and shows a sharply declining stock since 1976 (Figure 15). The revised southern trawl logbook index also corresponds well to the logbook index used in the previous assessment and indicates a declining stock since 1979 (Figure 16). A summary of the Delta GLM results for the northern area is presented in Table 21 and results from the southern area are presented in Table 22.

Other Candidate Indices Considered But Not Used

At the request of the lingcod Stock Assessment Team (STAT), recreational catch and effort data from WDFW Ocean Sampling Program and RecFIN were analyzed by Drs. Alec MacCall and Steve Ralston (SWFSC, Santa Cruz) for four different regions including Southern and Northern California, Oregon and Washington (Table 23, Figure 17). Candidate indices were derived based on the Delta-GLM approach (assuming gamma error structure) that was used recently for black (Ralston and Dick, 2003) and bocaccio rockfish (MacCall, 2003). Evaluation of these new candidate indices of abundance resulted in the determination that potential biases in the input data sources precludes their use in the lingcod stock assessment. The STAT team concerns include 1) high index variability, 2) lack of a discernable index trend, 3) implausible temporal changes in abundance, and 4) unresolved input data assumptions.

In particular, the Washington database did not contain discard information needed to convert the estimate to total catch, as was done in the other estimates. For the other regions, analysis of RecFIN data indicated that the time trend of catch type A (landed catch) was constrained by bag limits and not informative. Discard was an integral part of estimating a CPUE trend from RecFIN data. MacCall calculated a "direct" CPUE from the raw intercept data on Aangs (anglers), Bangs (boat anglers), A, B1 (reported by angler to be dead) and B2 (reported by angler to be alive), but found cases in the dataset where Aangs had a value of 1, but the type B catches clearly represented the entire boat. The resulting indices were highly irregular and disregarded. To standardize RecFIN estimates (for the final "direct" catch estimate), MacCall assumed Aangs caught B1 and B2 catches and produced alternative indices where the year values from the delta GLM of type A catch and Aangs were expanded by the ratio of RecFIN estimated total catch (A+B1_B2)/A. The delta method was used to estimate variances of the "indirect" estimates from the variances of all the pieces and some assumed co-variances.

Because we were not confident that the type A catch and Aangs was reliable, the indices were not incorporated as model indices of abundance. We are concerned that the resulting catch rates may be affected by sampling and/or data entry error. A full evaluation of data quality is needed before using these data as a trend of lingcod abundance.

In addition to the candidate recreational indices discussed above, Jagielo et al. (2000) previously reviewed and analyzed a number of possible data sources for abundance trend information. Four indices of abundance, three derived from recreational CPUE data in the southern area and one derived from the shrimp trawl fishery bycatch in the northern area, were evaluated as candidates for modeling in 2000. Those candidate indices were not incorporated in final modeling in the 2000 assessment because it was difficult to assure that they were unbiased and/or representative of lingcod relative abundance. Recreational CPUE datasets are often problematic for use as unbiased indices of abundance, because catch rates may be effected by 1) variable target species by boat, 2) un-documented search time, 3) un-reported discards ,4) unknown spatial effort shifts, and 5) bag limit effects. Uncertainty also exists in the estimates of landings and effort due to sampling error.

Exploratory analyses conducted with the commercial trawl logbook data were also evaluated and subsequently not used in the model. Tow-by-tow catch rates (CPUE) were fitted to a two-stage model process using a generalized additive model (GAM, non-parametric method) to predict abundance indices across the time series. The data sets were filtered for tows where tow location (latitude and longitude) was known. Because of the lack of tow location, especially in the early part of the time series, index values in the early part of the time series were based on extrapolation. A comparison of Delta GLM and GAM results showed inconsistencies over the time series that appeared to be based on this extrapolation. Additionally, the GAM results included a smoothing process which may not have properly reflected underlying covariance in the data. Thus, the STAT team determined and the STAR panel concurred that the GAM analysis should be considered a work in progress and should not be used in the stock assessment.

Ageing error

Age reading error was modeled by incorporation of an age error transition matrix, which was developed from estimates of between-reader (within-lab) variability obtained from repeat age readings by two WDFW lingcod age readers (Figure 18). This age error transition matrix has not been modified since the last assessment.

Assessment

History of Modeling Approaches

The first assessment of lingcod provided to PFMC consisted of a yield-per-recruit analysis Adams (1986). Subsequently, an age structured assessment was prepared for a portion the northern area (PMFC areas 3A, 3B, and 3C-including Canada) by Jagielo (1994), using the Stock Synthesis model (Methot 1990). The assessment was subsequently updated to include the full Columbia INPFC area through 3C-N in Canada (Jagielo et al. 1997). Adams et al. (1999) subsequently conducted a length-based, age-structured assessment for the southern area (Eureka, Monterey, and Conception INPFC areas), using AD Model Builder (Fournier 1996). The first coastwide assessment of lingcod for the full PFMC management zone was conducted by Jagielo et al. 2000; that assessment (implemented in AD Model Builder) employed two age-structured models, conceptually and mathematically similar to the previous Stock Synthesis assessments of the northern area (Jagielo 1994, Jagielo et al. 1997).

Present Modeling Approach and Assessment Program

The present assessment updates the previous coastwide assessment (Jagielo et al. 2000) and is implemented in Coleraine using the executable code COLERA20.EXE (Hilborn et al. 2000). Coleraine is a statistical catch-at-age model programmed in AD Model Builder with a Microsoft Excel user interface and has been used for New Zealand assessments including blue whiting, ling, elephant fish, orange roughy and black oreo; in 2000 for Icelandic cod; and recently on the U.S. west coast for sablefish (Hilborn et al. 2001).

In Coleraine, recruitments are assumed to follow a Beverton-Holt spawner recruit curve with a lognormal penalty function for recruitment deviates (Hilborn et al. 2000, section 1.2.3); parameters are: average recruitment in the unfished state (R_0), steepness (h) - the fraction of recruitment obtained at 20% of virgin spawning biomass, and the standard deviation of annual recruitment residuals (Hilborn et al. 2000). In this stock assessment, the initial age composition was determined by assuming that the population was in equilibrium with a fixed, sex specific exploitation rate - U_{init}. (Hilborn et al. 2000, section 1.2.2)

As in the previous assessment, separate age structured models were constructed to analyze stock dynamics for the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas. To establish continuity between the previous and present assessments, the final data and parameter configuration for the northern area (LCN) model (derived in 2000) was implemented in Coleraine. The resulting estimates of female spawning biomass from Coleraine agreed well with the previous assessment results (Figure 19).

The following discussion covers the modeled data, model structure, and base model results; first for the northern area (LCN), followed by a discussion of the same topics for the southern area (LCS).

Lingcod-North (LCN): US-Vancouver and Columbia INPFC Areas

Model Description

List and Description of Likelihood Components in the LCN Model

The LCN model incorporated the following likelihood components, which are described mathematically in Hilborn et al.(2000); input data sources are specified by Table number:

12) Commercial Catch-At-Age: 1979-2002 (Table 7).
13) Recreational Catch-At-Age: 1980, 1986-2002 (Table 8).
14) Commercial Catch-At-Length: 1975-1978 (Table 11).
15) Recreational Catch-At-Length: 1981-1983 (Table 11).
16) NMFS Trawl Survey Catch-At-Age: 1992, 1995, 1998 and 2001 (Table 9).
17) NMFS Trawl Survey Catch-At-Length: 1986 and 1989 (Table 10)
18) WDFW Tag Survey Catch-At-Age: 1994-1997 (Table 9).
19) WDFW Tag Survey Catch-At-Length: 1986-1993 (Table 10).
20) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
21) WDFW Tag Survey Abundance (Numbers of Fish): 1986-1992 (Table 19).
22) Trawl Fishery Logbook CPUE Index: Washington and Oregon lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1976-1997 (Table 21).

The NMFS Trawl Survey Biomass, WDFW Tag Survey Abundance, and Trawl Fishery Logbook CPUE Index likelihood components were fit under a lognormal error structure (Hilborn et al. 2000, section 1.4.2). The fishery and survey catch-at-age and catch-at-length likelihood components were fit assuming a robust lognormal for proportions (Hilborn et al. 2000, section 1.4.1). In addition to the likelihood components listed above, a likelihood penalty component was included which corresponded to prior assumptions about recruitment variability (Hilborn et al. 2000, section 1.4.3).

Base Model Configuration

The LCN base model assumed a Beverton-Holt stock-recruitment relationship with lognormal error structure (with a steepness parameter h = 0.9 and CV = 1.0) to constrain wide variations in recruitment (Hilborn et al. 2000, section 1.2.3). Selectivity for the commercial and recreational fisheries and the NMFS and WDFW surveys was parameterized by a curve formed from two normal distributions (Hilborn et al. 2000, section 1.2.6). Three parameters are used in this formulation: 1) an age where selectivity = 1.0 (Full), 2) a standard deviation on the left side to describe ascending selectivity (Left), and 3) a standard deviation on the right side to describe descending selectivity (Right). The model did not incorporate an explicit treatment of discards. Base model inputs including priors, likelihood specifications, and fixed parameter values are tabulated in Appendix I, Tables 1 and 2.

Model Selection and Evaluation

Model selection was conducted beginning essentially with the STAR Panel approved formulation from the previous assessment (Jagielo et al. 2000) and proceeded using a procedure where alternate models were evaluated for model fit to the data (using the Akaike Information Criterion (AIC) (Akaike 1972)), and plausibility.

The base LCN model described herein employs one-period (time invariant) commercial and recreational fishery selectivity with estimation of both the left and right side portions of the selectivity curve (dome shaped fishery selectivity). Time invariant age of full selectivity for each of the NMFS and WDFW survey data were estimated, however it was necessary to hold the left and right side selectivity parameters fixed to obtain stable model results. A summary of negative log likelihood values, and both estimated and fixed model parameters of the LCN base model is provided in Appendix I, Table 3.

Base-Run Results

Base run (dome shaped fishery selectivity) model results are presented in Appendix I, Tables 1-3 and Appendix I, Figures 1-10. The Coleraine estimate of B_0 for the northern area is 23952 mt. The estimate of female spawning biomass for 2003 is 6859 mt. It should be noted that the Coleraine estimate of depletion (0.29) can differ from the estimate obtained from the rebuilding analysis (Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Uncertainty and Sensitivity Analyses

Coleraine estimates of the standard deviation of all model parameters (dome shaped fishery selectivity) is provided in Table 3a1.

The results of model profiling over selected fixed values used in the assessment are included in Appendix I, Tables 3a-3e.

A series of base model runs were conducted to examine the effect of different values of the historical exploitation rate (U_{init}) (Appendix I Table 3a). This parameter, which is assumed at a fixed value of 0.09 in the model, is used to estimate the initial age composition of the model in 1973. The profile over U_{init} ranged from 0.03 to 0.15. The value of 0.09 was selected for the final base model, because it was used in the previous assessment, and is consistent with the observed landings prior to 1973.

The base model was also profiled over different fixed values of natural mortality (M) (Appendix I , Table 3b). The profile over M ranged from 0.14-0.22 for females, and 0.26-0.38 for males. The values of 0.18 (females) and 0.32 (males), as used in previous assessments, were chosen for use in the 2003 final base model.

An additional series of model runs were conducted where the effect of different fixed values of the Beverton-Holt stock-recruitment steepness parameter (*h*) was evaluated (Appendix I, Table

3c). The profile over h ranged from 0.5 to 0.9. This parameter was set at the fixed value of 0.9 in the final base model.

Base model profiles were also conducted using different combinations of the Beverton-Holt stock-recruitment steepness parameter (h) and natural mortality (M) (Table 3d), and different combinations of assumed asymptotic and dome shaped fishery selectivity (Table 3e).

A retrospective analysis was performed to compare the base model estimates of spawning biomass with a base model configured with 1999 as the end year (Appendix I, Figure 11a). The estimates of spawning biomass agreed well for the 1973-1999 time series.

An historic analysis was conducted by plotting the estimates of spawning biomass from the previous assessment (Jagielo et al. 2000) with the estimates of spawning biomass from the present assessment (Appendix I, Figure 11b). Both assessments showed a similar declining trend over the time series, with particularly close agreement since 1992.

Lingcod South (LCS): Eureka, Monterey, and Conception INPFC Areas

Model Description

List and Description of Likelihood Components in the LCS Model

The LCS model incorporated the following likelihood components, which are described mathematically in Hilborn et al. 2000; input data sources are specified by Table number:

1) Commercial Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
2) Recreational Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
3) NMFS Trawl Survey Catch-At-Age: 1995, 1998 and 2001 (Table 12).
4) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
5) Trawl Fishery Logbook CPUE Index: Oregon and California lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1978-1997 (Table 22).

As for the northern model, the NMFS Trawl Survey Biomass and Trawl Fishery Logbook CPUE Index likelihood components for the southern model were fit under a lognormal error structure (Hilborn et al. 2000, section 1.4.2), and the fishery and survey catch-at-age and catch-at-length likelihood components were fit assuming a robust lognormal for proportions (Hilborn et al. 2000, section 1.4.1). In addition to the likelihood components listed above, a likelihood penalty component was included which corresponded to prior assumptions about recruitment variability (Hilborn et al. 2000, section 1.4.3).

Base Model Configuration

The southern (LCS) model was configured in a manner very similar to the northern (LCN) model. The LCS base model assumed a Beverton-Holt stock-recruitment relationship with lognormal error structure (with a steepness parameter h = 0.9 and CV = 1.0) to constrain wide variations in recruitment (Hilborn et al. 2000, section 1.2.3). Selectivity for the commercial and recreational fisheries and the NMFS survey was parameterized by a curve formed from two normal distributions (Hilborn et al. 2000, section 1.2.6). Three parameters are used in this formulation: 1) an age where selectivity = 1.0 (Full), 2) a standard deviation on the left side to describe ascending selectivity (Left), and 3) a standard deviation on the right side to describe descending selectivity (Right). The model did not incorporate an explicit treatment of discards. Base model inputs including priors, likelihood specifications, and fixed parameter values are tabulated in Appendix I, Tables 4 and 5.

Model Selection and Evaluation

Model selection was conducted beginning essentially with the STAR Panel approved formulation from the previous assessment (Jagielo et al. 2000) and proceeded using a procedure where alternate models were evaluated for model fit to the data (using the Akaike Information Criterion (AIC) (Akaike 1972)), and plausibility.

The base LCS model described herein employs one-period (time invariant) commercial and recreational fishery selectivity with estimation of left and right side portions of the selectivity curve. Compared to the northern (LCN) model, available data for the southern area are sparse. For the NMFS survey data, it was necessary to hold the age of full selectivity as well as left and right side selectivity parameters fixed to obtain stable model results. A summary of negative log likelihood values, and both estimated and fixed model parameters of the LCS base model is provided in Appendix I, Table 6.

Base-Run Results

Base run (dome shaped fishery selectivity) model results are presented in Appendix I, Tables 4-6 and Appendix I, Figures 12a-16. The Coleraine estimate of B_0 for the southern area is 23267 mt. The estimate of female spawning biomass for 2003 is 3806 mt. It should be noted that the Coleraine estimate of depletion (0.16) can differ from the estimate obtained from the rebuilding analysis (0.17)(Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Uncertainty and Sensitivity Analyses

Coleraine estimates of the standard deviation of all model parameters (dome shaped fishery selectivity) is provided in Table 6a1.

The results of model profiling over selected fixed values used in the assessment are included in Appendix I, Tables 6a-6e.

A series of base model runs were conducted to examine the effect of different values of the historical exploitation rate (U_{init}) (Appendix I Table 6a). This parameter, which is assumed at a fixed value of 0.07 in the model, is used to estimate the initial age composition of the model in 1973. The profile over U_{init} ranged from 0.03 to 0.10. The value of 0.07 was selected for the final base model, because it was used in the previous assessment, and is consistent with the observed landings prior to 1973.

The base model was also profiled over different fixed values of natural mortality (M) (Appendix I Table 6b). The profile over M ranged from 0.14-0.22 for females, and 0.26-0.38 for males. The values of 0.18 (females) and 0.32 (males), as used in previous assessments, were chosen for use in the 2003 final base model.

An additional series of model runs were conducted where the effect of different fixed values of the Beverton-Holt stock-recruitment steepness parameter (*h*) were evaluated (Appendix I Table 6c). This parameter was set at the fixed value of 0.9 in the model. The profile over *h* ranged from 0.5 to 0.9.

Base model profiles were also conducted using different combinations of the Beverton-Holt stock-recruitment steepness parameter (*h*) and natural mortality (M) (Table 6d), and different combinations of assumed asymptotic and dome shaped fishery selectivity (Table 6e).

An historic analysis was conducted by plotting the estimates of spawning biomass from the previous assessment (Jagielo et al, 2000) with the estimates of spawning biomass from the present assessment (Appendix I, Figure 17). Both assessments showed a declining trend over the time series and fairly close agreement in recent years; however, the present assessment shows a decline from substantially higher spawning stock size estimates early in the time series.

Coastwide Summary

Target Fishing Mortality Rates and Harvest Projections

As an overfished species with a rebuilding plan, target fishing mortality rates for lingcod are a function of alternative rebuilding trajectories, and are also constrained by the ABC rule. Six rebuilding analysis projections were produced using separate sets of information derived from the present stock assessment (Appendix II). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. For both the asymptotic and domed fishery selectivity models, target fishing mortality and yield was constrained by the ABC rule. F_{45}% fishing mortality rates were 0.12 for the north, and 0.18 for the south (Appendix II, Table 1). Coastwide rebuilding yields for 2004-2008 (under the model assumption of asymptotic fishery selectivity) range from 1820 to 2053 mt. Coastwide rebuilding yields under the model assumption of dome shaped fishery selectivity range from 2041 to 2123 mt (Appendix II, Table 2).

Recommendations: Research and Data Needs

1) Emphasis should be placed on improving fishery age structure sampling size and geographical coverage in both regions.

2) More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment. Surveys of areas inaccessible to trawl survey gear should be conducted to address the issue of the habitat bias of trawl surveys.

3) In the southern region, CPFV observer project CPUE data should be analyzed (on a reef-specific basis) using a General Linear Model (GLM) analysis, and evaluated for use as an index of abundance.

4) Coastwide enumeration of at-sea discards (e.g. by an on-board observer program) is needed to properly account for total fishery mortality.

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Table 1. History of PFMC lingcod Acceptable Biological catches (ABC's), Harvest guidelines or Optimum yields (OT's) and landings. Source:PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information.

	US Vancouver	Columbia	US Vancouver-Columbia		Eureka	Monterey	Conception	Eureka-Monterey-Conception		Coastwide		
Year	ABC	ABC	ABC	Landings	ABC	ABC	ABC	ABC	Landings	ABC	HG or OY	Harvest
1983	1,000	4,000	5,000	3,155	500	1,100	400	2,000	1,691	7,000		4,971
1984	1,000	4,000	5,000	3,163	500	1,100	400	2,000	1,555	7,000		4,719
1985	1,000	4,000	5,000	3,215	500	1,100	400	2,000	1,726	7,000		4,945
1986	1,000	4,000	5,000	1,396	500	1,100	400	2,000	1,517	7,000		2,934
1987	1,000	4,000	5,000	1,724	500	1,100	400	2,000	1,922	7,000		3,667
1988	1,000	4,000	5,000	1,763	500	1,100	400	2,000	2,044	7,000		3,930
1989	1,000	4,000	5,000	2,373	500	1,100	400	2,000	2,316	7,000		4,705
1990	1,000	4,000	5,000	1,868	500	1,100	400	2,000	1,966	7,000		3,845
1991	1,000	4,000	5,000	2,437	500	1,100	400	2,000	1,647	7,000		4,095
1992	1,000	4,000	5,000	1,391	500	1,100	400	2,000	1,467	7,000		2,870
1993	1,000	4,000	5,000	1,659	500	1,100	400	2,000	1,374	7,000		2,907
1994	1,000	4,000	5,000	1,449	500	1,100	400	2,000	1,091	7,000	4,000	2,424
1995			1,300	971	300	700	100	1,100	1,067	2,400	2,400	1,882
1996			1,300	1,120	300	700	100	1,100	937	2,400	2,400	2,070
1997			1,300	1,049	300	700	100	1,100	912	2,400	2,400	1,981
1998			1,021	225	139	325	46	510	496	1,532	838	707
1999			450	262	139	325	46	510	545	960	730	831
2000			450					250		700	378	446
2001			610					510		1,120	611	445
2002										745	577	873
2003										841	651	

Table 2. History of lingcod commercial trawl trip limits (thousand lbs) Source:PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information. Note: Exception to commercial size limits: starting in 1996, trawl gear was allowed retention of 100 lb. at size less than minimum size limit.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
< 1995	No trip limit regulations											
1995	20	20	20	20	20	20	20	20	20	20	20	20
1996	40		40		40		40		40		40	
1997	40		40		40		40		40		40	
1998	1		1		1		1		1		1	
1999	1.5			1.5			1			0.5	0.5	0.5
2000	Prohibited				0.4	0.4	0.4	0.4	0.4	0.4	Prohibited	
2001	Prohibited				0.4	0.4	0.4	0.4	0.4	0.5	Prohibited	
2002 1/	0.8		0.8		1		1		0.5	0.5	0.5	0.5
2003	0.8		0.8		1		1		0.8		0.8	

Prohibited Periods
Commercial size limit 0f 22" `1995-1997 then 24" thereafter
Gear restrictions for rockfish retention beginning in 2001
1/ South of 40^0 10' lingcod prohibited beginning July 1st

Table 3. History of lingcod size limits (inches) and recreational bag limits (number of fish): Source: PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information.

State	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
				Daily Bag Limits						
Washington	3	3	3	3	3	2	2	2	2	2
Oregon	3	3	3	3	3	2	2	2	2	2
California	5	5	5	5	5	2	2	2	2	2
				Size Limits (inches)						
Washington	none	22	22	22	24	24	24	24	24	24
Oregon	none	22	22	22	24	24	24	24	24	24
California [1/]	none	22	22	22	24	24	26	26	22	22

[1/] Beginning in 2000; South of 34^0 27' N. Lat lingcod prohibited January-February and South of Cape Mendencino and north of 34^0 27' N. Lat lingcod prohibited March-June

Table 4. Estimated commercial lingcod catch (mt) for California (1916-1955), Oregon (1950-1953) and Washington ()1935-1955).

Historical Commercial lingcod landings

Year	California [1/] Total (mt)	Oregon 2[/] Total (mt)	Washington [3/] Total (mt)
1916	280		
1917	422		
1918	415		
1919	482		
1920	312		
1921	193		
1922	258		
1923	212		
1924	182		
1925	310		
1926	295		
1927	252		
1928	387		
1929	529		
1930	584		
1931	558		
1932	408		
1933	494		
1934	389		
1935	462		0
1936	344		0
1937	439		1
1938	293		0
1939	262		0
1940	314		10
1941	240		51
1942	143		41
1943	326		162
1944	338		523
1945	344		237
1946	524		229
1947	880		65
1948	933		132
1949	751		109
1950	869	312	92
1951	758	379	106
1952	620	224	93
1953	432	139	40
1954	430		66
1955	438		63
	428	264	106

[1/] Leet et al. 1992. California's living marine resources and their utilization
[1/] Forrester, 1973.
[2/] "Fisheries Statistics for Oregon 1950-1953" author Harrison S. Smith
[3/] Anonymous, 1955 WDF Commercial Fishing Statistical Report.

Table 5. Estimated commercial and recreational lingcod catch (mt) for northern (1916-1955) and southern areas (Eureka, Monterey and Conception), 1956 to 2002.

	Northern Area			Southern Area			
	U.S. Vancouver - Columbia			Eureka-Monterey-Conception			Coastwide
Year	Commercial	Recreation	Total (mt)	Commercial	Recreation	Total (mt)	Total (mt)
1956	920		920	422	113	536	1,455
1957	1,000		1,000	744	114	858	1,858
1958	1,133		1,133	726	120	845	1,979
1959	1,863		1,863	638	94	732	2,594
1960	2,028		2,028	593	85	678	2,706
1961	1,875		1,875	653	70	724	2,599
1962	1,323		1,323	504	76	581	1,904
1963	938		938	514	83	597	1,534
1964	1,257		1,257	379	76	455	1,712
1965	1,538		1,538	369	100	469	2,006
1966	1,813		1,813	363	134	497	2,311
1967	1,244		1,244	426	131	557	1,800
1968	1,626		1,626	496	128	624	2,250
1969	1,148		1,148	505	98	603	1,751
1970	851		851	695		695	1,546
1971	1,009		1,009	952		952	1,961
1972	952		952	1,472		1,472	2,425
1973	1,326	76	1,402	1,615	403	2,018	3,420
1974	1,549	76	1,625	1,735	399	2,134	3,759
1975	2,019	85	2,104	1,447	429	1,876	3,981
1976	1,662	69	1,731	1,415	422	1,837	3,56[illegible]
1977	1,671	76	1,747	769	284	1,053	2,79[illegible]
1978	1,346	70	1,416	914	334	1,248	2,66[illegible]
1979	2,211	82	2,292	1,434	340	1,774	4,06[illegible]
1980	2,004	93	2,097	1,275	2,226	3,501	5,59[illegible]
1981	1,907	128	2,035	1,397	1,169	2,566	4,60[illegible]
1982	2,241	128	2,369	1,598	877	2,475	4,84[illegible]
1983	3,069	114	3,183	1,218	586	1,804	4,98[illegible]
1984	3,008	156	3,163	1,047	509	1,555	4,71[illegible]
1985	3,127	90	3,217	752	974	1,726	4,94[illegible]
1986	1,311	95	1,405	601	928	1,529	2,93[illegible]
1987	1,623	111	1,735	980	950	1,930	3,66[illegible]
1988	1,655	115	1,769	1,118	1,036	2,154	3,92[illegible]
1989	2,230	146	2,376	1,356	964	2,320	4,697
1990	1,746	123	1,869	1,187	781	1,968	3,837
1991	2,320	119	2,438	844	803	1,647	4,085
1992	1,207	185	1,392	676	792	1,468	2,860
1993	1,429	231	1,660	779	457	1,236	2,896
1994	1,215	236	1,451	691	270	962	2,412
1995	861	113	974	610	287	897	1,871
1996	1,004	121	1,125	559	376	935	2,060
1997	932	117	1,049	636	281	917	1,965
1998	152	73	225	198	267	465	690
1999	168	96	264	190	360	550	813
2000	71	80	150	71	206	277	427
2001	67	91	158	88	178	266	425
2002	94	127	221	108	524	632	852
Average Catch							
1960's	1,479		1,479	480	98	578	2,057
1970's	1,459	76	1,513	1,245	373	1,506	3,019
1980's	2,218	117	2,335	1,134	1,022	2,156	4,491
1990-1997	1,339	156	1,495	748	506	1,254	2,748
1998-2000	110	93	204	131	307	438	642

Table 6. Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

U.S Vancouver INPFC Area - lingcod landings in metric tons

Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	65.3	0.0	26.6	0.0	53.5	368.8	1.3	515.5
1982	67.6	0.0	76.6	0.4	115.3	336.5	0.2	596.6
1983	36.6	0.0	119.7	0.0	201.3	820.4	18.4	1196.4
1984	63.9	0.0	131.3	3.0	201.5	1346.5	2.1	1748.3
1985	100.2	0.0	247.2	0.5	178.0	1326.2	1.5	1853.6
1986	50.3	0.0	0.0	0.0	70.8	447.8	6.1	575.0
1987	94.5	0.0	0.2	0.0	43.6	589.2	4.3	731.8
1988	69.0	0.0	0.2	0.0	74.9	478.0	0.4	622.5
1989	91.2	0.0	0.1	0.0	119.1	789.2	0.2	999.8
1990	139.9	0.0	0.0	0.0	85.0	762.4	0.5	987.8
1991	80.9	0.0	0.0	0.0	26.0	1345.2	0.3	1452.4
1992	54.6	0.0	0.0	0.0	31.4	469.6	0.1	555.7
1993	35.9	0.0	0.0	0.0	20.3	595.0	0.8	652.0
1994	34.8	0.0	0.0	0.0	21.2	472.7	1.4	530.1
1995	21.3	0.0	0.0	0.0	8.8	260.0	2.8	292.9
1996	35.2	0.0	0.0	0.0	5.8	319.5	4.7	365.2
1997	35.5	0.0	0.0	0.0	12.1	253.2	0.2	301.0
1998	8.4	0.0	0.0	0.0	2.2	39.3	0.0	49.9
1999	15.1	0.0	0.0	0.0	1.8	29.9	0.1	46.9
2000	10.5	0.0	0.0	0.0	3.3	8.1	0.0	21.9
2001	12.4	0.0	0.0	0.0	1.7	11.0	0.1	25.2
2002	10.4	0.0	0.0	0.0	1.9	29.9	0.0	42.2

Columbia INPFC Area - lingcod landings in metric tons

Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	27.2	0.8	45.5	3.5	29.2	1208.4	76.8	1391.4
1982	47.8	0.0	0.2	3.2	24.3	1497.9	71.0	1644.4
1983	37.0	0.2	10.8	2.1	31.5	1706.9	84.4	1872.9
1984	34.7	0.2	3.0	0.8	17.4	1154.2	49.1	1259.4
1985	53.8	0.0	0.0	1.4	43.3	1129.9	44.8	1273.2
1986	52.9	0.0	0.0	0.6	43.8	554.5	83.9	735.7
1987	80.7	0.1	0.0	0.7	20.3	715.8	73.9	891.5
1988	75.8	0.0	0.0	0.7	19.2	903.2	33.2	1032.1
1989	99.5	0.0	0.0	0.2	28.8	1053.8	48.2	1230.5
1990	62.4	0.0	0.0	0.1	11.6	662.5	21.7	758.3
1991	32.1	0.0	0.0	0.4	4.1	813.5	17.1	867.2
1992	55.1	0.0	0.0	0.1	8.8	571.8	15.3	651.1
1993	59.0	0.3	0.0	0.3	12.3	678.8	26.6	777.3
1994	102.4	0.0	0.0	1.0	5.8	534.5	41.5	685.2
1995	39.3	0.0	0.0	0.3	4.4	482.6	41.1	567.7
1996	48.4	0.0	0.0	0.2	5.9	555.1	28.7	638.3
1997	58.0	0.0	0.0	0.5	9.0	544.9	18.4	630.8
1998	10.7	0.0	0.0	0.3	3.0	81.3	7.1	102.4
1999	12.0	0.0	0.0	0.2	4.8	75.6	28.1	120.7
2000	7.1	0.0	0.0	0.1	6.1	20.8	14.7	48.8
2001	10.8	0.0	0.0	1.4	5.0	18.1	6.5	41.8
2002	8.4	0.0	0.0	0.9	2.9	33.4	6.2	51.8

Table 6 (continued). Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

Eureka INPFC Area - lingcod landings in metric tons

Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	13.6	0.5	0.0	0.0	8.3	349.2	8.8	380.4
1982	15.2	2.4	0.0	0.4	12.9	510.9	12.8	554.6
1983	26.1	16.0	0.0	1.3	2.4	363.8	0.2	409.8
1984	5.2	15.4	0.0	0.2	3.4	262.8	1.0	288.0
1985	41.8	9.0	0.1	0.9	1.2	183.4	1.6	238.0
1986	81.6	16.7	0.0	1.8	8.5	95.1	3.5	207.2
1987	104.0	11.7	0.0	0.3	0.5	203.9	1.1	321.5
1988	106.8	22.1	0.0	0.3	0.3	179.7	3.1	312.3
1989	175.4	18.9	0.0	1.5	1.1	188.6	3.7	389.2
1990	173.6	8.8	0.0	0.3	4.1	231.6	3.4	421.8
1991	65.5	1.3	0.0	0.0	0.0	139.9	5.9	212.6
1992	59.3	1.8	0.0	0.1	0.0	105.0	3.7	169.9
1993	40.6	1.0	0.2	0.1	0.3	153.3	1.8	197.3
1994	53.8	0.7	0.3	0.2	0.2	160.3	12.5	228.0
1995	90.8	1.5	0.7	0.2	0.2	132.9	5.8	232.1
1996	73.9	0.0	0.0	0.2	2.8	118.0	8.5	203.4
1997	109.1	0.0	0.1	0.2	0.1	149.4	5.1	264.0
1998	40.4	0.2	0.0	0.2	0.6	56.8	1.0	99.2
1999	43.2	0.2	0.0	0.3	1.1	56.6	3.8	105.2
2000	21.7	0.0	0.0	0.4	0.3	19.6	0.5	42.5
2001	32.5	0.0	0.0	0.3	0.2	19.7	0.3	53.0
2002	38.3	0.0	0.0	1.1	0.1	23.5	0.1	63.1

Monterey INPFC Area - lingcod landings in metric tons

Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	38.2	5.4	8.8	2.7	21.2	771.5	0.3	848.1
1982	22.2	16.1	49.5	1.3	14.9	737.1	0.0	841.1
1983	10.0	85.6	80.8	0.5	1.7	580.9	0.2	759.7
1984	3.4	160.0	25.6	0.0	1.0	547.3	0.0	737.3
1985	15.3	158.8	90.0	1.6	3.7	220.0	0.0	489.4
1986	52.5	91.7	90.9	2.1	0.7	128.3	0.0	366.2
1987	66.1	73.0	159.0	0.9	1.1	315.7	0.1	615.9
1988	99.1	63.5	274.4	2.8	1.4	299.3	0.0	740.5
1989	197.5	70.9	215.4	2.2	0.4	415.7	0.0	902.1
1990	153.6	48.8	176.0	1.1	8.9	318.7	0.0	707.1
1991	131.0	23.4	103.1	0.9	0.7	299.7	0.0	558.8
1992	128.4	35.2	85.5	0.7	1.0	190.6	0.0	441.4
1993	110.1	3.0	106.0	0.3	2.6	277.5	0.1	499.6
1994	84.1	3.1	72.1	0.3	12.4	224.4	0.5	396.9
1995	73.8	1.2	48.9	0.9	8.9	184.9	0.4	319.0
1996	93.1	0.5	7.6	1.2	4.8	205.6	0.9	313.7
1997	89.8	0.1	27.4	2.0	1.9	218.8	0.9	340.9
1998	30.4	0.1	3.7	8.9	0.4	35.9	0.3	79.7
1999	24.4	0.1	0.8	1.6	0.6	42.3	0.2	70.0
2000	10.3	0.0	3.3	0.2	0.4	10.7	0.2	25.1
2001	14.8	0.0	0.4	0.6	1.2	9.9	0.0	26.9
2002	18.3	0.1	0.0	0.2	0.7	15.4	0.1	34.8

Table 6 (continued). Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

Conception INPFC Area - lingcod landings in metric tons							Shrimp	
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Trawl	Total
1981	5.3	0.1	10.4	0.5	1.4	149.2	1.7	168.6
1982	4.4	0.1	27.5	0.1	0.2	161.4	8.4	202.1
1983	0.9	0.5	4.8	0.0	0.1	41.9	0.3	48.5
1984	0.6	0.9	3.3	0.0	0.0	13.1	3.4	21.3
1985	1.1	3.2	9.6	0.0	0.0	10.6	0.3	24.8
1986	2.8	2.3	13.8	0.2	0.3	8.2	0.0	27.6
1987	6.2	3.3	17.1	0.2	0.7	14.9	0.0	42.4
1988	4.8	3.7	39.3	0.0	0.0	17.3	0.0	65.1
1989	4.3	4.3	34.4	0.5	0.0	21.5	0.0	65.0
1990	5.5	3.2	25.3	0.2	0.0	23.7	0.0	57.9
1991	11.0	2.9	43.8	0.1	0.0	14.7	0.0	72.5
1992	20.4	3.2	25.3	0.2	0.0	15.8	0.0	64.9
1993	24.8	2.6	44.1	0.1	0.0	10.0	0.0	81.6
1994	18.4	0.6	21.6	1.5	0.2	21.3	2.6	66.2
1995	27.8	0.4	8.1	3.1	0.2	17.0	2.2	58.8
1996	24.1	0.6	4.8	6.7	0.2	5.1	0.6	42.1
1997	17.4	0.0	2.4	5.2	0.1	5.1	0.4	30.6
1998	10.2	0.0	1.4	2.9	0.1	3.4	0.8	18.8
1999	10.3	0.0	0.4	2.1	0.0	1.5	0.2	14.5
2000	2.9	0.0	0.0	0.6	0.0	0.1	0.1	3.7
2001	5.8	0.0	0.3	1.2	0.0	0.8	0.1	8.2
2002	8.4	0.0	0.1	1.4	0.1	0.1	0.0	10.1

Table 6a. Estimates of lingcod discard, live and dead, in the recreational fishery by State.

MRFSS estimates of % lingcod catch (#'s of fish) that was discarded dead (B1 catches)

YEAR	SOUTHERN CALIFORNIA	NORTHERN CALIFORNIA	OREGON	WASHINGTON	ALL SUBREGIONS
1980	2%	36%	37%	40%	21%
1981	11%	23%	18%	140%	31%
1982	12%	10%	14%	126%	23%
1983	13%	7%	43%	57%	19%
1984	8%	6%	7%	33%	8%
1985	18%	6%	8%	45%	10%
1986	5%	12%	17%	150%	13%
1987	25%	16%	18%	106%	23%
1988	60%	44%	3%	1100%	45%
1989	5%	24%	2%	100%	17%
1993	50%	12%	na	na	9%
1994	13%	6%	na	na	3%
1995	14%	6%	na	na	4%
1996	0%	12%	na	na	8%
1997	0%	1%	na	na	1%
1998	0%	9%	na	na	6%
1999	0%	7%	na	na	5%
2000	0%	10%	na	na	6%
2001	0%	14%	na	na	7%
2002	20%	5%	na	na	14%
2003	0%	0%	na	na	7%

MRFSS estimates of % lingcod catch (#'s of fish) that was discarded live (B2 catches)

YEAR	SOUTHERN CALIFORNIA	NORTHERN CALIFORNIA	OREGON	WASHINGTON	SUBREGIONS
1980	6%	4%	0%	0%	5%
1981	35%	7%	4%	37%	12%
1982	16%	14%	6%	23%	12%
1983	31%	12%	17%	10%	14%
1984	27%	13%	0%	22%	13%
1985	59%	10%	0%	9%	16%
1986	162%	35%	0%	0%	59%
1987	107%	38%	2%	29%	46%
1988	122%	39%	3%	0%	52%
1989	70%	39%	2%	0%	38%
1993	117%	57%	57%	na	52%
1994	88%	61%	41%	na	45%
1995	157%	65%	58%	na	60%
1996	400%	46%	83%	na	68%
1997	75%	78%	477%	na	163%
1998	250%	81%	767%	na	220%
1999	378%	73%	76%	na	89%
2000	1867%	428%	253%	na	397%
2001	1733%	590%	147%	na	514%
2002	1224%	271%	95%	57%	374%
2003	3100%	167%	200%		387%

Note: the 2002 Washington estimate is derived from data collected by WDFW.

Table 7. Commercial fishery lingcod age composition used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Com	1979	694	0.000	0.003	0.004	0.015	0.031	0.052	0.094	0.207	0.236	0.145	0.050	0.018	0.017	0.017	0.030	0.031	0.006	0.000	0.000	0.000
Com	1980	1853	0.000	0.004	0.019	0.029	0.051	0.113	0.120	0.128	0.134	0.087	0.049	0.038	0.025	0.015	0.015	0.008	0.006	0.002	0.000	0.001
Com	1981	1325	0.000	0.007	0.053	0.070	0.067	0.059	0.073	0.073	0.085	0.119	0.050	0.013	0.012	0.006	0.009	0.000	0.000	0.000	0.000	0.000
Com	1982	469	0.000	0.013	0.039	0.093	0.124	0.160	0.136	0.067	0.037	0.052	0.054	0.010	0.030	0.000	0.009	0.009	0.000	0.001	0.000	0.000
Com	1983	443	0.000	0.019	0.110	0.137	0.161	0.085	0.052	0.044	0.021	0.018	0.037	0.039	0.020	0.014	0.011	0.008	0.014	0.005	0.003	0.003
Com	1984	339	0.000	0.000	0.036	0.121	0.206	0.196	0.080	0.048	0.022	0.016	0.010	0.018	0.013	0.001	0.001	0.001	0.001	0.000	0.000	0.000
Com	1985	312	0.000	0.000	0.002	0.040	0.101	0.235	0.285	0.078	0.077	0.040	0.016	0.009	0.016	0.000	0.008	0.000	0.000	0.000	0.000	0.000
Com	1986	663	0.000	0.003	0.026	0.069	0.106	0.147	0.160	0.156	0.084	0.054	0.043	0.018	0.006	0.012	0.018	0.004	0.005	0.006	0.000	0.000
Com	1987	741	0.000	0.008	0.046	0.085	0.127	0.172	0.137	0.104	0.102	0.041	0.015	0.005	0.001	0.003	0.001	0.003	0.004	0.000	0.001	0.000
Com	1988	821	0.000	0.031	0.144	0.064	0.097	0.101	0.079	0.094	0.058	0.045	0.022	0.013	0.007	0.000	0.000	0.000	0.000	0.005	0.003	0.000
Com	1989	786	0.000	0.004	0.120	0.309	0.161	0.075	0.048	0.024	0.022	0.017	0.008	0.000	0.008	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Com	1990	887	0.000	0.013	0.041	0.179	0.167	0.088	0.072	0.049	0.032	0.021	0.036	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1991	999	0.000	0.034	0.082	0.119	0.199	0.157	0.099	0.057	0.032	0.028	0.011	0.013	0.006	0.000	0.007	0.000	0.001	0.002	0.000	0.000
Com	1992	1140	0.000	0.175	0.142	0.119	0.085	0.071	0.083	0.042	0.026	0.010	0.015	0.009	0.000	0.004	0.008	0.001	0.000	0.000	0.000	0.000
Com	1993	1022	0.000	0.116	0.173	0.100	0.102	0.071	0.135	0.032	0.010	0.073	0.004	0.015	0.006	0.002	0.005	0.000	0.001	0.000	0.000	0.000
Com	1994	1034	0.000	0.107	0.308	0.194	0.095	0.039	0.019	0.025	0.011	0.006	0.002	0.003	0.001	0.001	0.004	0.000	0.000	0.000	0.000	0.000
Com	1995	1093	0.000	0.021	0.187	0.347	0.144	0.055	0.018	0.004	0.007	0.003	0.003	0.002	0.000	0.000	0.001	0.006	0.000	0.000	0.000	0.000
Com	1996	820	0.000	0.058	0.124	0.266	0.276	0.058	0.043	0.027	0.012	0.008	0.008	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000
Com	1997	673	0.000	0.028	0.165	0.200	0.159	0.135	0.041	0.032	0.020	0.033	0.024	0.001	0.002	0.003	0.008	0.002	0.000	0.002	0.000	0.000
Com	1998	706	0.000	0.023	0.224	0.269	0.155	0.081	0.041	0.018	0.007	0.004	0.001	0.001	0.003	0.000	0.001	0.000	0.001	0.000	0.000	0.000
Com	1999	750	0.000	0.011	0.087	0.247	0.223	0.105	0.064	0.049	0.027	0.007	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	310	0.000	0.003	0.057	0.136	0.273	0.147	0.064	0.035	0.030	0.015	0.004	0.009	0.005	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Com	2001	548	0.000	0.031	0.079	0.151	0.142	0.155	0.099	0.027	0.026	0.015	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	694	0.000	0.021	0.135	0.138	0.098	0.091	0.060	0.050	0.022	0.026	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Com	1979	694	0.000	0.001	0.003	0.005	0.018	0.007	0.008	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1980	1853	0.000	0.000	0.009	0.014	0.031	0.053	0.018	0.016	0.009	0.001	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1981	1325	0.000	0.001	0.010	0.045	0.048	0.060	0.064	0.050	0.020	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1982	469	0.000	0.004	0.013	0.016	0.044	0.025	0.032	0.019	0.010	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1983	443	0.000	0.005	0.034	0.061	0.077	0.015	0.002	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1984	339	0.000	0.000	0.003	0.030	0.034	0.094	0.052	0.003	0.006	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1985	312	0.000	0.000	0.000	0.016	0.015	0.015	0.044	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1986	663	0.000	0.005	0.005	0.013	0.019	0.025	0.004	0.006	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1987	741	0.000	0.007	0.020	0.008	0.044	0.033	0.023	0.006	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1988	821	0.000	0.020	0.050	0.050	0.033	0.008	0.005	0.004	0.004	0.030	0.008	0.016	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000
Com	1989	786	0.000	0.001	0.066	0.076	0.024	0.019	0.010	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1990	887	0.000	0.006	0.041	0.106	0.066	0.026	0.026	0.004	0.013	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1991	999	0.000	0.027	0.018	0.032	0.029	0.018	0.015	0.008	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1992	1140	0.000	0.074	0.072	0.017	0.013	0.014	0.005	0.008	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	1022	0.000	0.050	0.051	0.040	0.006	0.002	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	1034	0.000	0.024	0.091	0.047	0.013	0.002	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	1093	0.000	0.009	0.052	0.107	0.028	0.002	0.002	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	820	0.000	0.011	0.038	0.025	0.018	0.011	0.000	0.003	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	673	0.000	0.014	0.068	0.022	0.023	0.011	0.006	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	706	0.000	0.005	0.064	0.045	0.018	0.019	0.013	0.003	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1999	750	0.000	0.005	0.032	0.046	0.041	0.015	0.021	0.007	0.004	0.003	0.002	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Com	2000	310	0.000	0.000	0.013	0.023	0.107	0.054	0.010	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	548	0.000	0.014	0.015	0.069	0.062	0.048	0.028	0.017	0.011	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	694	0.000	0.031	0.069	0.069	0.062	0.018	0.044	0.015	0.015	0.013	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8. Recreational fishery lingcod age composition used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			Female Proportion-at-age																			
Rec	1980	226	0.000	0.004	0.022	0.022	0.018	0.031	0.049	0.009	0.013	0.013	0.009	0.000	0.004	0.013	0.004	0.000	0.000	0.000	0.000	0.000
Rec	1986	341	0.000	0.003	0.015	0.056	0.062	0.053	0.062	0.062	0.050	0.032	0.026	0.018	0.012	0.009	0.009	0.003	0.006	0.006	0.003	0.000
Rec	1987	274	0.000	0.018	0.018	0.062	0.077	0.036	0.033	0.036	0.018	0.015	0.004	0.000	0.007	0.004	0.004	0.000	0.000	0.000	0.000	0.004
Rec	1988	250	0.004	0.044	0.112	0.044	0.024	0.008	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1989	227	0.000	0.013	0.044	0.062	0.040	0.031	0.040	0.013	0.013	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1990	207	0.005	0.019	0.029	0.068	0.063	0.034	0.010	0.000	0.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1991	247	0.000	0.004	0.065	0.040	0.032	0.077	0.057	0.012	0.028	0.012	0.012	0.016	0.012	0.004	0.016	0.008	0.016	0.000	0.000	0.000
Rec	1992	499	0.000	0.048	0.070	0.068	0.048	0.044	0.030	0.024	0.014	0.010	0.004	0.006	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000
Rec	1993	530	0.002	0.049	0.096	0.081	0.049	0.038	0.023	0.015	0.006	0.008	0.002	0.002	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Rec	1994	449	0.000	0.009	0.076	0.114	0.085	0.085	0.024	0.011	0.007	0.009	0.009	0.004	0.011	0.000	0.000	0.002	0.002	0.000	0.000	0.000
Rec	1995	643	0.000	0.005	0.042	0.096	0.106	0.059	0.058	0.019	0.012	0.006	0.005	0.002	0.000	0.002	0.002	0.000	0.002	0.000	0.000	0.000
Rec	1996	461	0.000	0.007	0.098	0.143	0.117	0.069	0.048	0.015	0.013	0.007	0.004	0.002	0.000	0.002	0.004	0.000	0.000	0.000	0.000	0.000
Rec	1997	446	0.000	0.007	0.087	0.108	0.092	0.085	0.029	0.020	0.009	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	416	0.002	0.007	0.067	0.147	0.127	0.079	0.067	0.024	0.019	0.002	0.002	0.007	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1999	609	0.000	0.000	0.053	0.138	0.149	0.085	0.053	0.033	0.011	0.003	0.003	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Rec	2000	610	0.000	0.002	0.036	0.110	0.159	0.098	0.079	0.028	0.011	0.005	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	961	0.000	0.000	0.019	0.087	0.149	0.134	0.083	0.040	0.020	0.011	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	1098	0.000	0.001	0.054	0.160	0.147	0.095	0.074	0.036	0.015	0.015	0.011	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Rec	1980	226	0.000	0.009	0.080	0.146	0.173	0.142	0.137	0.049	0.040	0.009	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1986	341	0.000	0.006	0.053	0.100	0.059	0.041	0.053	0.067	0.044	0.029	0.018	0.021	0.006	0.006	0.006	0.003	0.000	0.003	0.003	0.000
Rec	1987	274	0.000	0.091	0.113	0.109	0.109	0.073	0.073	0.044	0.015	0.015	0.000	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1988	250	0.000	0.216	0.372	0.080	0.056	0.020	0.004	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1989	227	0.000	0.044	0.194	0.220	0.123	0.057	0.035	0.031	0.018	0.009	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1990	207	0.000	0.034	0.135	0.242	0.237	0.072	0.019	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
Rec	1991	247	0.000	0.028	0.113	0.109	0.069	0.126	0.028	0.065	0.012	0.012	0.012	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.000
Rec	1992	499	0.002	0.072	0.166	0.124	0.092	0.080	0.052	0.014	0.012	0.004	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	530	0.000	0.070	0.230	0.138	0.075	0.038	0.025	0.021	0.004	0.013	0.011	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	449	0.002	0.024	0.151	0.156	0.078	0.049	0.029	0.027	0.013	0.004	0.011	0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	643	0.000	0.014	0.082	0.221	0.134	0.075	0.023	0.012	0.011	0.006	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.000
Rec	1996	461	0.000	0.007	0.087	0.111	0.121	0.078	0.028	0.024	0.002	0.002	0.007	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Rec	1997	446	0.000	0.013	0.099	0.173	0.110	0.067	0.056	0.004	0.013	0.007	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	416	0.000	0.010	0.058	0.120	0.127	0.065	0.041	0.022	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1999	609	0.000	0.000	0.048	0.128	0.123	0.087	0.043	0.021	0.010	0.000	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	610	0.000	0.002	0.034	0.077	0.148	0.108	0.054	0.026	0.007	0.003	0.003	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	961	0.000	0.002	0.016	0.083	0.106	0.114	0.058	0.034	0.020	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	1098	0.000	0.000	0.028	0.100	0.118	0.066	0.045	0.020	0.006	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 9. NMFS Trawl Survey and WDFW Cape Flattery survey age composition used in the northern (LCN) model.

Survey	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NMFS	1992	74	0.068	0.149	0.149	0.135	0.014	0.054	0.014	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000
NMFS	1995	208	0.091	0.101	0.207	0.130	0.058	0.043	0.019	0.005	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	367	0.114	0.101	0.120	0.112	0.109	0.090	0.049	0.014	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	563	0.108	0.206	0.121	0.036	0.021	0.027	0.027	0.025	0.016	0.012	0.004	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
NMFS	1992	74	0.054	0.203	0.027	0.027	0.014	0.054	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1995	208	0.043	0.067	0.077	0.058	0.034	0.029	0.014	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
NMFS	1998	367	0.065	0.068	0.084	0.030	0.019	0.005	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	563	0.085	0.171	0.091	0.021	0.005	0.005	0.005	0.004	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-age																			
WDFW	1994	100	0.000	0.000	0.000	0.040	0.150	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1995	281	0.000	0.107	0.053	0.046	0.018	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1996	511	0.022	0.147	0.104	0.051	0.012	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1997	498	0.010	0.197	0.139	0.024	0.010	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
WDFW	1994	100	0.000	0.000	0.000	0.280	0.420	0.080	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1995	281	0.000	0.206	0.185	0.295	0.060	0.014	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1996	511	0.031	0.319	0.225	0.070	0.012	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1997	498	0.014	0.309	0.227	0.046	0.014	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table10. NMFS Trawl Survey and WDFW Cape Flattery survey size composition data (cm) used in the northern (LCN) model.

Survey	Year	Tot. No.Fish	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
			Female Proportion-at-size (cm)																					
NMFS	1986	220	0.000	0.000	0.000	0.001	0.007	0.005	0.014	0.002	0.006	0.010	0.000	0.000	0.000	0.001	0.017	0.000	0.010	0.053	0.011	0.029	0.108	0.010
NMFS	1989	470	0.001	0.000	0.003	0.038	0.019	0.020	0.003	0.000	0.008	0.039	0.006	0.020	0.002	0.002	0.012	0.009	0.026	0.061	0.034	0.061	0.060	0.013
			Male Proportion-at-size (cm)																					
NMFS	1986	220	0.000	0.001	0.000	0.022	0.003	0.009	0.002	0.001	0.000	0.000	0.012	0.001	0.000	0.005	0.006	0.031	0.066	0.022	0.003	0.012	0.028	0.051
NMFS	1989	470	0.020	0.000	0.002	0.003	0.008	0.002	0.001	0.000	0.000	0.025	0.016	0.039	0.004	0.005	0.008	0.012	0.009	0.040	0.043	0.039	0.012	0.003
			Female Proportion-at-size (cm)																					
WDFW	1986	484	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.006	0.004	0.008	0.008	0.010	0.014	0.008	0.025	0.000	0.006	0.002	0.004
WDFW	1987	542	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.022	0.013	0.022	0.006	0.006	0.006	0.011	0.009	0.011	0.011	0.006	0.011	0.004	0.006
WDFW	1988	978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.009	0.015	0.028	0.028	0.021	0.009	0.005	0.005	0.006	0.004	0.000
WDFW	1989	964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.006	0.004	0.001	0.001	0.008	0.012	0.007	0.007	0.016	0.018	0.012	0.010	0.003
WDFW	1990	971	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.020	0.041	0.014	0.014	0.004	0.011	0.028	0.028	0.009	0.007	0.005	0.009	0.007	0.009
WDFW	1991	1017	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.017	0.024	0.010	0.010	0.013	0.025	0.036	0.029	0.013	0.007	0.005	0.011	0.003	0.004
WDFW	1992	1003	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.015	0.027	0.038	0.011	0.008	0.014	0.034	0.024	0.021	0.013	0.017	0.009	0.005	0.003	0.005
WDFW	1993		0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.015	0.024	0.040	0.030	0.012	0.013	0.019	0.025	0.026	0.012	0.005	0.006	0.003	0.003	0.003
			Male Proportion-at-size (cm)																					
WDFW	1986	484	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.029	0.017	0.045	0.056	0.089	0.085	0.066	0.103	0.058	0.074	0.074	0.029	0.029	0.019
WDFW	1987	542	0.000	0.000	0.000	0.000	0.000	0.006	0.020	0.042	0.046	0.031	0.015	0.018	0.054	0.066	0.055	0.089	0.083	0.089	0.057	0.042	0.031	0.028
WDFW	1988	978	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.017	0.045	0.102	0.137	0.131	0.072	0.043	0.049	0.044	0.049	0.040	0.021	0.021
WDFW	1989	964	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.004	0.015	0.017	0.015	0.015	0.032	0.058	0.141	0.150	0.150	0.103	0.054	0.025	0.025	0.022
WDFW	1990	971	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.024	0.037	0.039	0.020	0.019	0.036	0.050	0.044	0.025	0.062	0.080	0.115	0.071	0.051	0.016
WDFW	1991	1017	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.017	0.060	0.052	0.026	0.045	0.085	0.102	0.076	0.043	0.043	0.040	0.033	0.048	0.034	0.033
WDFW	1992	1003	0.000	0.000	0.001	0.000	0.000	0.011	0.028	0.080	0.103	0.060	0.029	0.044	0.074	0.077	0.067	0.039	0.027	0.021	0.022	0.013	0.013	0.012
WDFW	1993		0.000	0.000	0.000	0.000	0.000	0.002	0.027	0.084	0.114	0.107	0.062	0.059	0.069	0.076	0.047	0.032	0.017	0.022	0.014	0.007	0.003	0.003

Survey	Year	Tot. No.Fish	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
			Female Proportion-at-size (cm)																			
NMFS	1986	220	0.012	0.050	0.033	0.096	0.023	0.026	0.013	0.026	0.026	0.012	0.001	0.026	0.000	0.007	0.013	0.000	0.000	0.000	0.000	0.006
NMFS	1989	470	0.027	0.014	0.007	0.015	0.010	0.011	0.017	0.003	0.017	0.006	0.014	0.023	0.005	0.001	0.006	0.002	0.003	0.005	0.000	0.003
			Male Proportion-at-size (cm)																			
NMFS	1986	220	0.022	0.010	0.001	0.012	0.028	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1989	470	0.018	0.052	0.000	0.003	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-size (cm)																			
WDFW	1986	484	0.002	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1987	542	0.007	0.006	0.000	0.002	0.000	0.004	0.000	0.000	0.000	0.002	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1988	978	0.004	0.006	0.005	0.006	0.002	0.003	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
WDFW	1989	964	0.002	0.002	0.002	0.003	0.001	0.003	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001
WDFW	1990	971	0.014	0.012	0.014	0.004	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1991	1017	0.004	0.001	0.001	0.002	0.003	0.001	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1992	1003	0.002	0.003	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1993		0.000	0.002	0.000	0.002	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																			
WDFW	1986	484	0.029	0.019	0.019	0.010	0.010	0.000	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1987	542	0.013	0.015	0.002	0.009	0.002	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1988	978	0.024	0.011	0.007	0.007	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1989	964	0.016	0.017	0.004	0.004	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1990	971	0.009	0.009	0.012	0.004	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1991	1017	0.020	0.005	0.006	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1992	1003	0.011	0.009	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1993		0.002	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11 Commercial and Recreational fishery size composition data (cm) used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
			Female Proportion-at-size (cm)																					
Com	1975	146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.003	0.003	0.007	0.007	0.011	0.021	0.021	0.033
Com	1976	483	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.010	0.019	0.015	0.023	0.023	0.039
Com	1977	262	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.001	0.006	0.000	0.018	0.091	0.041	0.037	0.035	0.014	0.011
			Male Proportion-at-size (cm)																					
Com	1975	146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.003	0.003	0.008	0.011	0.017	0.037	0.053	0.069	0.053
Com	1976	483	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.004	0.004	0.002	0.013	0.010	0.023	0.037	0.043
Com	1977	262	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.022	0.006	0.011	0.028	0.001	0.000	0.000
			Female Proportion-at-size (cm)																					
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000	0.010
Rec	1982	72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.051	0.000	0.000	0.026	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																					
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.020	0.000	0.020	0.082	0.061	0.102	0.071	0.071	0.041	0.071	0.031	0.031	0.133
Rec	1982	72	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.014	0.014	0.000	0.014	0.069	0.069	0.097	0.097	0.111	0.083	0.014	0.069	0.042	0.069
Rec	1983	39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.051	0.000	0.026	0.000	0.000	0.051	0.000	0.128	0.103	0.051	0.128	0.026	0.103	0.000

Fishery	Year	Tot. No.Fish	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
			Female Proportion-at-size (cm)																			
Com	1975	146	0.058	0.075	0.078	0.049	0.038	0.030	0.027	0.017	0.012	0.014	0.017	0.012	0.013	0.011	0.009	0.003	0.005	0.002	0.002	0.003
Com	1976	483	0.042	0.076	0.065	0.083	0.060	0.069	0.047	0.043	0.033	0.016	0.014	0.008	0.025	0.021	0.008	0.004	0.002	0.002	0.004	0.008
Com	1977	262	0.008	0.008	0.011	0.004	0.023	0.053	0.069	0.088	0.038	0.073	0.050	0.042	0.023	0.050	0.073	0.042	0.061	0.061	0.050	0.172
Com	1978	223	0.011	0.025	0.014	0.030	0.002	0.032	0.023	0.025	0.055	0.099	0.037	0.055	0.051	0.032	0.022	0.054	0.023	0.037	0.004	0.017
			Male Proportion-at-size (cm)																			
Com	1975	146	0.052	0.033	0.022	0.016	0.009	0.008	0.002	0.002	0.002	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Com	1976	483	0.039	0.017	0.014	0.012	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1977	262	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.006	0.011	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-size (cm)																			
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.010	0.000	0.000	0.000
Rec	1982	72	0.000	0.000	0.000	0.000	0.014	0.000	0.014	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.000	0.000	0.026	0.051	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																			
Rec	1981	98	0.031	0.031	0.000	0.051	0.031	0.010	0.010	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1982	72	0.014	0.028	0.028	0.000	0.000	0.028	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.026	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 12. Age composition of fisheries and surveys used in the southern (LCS) model.

Fishery	Year	Tot. No.Fish	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			Female Proportion-at-age																			
Com	1992	289	0.000	0.138	0.289	0.091	0.041	0.041	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	787	0.000	0.267	0.301	0.083	0.034	0.012	0.009	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	538	0.000	0.088	0.241	0.135	0.041	0.047	0.017	0.005	0.023	0.001	0.011	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	267	0.000	0.016	0.079	0.261	0.107	0.068	0.033	0.014	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	302	0.000	0.028	0.226	0.138	0.097	0.104	0.019	0.005	0.004	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	728	0.000	0.031	0.173	0.198	0.160	0.053	0.055	0.033	0.009	0.008	0.001	0.001	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	287	0.000	0.053	0.253	0.142	0.055	0.000	0.145	0.073	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	61	0.000	0.000	0.000	0.048	0.286	0.000	0.333	0.095	0.000	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	262	0.000	0.000	0.111	0.250	0.083	0.167	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	249	0.000	0.011	0.055	0.313	0.168	0.127	0.050	0.022	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Com	1992	289	0.000	0.092	0.120	0.079	0.063	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	787	0.000	0.076	0.077	0.064	0.023	0.037	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	538	0.000	0.082	0.147	0.081	0.032	0.024	0.012	0.001	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	267	0.000	0.002	0.101	0.194	0.080	0.027	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	302	0.000	0.038	0.126	0.075	0.056	0.048	0.021	0.009	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	728	0.000	0.036	0.126	0.083	0.000	0.013	0.000	0.000	0.000	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	287	0.000	0.000	0.093	0.036	0.038	0.019	0.019	0.019	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	61	0.000	0.000	0.000	0.048	0.095	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	262	0.000	0.000	0.056	0.083	0.194	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	249	0.000	0.000	0.024	0.037	0.066	0.032	0.033	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-age																			
Rec	1992	49	0.000	0.000	0.020	0.061	0.020	0.082	0.000	0.041	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	294	0.000	0.024	0.156	0.173	0.099	0.065	0.041	0.037	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	196	0.000	0.010	0.107	0.133	0.117	0.082	0.051	0.046	0.015	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	525	0.000	0.006	0.053	0.215	0.114	0.040	0.029	0.013	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1996	545	0.002	0.007	0.110	0.110	0.180	0.101	0.040	0.020	0.013	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1997	212	0.000	0.000	0.052	0.151	0.118	0.085	0.038	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	70	0.000	0.000	0.014	0.114	0.214	0.086	0.100	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	48	0.000	0.000	0.000	0.083	0.125	0.104	0.063	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	396	0.000	0.000	0.000	0.040	0.114	0.149	0.093	0.056	0.043	0.028	0.008	0.005	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	409	0.000	0.000	0.010	0.049	0.144	0.095	0.095	0.059	0.020	0.017	0.005	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Rec	1992	49	0.000	0.082	0.102	0.184	0.122	0.082	0.061	0.082	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	294	0.000	0.020	0.136	0.116	0.054	0.031	0.014	0.007	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	196	0.000	0.010	0.082	0.184	0.082	0.046	0.020	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	525	0.002	0.010	0.091	0.261	0.080	0.055	0.013	0.008	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1996	545	0.000	0.002	0.095	0.088	0.138	0.055	0.022	0.007	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1997	212	0.000	0.000	0.075	0.222	0.123	0.104	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	70	0.000	0.000	0.014	0.129	0.129	0.100	0.057	0.000	0.014	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	48	0.000	0.000	0.000	0.104	0.167	0.146	0.083	0.042	0.042	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	396	0.000	0.000	0.003	0.040	0.111	0.162	0.073	0.040	0.020	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	409	0.000	0.000	0.017	0.071	0.178	0.115	0.081	0.032	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Survey	Year	Tot. No.Fish	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			Female Proportion-at-age																			
NMFS	1995	208	0.260	0.168	0.048	0.034	0.024	0.014	0.005	0.000	0.010	0.005	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	221	0.226	0.231	0.072	0.027	0.032	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	197	0.183	0.274	0.056	0.005	0.036	0.010	0.010	0.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
NMFS	1995	208	0.163	0.178	0.014	0.019	0.014	0.024	0.000	0.010	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	221	0.122	0.149	0.036	0.036	0.018	0.018	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	197	0.157	0.157	0.061	0.005	0.010	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000

Table 13. Lingcod length, weight, and fraction mature at age data used in the northern (LCN) model.

Males						Females					
	Length		Weight		Fraction		Length		Weight		Fraction
Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature	Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature
1	42.0	16.5	0.65	1.4	0.17	1	43.0	16.9	0.62	1.4	0.04
2	48.9	19.3	1.07	2.4	0.37	2	51.6	20.3	1.16	2.6	0.09
3	54.9	21.6	1.54	3.4	0.63	3	59.4	23.4	1.87	4.1	0.21
4	60.0	23.6	2.06	4.5	0.83	4	66.4	26.1	2.73	6.0	0.42
5	64.4	25.4	2.58	5.7	0.93	5	72.7	28.6	3.72	8.2	0.66
6	68.2	26.8	3.11	6.8	0.98	6	78.4	30.9	4.80	10.6	0.84
7	71.5	28.1	3.61	8.0	0.99	7	83.5	32.9	5.95	13.1	0.93
8	74.3	29.2	4.09	9.0	1.00	8	88.1	34.7	7.15	15.8	0.97
9	76.7	30.2	4.54	10.0	1.00	9	92.3	36.3	8.36	18.4	0.99
10	78.8	31.0	4.95	10.9	1.00	10	96.0	37.8	9.57	21.1	1.00
11	80.6	31.7	5.32	11.7	1.00	11	99.4	39.1	10.77	23.7	1.00
12	82.2	32.4	5.66	12.5	1.00	12	102.4	40.3	11.93	26.3	1.00
13	83.5	32.9	5.96	13.1	1.00	13	105.2	41.4	13.05	28.8	1.00
14	84.7	33.3	6.23	13.7	1.00	14	107.7	42.4	14.12	31.1	1.00
15	85.7	33.7	6.46	14.3	1.00	15	109.9	43.3	15.14	33.4	1.00
16	86.5	34.1	6.67	14.7	1.00	16	111.9	44.1	16.10	35.5	1.00
17	87.2	34.3	6.86	15.1	1.00	17	113.7	44.8	17.00	37.5	1.00
18	87.9	34.6	7.02	15.5	1.00	18	115.3	45.4	17.85	39.3	1.00
19	88.4	34.8	7.16	15.8	1.00	19	116.8	46.0	18.63	41.1	1.00
20	88.9	35.0	7.28	16.1	1.00	20	118.1	46.5	19.36	42.7	1.00

Growth Parameters:		Weight Parameters:		Maturity Parameters:		Growth Parameters:		Weight Parameters:		Maturity Parameters:	
Linf	91.816869	a	0.003953	Alpha	1.060	Linf	130.18329	a	0.00176	Alpha	0.994
K	0.149260	b	3.214900	Beta	2.506	K	0.104103	b	3.397800	Beta	4.323
L1	41.999173					L1	42.98222				

Table 14. Lingcod biological parameters used in the northern (LCN) model.

Parameter	Male Estimate	Female Estimate
Growth[1]		
Linf	91.817	130.183
K	0.149	0.104
L1	41.999	42.982
T_0	-3.097	-2.850
n	6274	16884
Length-Weight[2]		
a	0.003953	0.001760
b	3.214900	3.397800
R sq	0.52	0.71
n	5149	12079
Maturity[3]		
Alpha	1.060	0.994
Beta	2.506	4.323
n	15	21
Natural Mortality[4]		
M	0.32	0.18
Fecundity[5]		
a		2.82406E-04
b		3.0011

[1] Growth Model: L = Linf + (L1-Linf) * exp(K * (1-Age))

[2]Length Weight Model: $W = a*L^b$

[3]Maturity Model: P = 1/(1+exp(-Alpha * (Age-Beta)))

[4]Natural Mortality: Data source: Jagielo (1994); derived from an average of values using methods of Hoenig (1983), Alverson and Carney (1975), and Pauly (1980).

Table 15. Intentionally Omitted.

Table 16. Mean length, weight and fraction of lingcod mature at age used in the LCS model. Survey data only were used for ages 1-3. Survey and fishery data were used for ages 4+.

Males						Females					
	Length		Weight		Fraction		Length		Weight		Fraction
Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature	Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature
1	34.3	13.5	0.34	0.7	0.06	1	35.1	13.8	0.31	0.7	0.04
2	43.7	17.2	0.75	1.6	0.18	2	45.6	18.0	0.76	1.7	0.11
3	51.3	20.2	1.25	2.7	0.43	3	54.7	21.5	1.41	3.1	0.29
4	57.4	22.6	1.79	3.9	0.72	4	62.5	24.6	2.23	4.9	0.55
5	62.3	24.5	2.32	5.1	0.90	5	69.3	27.3	3.16	7.0	0.79
6	66.2	26.0	2.82	6.2	0.97	6	75.2	29.6	4.17	9.2	0.92
7	69.3	27.3	3.27	7.2	0.99	7	80.2	31.6	5.20	11.5	0.97
8	71.8	28.2	3.66	8.1	1.00	8	84.6	33.3	6.24	13.7	0.99
9	73.7	29.0	3.99	8.8	1.00	9	88.4	34.8	7.24	16.0	1.00
10	75.3	29.7	4.28	9.4	1.00	10	91.7	36.1	8.20	18.1	1.00
11	76.6	30.2	4.51	10.0	1.00	11	94.6	37.2	9.09	20.0	1.00
12	77.6	30.6	4.71	10.4	1.00	12	97.0	38.2	9.92	21.9	1.00
13	78.4	30.9	4.87	10.7	1.00	13	99.2	39.0	10.68	23.5	1.00
14	79.1	31.1	5.00	11.0	1.00	14	101.0	39.8	11.37	25.1	1.00
15	79.6	31.3	5.11	11.3	1.00	15	102.6	40.4	11.99	26.4	1.00
16	80.0	31.5	5.20	11.5	1.00	16	104.0	40.9	12.55	27.7	1.00
17	80.4	31.6	5.27	11.6	1.00	17	105.2	41.4	13.04	28.8	1.00
18	80.6	31.7	5.32	11.7	1.00	18	106.2	41.8	13.48	29.7	1.00
19	80.8	31.8	5.37	11.8	1.00	19	107.1	42.2	13.87	30.6	1.00
20	81.0	31.9	5.40	11.9	1.00	20	107.9	42.5	14.22	31.3	1.00
Growth Parameters:		Weight Parameters:		Maturity Parameters:		Growth Parameters:		Weight Parameters:		Maturity Parameters:	
Linf	81.693959	a	0.003953	Alpha	1.240	Linf	112.81069	a	0.00176	Alpha	1.129
K	0.223233	b	3.214900	Beta	3.233	K	0.144902	b	3.397800	Beta	3.814
L1	34.252704					L1	35.113463				

Table 17. Lingcod biological parameters used in the southern (LCS) model.

Parameter	Male Estimate	Female Estimate
Growth[1]		
Linf	81.694	112.811
K	0.223	0.145
L1	34.253	35.113
T_0	-1.435	-1.573
n	986	1780
Length-Weight[2]		
a	0.003953	0.001760
b	3.214900	3.397800
R sq	0.52	0.71
n	5149	12079
Maturity[3]		
Alpha	1.240	1.129
Beta	3.233	3.814
R sq	0.989	0.994
Natural Mortality[4]		
M	0.32	0.18
Fecundity[5]		
a		2.82406E-04
b		3.0011

[1] Growth Model: L = Linf + (L1-Linf) * exp(K * (1-Age))

[2] Length Weight Model: $W = a*L^b$

[3] Maturity Model: P = 1/(1+exp(-Alpha * (Age-Beta)))

[4] Natural Mortality: Data source: Jagielo (1994); derived from an average of values using methods of Hoenig (1983), Alverson and Carney (1975), and Pauly (1980).

Table 18. NMFS trawl survey lingcod biomass estimates by INPFC area for combined depth strata. Note: The shallow depth strata was 50-100 fm. in 1977, and 30-100 fm. for all other years.

NMFS Trawl Survey lingcod biomass (mt) estimates for combined depth strata by INPFC

Standard analysis which includes all good perfromance hauls.

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	CV	Columbia +US Vancouver	CV
1977	69	1,800	274	12,648	2,277	2,074	0.32	14,925	0.77
1980		671	431	8,699	1,281	1,102	0.29	9,979	0.65
1983		1,467	494	4,026	1,805	1,962	0.33	5,831	0.15
1986		611	316	1,828	988	926	0.21	2,816	0.12
1989	54	2,107	473	3,649	1,863	2,580	0.20	5,512	0.29
1992	27	484	148	3,071	1,069	632	0.24	4,140	0.49
1995	42	703	179	1,320	552	881	0.28	1,872	0.16
1998	34	651	219	2,002	1,018	871	0.27	3,020	0.26
2001	85	693	654	3,903	1,324	1,347	0.12	5,227	0.27

Including all good perfrmance hauls, but excluding tows identified as "water hauls"

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	CV	Columbia +US Vancouver	CV
1977	74	2,368	624	12,773	2,270	2,993	0.14	15,043	0.77
1980		929	608	3,219	1,361	1,537	0.31	4,580	0.31
1983		1,523	556	4,306	1,962	2,079	0.33	6,268	0.16
1986		611	315	1,860	951	926	0.21	2,812	0.12
1989	54	2,168	540	3,933	1,922	2,708	0.20	5,856	0.30
1992	32	476	154	3,071	1,084	630	0.25	4,155	0.49
1995	46	703	199	1,329	555	901	0.27	1,884	0.16
1998	34	651	219	2,002	1,018	871	0.27	3,020	0.26
2001	85	693	654	3,903	1,324	1,347	0.12	5,227	0.27

Difference in estimated biomass (mt) by including and excluding "water hauls"

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	Columbia +US Vancouver
1977	5	569	350	125	-7	919	118
1980	0	258	177	-5,480	81	435	-5,399
1983	0	55	61	280	157	117	437
1986	0	0	-1	33	-37	-1	-4
1989	1	61	67	284	60	128	344
1992	6	-8	6	0	15	-2	15
1995	3	0	20	9	3	20	12
1998	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0

Table 19. WDFW Cape Flattery tag survey index used in the northern (LCN) assessment. Estimates for the years 1986-1992 were obtained from Jagielo (1995).

Year	Number of Fish	Standard Deviation
1986	119700	18800
1987	208500	31800
1988	165400	19000
1989	149000	13500
1990	123800	10300
1991	114400	9500
1992	127300	11000

Table 20. Number of logbook tows used to develop trawl logbook CPUE indices in southern and northern waters.

Total number of logbook tows by PMFC Area

Year	1A	1B	1C	2A	2B	2C	2C	3A	3B	3C
1976	0	0	0	673	2783	1433	1433	3966	0	0
1977	0	0	0	447	1290	1747	1747	2051	0	0
1978	2048	9495	8702	985	1951	1638	1638	3142	0	0
1979	2472	10552	12756	1764	3007	1981	1981	5583	0	0
1980	2036	8895	7958	1137	1101	1048	1048	4479	0	0
1981	5566	19492	16002	3701	3806	1396	1396	5270	0	0
1982	2412	10345	7970	2845	5267	4503	4503	8446	0	0
1983	1494	9416	7465	2330	5324	1195	1195	4912	0	0
1984	1683	6883	7629	1657	2320	1927	1927	5644	0	0
1985	2699	8366	7142	1140	2784	2928	2928	3606	0	0
1986	2865	9941	5151	770	1432	2053	2053	5520	4338	3816
1987	3030	6630	5070	1415	5016	2765	2765	10821	3520	3287
1988	3182	6847	6209	1456	5117	7490	3751	11027	4607	4077
1989	4338	8000	5777	1431	5232	12348	6183	12492	5711	5352
1990	3622	6483	5601	1504	4786	10598	5319	9211	4491	5759
1991	3296	8931	5197	1736	6713	14917	7504	12067	5630	6460
1992	3393	10158	4210	1487	5468	14288	7190	10485	4936	5905
1993	2450	9936	4205	1827	5674	8702	8702	8491	4797	5711
1994	2662	8995	3940	1531	3888	7176	7176	7130	3674	4951
1995	2721	8688	4986	1372	3699	9378	4696	7205	3825	3230
1996	2697	9568	4968	1424	3320	9388	4699	8199	3605	2643
1997	1867	8000	4763	1717	3550	9194	4603	5706	2072	2271
1998	2673	5792	3776	2184	3228	7516	3759	4236	2066	2262
1999	3403	5258	4064	1637	2712	6026	3014	4341	1809	1841
2000	1702	3692	3278	728	2095	5423	2716	4451	2045	1638
2001	2261	3090	3078	1161	2140	6376	3195	3574	2072	1935
2002	3310	4640	3114	726	1278	4345	2176	3337	2560	1577
	69,882	208,093	153,011	39,665	90,908	154,599	96,117	169,375	61,758	62,715

Table 21. Summary of estimated Delta GLM logbook index results in the northern region, indicating: 1) sample size (# of tows), 2) the percentage of tows with lingcod present (2003 index % positive), and 3) the computed index values used in the 2003 LCN stock assessment model. The logbook index values used in the 2000 assessment are provided for comparison.

Northern Area Trawl Logbook Index

Year	2000 Index Index Value	2003 Index # of Tows	 % Positive	 Index Value
1976		9,615	62%	20.33
1977		6,835	52%	16.16
1978		8,369	54%	10.79
1979		12,552	58%	11.37
1980		7,676	64%	11.32
1981		11,868	63%	13.33
1982		22,719	50%	9.29
1983	335.9	12,626	51%	9.32
1984	218.3	11,818	44%	6.99
1985	296.7	12,246	36%	6.26
1986	271.6	19,212	23%	3.58
1987	287.0	28,174	31%	4.24
1988	218.1	39,808	27%	4.56
1989	201.2	53,483	25%	5.45
1990	201.1	45,443	23%	4.36
1991	157.4	60,704	22%	3.94
1992	153.8	55,370	19%	2.23
1993	102.9	42,077	28%	2.74
1994	157.6	33,995	28%	2.82
1995	40.6	36,715	21%	2.47
1996	127.3	36,543	22%	2.54
1997	123.0	31,987	21%	2.36

Table 22. Summary of estimated Delta GLM logbook index results in the southern region, indicating: 1) sample size (# of tows), 2) the percentage of tows with lingcod present (2003 index % positive), and 3) the computed index values used in the 2003 LCS stock assessment model. The logbook index values used in the 2000 assessment are provided for comparison.

Southern Area Trawl Logbook Index

	2000 Index	2003 Index		
Year	Index Value	# of Tows	% Positive	Index Value
1978	44.51	21,230	34%	5.80
1979	49.23	27,544	47%	11.75
1980	45.79	20,026	47%	9.57
1981	49.65	44,761	46%	7.29
1982	45.62	23,572	47%	7.37
1983	29.16	20,705	43%	8.88
1984	25.46	17,852	39%	7.56
1985	15.53	19,347	31%	3.56
1986	17.41	18,727	24%	3.10
1987	27.25	16,145	33%	5.42
1988	26.32	17,694	31%	5.63
1989	28.99	19,546	32%	7.30
1990	29.97	17,210	28%	6.18
1991	22.27	19,160	31%	3.75
1992	18.58	19,248	27%	3.12
1993	20.51	18,418	28%	3.84
1994	21.56	17,128	25%	3.63
1995	20.35	17,767	25%	3.87
1996	16.65	18,657	26%	3.12
1997	18.81	16,347	28%	3.30

Table 23. Recreational lingcod CPUE for boat-based fisheries using the "indirect" method on RecFIN creel data for northern California, southern California and Oregon. WDFW sport creel data was used to develop the Washington lingcod CPUE index.

Recreational lingcod catch-per-unit-effort (CPUE) for boat-based fisheries

	Southern California [1/]		Northern California [1/]		Oregon [1/]		Washington [2/]
YEAR	CPUE	SE	CPUE	SE	CPUE	SE	CPUE
1980	0.12	0.03	1.02	0.20	0.89	0.15	
1981	0.08	0.02	0.62	0.14	0.78	0.17	
1982			0.34	0.10	1.08	0.17	
1983	0.03	0.01	0.35	0.09	1.06	0.18	
1984	0.01	0.01	0.44	0.09	0.57	0.07	
1985	0.04	0.01	0.41	0.06	0.64	0.07	
1986			0.59	0.11	0.37	0.08	
1987			0.59	0.14	0.65	0.10	
1988	0.04	0.02	0.74	0.21	0.43	0.05	
1989	0.14	0.03	0.59	0.11	1.00	0.09	
1990							0.49
1991							0.47
1992							0.63
1993					1.23	0.08	0.76
1994	0.06	0.03			1.32	0.09	0.83
1995					0.77	0.10	0.53
1996	0.09	0.05	0.65	0.07	0.94	0.10	0.48
1997			0.70	0.16	1.25	0.10	0.47
1998	0.09	0.03	0.73	0.13	0.50	0.06	0.24
1999	0.12	0.03	0.52	0.06	0.59	0.06	0.37
2000	0.08	0.05	1.51	0.28	0.50	0.06	0.24
2001	0.23	0.17	0.83	0.17	1.03	0.17	0.32
2002	0.34	0.09	1.18	0.18	0.99	0.18	0.11

[1/] RecFIN creel data used in the analysis.
[2/] WDFW creel data used in the analysis.

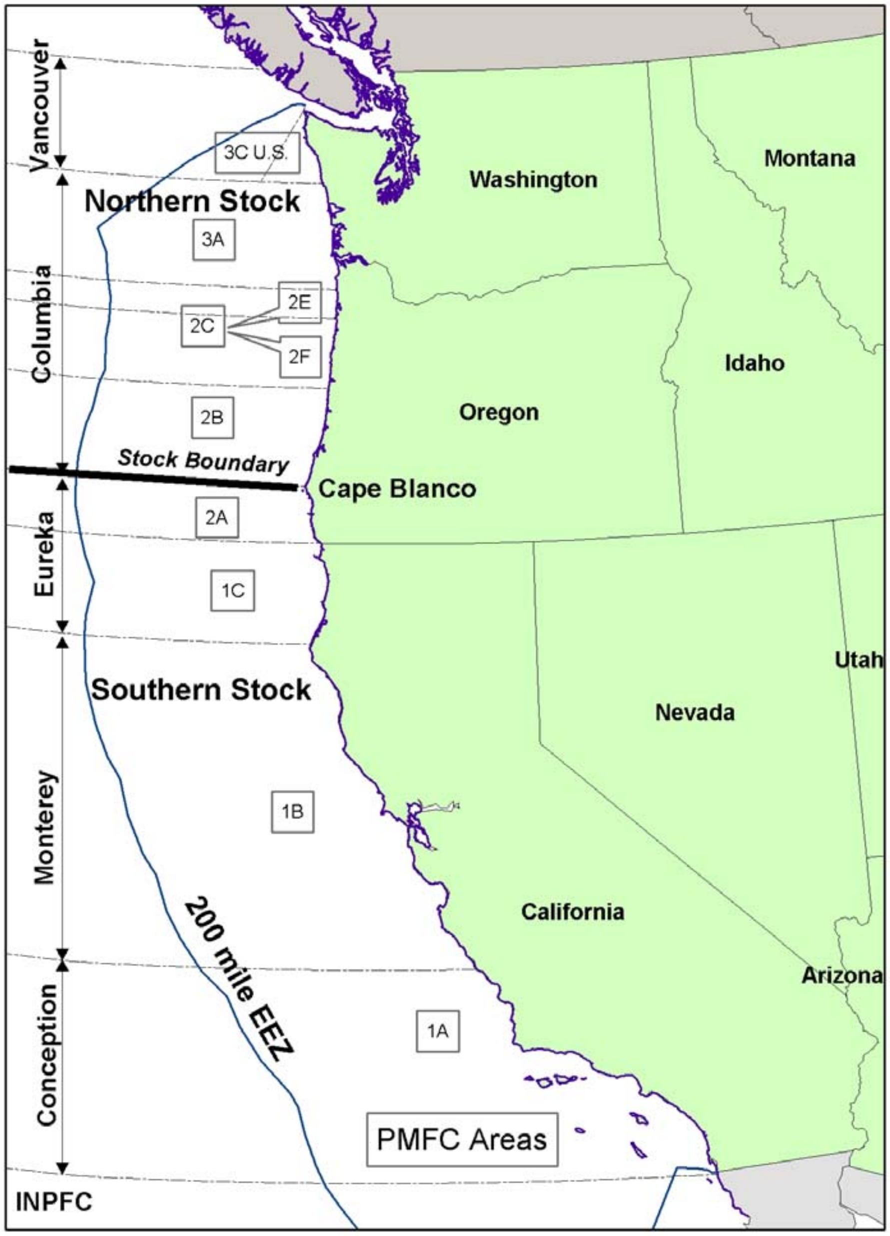


Figure 1. Lingcod stock boundaries and location of PMFC and INPFC Areas.

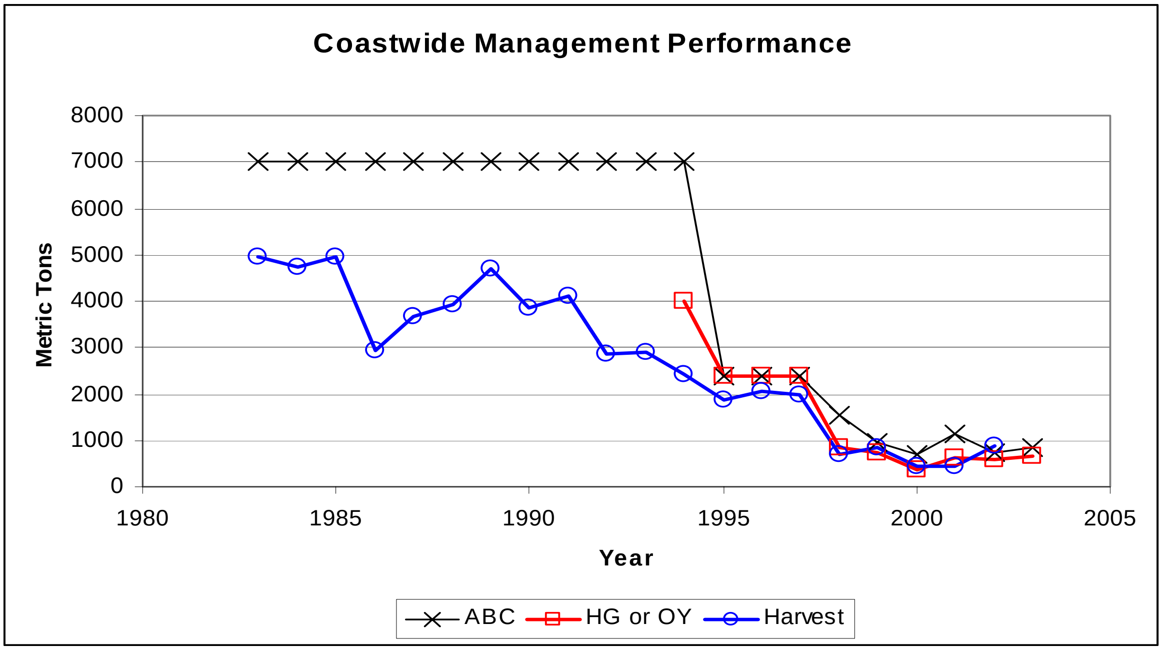


Figure 2. Comparison of lingcod ABC, OY and landings (mt) between 1983 and 2003.

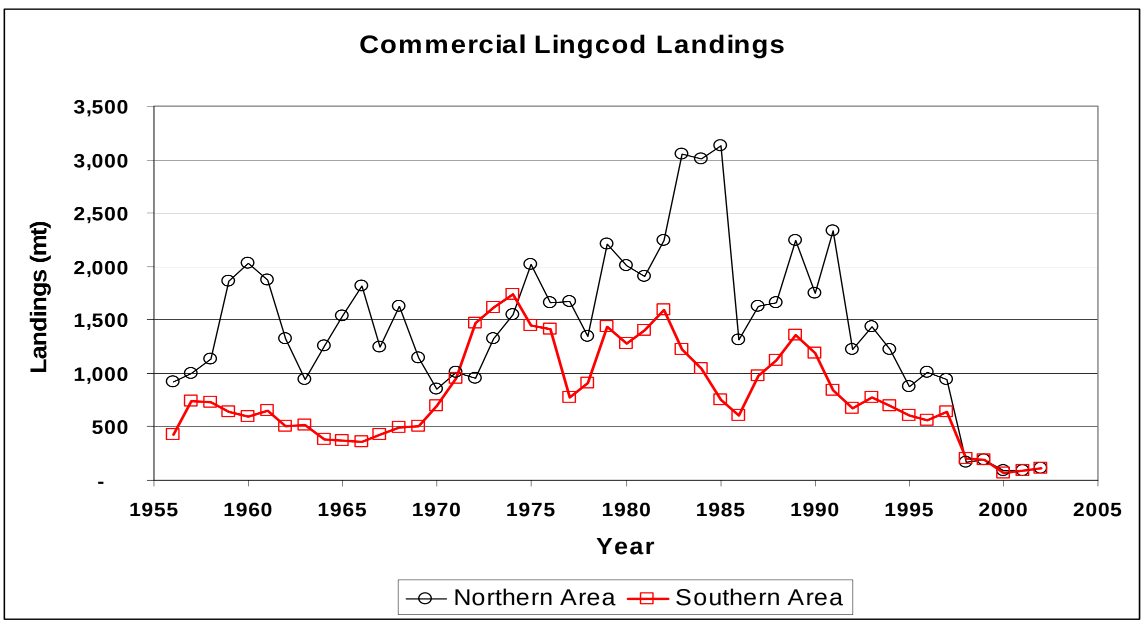


Figure 3. Comparison of commercial lingcod landings in the northern (U.S. Vancouver and Columbia) and southern (Eureka, Monterey and conception) areas.

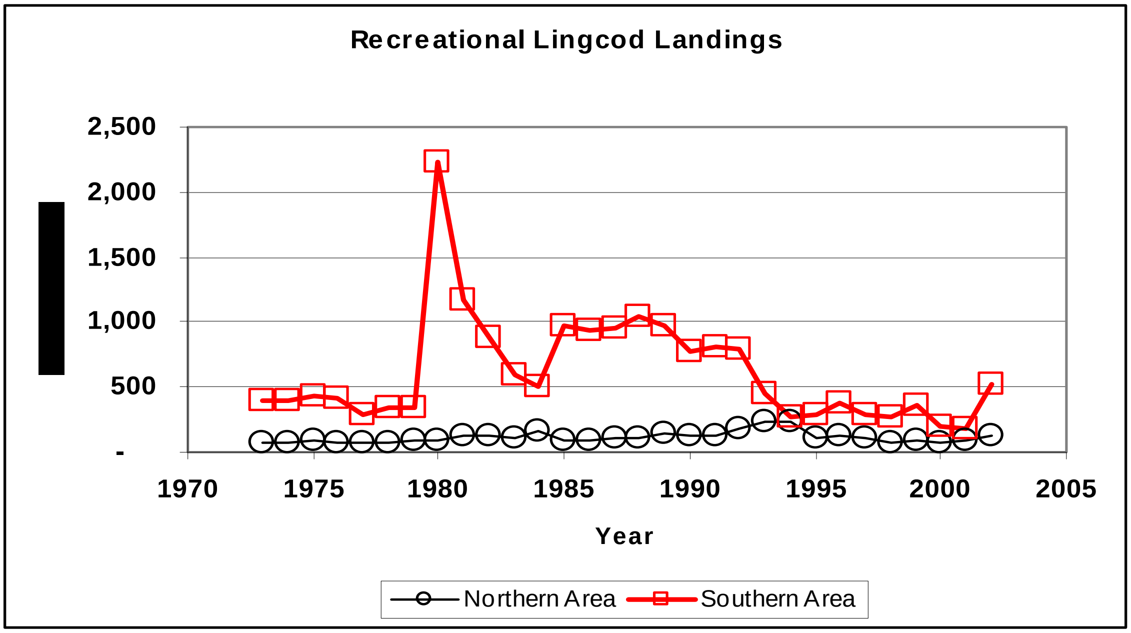


Figure 4. Comparison of recreational lingcod landings in the northern (U.S. Vancouver and Columbia) and southern (Eureka, Monterey and conception) areas.

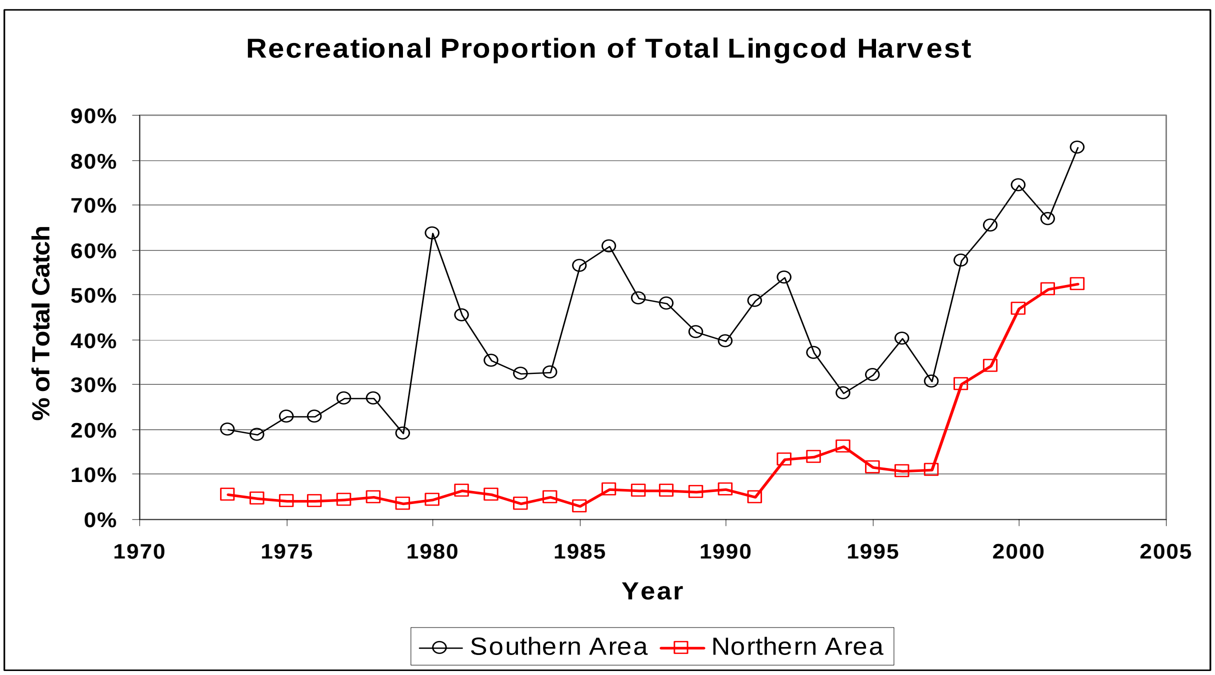


Figure 5. Recreational proportion of total lingcod harvest in the southern (INPFC Areas Eureka, Monterey and Conception) and northern areas (INPFC areas Columbia and U.S. Vancouver).

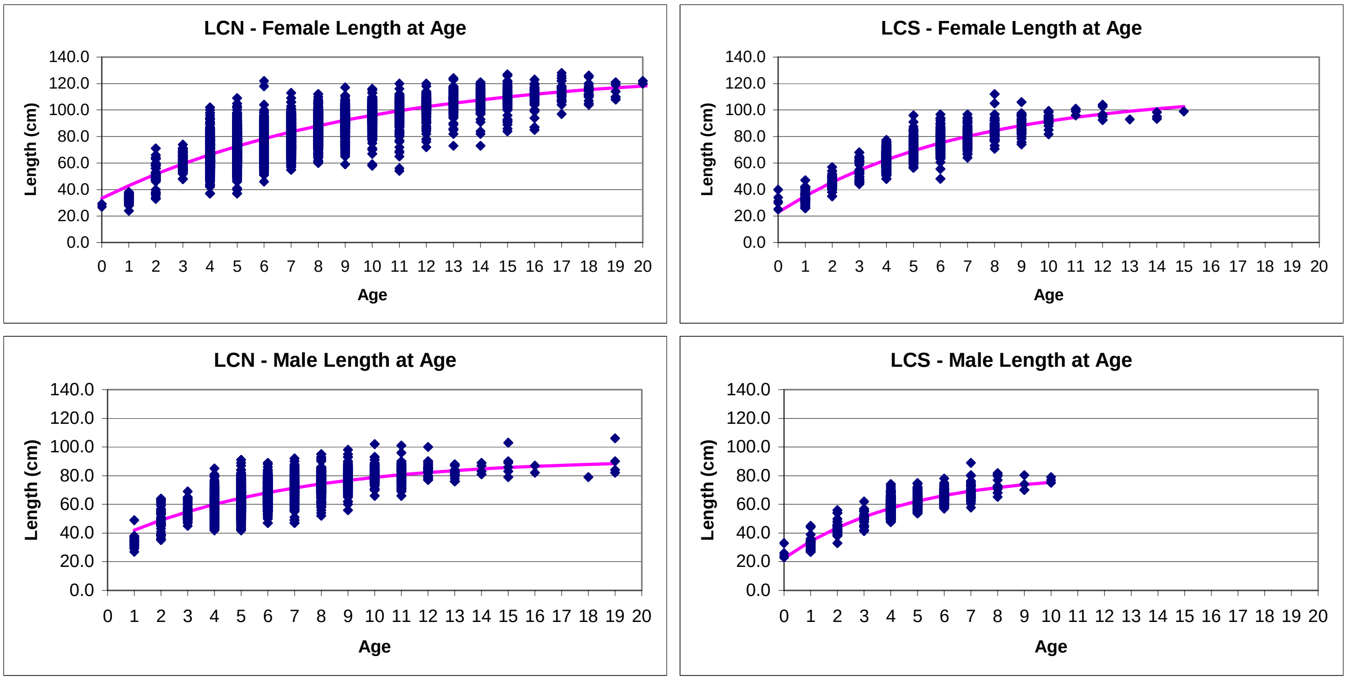


Figure 6. Length-at-age data fit to the von Bertalanffy growth model for the northern (LCN) and southern (LCS) areas. Survey data only were used for ages 1-3. Both survey and fishery data were used for ages 4+.

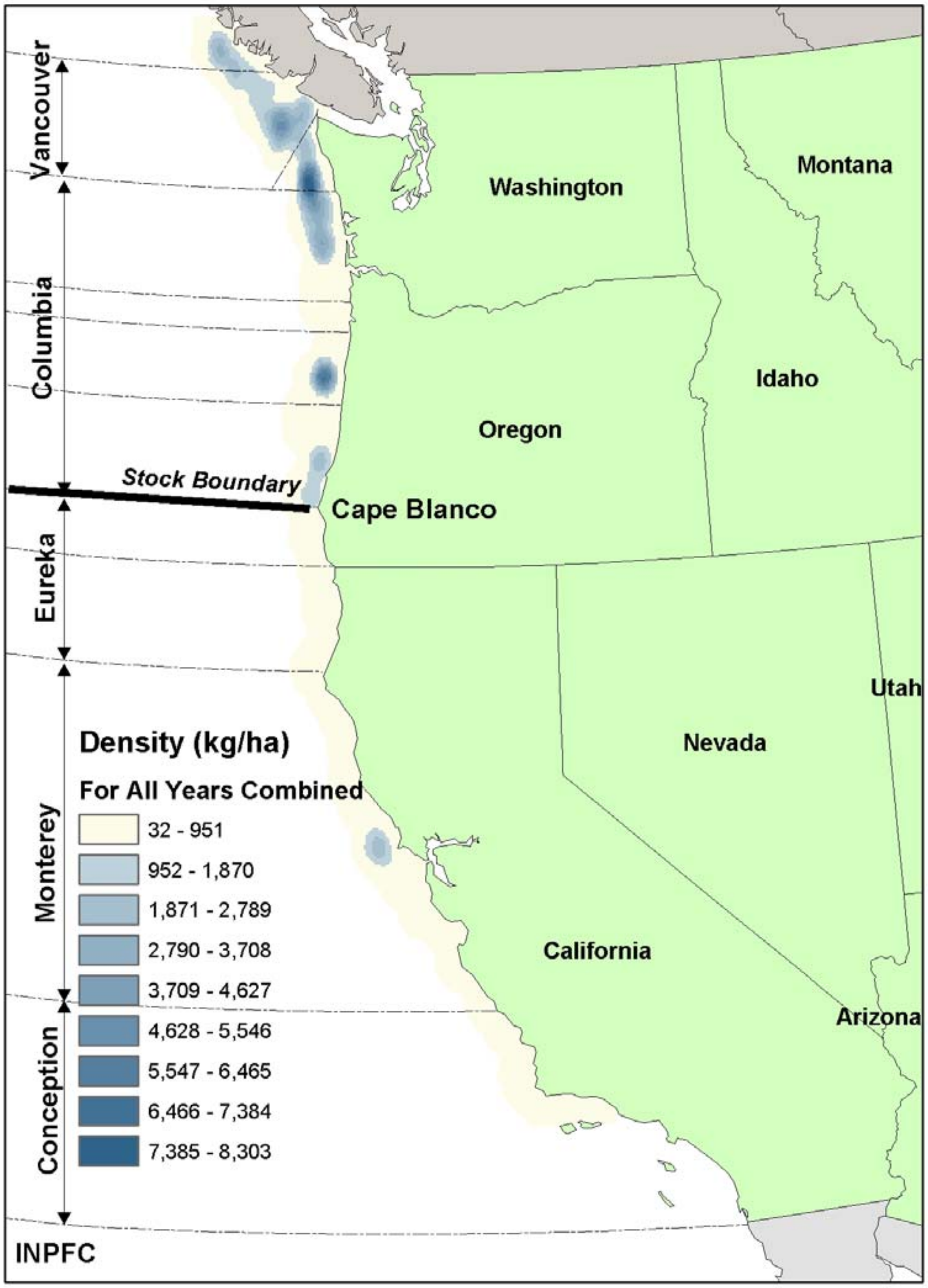


Figure 7. Coastwide distribution of lingcod (kg/ha) from the NMFS tow catches across all years and areas.

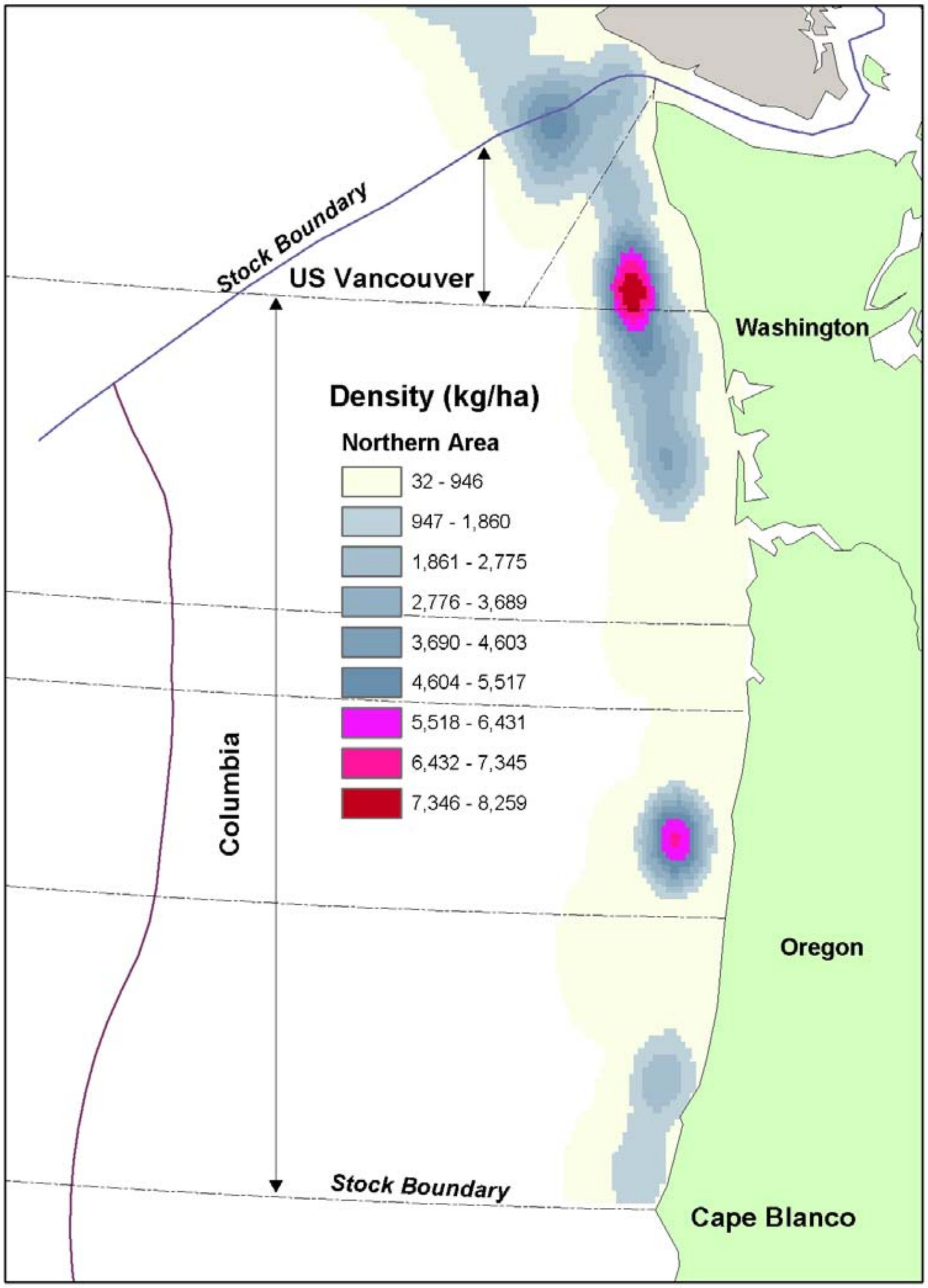


Figure 8. Northern distribution of lingcod (kg/ha) from the NMFS tow catches across all years.

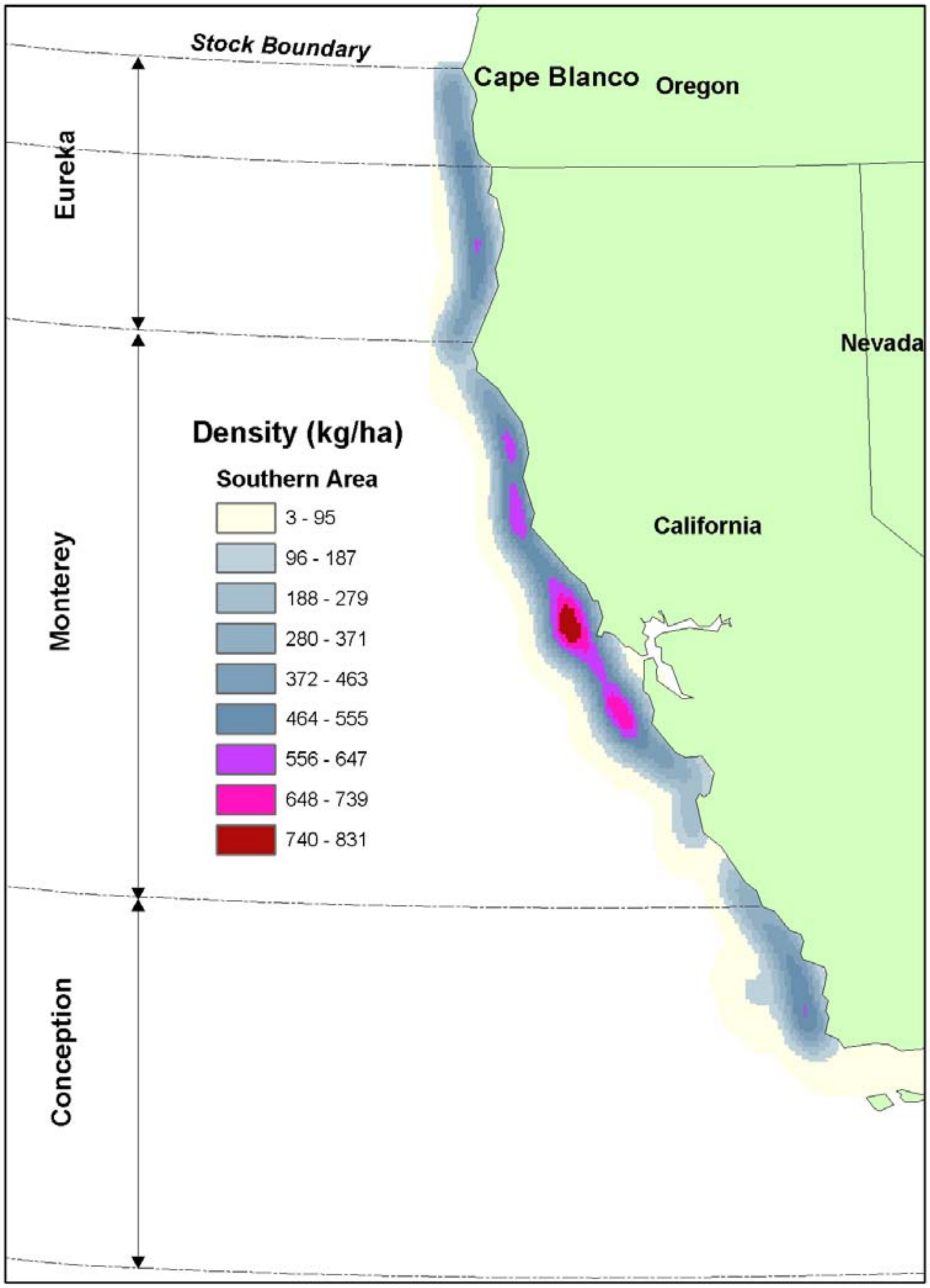


Figure 9. Southern distribution of lingcod (kg/ha) from the NMFS tow catches across all years.

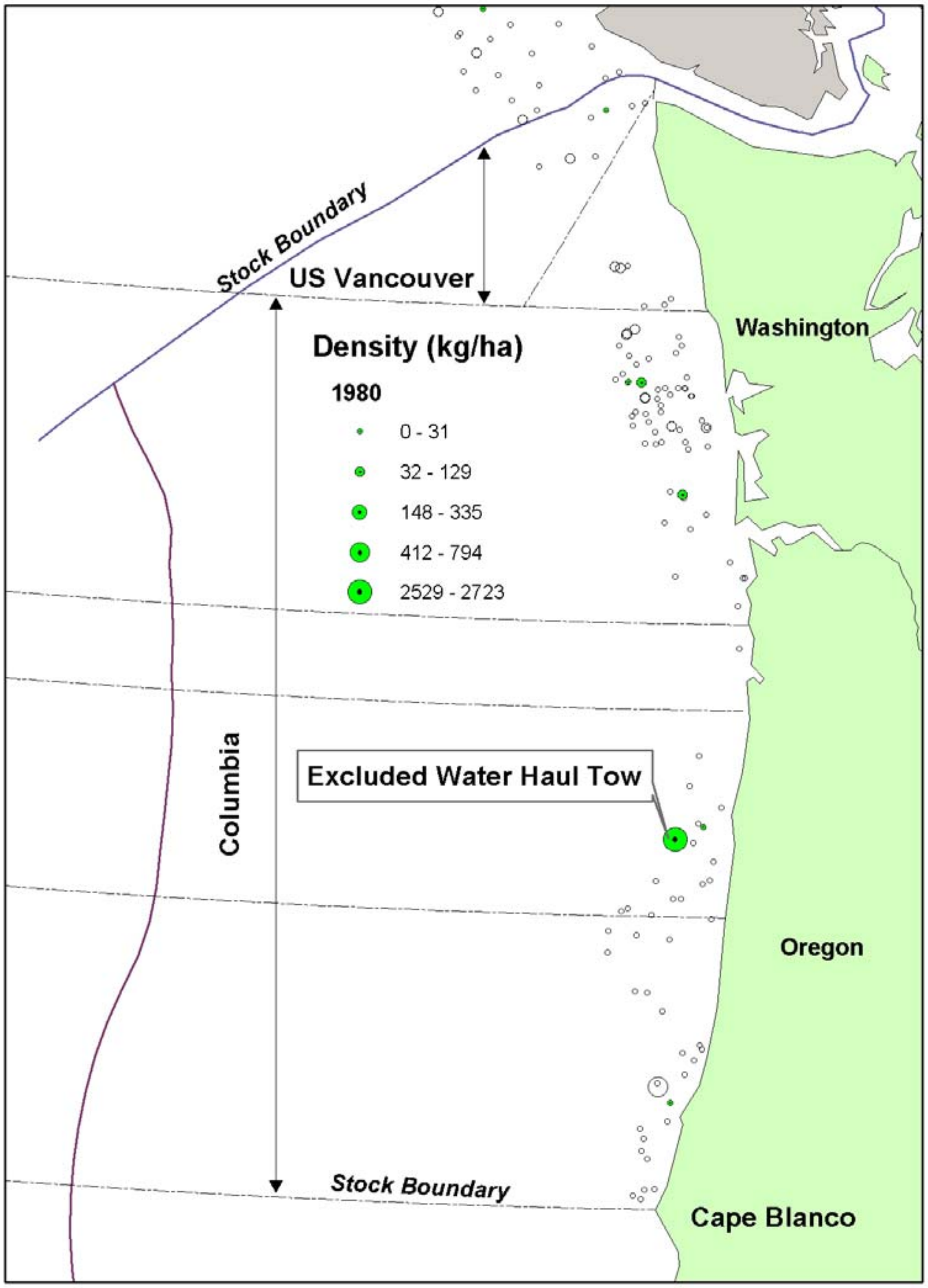


Figure 10. Location of excluded "water haul" tows (dark circles) from the 1980 NMFS Triennial Trawl Survey lingcod biomass estimate.

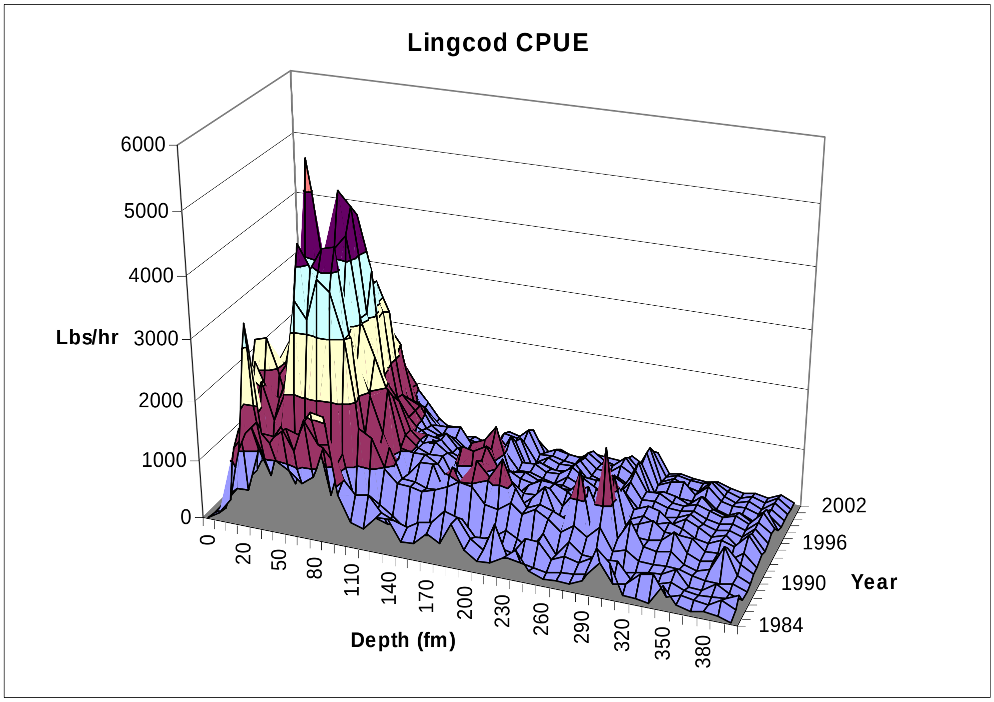


Figure 11. Mean lingcod CPUE calculated from raw data for all tows with a recorded depth.

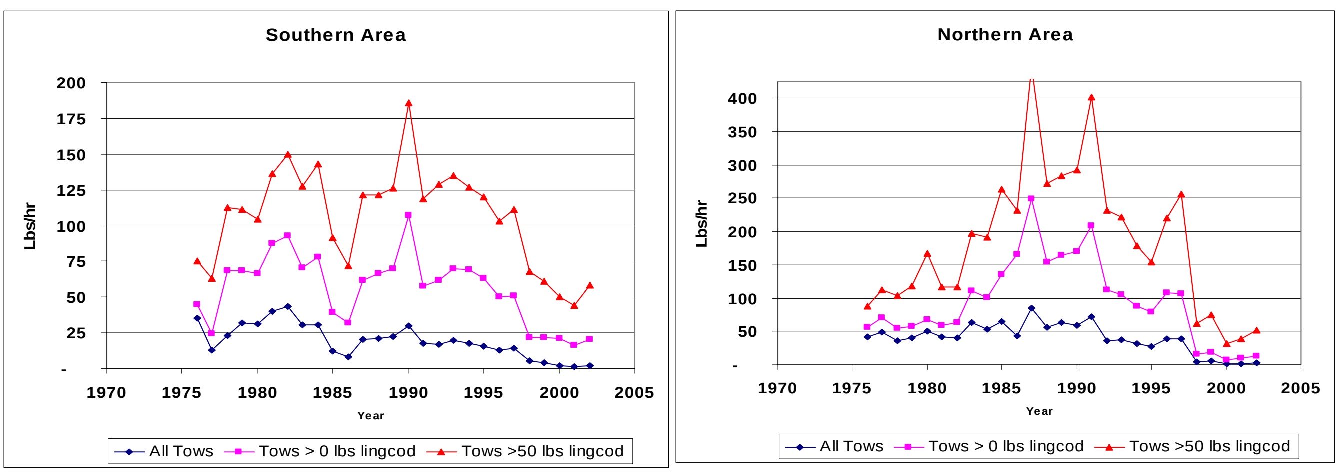
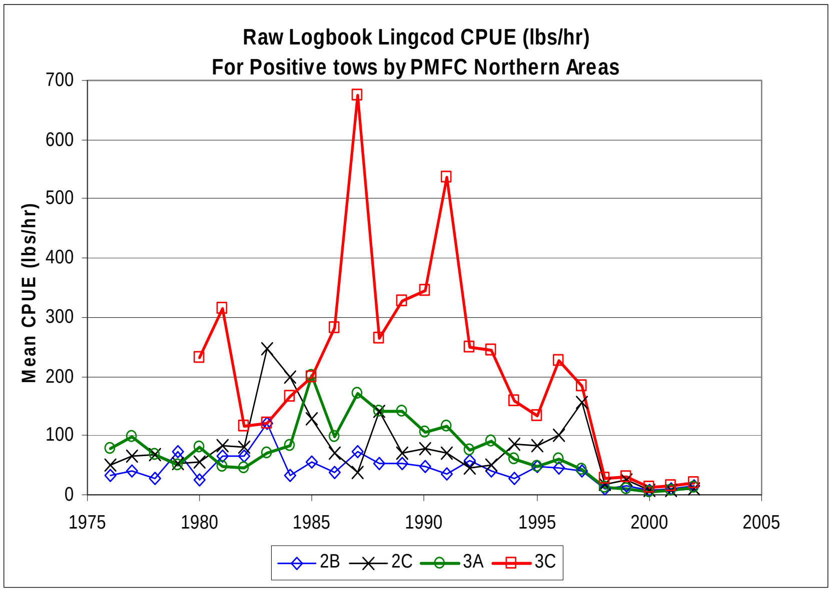


Figure 12. Mean CPUE for the southern and northern areas calculated from raw data for all tows, tows with >0 lbs lingcod catch, and tows with >50 lbs lingcod catch.



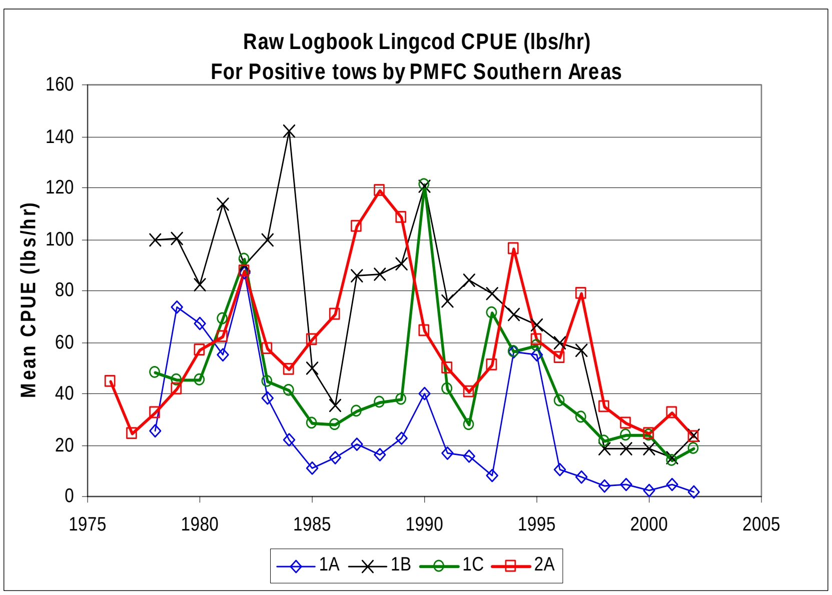


Figure 13. Mean CPUE by PMFC areas in the southern and northern areas calculated from raw data for tows with >0 lbs lingcod catch.

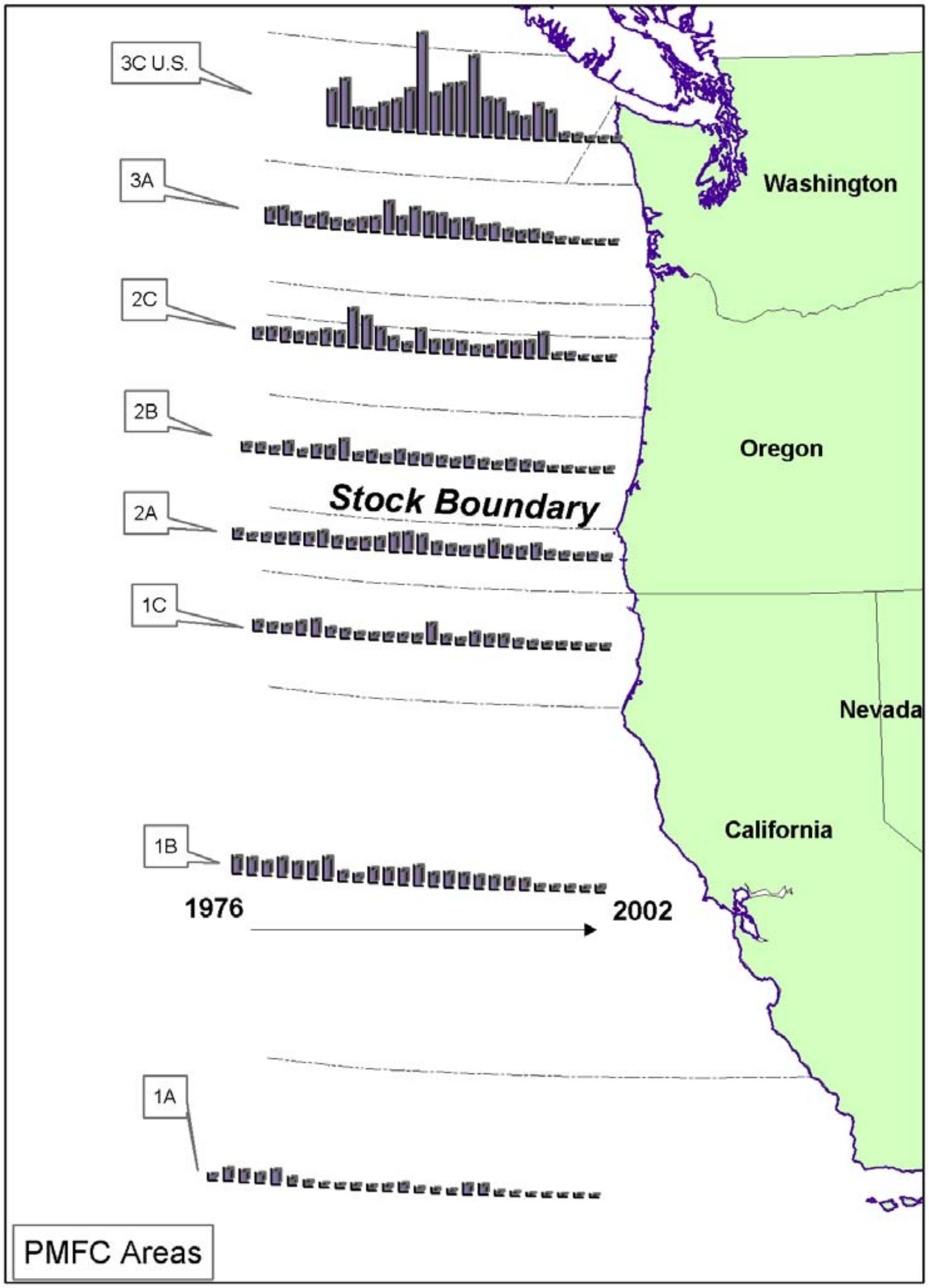


Figure 14. Time series (1976-2002) of observed lingcod trawl logbook CPUE (lbs/hr) by PMFC Area.

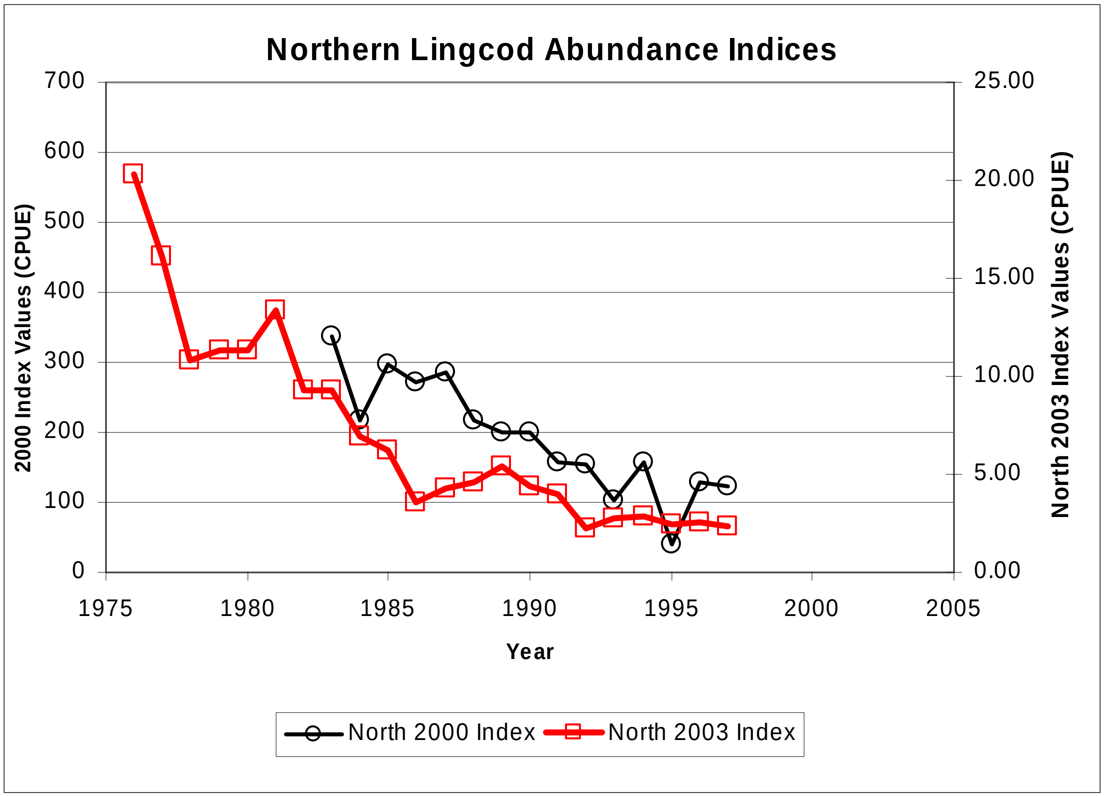


Figure 15. Comparison of the northern trawl logbook lingcod abundance trend to the northern trawl logbook index used in the 2000 lingcod stock assessment.

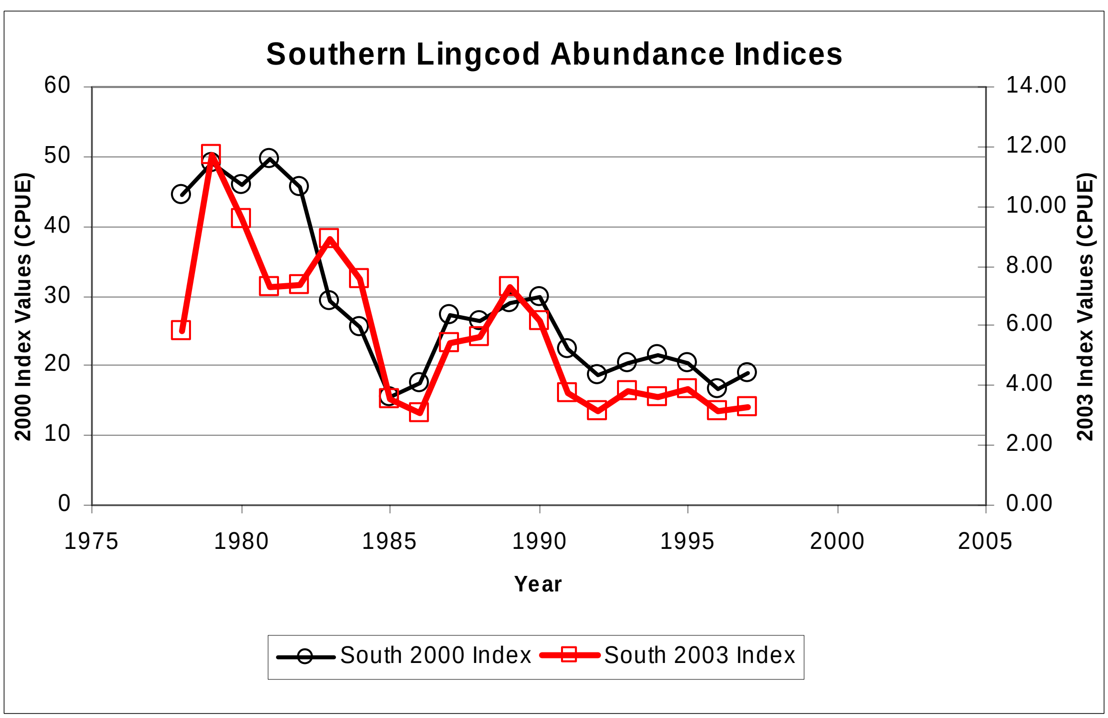


Figure 16. Comparison of the southern trawl logbook lingcod abundance trend to the southern trawl logbook index used in the 2000 lingcod stock assessment.

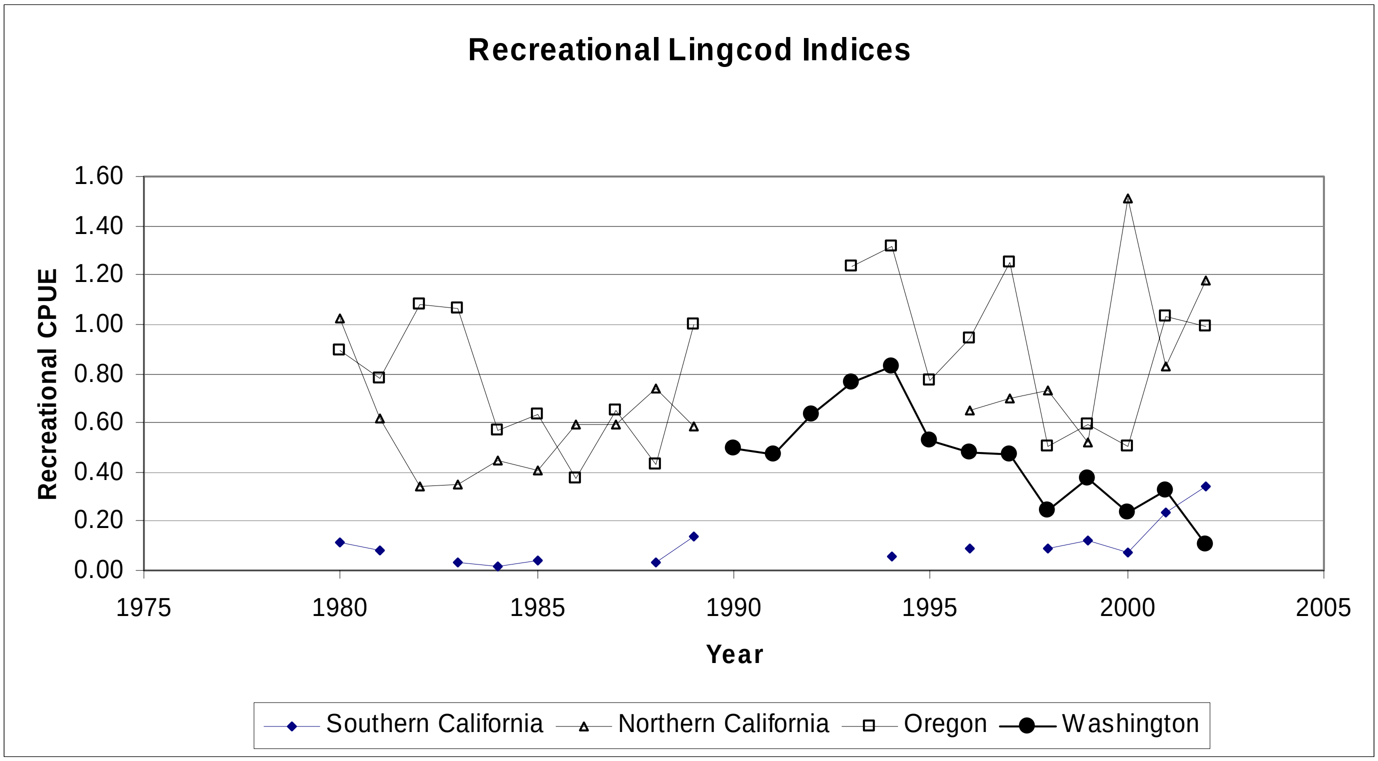


Figure 17. Candidate recreational lingcod CPUE for boat-based fisheries using the "indirect" method on RecFIN creel data for northern and southern California and Oregon and using WDFW sport creel data for the Washington index. These indices were not used in the base models.

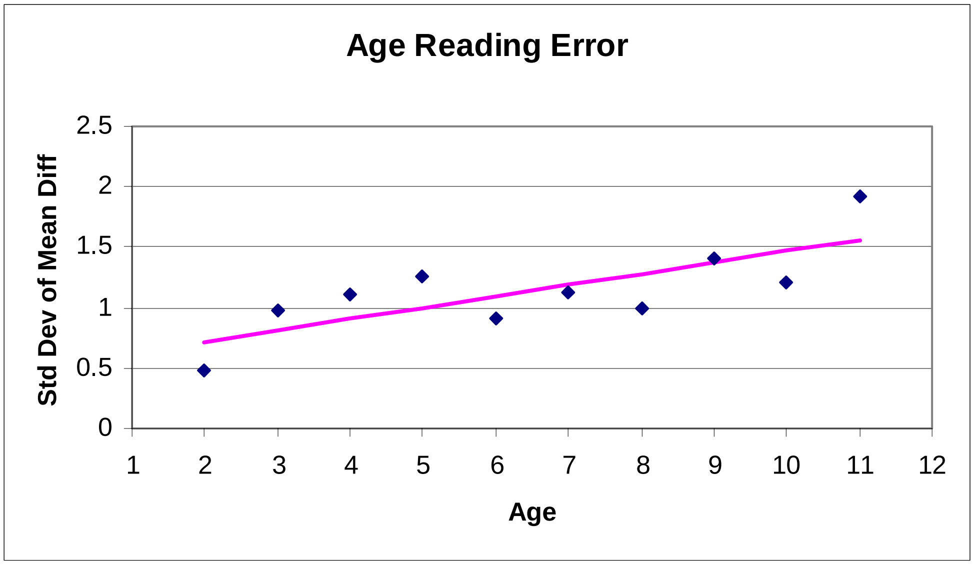


Figure 18. Between-reader (within-lab) estimates of WDFW age reading error variability.

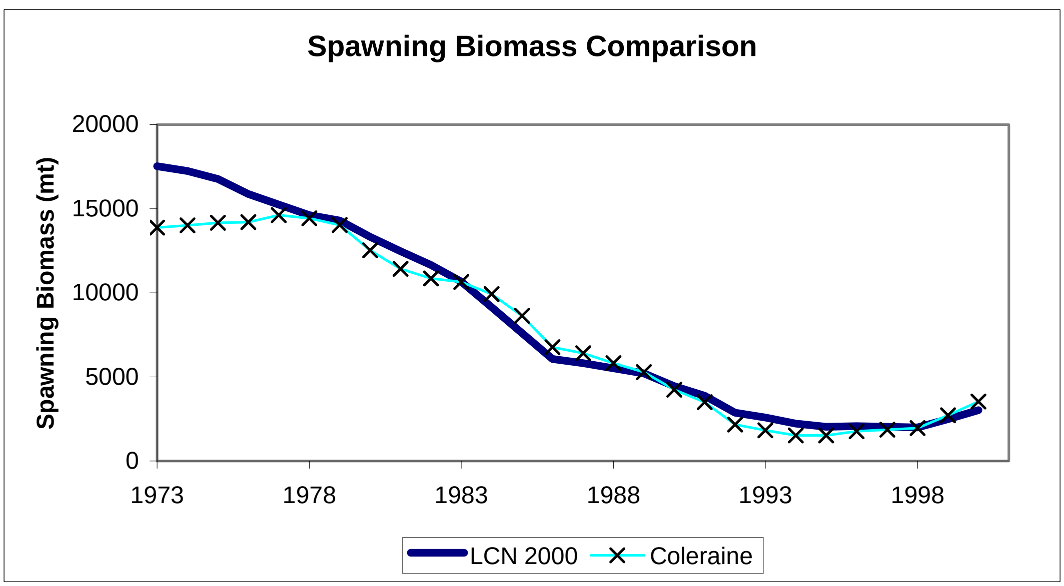


Figure 19. Comparison of LCN model estimates of spawning biomass (mt) (Jagielo et al. 2000) with Coleraine estimates of spawning biomass using the same input data.

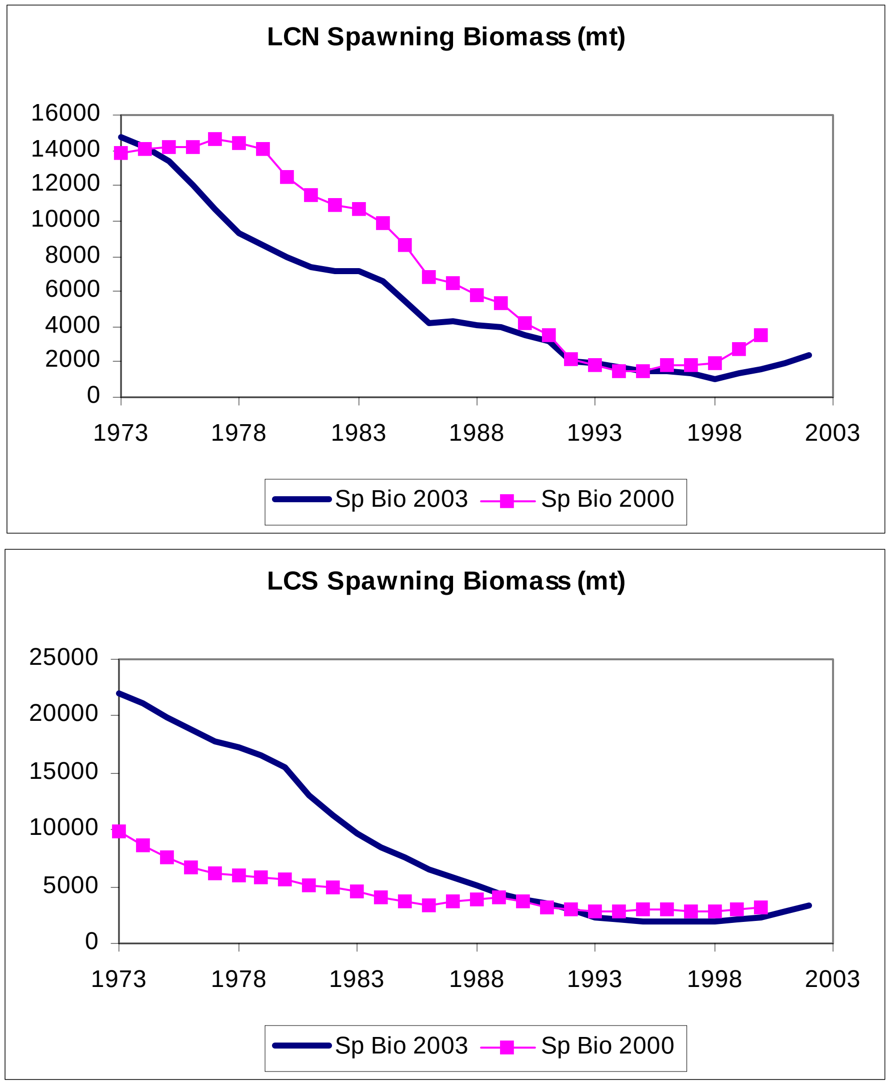


Figure 20. Comparison of LCN and LCS model estimates of spawning biomass (mt) from the 2000 assessment (Jagielo et al. 2000) with estimates of spawning biomass from the present assessment.

Appendix I. Base Model Output.

Assessment of Lingcod for the Pacific Fishery Management Council in 2003

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Figure 6. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-length.

Figure 7. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-length.

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Lingcod South (LCS): Eureka, Monterey, and Conception INPFC Areas

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Table 6d. Coleraine output for the northern area (LCS) base model: Profile over combinations of natural mortality rate (M) and B-H spawner-recruit steepness (*h*).

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Figure 12a. Coleraine output for the southern area (LCS) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

Figure 12b. Coleraine output for the southern area (LCS) base model: Estimated selectivity for the commercial fishery, recreational fishery, and NMFS trawl survey.

Figure 13. Coleraine output for the southern area (LCS) base model: Model fits to indices of abundance; NMFS trawl survey and trawl logbook.

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Figure 15. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

Figure 16. Coleraine output for the southern area (LCS) base model: Model fits to NMFS trawl survey catch-at-age.

Figure 17. Coleraine output for the southern area (LCS) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.

Table 1. Coleraine input file for the northern area (LCN) base model: Priors.

Priors

Phase	Low Bound	High Bound	Prior Type (0=uniform, 1=normal, 2=lognormal)	Mean	CV	Seed Value
R0 (Recruitment in virgin condition)						
1	0.1	1000000	0	0	0	1804.62
h (steepness of spawner-recruit curve)						
-1	0.01	5	0	0.7	1	0.9
M (natural mortality)						
-1	0.05	0.15	0	0.1	0.1	0.18
-1	0.05	0.15	0	0.1	0.1	0.32
Log init dev prior: deviates for initial age structure: uniform or normal only						
-5	-15	15	1	0	0.1	0
log rec dev prior (uniform or normal only)						
2	-15	15	1	0	0.2	0
Initial R (= # 1-yr olds in yr 1/R0; unfished = 1)						
-1	0	2	0	1	0.1	1
Initial u (exploitation rate for initial age structure; 0=unfished)						
-1	0	0.1	0	0	0.1	0.09
-1	0	0.1	0	0	0.1	0.09
Plus scale						
-1	0	2	0	0	0.6	1
-1	0	2	0	0	0.6	1
Age of full selectivity - Females						
3	1	18	0	4	0.6	4.00
3	1	18	0	4	0.6	4.00
Fishery age of full selectivity difference by sex (Delta)						
3	-5	5	0	0	0.6	0
3	-5	5	0	0	0.6	0
Fishery variance of Left side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	-12.1568
4	-15	15	0	0	0.6	-15
Fishery variance of Right side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	14.9999
4	-15	15	0	0	0.6	2.87946
Fishery age of full selectivity deviation by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Left side selectivity by year						
-1	-15	15	1	0	0.1	0
-1	-15	15	1	0	0.1	0
Fishery variance of Right side selectivity by year						
-1	-15	15	1	0	0.1	0
-1	-15	15	1	0	0.1	0
Log q CPUE						
1	-15	15	0	0	0.1	-6.72892
Log q CPUE error						
-1	-5	5	0	0	0.6	0
Log q Survey						
1	-5	5	0	0	0.2	-0.276796
1	-5	6	0	0	0.2	4.80661
Survey age of full selectivity - Females						
3	1	15	0	0	0.6	4.24582
3	1	15	0	0	0.6	7.43203
Survey age of full selectivity difference by sex (Delta)						
3	-5	5	0	0	0.6	-1.09
3	-5	5	0	0	0.6	-5
Survey variance Left side selectivity						
5	-15	15	0	0	0.6	-0.219137
5	-15	15	0	0	0.6	-0.830671
Survey variance Right side selectivity						
5	-15	15	0	0	0.6	4.5791
5	-15	15	0	0	0.6	4.78909

Table 2. Coleraine input file for the northern area (LCN) base model: Likelihood and fixed parameter specifications.

Likelihoods (1= norm; 2 = lognorm; 3= robust norm; 4=robust lognorm; 12 = robust lognormal for proportions)

Parameter		
CPUE likelihood Type	2	
Commercial catch at age likelihood type	12	12
Commercial catch at length likelihood type	12	12
Survey likelihood type	2	2
Survey Index type (1=weight; 2=numbers)	1	2
Survey vulnerability type (1=age; 2=length)	1	1
Survey no-sex C@L likelihood type	0	0
Survey catch at length likelihood type	12	12
Survey catch at age likelihood type	12	12

Fixed Parameters

Parameter		
Bi-scalar of length-weight relationship	0.0018	0.0040
bii exponent of length-weight relationship	3.3978	3.2149
L-infinity of the vonBertanlanffy growth equation	130.1833	91.8169
k of the vonBertanlanffy growth equation	0.1041	0.1493
t0 of the vonBertanlanffy growth equation	-2.8497	-3.0970
Brody parameter	0.2000	0.2000
Mean length of age 1 fish	42.9822	41.9992
Length at oldest age	118.1188	88.8944
S.d. of length at age of 1-year old fish	2.7223	2.0968
S.d. of length at age of oldest fish	9.9838	7.5582

Table 3. Coleraine output file for the northern area (LCN) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

B0		23952
Depletion		0.29
	No. of Parameters:	**51**
Likelihoods	**AIC:**	**-14946**
Trawl Logbook CPUE		4.7
Com Catch-At-Age		-1955.8
Rec Catch-At-Age		-1567.0
Com Catch-At-Length		-810.3
Rec Catch-At-Length		-626.4
NMFS Trawl Survey		2.9
WDFW Tag Survey		1.7
NMFS Survey Catch-At-Age		-318.1
WDFW Survey Catch-At-Age		-353.2
NMFS Survey Catch-At-Length		-318.9
WDFW Survey Catch-At-Length		-1606.4
		0
		0
Penalties: B-H Recruitment		22.6
	Total Likelihood:	**-7524.2**
Parameters		
R0		1805
h		0.9
M Females		0.18
M Males		0.32
Rinit		1
Uinit Females		0.09
Uinit Males		0.09
Init Plus Grp Resid Females		1
Init Plus Grp Resid Males		1
Selectivity - Full Com		4.00
Selectivity - Full Rec		4.00
Selectivity - Left Side Com		-12.16
Selectivity - Left Side Rec		-15.00
Selectivity - Right Side Com		15.00
Selectivity - Right Side Rec		2.88
Selectivity - Full - Yr Error Com		0
Selectivity - Full - Yr Error Rec		0
Selectivity - Left - Yr Error Com		0
Selectivity - Left - Yr Error Rec		0
Selectivity - Right - Yr Error Com		0
Selectivity - Right - Yr Error Rec		0
Trawl Logbook CPUE - log(q)		-6.73
Trawl Logbook CPUE - q Yr Error		0.00
Trawl Logbook CPUE q		0.00
NMFS Trawl Survey q		-0.28
WDFW Tag Survey q		4.81
Selectivity - Full NMFS Survey		4.25
Selectivity - Full WDFW Survey		7.43
Selectivity - Left NMFS Survey		-0.22
Selectivity - Left WDFW Survey		-0.83
Selectivity - Right NMFS Survey		4.58
Selectivity - Right WDFW Survey		4.79
Log Initial Age Comp Dev		0.00
Log Rec Dev		-0.2891

Table 3a.1. Coleraine output for the northern area (LCN) base model. Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	1.8046e+003	5.6175e+001
2	log_RecDev	-2.8907e-001	1.7899e-001
3	log_RecDev	-3.1635e-001	1.9415e-001
4	log_RecDev	-1.3456e-001	1.7700e-001
5	log_RecDev	-2.0427e-001	1.9747e-001
6	log_RecDev	-2.2905e-001	1.9279e-001
7	log_RecDev	-1.5507e-001	1.8728e-001
8	log_RecDev	-1.4527e-001	1.8877e-001
9	log_RecDev	4.2838e-001	1.6512e-001
10	log_RecDev	-8.9725e-002	1.7300e-001
11	log_RecDev	3.5796e-002	1.9356e-001
12	log_RecDev	-3.8628e-001	1.5556e-001
13	log_RecDev	-8.7539e-002	1.6889e-001
14	log_RecDev	-5.6214e-002	1.8895e-001
15	log_RecDev	7.6997e-001	8.4586e-002
16	log_RecDev	-1.9187e-001	1.4136e-001
17	log_RecDev	-4.5506e-001	1.5797e-001
18	log_RecDev	-2.1885e-001	1.2306e-001
19	log_RecDev	1.2543e-002	1.1650e-001
20	log_RecDev	6.7353e-002	1.0712e-001
21	log_RecDev	4.3182e-002	1.1598e-001
22	log_RecDev	-2.0990e-001	1.6596e-001
23	log_RecDev	7.1103e-002	1.3459e-001
24	log_RecDev	2.8221e-001	1.4720e-001
25	log_RecDev	1.6941e-001	1.5865e-001
26	log_RecDev	-6.2276e-002	1.6827e-001
27	log_RecDev	3.9475e-002	1.7187e-001
28	log_RecDev	2.3747e-001	1.8825e-001
29	log_RecDev	8.4688e-002	2.1109e-001
30	log_RecDev	2.8128e-003	2.0038e-001
31	log_RecDev	0.0000e+000	2.0000e-001
32	log_RecDev	0.0000e+000	2.0000e-001
33	Sfullest	4.0000e+000	2.0585e-003
34	Sfullest	4.0008e+000	6.0985e-005
35	Sfulldelta	2.2791e-003	3.6505e-001
36	Sfulldelta	-7.5684e-004	1.2916e-004
37	log_varLest	-1.2369e+001	3.2042e+002
38	log_varLest	-1.5000e+001	4.3806e-002
39	log_varRest	1.5000e+001	3.8942e-001
40	log_varRest	2.8795e+000	4.8134e-001
41	log_qCPUE	-6.7289e+000	5.2017e-002
42	log_qsurvey	-2.7680e-001	1.5135e-001
43	log_qsurvey	4.8066e+000	7.6105e-002
44	surveySfullest	4.2458e+000	4.2222e-001
45	surveySfullest	7.4320e+000	1.4611e-001
46	surveySfulldeltaest	-1.0930e+000	2.2191e-001
47	surveySfulldeltaest	-5.0000e+000	1.2529e-005
48	log_surveyvarL	-2.1914e-001	6.3816e-001
49	log_surveyvarL	-8.3067e-001	2.8254e-001
50	log_surveyvarR	4.5791e+000	1.3811e+000
51	log_surveyvarR	4.7891e+000	1.2618e+000
52	Ro_mcmc	1.8046e+003	5.6175e+001

Table 3a. Coleraine output for the northern area (LCN) base model: Profile over historical exploitation rate (U_{init}); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Runs 4 and 5 did not fully converge.

B0	26853	27556	28072	28079	29503
Depletion	0.16	0.15	0.14	0.13	0.12
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	nu1out.txt	nu2out.txt	nu3out.txt	nu4out.txt	nu5out.txt
No. of Parameters:	47	47	47	47	47
Likelihoods AIC:	**-14888**	**-14886**	**-14884**	**-14919**	**-14886**
Trawl Logbook CPUE	4.2	4.3	4.3	4.2	4.4
Com Catch-At-Age	-1950.1	-1951.4	-1953.6	-1962.6	-1961.4
Rec Catch-At-Age	-1566.1	-1565.5	-1564.5	-1566.3	-1565.7
Com Catch-At-Length	-809.5	-808.9	-808.7	-810.3	-808.0
Rec Catch-At-Length	-630.2	-630.4	-630.6	-629.5	-630.2
NMFS Trawl Survey	5.7	6.0	6.4	8.6	6.7
WDFW Tag Survey	5.3	5.5	5.7	5.1	5.6
NMFS Survey Catch-At-Age	-315.5	-315.4	-315.2	-349.1	-314.7
WDFW Survey Catch-At-Age	-339.2	-339.1	-339.0	-337.9	-338.7
NMFS Survey Catch-At-Length	-316.0	-316.5	-317.1	-303.4	-318.3
WDFW Survey Catch-At-Length	-1606.5	-1606.5	-1606.4	-1600.1	-1604.5
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	26.9	28.0	30.0	34.9	34.9
Total Likelihood:	**-7490.9**	**-7489.8**	**-7488.8**	**-7506.4**	**-7489.8**
Parameters					
R0	2023	2076	2115	2116	2223
h	0.7	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32	0.32
Rinit	1	1	1	1	1
Uinit Females	**0.03**	**0.06**	**0.09**	**0.12**	**0.15**
Uinit Males	**0.03**	**0.06**	**0.09**	**0.12**	**0.15**
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	3.94	3.99
Selectivity - Full Rec	4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-15.00	-15.00	-6.28	-5.54
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.76	4.89	5.15	15.00	15.00
Selectivity - Right Side Rec	2.65	2.61	2.55	2.53	2.55
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.71	-6.71	-6.72	-6.80	-6.79
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	-0.12	-0.11	-0.10	-0.27	-0.09
WDFW Tag Survey q	5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.17	5.18	5.20	2.88	5.22
Selectivity - Full WDFW Survey	8.87	8.87	8.88	8.91	8.90
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3164	-0.3173	-0.3136	-0.3398	-0.3502

Table 3b. Coleraine output for the northern area (LCN) base model: Profile over natural mortality rate (M); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Runs 4 and 5 did not fully converge.

B0	37513	32531	28072	24706	23597
Depletion	0.11	0.12	0.14	0.16	0.20
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	nm1out.txt	nm2out.txt	nm3out.txt	nm4out.txt	nm5out.txt
No. of Parameters:	47	47	47	47	47
Likelihoods AIC:	**-14827**	**-14882**	**-14884**	**-14937**	**-14947**
Trawl Logbook CPUE	4.5	4.4	4.3	4.1	4.3
Com Catch-At-Age	-1955.0	-1947.6	-1953.6	-1968.2	-1975.4
Rec Catch-At-Age	-1558.7	-1564.5	-1564.5	-1563.5	-1563.4
Com Catch-At-Length	-799.4	-808.5	-808.7	-813.4	-814.2
Rec Catch-At-Length	-631.4	-630.4	-630.6	-629.0	-628.0
NMFS Trawl Survey	6.5	9.1	6.4	7.0	4.9
WDFW Tag Survey	12.3	5.9	5.7	5.5	5.3
NMFS Survey Catch-At-Age	-315.6	-361.7	-315.2	-307.7	-318.4
WDFW Survey Catch-At-Age	-348.6	-339.5	-339.0	-338.7	-339.2
NMFS Survey Catch-At-Length	-317.3	-278.9	-317.1	-335.3	-316.4
WDFW Survey Catch-At-Length	-1588.9	-1606.1	-1606.4	-1606.6	-1607.3
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	31.1	30.0	30.0	30.5	27.5
Total Likelihood:	**-7460.5**	**-7487.8**	**-7488.8**	**-7515.4**	**-7520.3**
Parameters					
R0	1692	1917	2115	2338	2762
h	0.7	0.7	0.7	0.7	0.7
M Females	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**
M Males	**0.28**	**0.3**	**0.32**	**0.35**	**0.38**
Rinit	1	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	3.94	3.94
Selectivity - Full Rec	4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-15.00	-15.00	-5.58	-6.17
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.51	4.62	5.15	15.00	15.00
Selectivity - Right Side Rec	2.37	2.49	2.55	2.51	2.55
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.66	-6.66	-6.72	-6.79	-6.81
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.06	-0.35	-0.10	0.14	-0.16
WDFW Tag Survey q	5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.30	3.49	5.20	5.31	5.24
Selectivity - Full WDFW Survey	8.68	8.87	8.88	8.97	8.97
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3619	-0.3151	-0.3136	-0.3685	-0.3849

Table 3c. Coleraine output for the northern area (LCN) base model: Profile over B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Run 5 did not fully converge.

B0	35141	31331	28072	25212	23977
Depletion	0.07	0.11	0.14	0.20	0.28
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	nh1out.txt	nh2out.txt	nh3out.txt	nh4out.txt	nh5out.txt
No. of Parameters:	47	47	47	47	47
Likelihoods AIC:	**-14783**	**-14856**	**-14884**	**-14917**	**-14931**
Trawl Logbook CPUE	4.4	4.4	4.3	4.4	5.0
Com Catch-At-Age	-1954.7	-1949.5	-1953.6	-1959.6	-1959.0
Rec Catch-At-Age	-1558.9	-1562.7	-1564.5	-1566.4	-1566.5
Com Catch-At-Length	-795.5	-806.7	-808.7	-810.6	-809.9
Rec Catch-At-Length	-632.0	-631.8	-630.6	-628.8	-628.1
NMFS Trawl Survey	12.8	8.5	6.4	4.3	3.2
WDFW Tag Survey	9.7	5.5	5.7	5.5	5.2
NMFS Survey Catch-At-Age	-315.3	-314.2	-315.2	-316.4	-317.2
WDFW Survey Catch-At-Age	-345.6	-339.2	-339.0	-339.7	-342.0
NMFS Survey Catch-At-Length	-317.6	-316.7	-317.1	-317.3	-316.6
WDFW Survey Catch-At-Length	-1589.8	-1606.0	-1606.4	-1607.0	-1608.8
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	43.9	33.4	30.0	26.0	22.0
Total Likelihood:	**-7438.6**	**-7474.9**	**-7488.8**	**-7505.6**	**-7512.6**
Parameters					
R0	2648	2361	2115	1900	1807
h	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
M Females	0.18	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32	0.32
Rinit	1	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	3.95	3.87
Selectivity - Full Rec	4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-15.00	-15.00	-2.83	-4.95
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.34	4.55	5.15	15.00	15.00
Selectivity - Right Side Rec	2.32	2.43	2.55	2.69	2.81
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.72	-6.68	-6.72	-6.78	-6.74
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.01	-0.12	-0.10	-0.11	-0.15
WDFW Tag Survey q	5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.31	5.19	5.20	5.19	5.17
Selectivity - Full WDFW Survey	8.80	8.86	8.88	8.89	8.88
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00	0.00
Log Rec Dev	-0.4229	-0.3194	-0.3136	-0.3104	-0.2775

Table 3d. Coleraine output for the northern area (LCN) base model: Profile over combinations of natural mortality rate (M) and B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	45025	21087	29030	30300
Depletion	0.08	0.38	0.10	0.20
	RUN9	**RUN10**	**RUN11**	**RUN12**
Input File	nhlml.txt	nhhmh.txt	nhlmh.txt	nhhml.txt
No. of Parameters:				
Likelihoods **AIC:**				
Trawl Logbook CPUE	4.2	5.7	3.9	4.4
Com Catch-At-Age	-1943.1	-1968.2	-1969.1	-1930.2
Rec Catch-At-Age	-1564.9	-1563.6	-1563.0	-1569.8
Com Catch-At-Length	-793.8	-812.6	-809.8	-804.7
Rec Catch-At-Length	-628.9	-625.3	-629.1	-628.2
NMFS Trawl Survey	6.9	3.8	10.3	3.9
WDFW Tag Survey	2.4	1.9	4.3	1.4
NMFS Survey Catch-At-Age	-309.3	-338.9	-320.5	-334.5
WDFW Survey Catch-At-Age	-358.9	-353.8	-341.7	-353.4
NMFS Survey Catch-At-Length	-329.9	-316.0	-316.7	-316.0
WDFW Survey Catch-At-Length	-1581.4	-1607.6	-1598.0	-1603.5
	0	0	0	0
	0	0	0	0
Penalties: B-H Recruitment	37.9	22.4	41.5	22.9
Total Likelihood:	**-7458.8**	**-7552.0**	**-7487.9**	**-7507.7**
Parameters				
R0	2031	2469	3398	1367
h	**0.5**	**0.9**	**0.5**	**0.9**
M Females	**0.14**	**0.22**	**0.22**	**0.14**
M Males	**0.26**	**0.38**	**0.38**	**0.26**
Rinit	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	4.00
Selectivity - Full Rec	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-6.82	-15.00	-15.00
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.14	15.00	4.75	5.11
Selectivity - Right Side Rec	2.64	2.81	2.35	3.09
Selectivity - Full - Yr Error Com	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.66	-6.74	-6.79	-6.66
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.60	-0.51	-0.22	-0.28
WDFW Tag Survey q	5.00	4.75	5.00	4.91
Selectivity - Full NMFS Survey	4.00	2.79	4.44	2.42
Selectivity - Full WDFW Survey	7.49	7.45	8.54	7.40
Selectivity - Left NMFS Survey	-15.00	0.01	-0.04	-0.45
Selectivity - Left WDFW Survey	-0.73	-0.82	0.58	-0.86
Selectivity - Right NMFS Survey	2.43	14.98	3.76	4.95
Selectivity - Right WDFW Survey	3.15	6.80	2.81	3.53
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3847	-0.3245	-0.3913	-0.2312

Table 3e. Coleraine output for the northern area (LCN) base model: Profile over combinations of domed and asymptotic fishery selectivity; Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	27761	24824	26807	25713
Depletion	0.13	0.11	0.11	0.13
	RUN3	**RUN4**	**RUN5**	**RUN6**
Input File	ndcdsin.txt	nacasin.txt	ndcasin.txt	nacdsin.txt
No. of Parameters:	51	49	50	50
Likelihoods AIC:	**-14879**	**-14857**	**-14796**	**-14877**
Trawl Logbook CPUE	4.6	6.1	5.8	5.7
Com Catch-At-Age	-1954.6	-1954.6	-1953.7	-1963.9
Rec Catch-At-Age	-1563.7	-1566.6	-1537.4	-1547.8
Com Catch-At-Length	-808.9	-813.0	-810.3	-811.4
Rec Catch-At-Length	-630.3	-617.3	-623.5	-638.3
NMFS Trawl Survey	4.4	6.7	5.6	4.9
WDFW Tag Survey	5.6	6.4	5.1	6.6
NMFS Survey Catch-At-Age	-328.3	-313.1	-314.6	-315.3
WDFW Survey Catch-At-Age	-338.9	-340.2	-337.6	-340.1
NMFS Survey Catch-At-Length	-304.5	-319.7	-317.4	-318.7
WDFW Survey Catch-At-Length	-1608.3	-1606.7	-1606.8	-1605.6
	0	0	0	0
	0	0	0	0
Penalties: B-H Recruitment	32.1	34.3	36.5	35.6
Total Likelihood:	**-7490.7**	**-7477.7**	**-7448.2**	**-7488.3**
Parameters				
R0	2092	1870	2020	1937
h	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32
Rinit	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	4.00
Selectivity - Full Rec	4.00	4.00	3.70	4.00
Selectivity - Left Side Com	-15.00	-11.68	-9.82	-11.21
Selectivity - Left Side Rec	-15.00	-14.47	-14.47	-15.00
Selectivity - Right Side Com	**5.28**	**15.00**	**5.81**	**15.00**
Selectivity - Right Side Rec	**2.51**	**15.00**	**15.00**	**1.64**
Selectivity - Full - Yr Error Com	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.72	-6.72	-6.76	-6.75
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	-0.20	-0.04	-0.10	-0.07
WDFW Tag Survey q	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.01	5.28	5.16	5.22
Selectivity - Full WDFW Survey	8.84	8.91	8.80	8.87
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3050	-0.3909	-0.3151	-0.2782

Figure 1. Coleraine output for the northern area (LCN) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

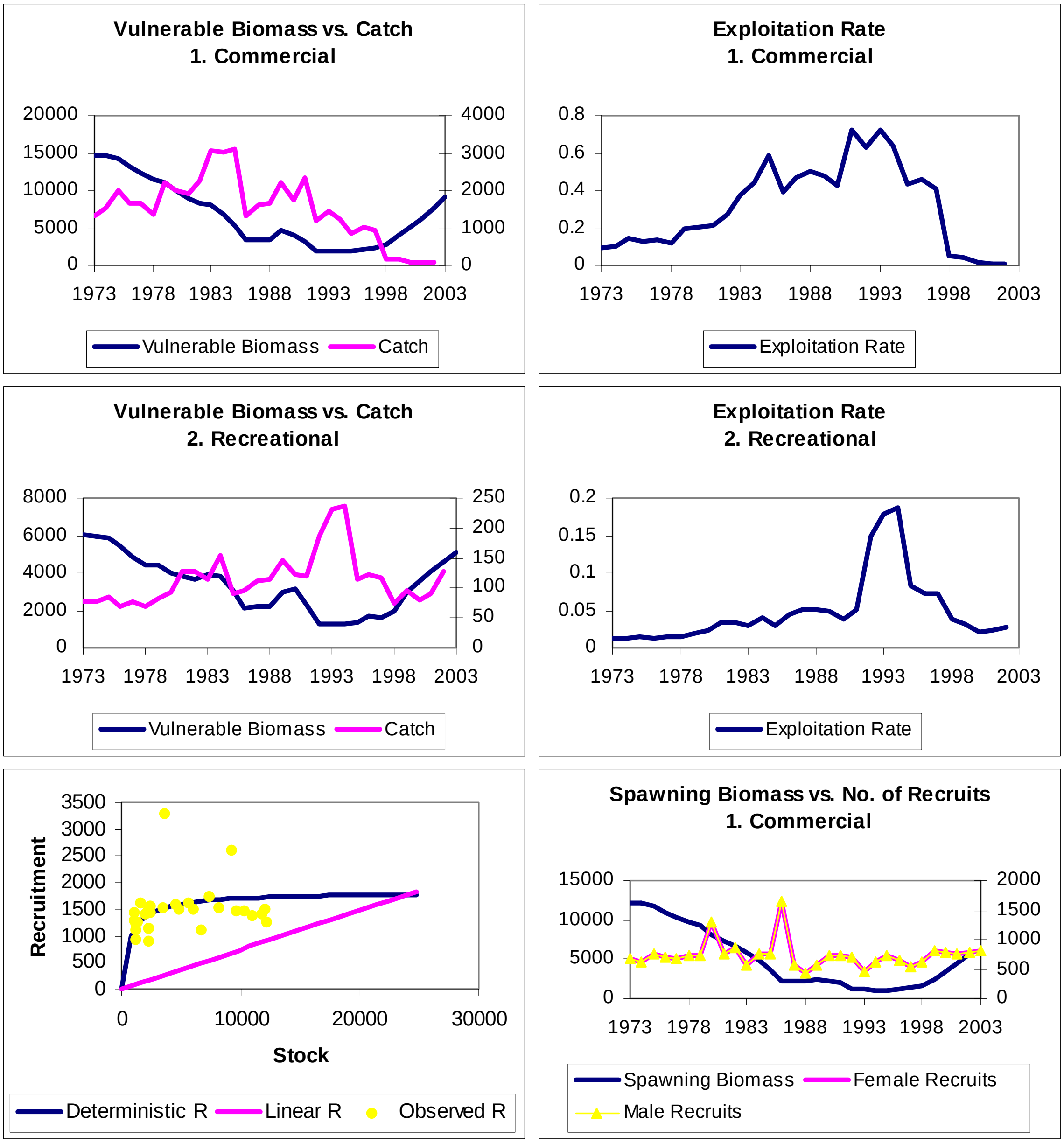


Figure 2. Coleraine output for the northern area (LCN) base model: Estimated selectivity for the commercial fishery, recreational fishery, NMFS trawl survey, and WDFW tagging survey.

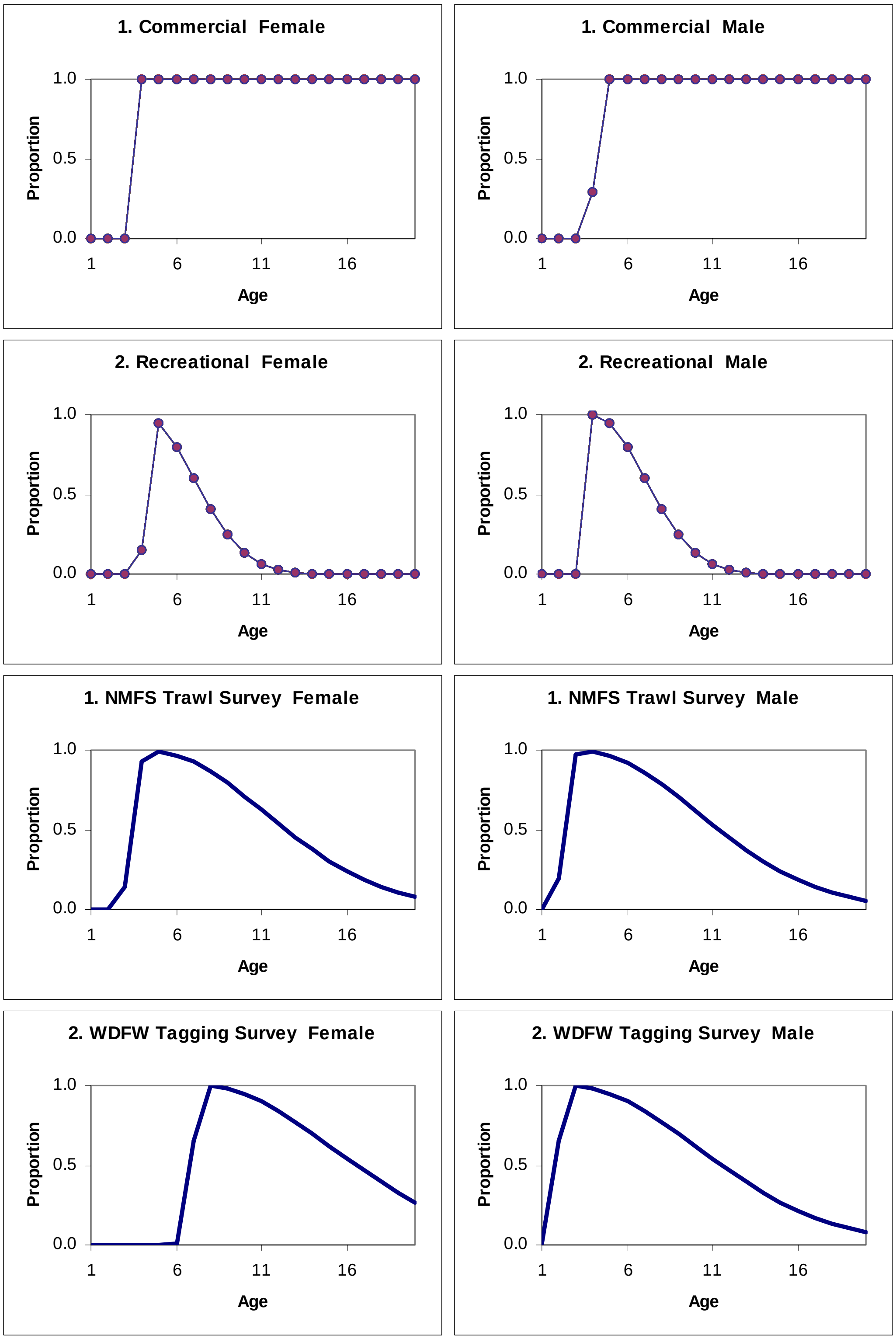


Figure 3. Coleraine output for the northern area (LCN) base model: Model fits to indices of abundance; NMFS trawl survey, WDFW tagging survey, and trawl logbook.

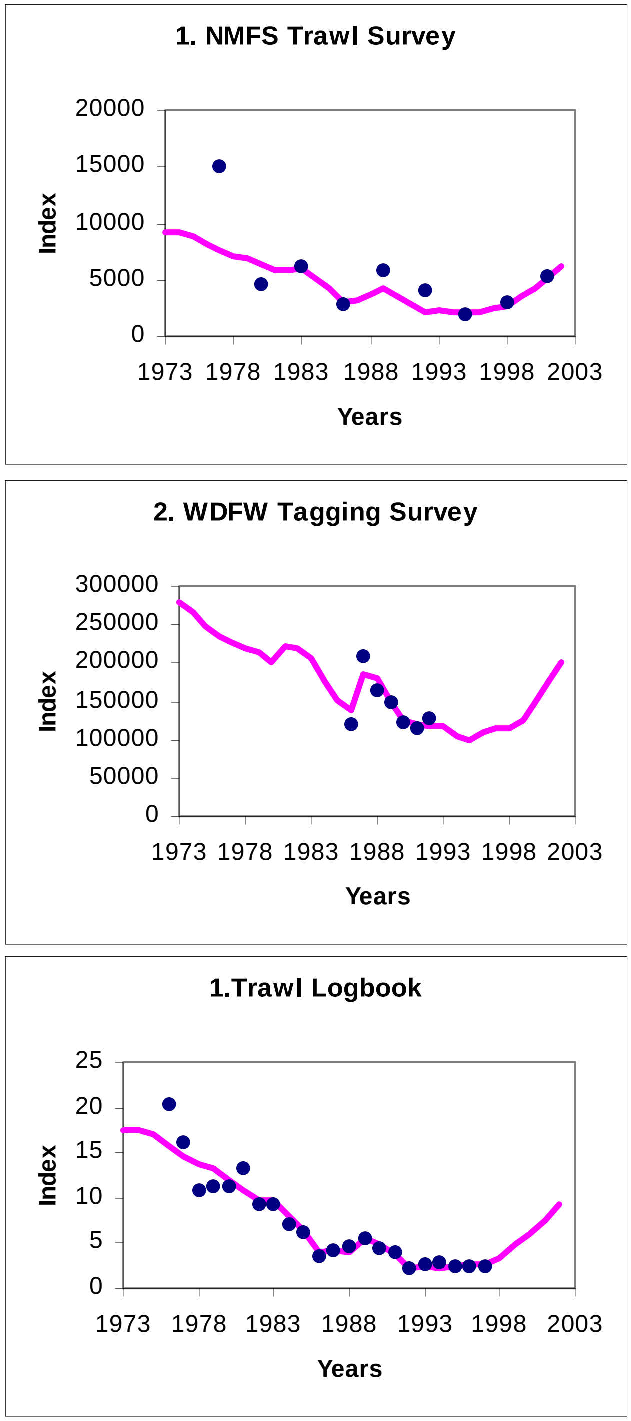


Figure 4. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

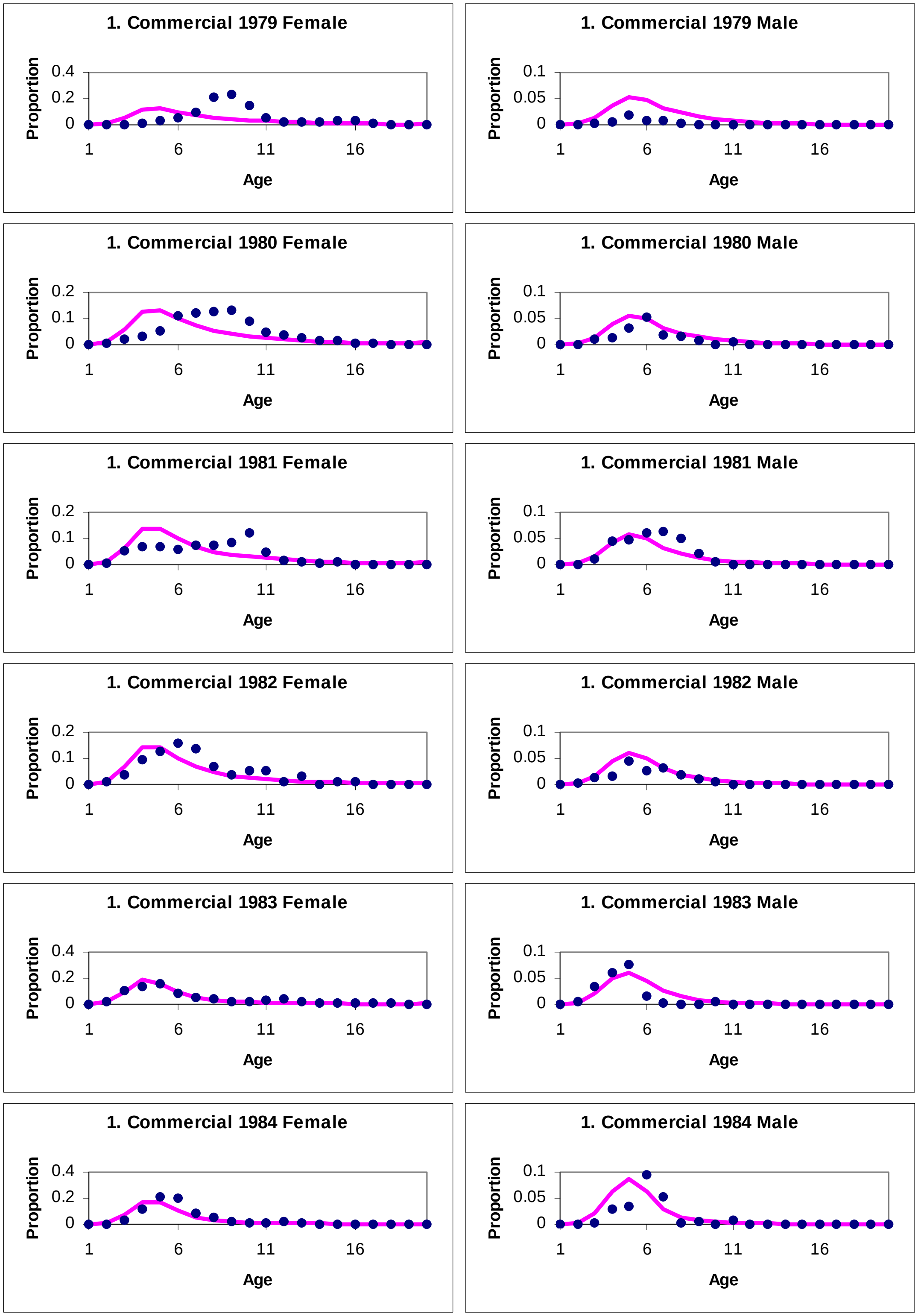


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

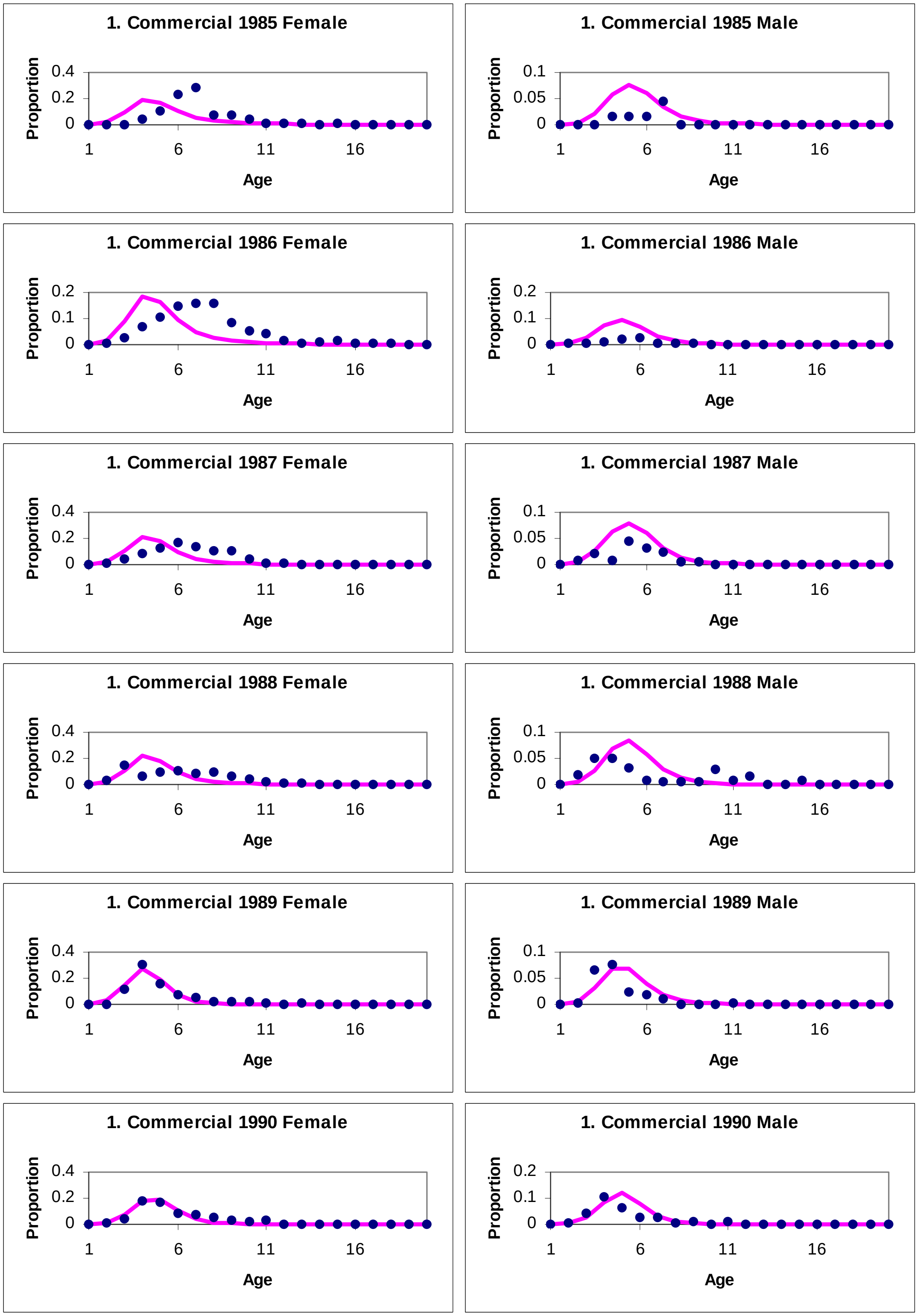


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

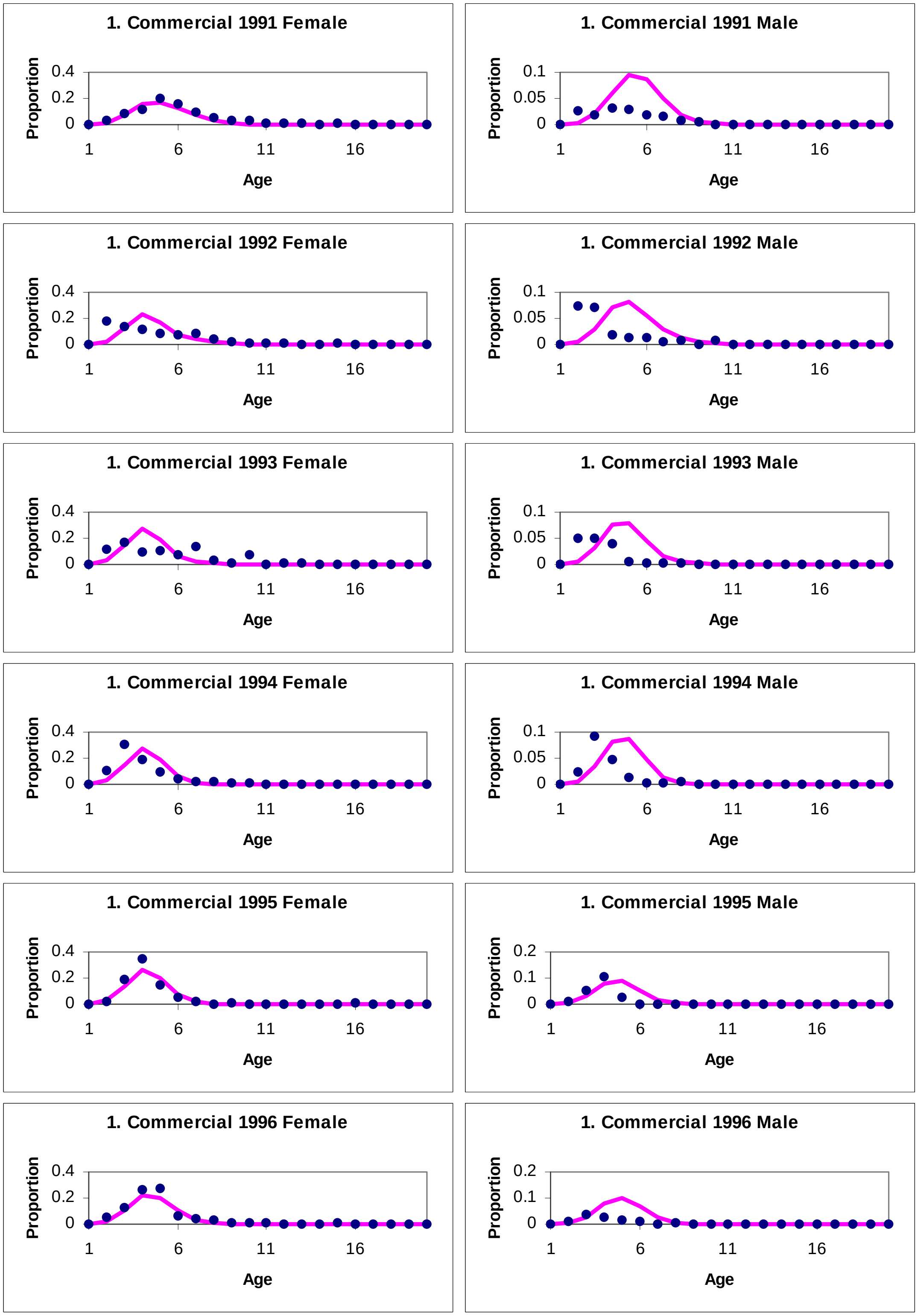


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

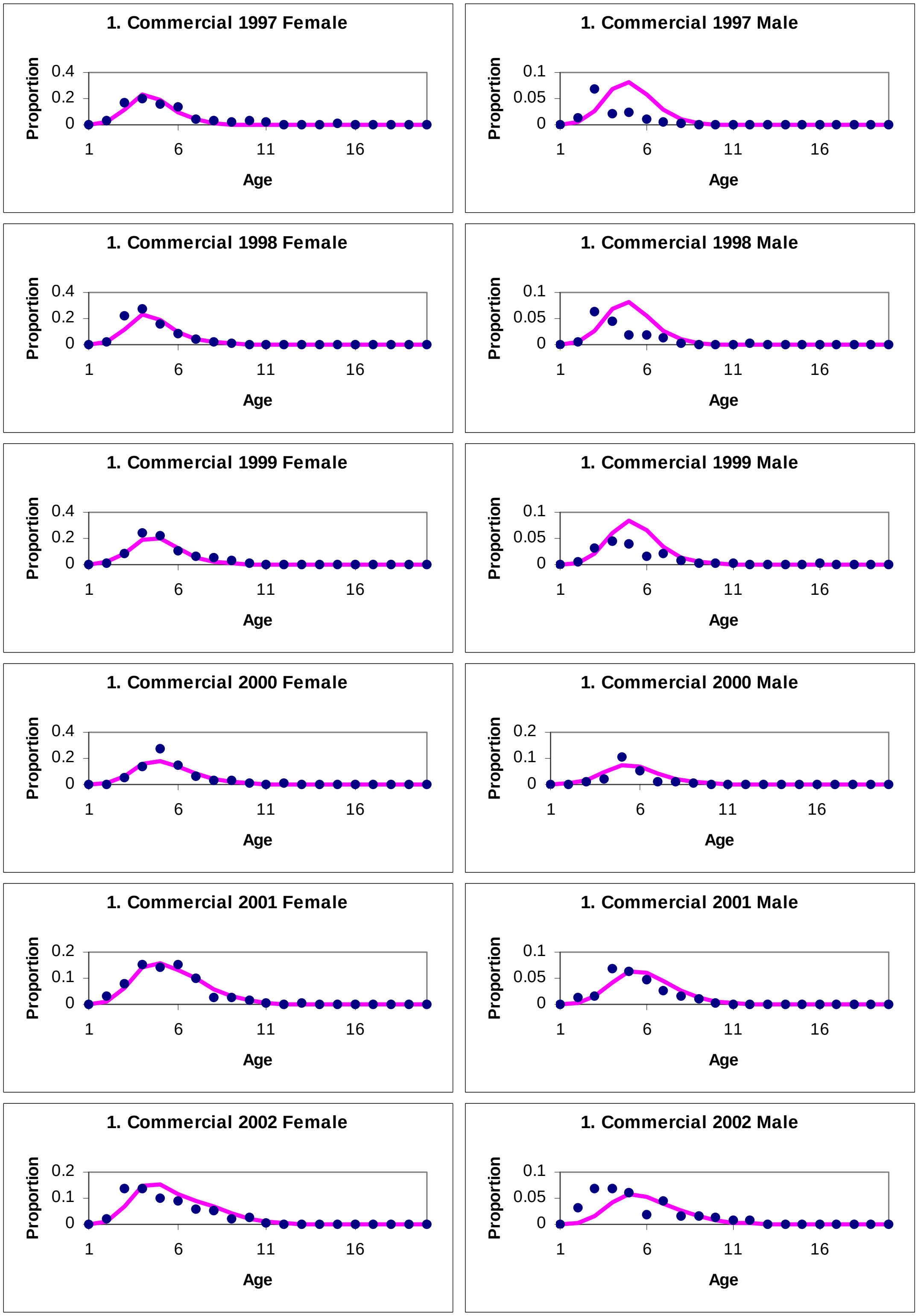


Figure 5. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

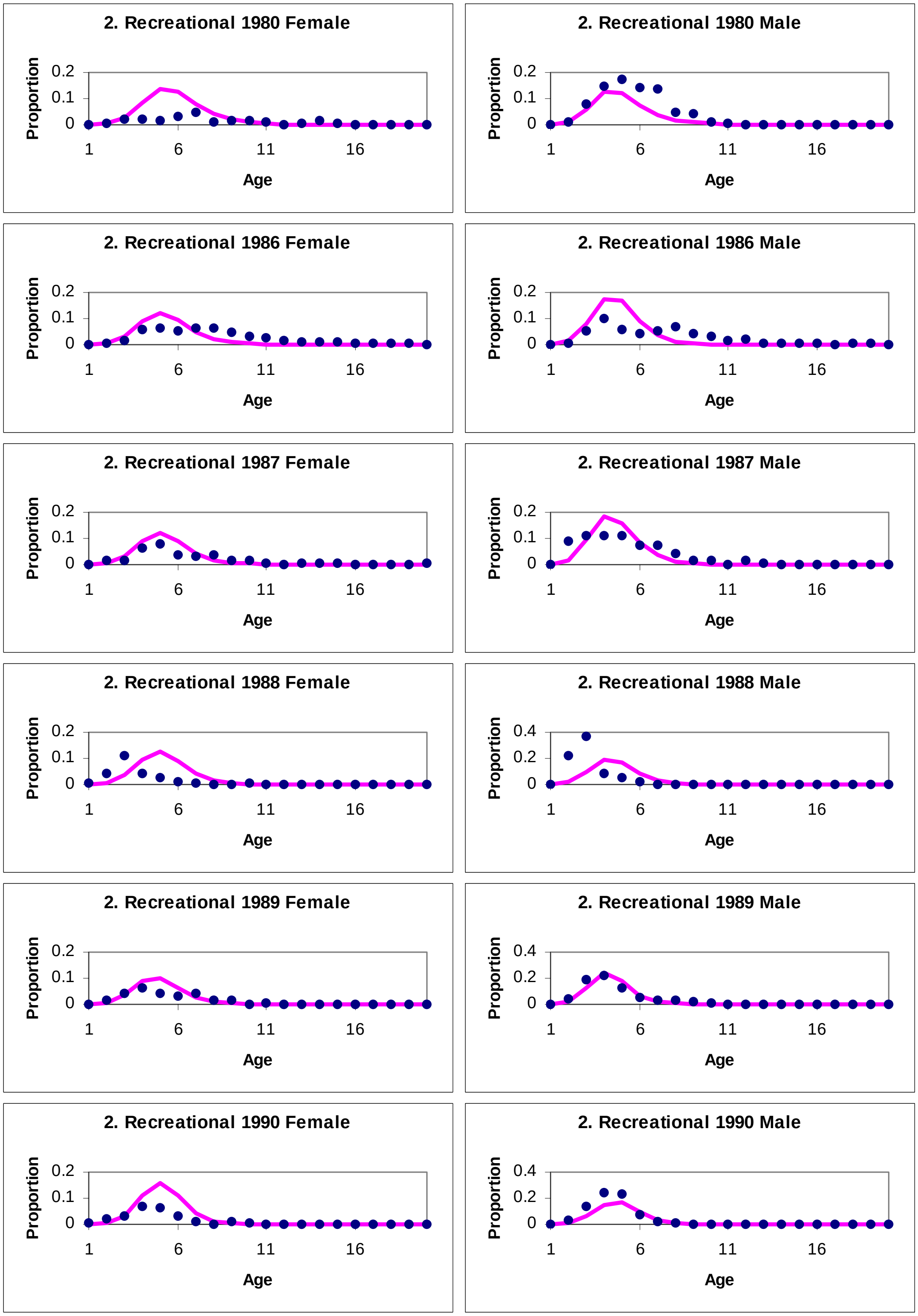


Figure 5, continued. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

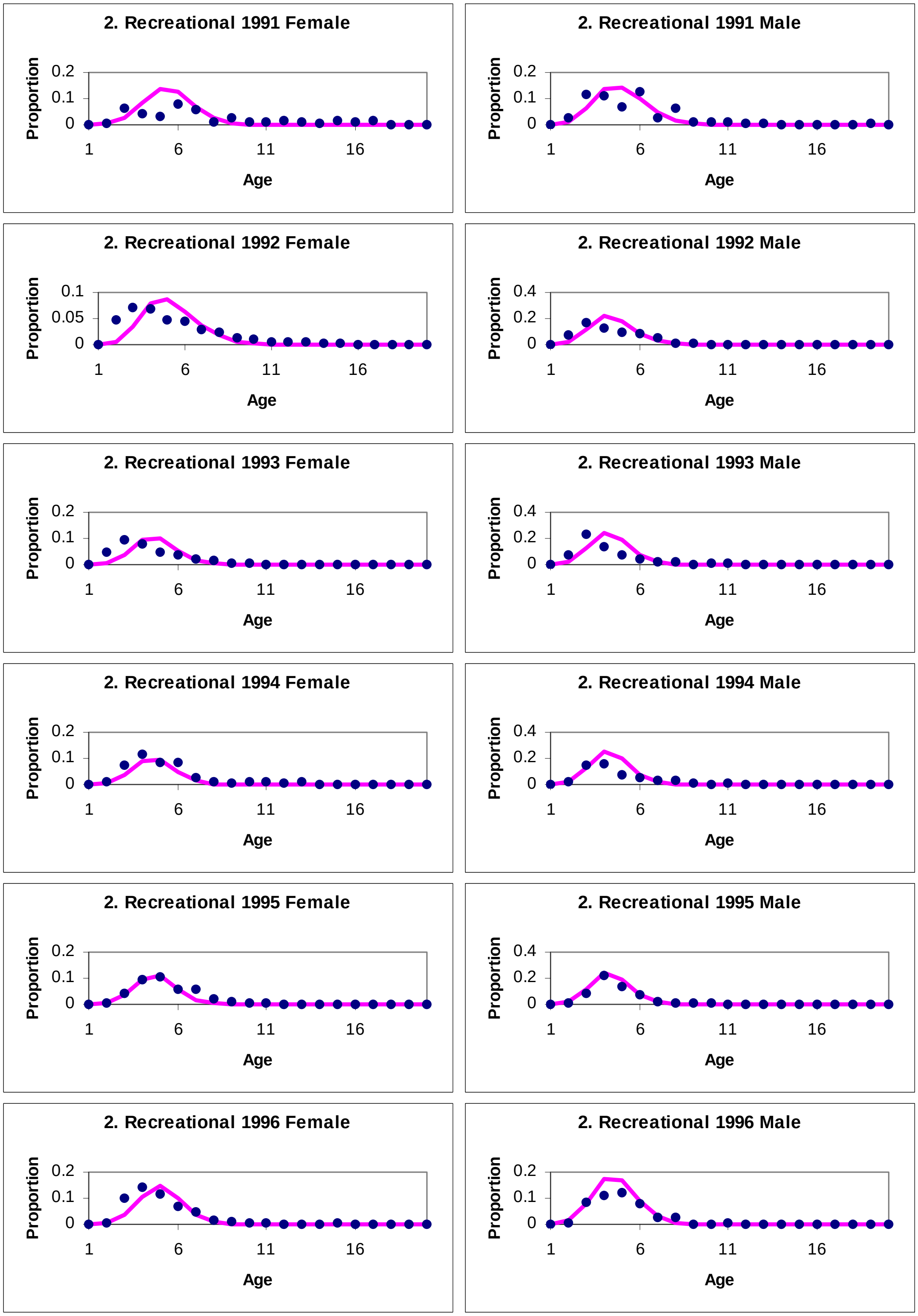


Figure 5, continued. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

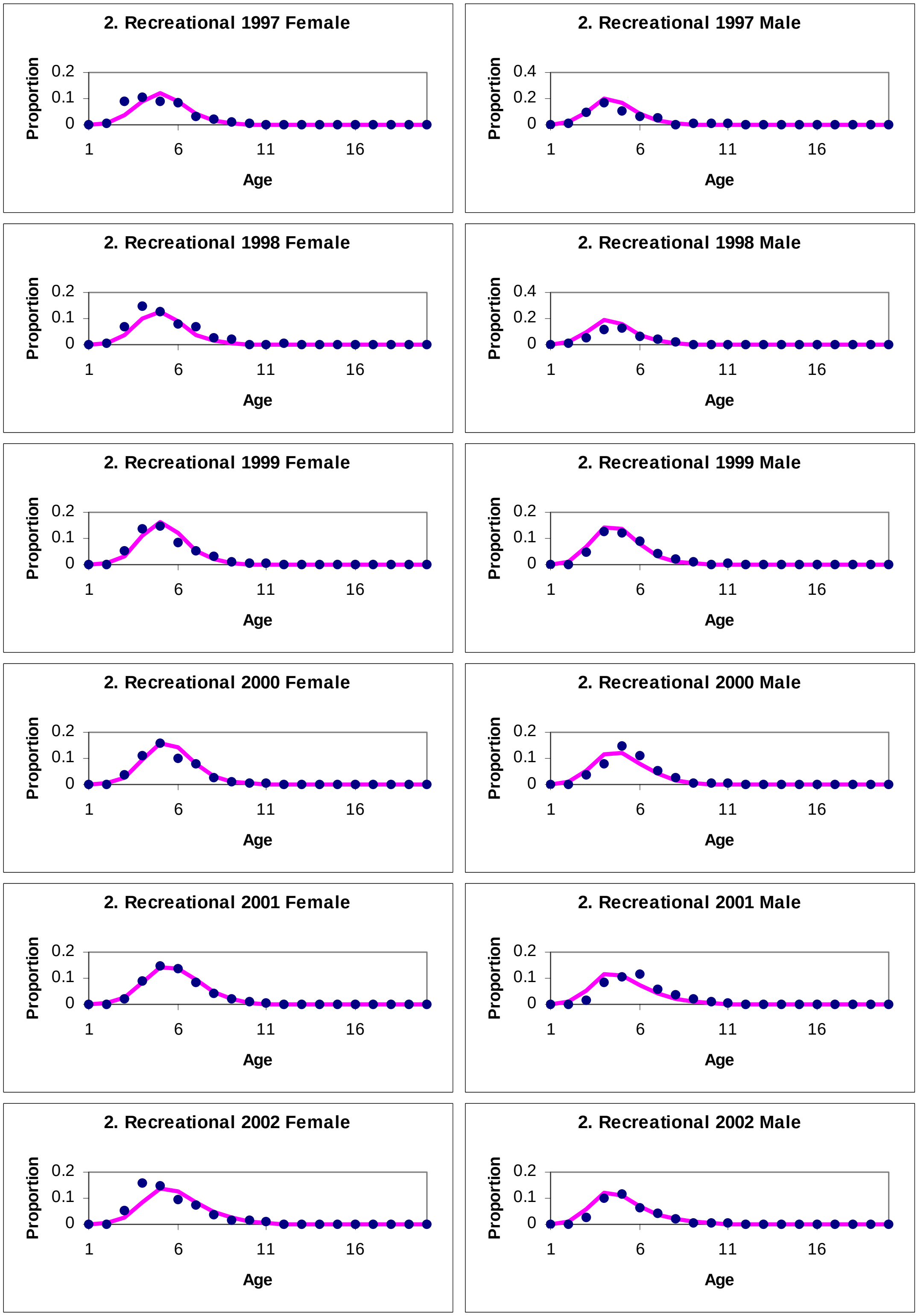


Figure 6. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-length.

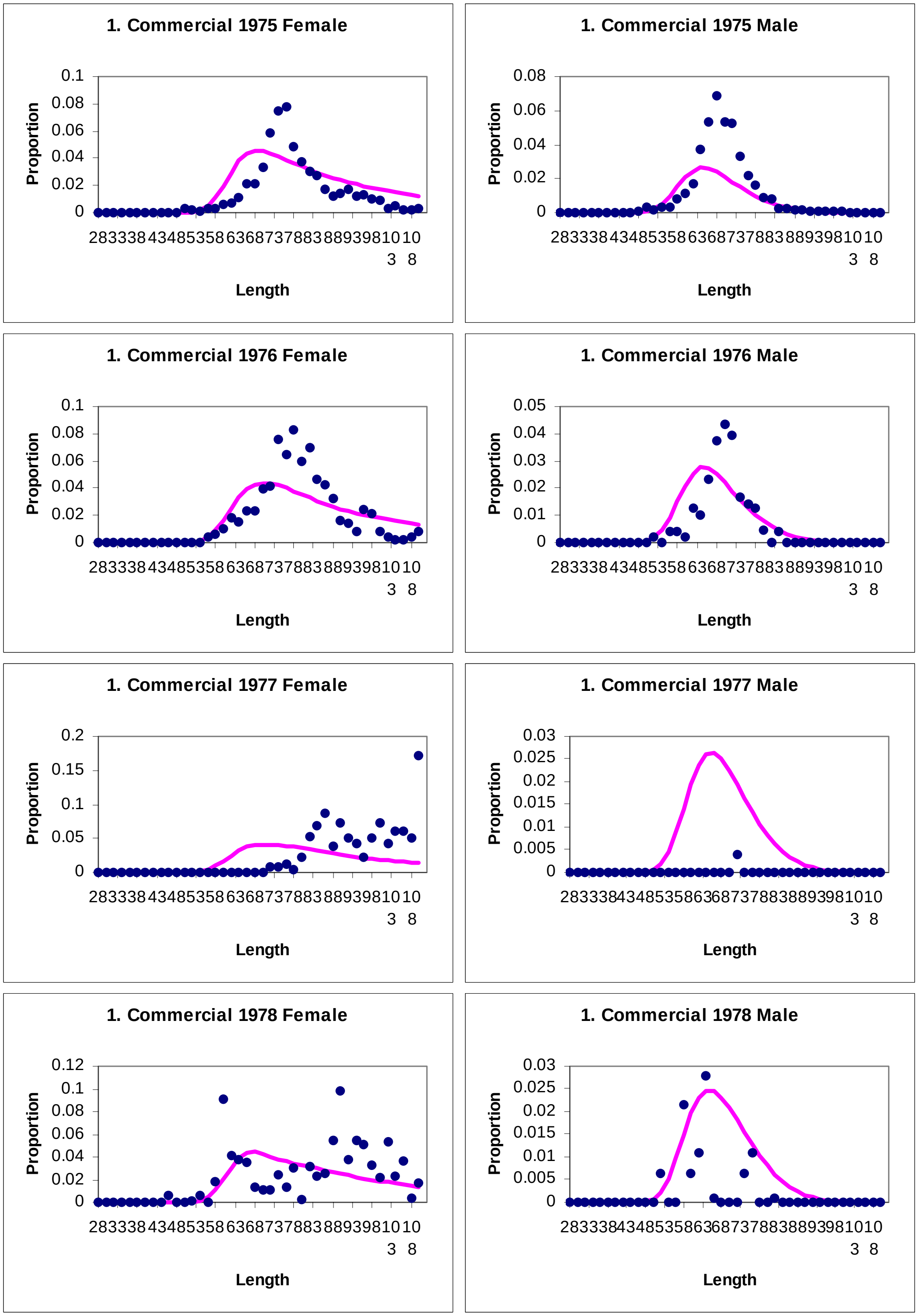


Figure 7. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-length.

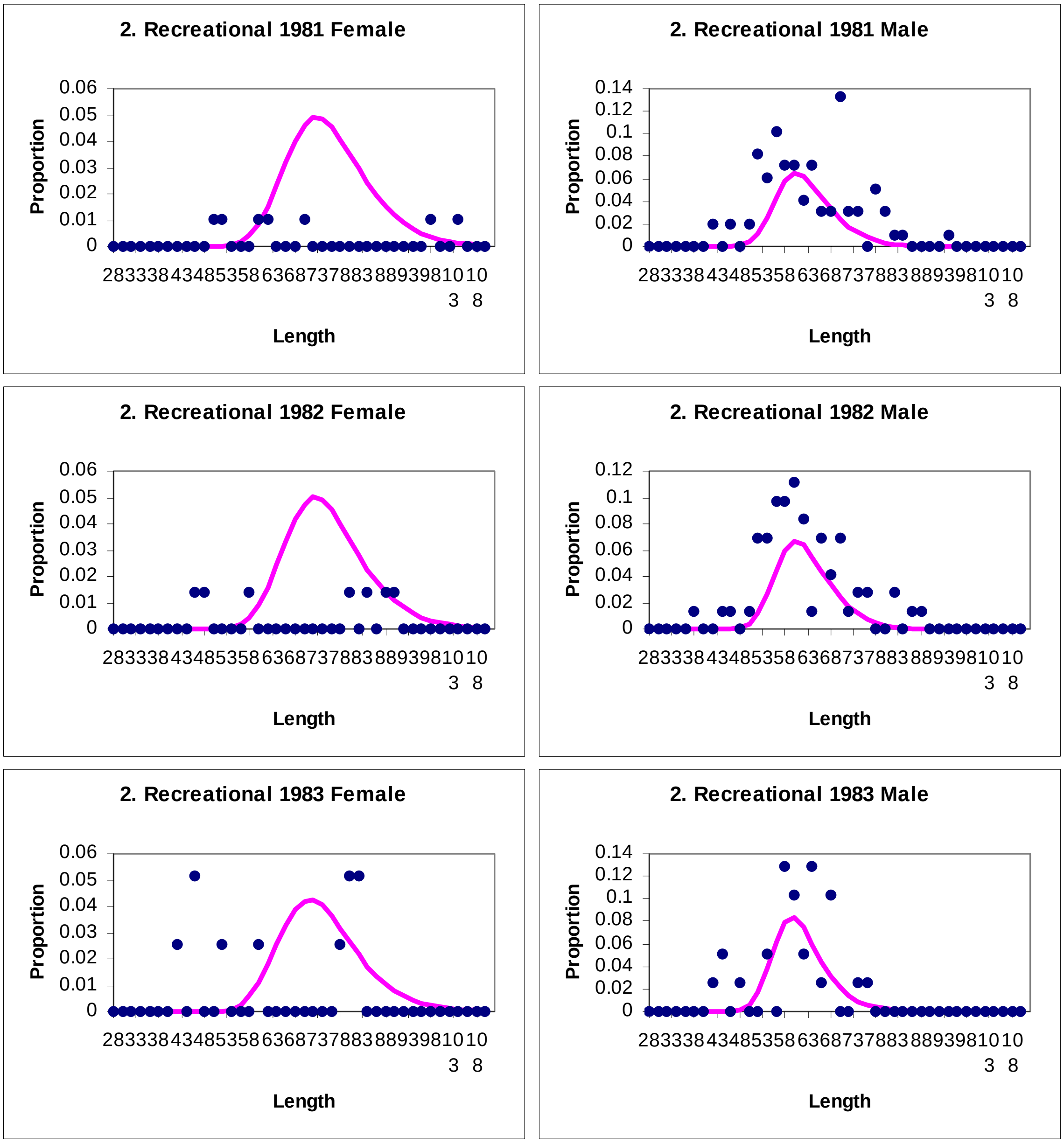


Figure 8. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey catch-at-age.

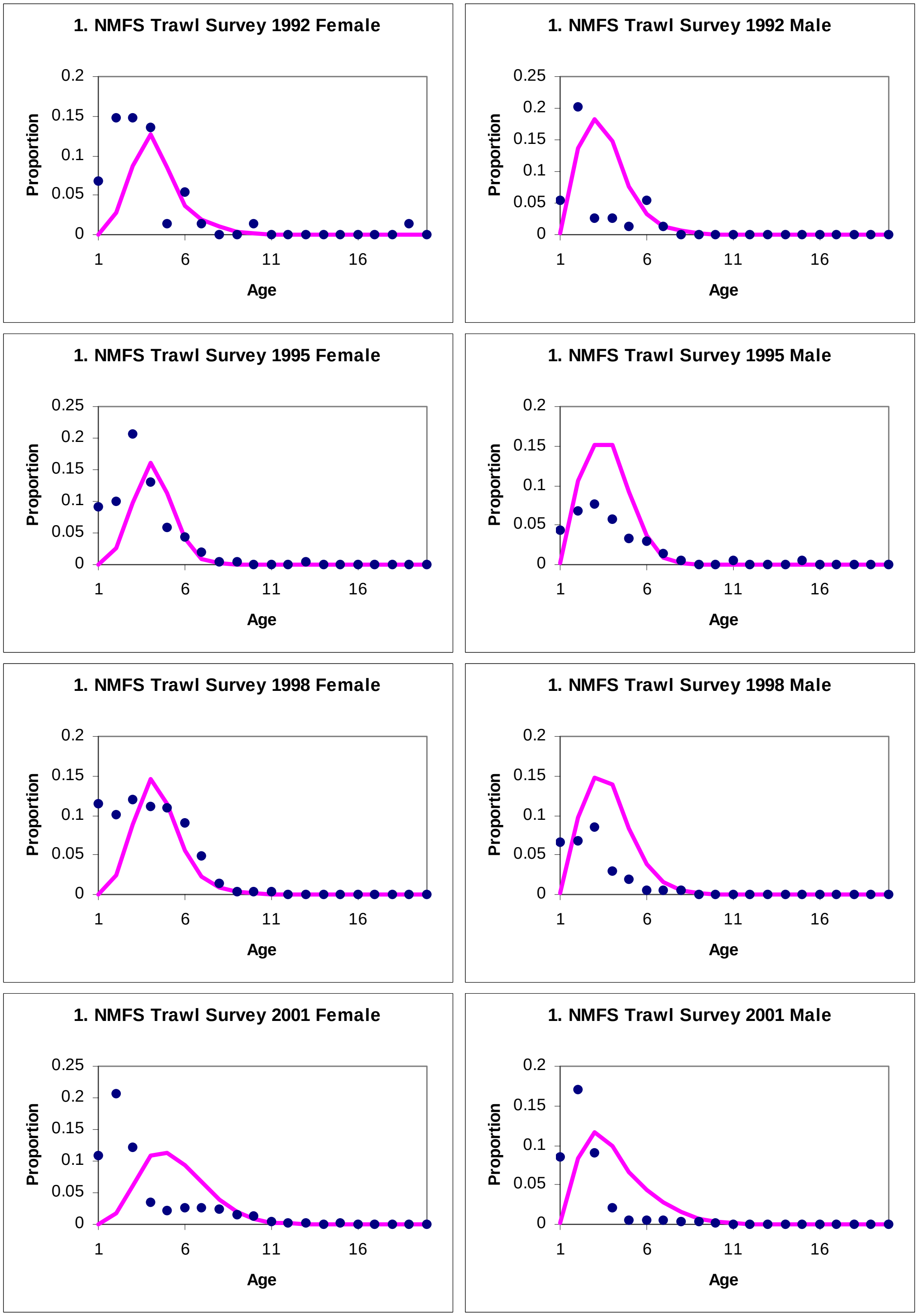


Figure 9. Coleraine output for the northern area (LCN) base model: Model fits to WDFW tagging survey catch-at-age.

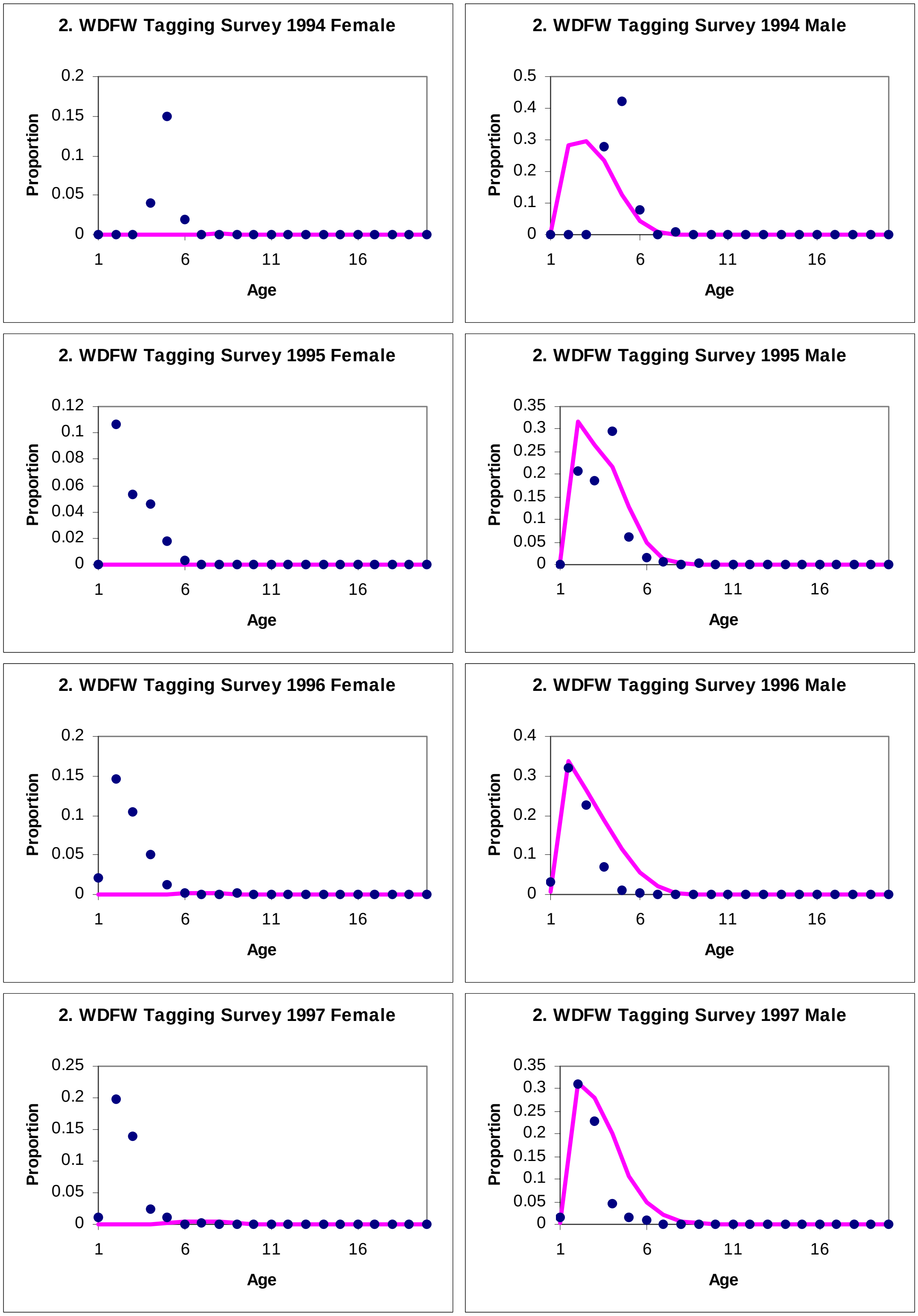


Figure 10. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey and WDFW tagging survey catch-at-length.

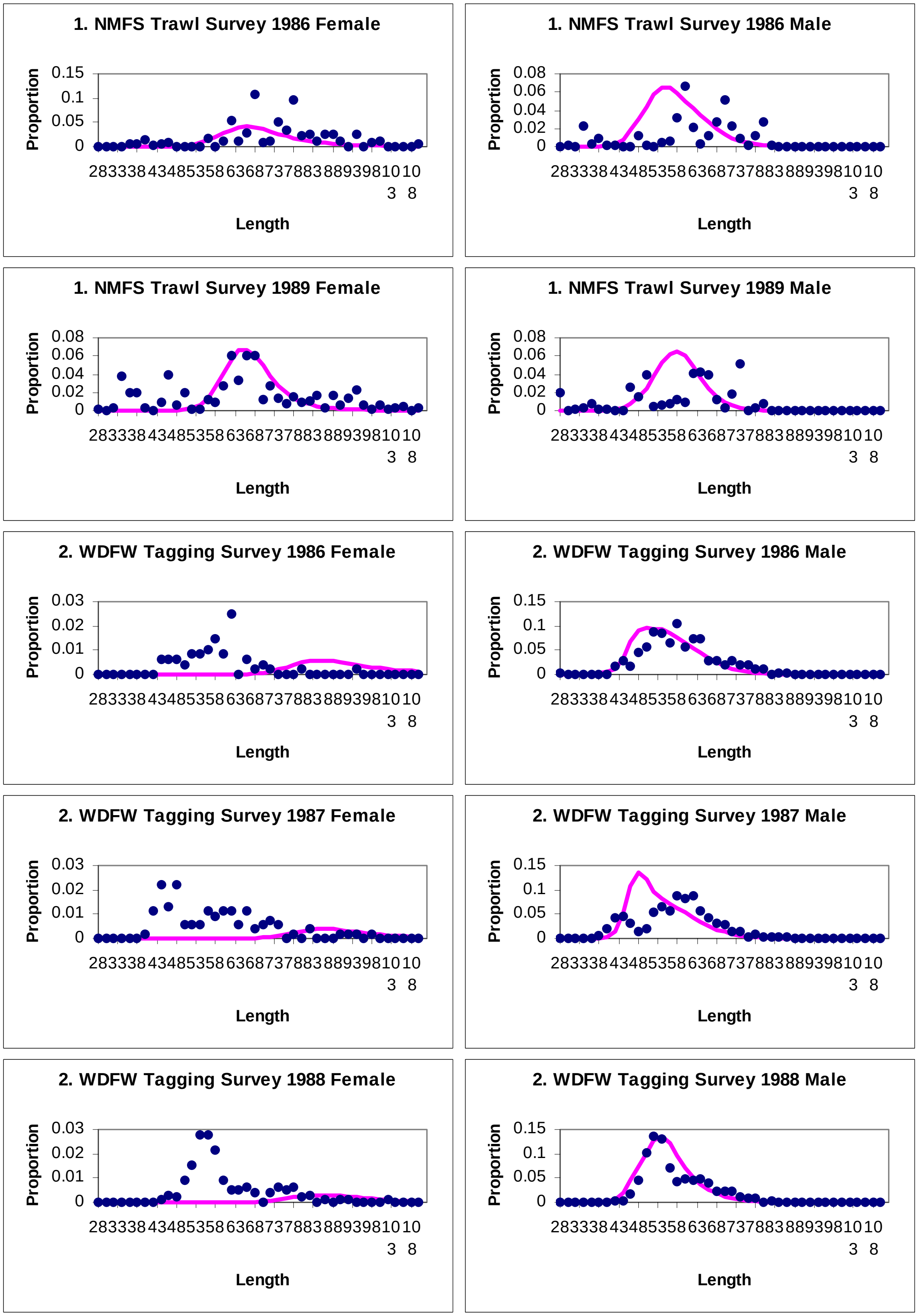


Figure 10, continued. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey and WDFW tagging survey catch-at-length.

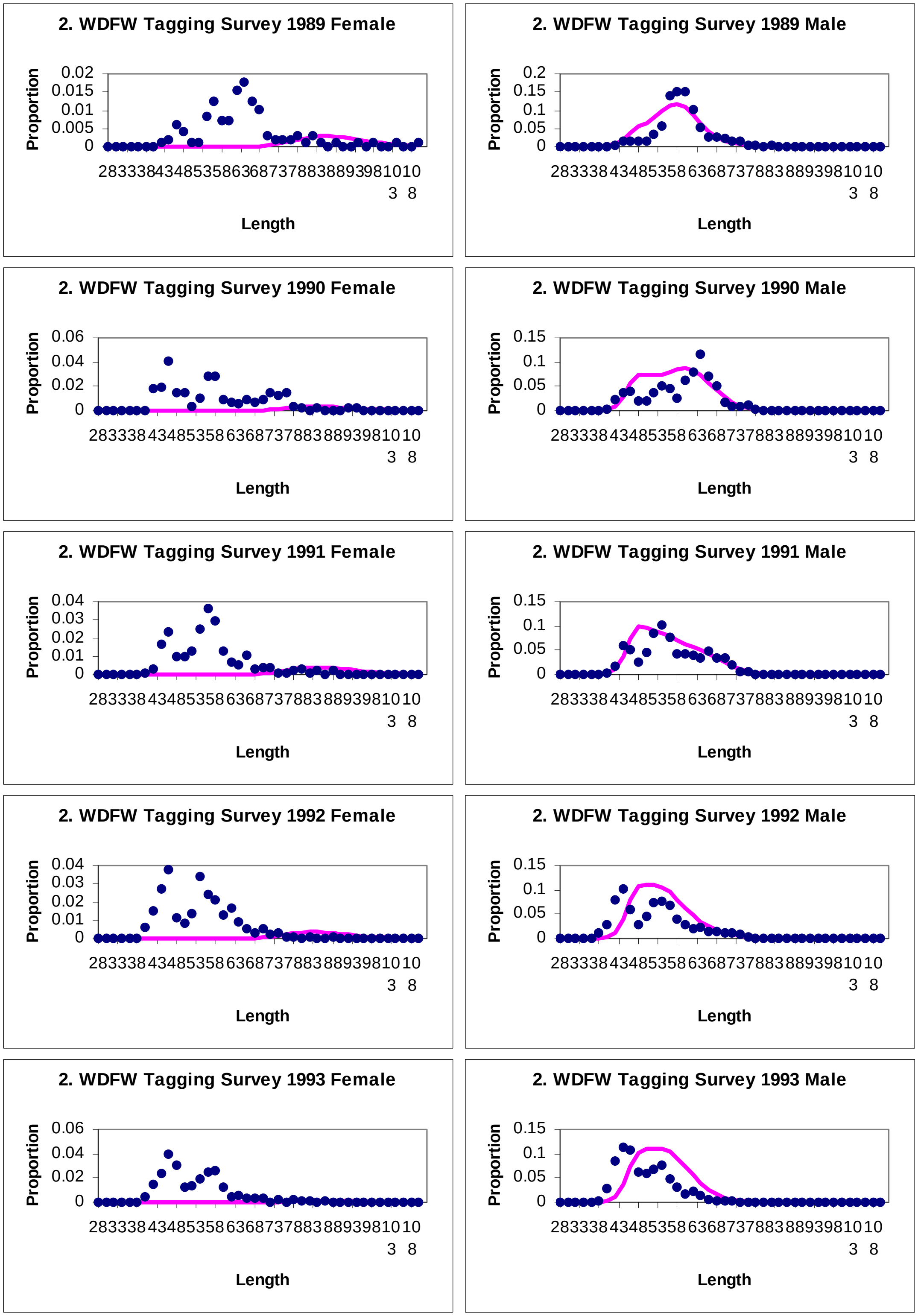


Figure 11a. Coleraine output for the northern area (LCN) base model: Retrospective analysis showing a comparison of base model estimates of spawning biomass with a base model configured with 1999 as the end year.

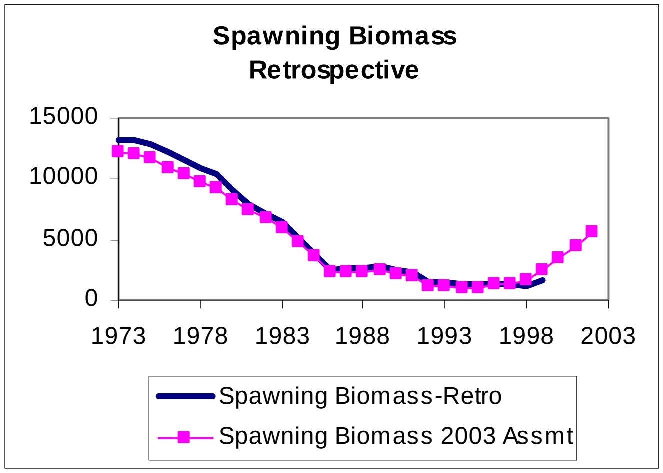


Figure 11b. Coleraine output for the northern area (LCN) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.

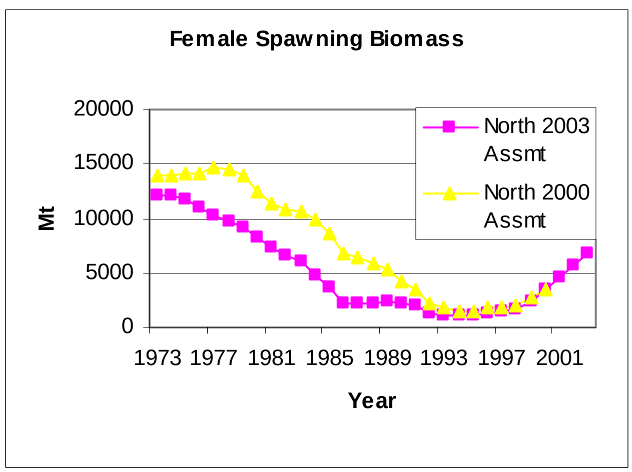


Table 4. Coleraine input for the southern area (LCS) base model: Priors.

Priors

Phase	Low Bound	High Bound	Prior Type (0=uniform, 1=normal, 2=lognormal)	Mean	CV	Seed Value
R0 (Recruitment in virgin condition)						
1	0.1	1000000	0	0	0	2100
h (steepness of spawner-recruit curve)						
-1	0.01	5	0	0.7	1	0.9
M (natural mortality)						
-1	0.05	0.5	0	0.1	0.1	0.18
-1	0.05	0.5	0	0.1	0.1	0.32
Log init dev prior: deviates for initial age structure: uniform or normal only						
-5	-15	15	1	0	0.1	0
log rec dev prior (uniform or normal only)						
2	-15	15	1	0	0.3	0
Initial R (= # 1-yr olds in yr 1/R0; unfished = 1)						
-1	0	2	0	1	0.1	1
Initial u (exploitation rate for initial age structure; 0=unfished)						
-1	0	0.25	0	0	0.1	0.07
-1	0	0.25	0	0	0.1	0.07
Plus scale						
-1	0	2	0	0	0.6	1
-1	0	2	0	0	0.6	1
Age of full selectivity - Females						
3	1	18	0	9	0.1	3.1
3	1	18	0	9	0.1	4.4
Fishery age of full selectivity difference by sex (Delta)						
4	-5	5	0	0	0.6	0
4	-5	5	0	0	0.6	0
Fishery variance of Left side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	-2.2
4	-15	15	0	0	0.6	-1.59
Fishery variance of Right side of selectivity curve (for both sexes)						
4	-15	20	0	0	0.6	1.27
4	-15	20	0	0	0.6	4.08
Fishery age of full selectivity deviation by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Left side selectivity by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Right side selectivity by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Log q CPUE						
1	-15	15	0	0	0.1	-5
Log q CPUE error						
-1	-5	5	0	0	0.6	0
Log q Survey						
1	-5	5	0	0	0.6	-1.6
Survey age of full selectivity - Females						
-3	1	15	0	0	0.6	2
Survey age of full selectivity difference by sex (Delta)						
-3	-5	5	0	0	0.6	-0.98
Survey variance Left side selectivity						
-1	-15	15	0	0	0.6	1
Survey variance Right side selectivity						
-1	-15	15	0	0	0.6	4

Table 5. Coleraine input for the southern area (LCS) base model: Likelihood and fixed parameter specifications.

Likelihoods (1= norm; 2 = lognorm; 3= robust norm; 4=robust lognorm; 12 = robust lognormal for proportions)

CPUE likelihood Type	2	
Commercial catch at age likelihood type	12	12
Commercial catch at length likelihood type	0	0
Survey likelihood type	2	
Survey Index type (1=weight; 2=numbers)	1	
Survey vulnerability type (1=age; 2=length)	1	
Survey no-sex C@L likelihood type	0	
Survey catch at length likelihood type	0	
Survey catch at age likelihood type	12	

Fixed Parameters

Bi-scalar of length-weight relationship	0.00176	0.003953
bii exponent of length-weight relationship	3.3978	3.2149
L-infinity of the vonBertanlanffy growth equation	112.8106921	81.6939587
k of the vonBertanlanffy growth equation	0.144901796	0.223232852
t0 of the vonBertanlanffy growth equation	-1.573476868	-1.434670218
Brody parameter	0.2	0.2
Mean length of age 1 fish	35.11346278	34.25270385
Length at oldest age	107.8592173	81.01141723
S.d. of length at age of 1-year old fish	2.453914279	2.005470452
S.d. of length at age of oldest fish	6.611169688	12.64731616

Table 6. Coleraine output for the southern area (LCS) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

B0		23267
Depletion		0.16
Input File		sfinalD.txt
	No. of Parameters:	**42**
Likelihoods	**AIC:**	**-4119.35**
Trawl Logbook CPUE		7.74394
Com Catch-At-Age		-901.306
Rec Catch-At-Age		-944.034
		0
		0
NMFS Trawl Survey		11.1914
NMFS Survey Catch-At-Age		-285.437
		0
		0
Penalties: B-H Recruitment		10.1668
	Total Likelihood:	**-2101.7**
Parameters		
R0		2078.06
h		0.9
M Females		0.18
M Males		0.32
Rinit		1
Uinit Females		0.07
Uinit Males		0.07
Init Plus Grp Resid Females		1
Init Plus Grp Resid Males		1
Selectivity - Full Com		3.06415
Selectivity - Full Rec		4.3183
Selectivity - Left Side Com		-2.11419
Selectivity - Left Side Rec		-2.2295
Selectivity - Right Side Com		1.68597
Selectivity - Right Side Rec		18.6204
Selectivity - Full - Yr Error Com		0
Selectivity - Full - Yr Error Rec		0
Selectivity - Left - Yr Error Com		0
Selectivity - Left - Yr Error Rec		0
Selectivity - Right - Yr Error Com		0
Selectivity - Right - Yr Error Rec		0
Trawl Logbook CPUE - log(q)		-6.04198
Trawl Logbook CPUE - q Yr Error		0
Trawl Logbook CPUE q		0.002377
NMFS Trawl Survey q		-1.16592
Selectivity - Full NMFS Survey		2
Selectivity - Left NMFS Survey		1
Selectivity - Right NMFS Survey		4
Log Initial Age Comp Dev		0
Log Rec Dev		0.099238

Table 6a1. Coleraine output for the northern area (LCS) base model: Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	2.0781e+003	2.3782e+002
2	log_RecDev	9.9238e-002	3.1898e-001
3	log_RecDev	6.5530e-002	3.0707e-001
4	log_RecDev	4.2964e-002	2.9432e-001
5	log_RecDev	2.5791e-001	3.0380e-001
6	log_RecDev	3.3624e-001	2.7087e-001
7	log_RecDev	4.2634e-002	2.6969e-001
8	log_RecDev	8.8769e-002	2.7599e-001
9	log_RecDev	2.5288e-001	2.6224e-001
10	log_RecDev	3.0206e-002	2.4572e-001
11	log_RecDev	-3.8550e-001	2.4041e-001
12	log_RecDev	-5.0205e-001	2.4508e-001
13	log_RecDev	-2.6237e-001	2.5661e-001
14	log_RecDev	4.7283e-002	2.5628e-001
15	log_RecDev	1.8749e-001	2.6556e-001
16	log_RecDev	2.1493e-001	2.4760e-001
17	log_RecDev	-4.3479e-002	2.3085e-001
18	log_RecDev	-2.3003e-001	2.0221e-001
19	log_RecDev	-3.7178e-001	1.3290e-001
20	log_RecDev	-6.6480e-002	1.6114e-001
21	log_RecDev	7.0937e-002	1.6600e-001
22	log_RecDev	-5.3427e-001	2.7745e-001
23	log_RecDev	1.4631e-001	2.1832e-001
24	log_RecDev	-7.3920e-002	2.5899e-001
25	log_RecDev	1.7241e-001	2.1276e-001
26	log_RecDev	-3.2389e-001	2.2811e-001
27	log_RecDev	-2.2586e-001	2.0123e-001
28	log_RecDev	-4.4538e-001	2.3628e-001
29	log_RecDev	2.6815e-001	2.5132e-001
30	log_RecDev	1.9006e-001	2.5074e-001
31	log_RecDev	-5.7526e-006	3.0000e-001
32	log_RecDev	0.0000e+000	3.0000e-001
33	Sfullest	3.0641e+000	1.5985e-001
34	Sfullest	4.3183e+000	8.7773e-001
35	Sfulldelta	6.1139e-001	5.2049e-001
36	Sfulldelta	-5.4450e-002	1.7624e-001
37	log_varLest	-2.1142e+000	1.8501e+000
38	log_varLest	-2.2295e+000	5.3795e+000
39	log_varRest	1.6860e+000	3.3559e-001
40	log_varRest	1.8620e+001	2.5797e+003
41	log_qCPUE	-6.0420e+000	1.1102e-001
42	log_qsurvey	-1.1659e+000	8.1025e-002
43	Ro_mcmc	2.0781e+003	2.3782e+002

Table 6a. Coleraine output for the southern area (LCS) base model: Profile over historical exploitation rate (U_{init}); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	26826	27127	28773	29020	28216
Depletion	0.16	0.16	0.15	0.15	0.15
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	su1out.txt	su2out.txt	su3out.txt	su4out.txt	su5out.txt
No. of Parameters:	42	42	42	42	42
Likelihoods AIC:	**-4122**	**-4122**	**-4123**	**-4122**	**-4121**
Trawl Logbook CPUE	9.4	9.4	6.9	6.9	9.4
Com Catch-At-Age	-905.2	-905.1	-902.5	-902.6	-905.0
Rec Catch-At-Age	-945.7	-945.7	-944.4	-944.4	-945.7
Com Catch-At-Length	0	0	0	0	0
Rec Catch-At-Length	0	0	0	0	0
NMFS Trawl Survey	11.0	11.1	10.6	10.6	11.2
WDFW Tag Survey	0	0	0	0	0
NMFS Survey Catch-At-Age	-281.1	-281.1	-284.5	-284.5	-281.1
WDFW Survey Catch-At-Age	0	0	0	0	0
NMFS Survey Catch-At-Length	0	0	0	0	0
WDFW Survey Catch-At-Length	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	8.4	8.5	10.6	10.6	8.6
Total Likelihood:	**-2103.0**	**-2102.9**	**-2103.3**	**-2103.2**	**-2102.6**
Parameters					
R0	2396	2423	2570	2592	2520
h	0.7	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32	0.32
Rinit	1	1	1	1	1
Uinit Females	**0.03**	**0.05**	**0.07**	**0.09**	**0.12**
Uinit Males	**0.03**	**0.05**	**0.07**	**0.09**	**0.12**
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	3.00	3.00	3.12	3.12	3.00
Selectivity - Full Rec	4.38	4.38	4.41	4.41	4.38
Selectivity - Left Side Com	-15.00	-15.00	-2.19	-2.19	-15.00
Selectivity - Left Side Rec	-1.83	-1.83	-1.57	-1.57	-1.85
Selectivity - Right Side Com	2.53	2.52	1.30	1.30	2.50
Selectivity - Right Side Rec	4.22	4.22	4.13	4.13	4.21
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.2301	-6.2290	-6.0538	-6.0537	-6.2254
Trawl Logbook CPUE - q Yr Error	0	0	0	0	0
Trawl Logbook CPUE q	0.0020	0.0020	0.0023	0.0023	0.0020
NMFS Trawl Survey q	-1.2645	-1.2639	-1.2682	-1.2670	-1.2622
WDFW Tag Survey q	0	0	0	0	0
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev	0	0	0	0	0
Log Rec Dev	-0.0310	-0.0297	-0.0072	-0.0057	-0.0253

Table 6b. Coleraine output for the southern area (LCS) base model: Profile over natural mortality rate (M); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Run 2 did not fully converge.

B0	35764	32507	28773	25842	23363
Depletion	0.15	0.14	0.15	0.16	0.17
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	sm1out.txt	sm2out.txt	sm3out.txt	sm4out.txt	sm5out.txt
No. of Parameters:	42	42	42	42	42
Likelihoods AIC:	**-4122**	**-4116**	**-4123**	**-4123**	**-4122**
Trawl Logbook CPUE	9.7	8.5	6.9	6.8	6.7
Com Catch-At-Age	-905.9	-902.4	-902.5	-902.6	-902.4
Rec Catch-At-Age	-945.8	-943.4	-944.4	-943.6	-942.6
Com Catch-At-Length	0	0	0	0	0
Rec Catch-At-Length	0	0	0	0	0
NMFS Trawl Survey	10.7	10.3	10.6	10.7	10.9
WDFW Tag Survey	0	0	0	0	0
NMFS Survey Catch-At-Age	-279.2	-281.7	-284.5	-285.5	-286.4
WDFW Survey Catch-At-Age	0	0	0	0	0
NMFS Survey Catch-At-Length	0	0	0	0	0
WDFW Survey Catch-At-Length	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	7.7	8.6	10.6	10.7	10.7
Total Likelihood:	**-2102.9**	**-2100.1**	**-2103.3**	**-2103.4**	**-2103.1**
Parameters					
R0	1960	2298	2570	2867	3174
h	0.7	0.7	0.7	0.7	0.7
M Females	0.14	0.16	0.18	0.2	0.22
M Males	0.28	0.3	0.32	0.35	0.38
Rinit	1	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	3.00	3.07	3.12	3.13	3.15
Selectivity - Full Rec	4.39	4.33	4.41	4.41	4.42
Selectivity - Left Side Com	-15.00	-2.53	-2.19	-2.08	-1.96
Selectivity - Left Side Rec	-1.73	-2.21	-1.57	-1.61	-1.67
Selectivity - Right Side Com	2.59	1.86	1.30	1.27	1.25
Selectivity - Right Side Rec	4.09	4.18	4.13	4.23	4.40
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.2108	-6.1409	-6.0538	-6.0711	-6.0850
Trawl Logbook CPUE - q Yr Error	0	0	0	0	0
Trawl Logbook CPUE q	0.0020	0.0022	0.0023	0.0023	0.0023
NMFS Trawl Survey q	-1.2218	-1.2302	-1.2682	-1.2887	-1.3088
WDFW Tag Survey q	0	0	0	0	0
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev	0	0	0	0	0
Log Rec Dev	-0.0312	-0.0305	-0.0072	-0.0003	0.0075

Table 6c. Coleraine output for the southern area (LCS) base model: Profile over B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	35277	30781	28773	26006	23264
Depletion	0.15	0.15	0.15	0.16	0.16
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	sh1out.txt	sh2out.txt	sh3out.txt	sh4out.txt	sh5out.txt
No. of Parameters:	42	42	42	42	42
Likelihoods AIC:	**-4117**	**-4116**	**-4123**	**-4121**	**-4119**
Trawl Logbook CPUE	6.5	7.9	6.9	7.2	7.7
Com Catch-At-Age	-903.4	-904.6	-902.5	-901.9	-901.3
Rec Catch-At-Age	-944.4	-942.5	-944.4	-943.8	-944.0
Com Catch-At-Length	0	0	0	0	0
Rec Catch-At-Length	0	0	0	0	0
NMFS Trawl Survey	11.7	11.3	10.6	10.7	11.2
WDFW Tag Survey	0	0	0	0	0
NMFS Survey Catch-At-Age	-283.3	-280.7	-284.5	-285.0	-285.4
WDFW Survey Catch-At-Age	0	0	0	0	0
NMFS Survey Catch-At-Length	0	0	0	0	0
WDFW Survey Catch-At-Length	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	12.4	8.3	10.6	10.4	10.2
Total Likelihood:	**-2100.5**	**-2100.2**	**-2103.3**	**-2102.4**	**-2101.7**
Parameters					
R0	3151	2749	2570	2323	2078
h	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
M Females	0.18	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32	0.32
Rinit	1	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	3.14	3.14	3.12	3.10	3.07
Selectivity - Full Rec	4.39	4.45	4.41	4.42	4.28
Selectivity - Left Side Com	-2.41	-3.08	-2.19	-2.15	-2.11
Selectivity - Left Side Rec	-1.69	-1.58	-1.57	-1.53	-2.47
Selectivity - Right Side Com	0.97	1.78	1.30	1.46	1.68
Selectivity - Right Side Rec	3.07	3.78	4.13	4.56	12.56
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.0647	-6.1545	-6.0538	-6.0562	-6.0418
Trawl Logbook CPUE - q Yr Error	0	0	0	0	0
Trawl Logbook CPUE q	0.0023	0.0021	0.0023	0.0023	0.0024
NMFS Trawl Survey q	-1.4176	-1.3126	-1.2682	-1.2223	-1.1659
WDFW Tag Survey q	0	0	0	0	0
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev	0	0	0	0	0
Log Rec Dev	-0.0406	-0.0418	-0.0072	0.0304	0.0987

Table 6d. Coleraine output for the southern area (LCS) base model: Profile over combinations of natural mortality rate (M) and B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	42274	17952	28712	29002
Depletion	0.12	0.26	0.17	0.17
	RUN10	**RUN11**	**RUN12**	**RUN13**
Input File	shlml.txt	shhmh.txt	shlmh.txt	shhml.txt
No. of Parameters:				
Likelihoods **AIC:**				
Trawl Logbook CPUE	8.4	10.0	6.3	10.2
Com Catch-At-Age	-907.0	-904.5	-903.5	-904.4
Rec Catch-At-Age	-941.8	-943.7	-941.9	-945.5
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
NMFS Trawl Survey	11.6	12.9	11.9	11.8
NMFS Survey Catch-At-Age	-277.5	-283.8	-285.3	-280.2
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
Penalties: B-H Recruitment	10.5	9.3	12.7	9.0
Total Likelihood:	**-2095.8**	**-2099.9**	**-2099.7**	**-2098.9**
Parameters				
R0	2316	2439	3901	1589
h	**0.5**	**0.9**	**0.5**	**0.9**
M Females	**0.14**	**0.22**	**0.22**	**0.14**
M Males	**0.26**	**0.38**	**0.38**	**0.26**
Rinit	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	3.10	3.00	3.19	3.00
Selectivity - Full Rec	4.49	4.09	4.00	4.40
Selectivity - Left Side Com	-2.52	-14.34	-2.09	-14.87
Selectivity - Left Side Rec	-1.57	-4.80	-15.00	-1.66
Selectivity - Right Side Com	1.87	2.91	0.87	2.96
Selectivity - Right Side Rec	3.92	19.38	3.19	4.45
Selectivity - Full - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Full - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Rec	0.00	0.00	0.00	0.00
Trawl Logbook CPUE - log(q)	-6.1675	-6.3072	-6.0970	-6.2420
Trawl Logbook CPUE - q Yr Error	0	0	0	0
Trawl Logbook CPUE q	0.0021	0.0018	0.0022	0.0019
NMFS Trawl Survey q	-1.2643	-1.3078	-1.4636	-1.1860
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.0923	0.1251	-0.0246	0.0766

Table 6e. Coleraine output for the southern area (LCS) base model: Profile over combinations of domed and asymptotic fishery selectivity; Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	28492	22525	27620	23809
Depletion	0.16	0.16	0.12	0.18
	RUN3	**RUN4**	**RUN6**	**RUN6**
Input File	sdcdsin.txt	sacasin.txt	sdcasin.txt	sacdsin.txt
No. of Parameters:	42	40	41	41
Likelihoods AIC:	**-4135**	**-4065**	**-4068**	**-4048**
Trawl Logbook CPUE	6.8	23.4	14.2	22.0
Com Catch-At-Age	-902.7	-898.1	-890.8	-896.7
Rec Catch-At-Age	-944.4	-937.8	-931.5	-925.7
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
NMFS Trawl Survey	4.9	6.2	5.5	6.1
NMFS Survey Catch-At-Age	-284.4	-280.9	-285.0	-280.7
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
Penalties: B-H Recruitment	10.6	14.4	12.4	9.8
Total Likelihood:	**-2109.3**	**-2072.6**	**-2075.2**	**-2065.2**
Parameters				
R0	2545	2012	2467	2126
h	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32
Rinit	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	3.13	2.00	2.01	2.99
Selectivity - Full Rec	4.40	4.07	3.76	5.86
Selectivity - Left Side Com	-2.21	-14.74	-7.54	-14.96
Selectivity - Left Side Rec	-1.60	-5.37	-11.25	0.63
Selectivity - Right Side Com	**1.27**	**15.00**	**3.82**	**20.00**
Selectivity - Right Side Rec	**4.09**	**15.00**	**10.48**	**0.00**
Selectivity - Full - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Full - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Rec	0.00	0.00	0.00	0.00
Trawl Logbook CPUE - log(q)	-6.0561	-6.8967	-6.6475	-7.0207
Trawl Logbook CPUE - q Yr Error	0	0	0	0
Trawl Logbook CPUE q	0.0023	0.0010	0.0013	0.0009
NMFS Trawl Survey q	-1.3135	-1.2049	-1.2125	-1.2856
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.0370	-0.1698	-0.1171	-0.1390

Figure 12a. Coleraine output for the southern area (LCS) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

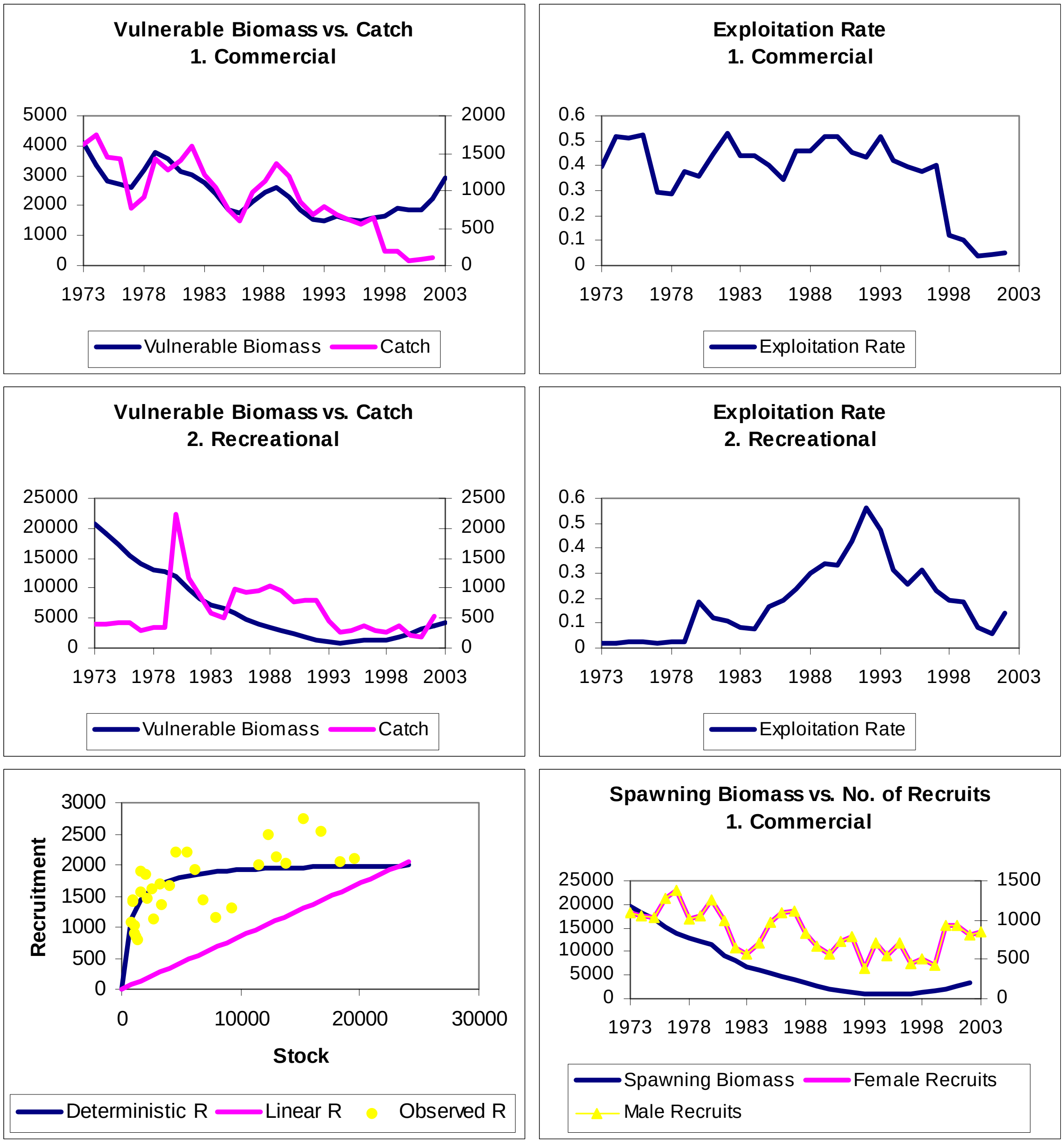


Figure 12b. Coleraine output for the southern area (LCS) base model: Estimated selectivity for the commercial fishery, recreational fishery, and NMFS trawl survey.

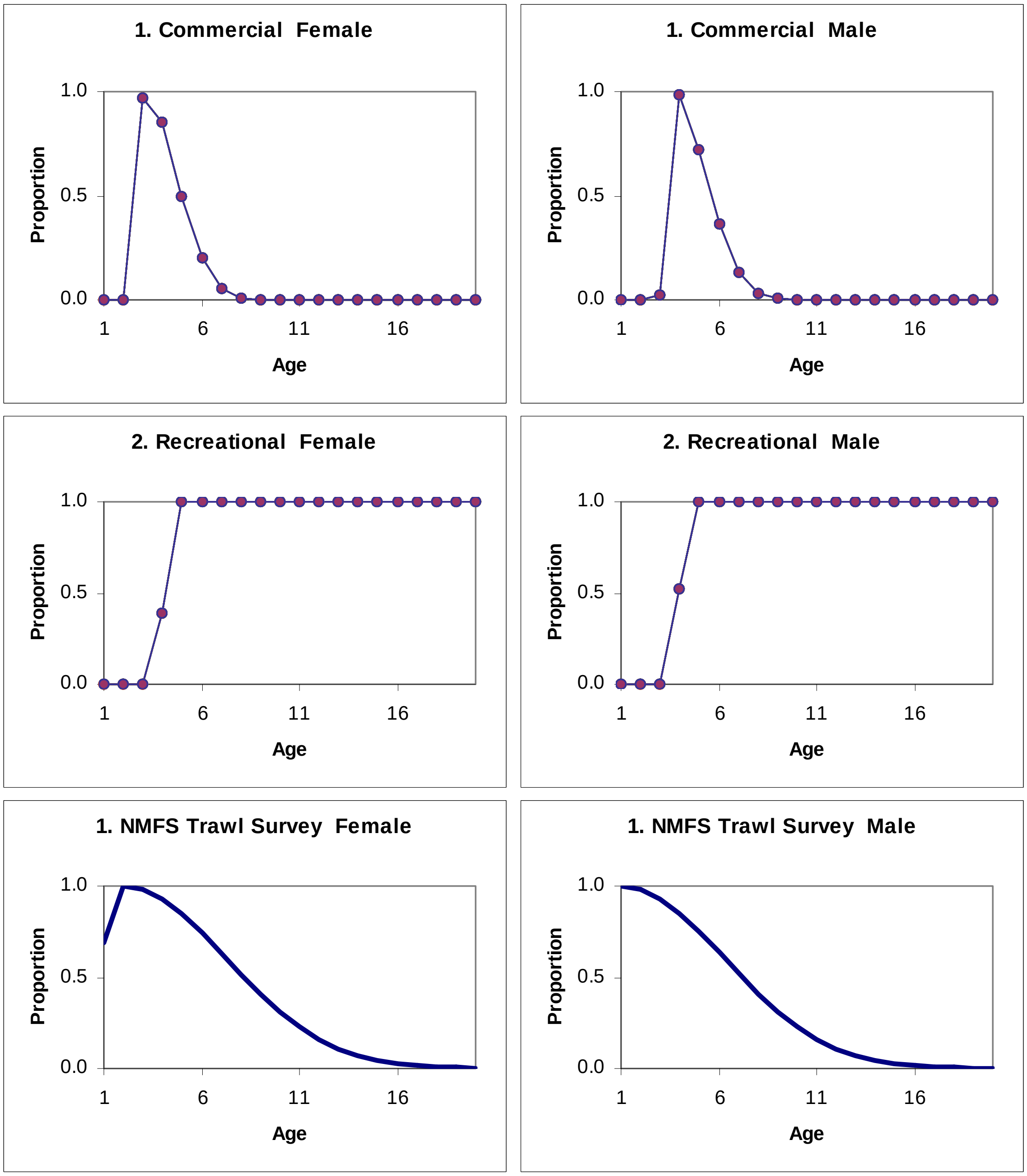
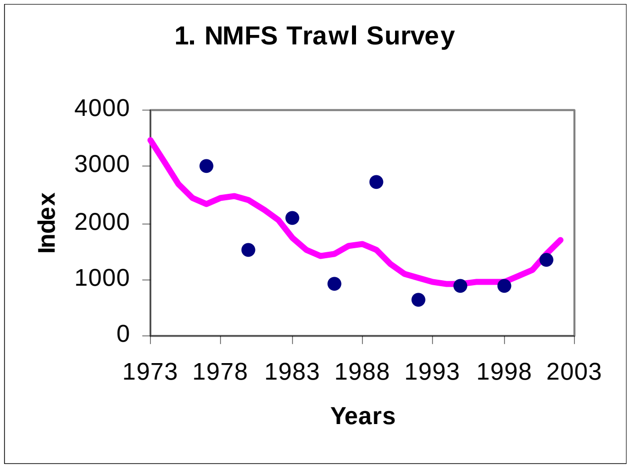


Figure 13. Coleraine output for the southern area (LCS) base model: Model fits to indices of abundance; NMFS trawl survey and trawl logbook.



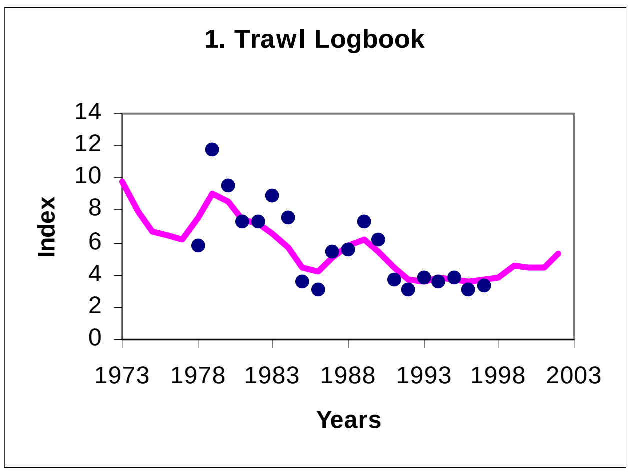


Figure 14. Coleraine output for the southern area (LCS) base model: Model fits to commercial fishery catch-at-age.

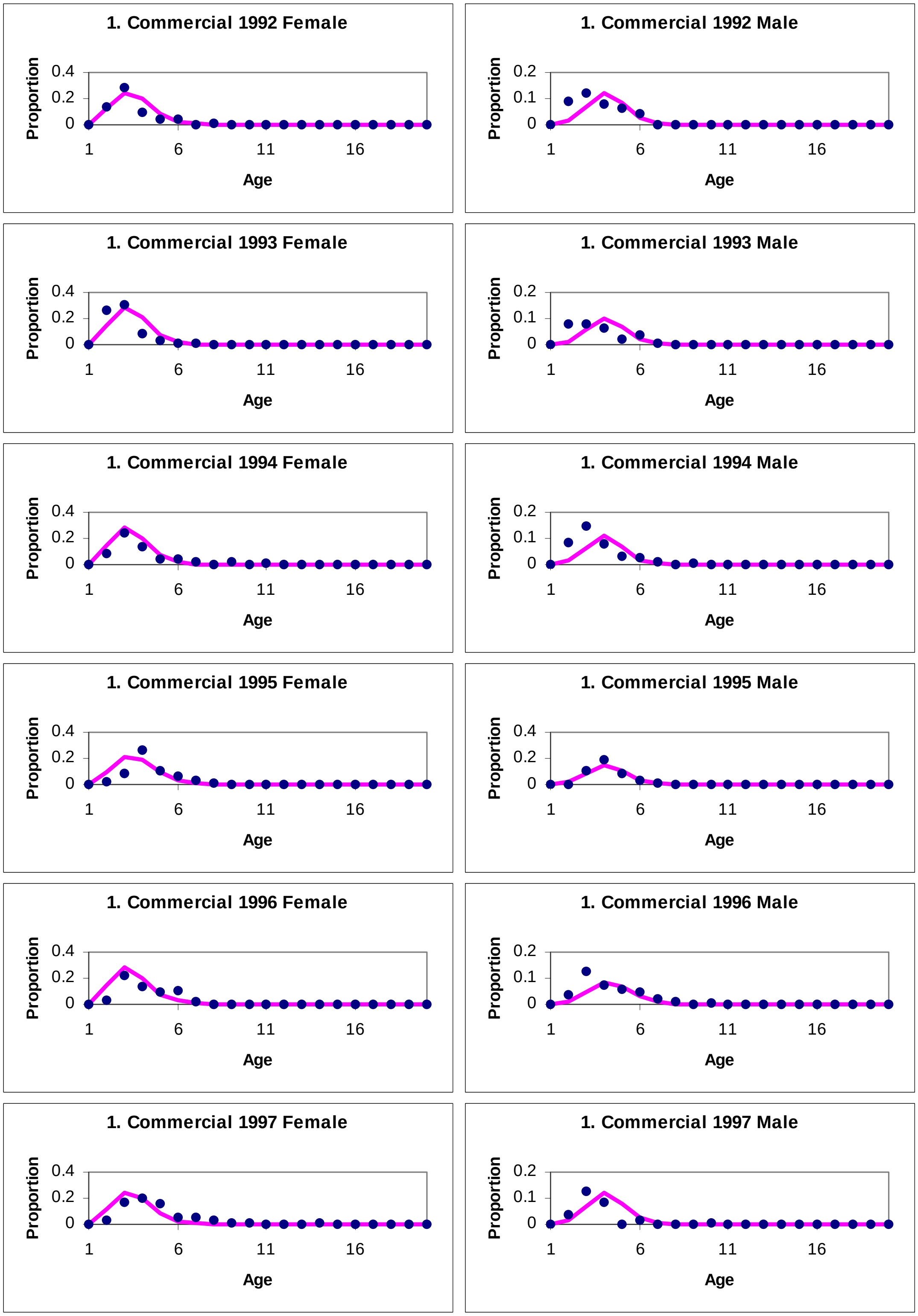


Figure 14, continued. Coleraine output for the southern area (LCS) base model: Model fits to commercial fishery catch-at-age.

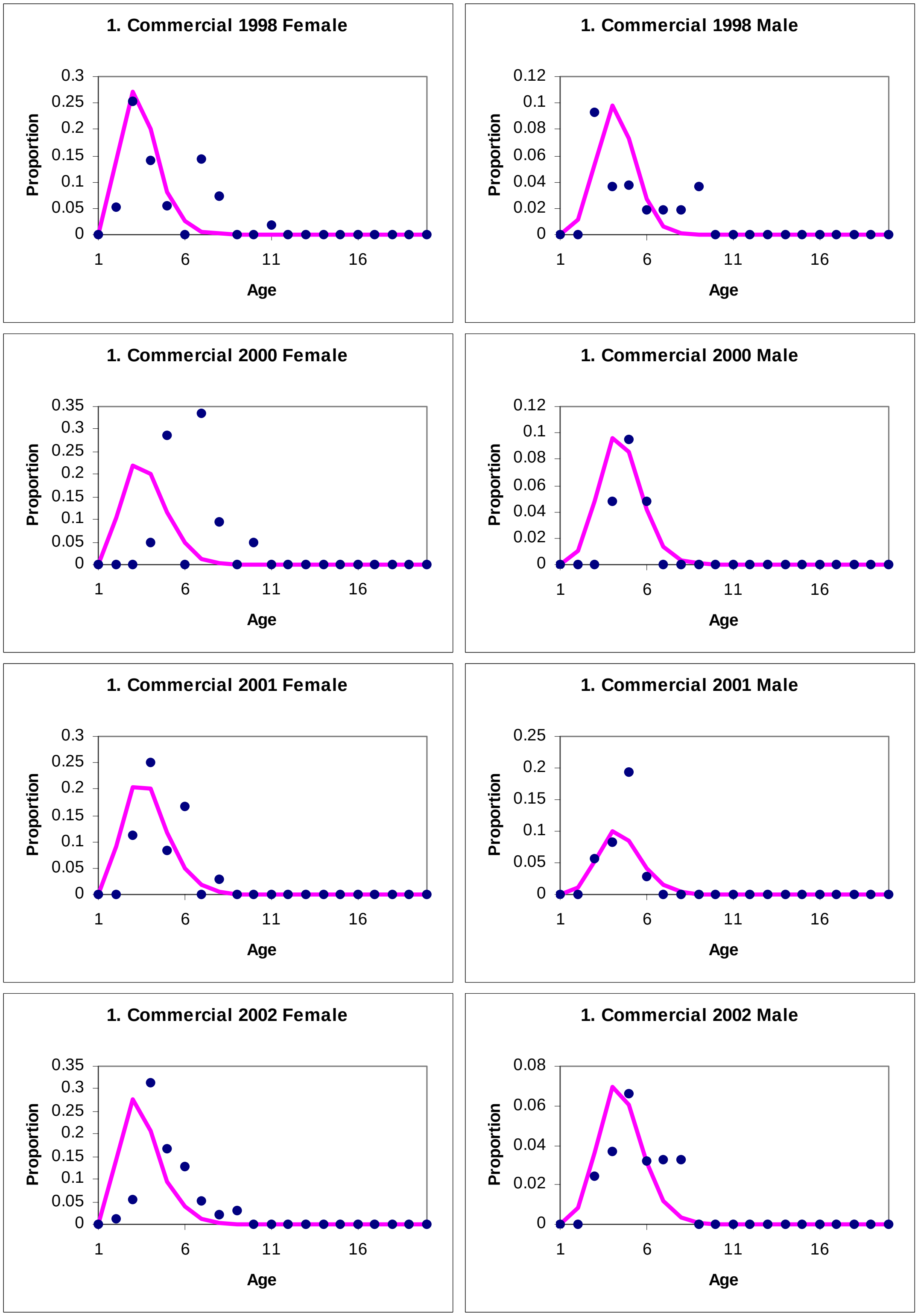


Figure 15. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

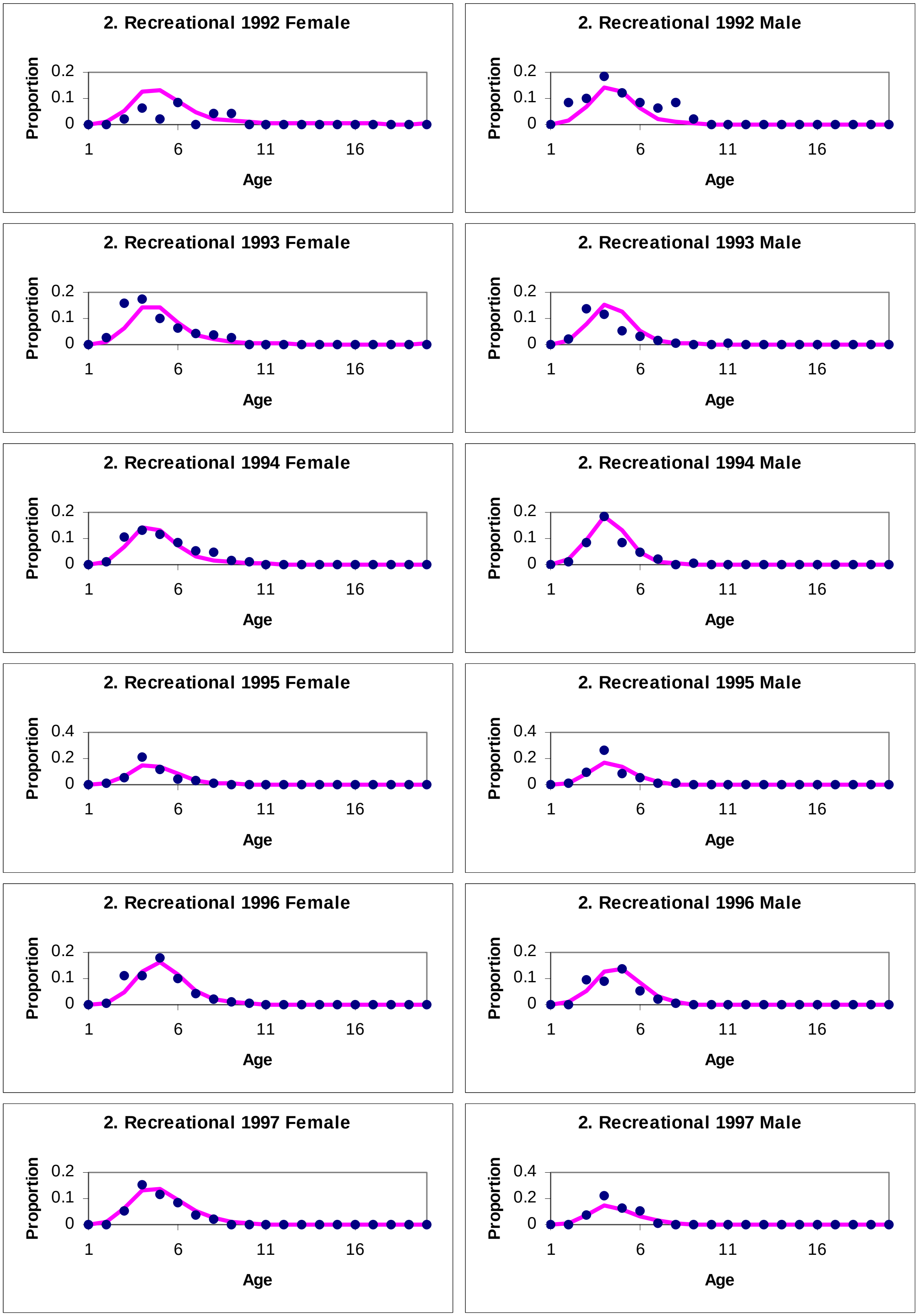


Figure 15, continued. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

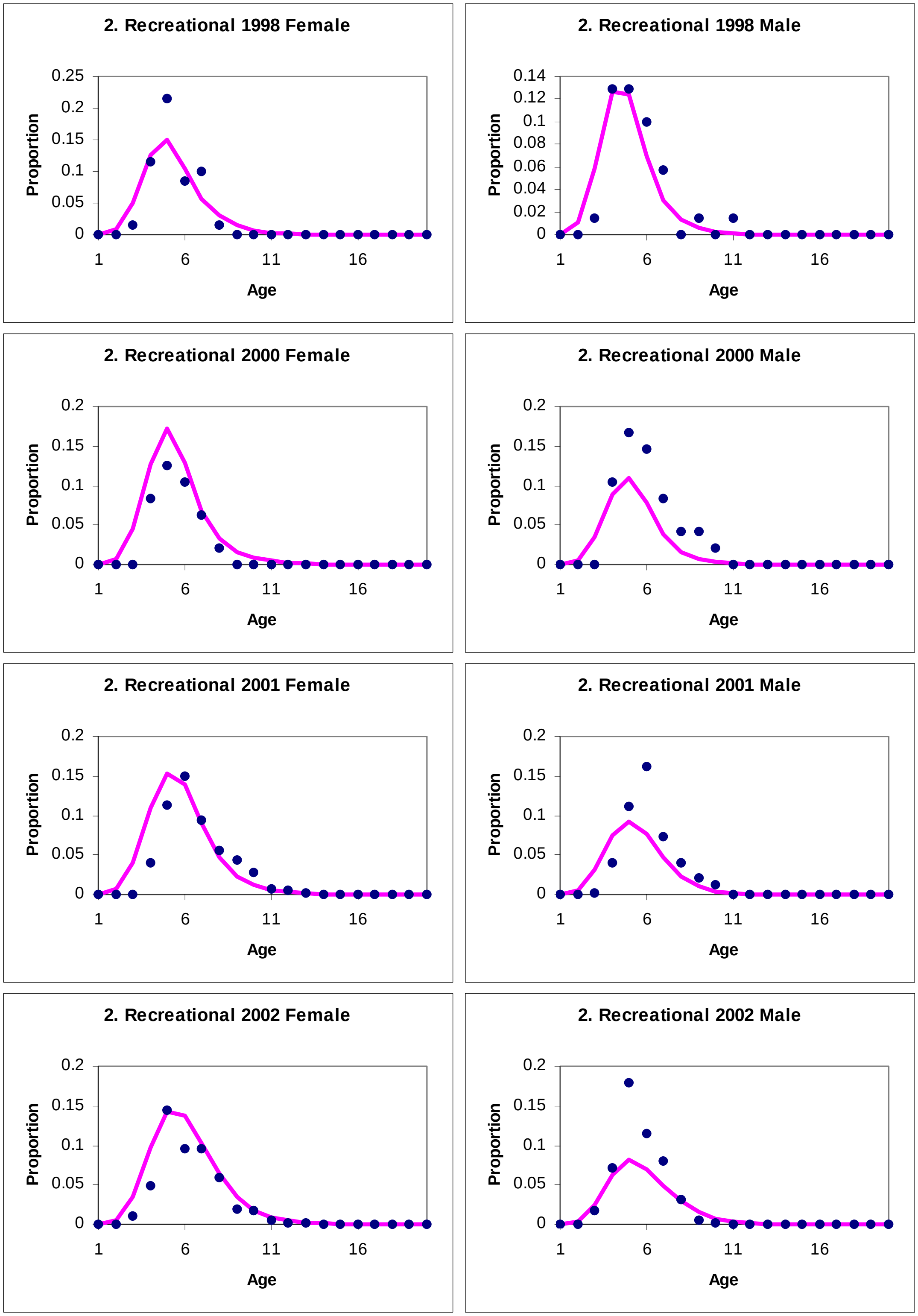


Figure 16. Coleraine output for the southern area (LCS) base model: Model fits to NMFS trawl survey catch-at-age.

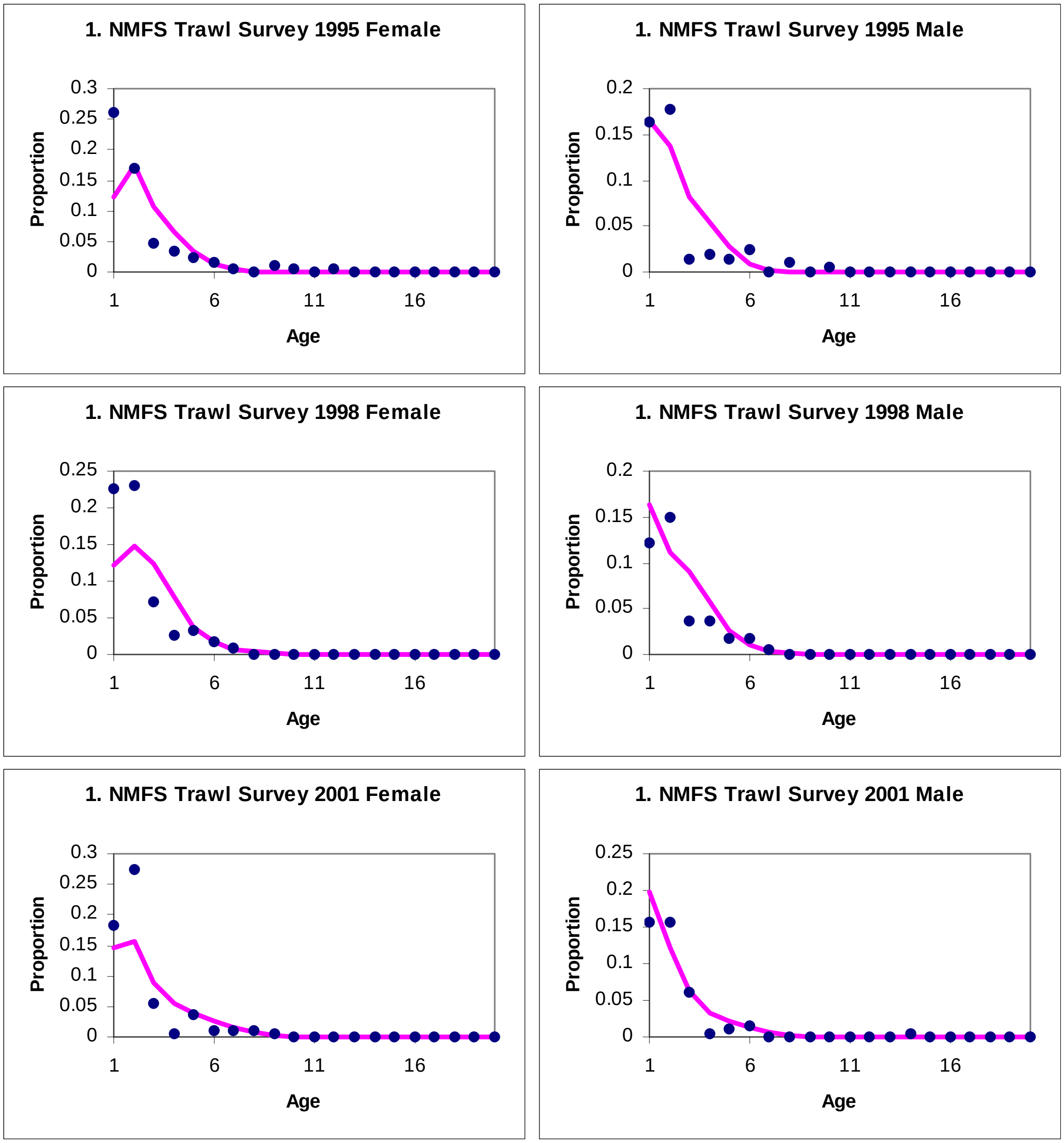
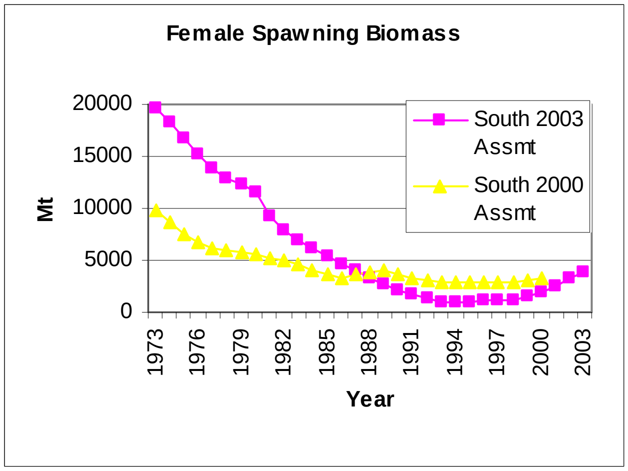


Figure 17. Coleraine output for the southern area (LCS) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.



Appendix II. Coastwide Lingcod Rebuilding Analysis

Assessment of Lingcod for the Pacific Fishery Management Council in 2003

Coastwide Lingcod Rebuilding Analysis

October, 2003

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History

In 1997, an assessment of lingcod prepared for the PFMC found that female spawning biomass estimates were below 25% of the unfished biomass level for the northern portion of the stock (Jagielo et al. 1997). An analysis was subsequently prepared which indicated that rebuilding to the $B_{40\%}$ level was possible within 10 years at F=0 (Jagielo 1999). Based on the analysis for the northern area, a 10 year rebuilding plan was implemented by PFMC for the entire West Coast (Washington-Oregon-California). The rebuilding plan began in 1999 and set the target date of the start of 2009 for achieving the $B_{40\%}$ spawning stock size.

Subsequently, a coastwide assessment for lingcod was completed in 2000 (Jagielo et al. 2000). The 2000 assessment provided separate estimates of spawning stock biomass for the northern (LCN: US-Vancouver and Columbia) and southern (LCS: Monterey, Eureka, Conception) areas. An updated rebuilding analysis was conducted with the 2000 stock assessment model results using the SSC default rebuilding analysis software (Punt 2001).

Recently, an updated lingcod stock assessment was conducted in 2003 (Jagielo et al. 2003) which provided new, separate estimates of spawning stock biomass for the northern (LCN) and southern (LCS) areas. The present rebuilding analysis utilizes information from the 2003 stock assessment and conforms to the SSC Terms of Reference for Groundfish Rebuilding Plans. This analysis provides new coastwide rebuilding trajectories that provide for lingcod rebuilding within the time frame originally established by PFMC in 1999.

Data and Parameters

This analysis uses the most recent version of the SSC Default Rebuilding Analysis software (Punt 2003). Six rebuilding analysis projections were produced using separate sets of information derived from the 2003 stock assessment (Jagielo et al. 2003). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. Data inputs for each rebuilding analysis projection included: 1) spawning output by age (the product of the weight-at-age and % maturity-at-age vectors); 2) sex-specific natural mortality; 3) age specific weight (kg), selectivity, and numbers of fish for the year 2002; and 4) vectors of annual recruitment (age 1 fish) and spawning biomass estimates (1973-2002). Age specific data were input for ages 1-20+, with 20+ serving as an accumulator age. The age composition for the beginning year of the rebuilding program (T_{min}) was derived from the 2003 stock assessment model estimates of the 1999 age composition. The population projection was configured to begin in 2002 with rebuilding occurring by the start of 2009 (year 10 from the original rebuilding start year of 1999). Catches were pre-specified for 2002 and 2003, and were derived from the projections for the years 2004-2008. Estimates of B_0 were computed using random draws from recruitments estimated for 1973-2002.

It should be noted that the Coleraine estimate of depletion from the 2003 stock assessment (Jagielo et al. 2003) can differ from the estimate obtained from the rebuilding analysis presented here, because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Management Reference Points

Comparison of the spawning stock estimates for 2002 with the estimates of virgin spawning stock size under the asymptotic model assumption indicate that the recent coastwide spawning population size is approximately 25% of virgin levels (Table 1). Under the domed model assumption, the estimate of depletion was similar at 24%. By contrast, the model estimates of F_{45} differed between the asymptotic ($F_{45} = 0.12$) vs. domed ($F_{45} = 0.18$) cases, indicating higher productivity under the domed fishery selectivity assumption. Consequently, projected yields under the domed model assumption tend to be higher than under the asymptotic model assumption (Table 2).

When compared to the domed fishery selectivity model, the asymptotic fishery selection model is generally more consistent with the assumptions made in the previous lingcod stock assessment (Jagielo et al. 2000) and rebuilding analysis (Jagielo and Hastie 2000). (In the 2000 lingcod assessment, all fisheries were assumed to be asymptotic, with the exception for male fishery selectivity in the northern area, which was allowed to be dome shaped.) Estimates of F_{45} for the 2003 asymptotic model (0.12-north; 0.12-south) are similar to the estimates of F_{45} from the 2000 assessment, with a slightly higher value for the south (0.12-north; 0.14-south).

Rebuilding Projections

Rebuilding projection inputs and outputs are reported for the coastwide asymptotic fishery selectivity model in Tables 3-4 and Figures 1-3. The same information for the domed fishery selectivity model is provided in Tables 5-6 and Figures 4-6. Population projections were conducted using the "recruits" in lieu of the "recruits-per-spawner" option provided by Punt (2003), which was consistent with the previous analysis (Jagielo and Hastie 2001). The basis for this choice was the lack of a credible spawner-recruit relationship for lingcod. Recruitments for the projections were randomly drawn from the values estimated from the most recent years (1986-2002) in the assessment (Jagielo et al. 2000)(Figure 2-asymptotic; Figure 5-domed).

Performance of alternative rebuilding policies

The projected coastwide yields for 2004-2008 under both the asymptotic and domed fishery selectivity assumptions are constrained by the ABC rule, for values of $P < 0.6$ (Table ES2). Coastwide ABC yield for 2004-2008 ranges from 1,820 mt to 2,053 mt for the asymptotic fishery selection model, compared to 2,141 mt to 2,123 mt for the domed fishery selectivity model.

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Table 1. Management reference points derived from the 2003 lingcod stock assessment (Jagielo et al. 2003). Alternative models included the assumption of asymptotic vs. domed fishery selectivity. Under each assumption, rebuilding projection input files were constructed for 1) coastwide (northern and southern model data pooled) and 2) northern and southern area model data separately.

	Asymptotic Fishery Selectivity			Domed Fishery Selectivity		
	Coastwide	Northern	Southern	Coastwide	Northern	Southern
FMSY proxy	0.121	0.124	0.122	0.184	0.165	0.190
FMSY SPR / SPR(F=0)	0.45	0.45	0.45	0.45	0.45	0.45
Virgin SPR	12.41	13.27	11.20	11.77	13.27	11.20
Virgin Spawning Output (mt)	36967	19434	16969	37115	19518	18848
Target Spawning Output (mt)	14787	7774	6788	14846	7807	7539
Current (2002) Spawning Output (mt)	9160	5410	3751	8931	5679	3253
Depletion ($SpBio_{2002}/SpBio_{Virgin}$)	0.25	0.28	0.22	0.24	0.29	0.17
Spawning Output (ydecl) (mt)	4203	2226	1972	4077	2464	1608

Table 2. Projected yield (mt) under model assumptions of asymptotic vs. domed fishery selectivity. Yields are shown for probability of recovery values ranging from P=0.5 to P=0.9, and for the 40-10 and ABC rules.

Model	Year	P= .5	P= .6	P= .7	P= .8	P= .9	Yr=Tmid	F=0	40-10 Rule	ABC Rule
Coastwide Asymptotic	**2004**	1843	1799	1750	1693	1631	1767	0	1429	1820
	2005	1947	1906	1859	1805	1744	1875	0	1753	1926
	2006	2006	1968	1924	1873	1816	1939	0	1970	1986
	2007	2043	2008	1967	1920	1866	1981	0	2085	2025
	2008	2069	2037	1999	1955	1904	2012	0	2102	2053
North Asymptotic	**2004**	1342	1328	1305	1285	1255	1339	0	1050	1109
	2005	1359	1346	1326	1309	1281	1356	0	1156	1149
	2006	1354	1343	1326	1311	1287	1352	0	1174	1168
	2007	1331	1322	1307	1294	1273	1330	0	1172	1168
	2008	1312	1304	1291	1279	1261	1311	0	1170	1166
South Asymptotic	**2004**	686	660	626	594	547	650	0	492	759
	2005	752	725	692	659	610	715	0	664	823
	2006	794	768	736	704	655	759	0	800	862
	2007	830	805	774	742	694	796	0	898	894
	2008	859	836	805	775	728	827	0	961	920
Coastwide Domed	**2004**	2058	2009	1962	1905	1838	2032	0	1616	2041
	2005	2135	2089	2045	1992	1930	2111	0	1966	2118
	2006	2138	2098	2058	2010	1953	2117	0	2137	2124
	2007	2139	2102	2066	2022	1969	2120	0	2182	2126
	2008	2135	2101	2067	2025	1976	2117	0	2167	2123
North Domed	**2004**	1512	1496	1478	1462	1440	1509	0	1164	1185
	2005	1477	1464	1449	1435	1416	1475	0	1198	1195
	2006	1438	1427	1414	1403	1387	1436	0	1194	1192
	2007	1376	1366	1355	1346	1332	1374	0	1165	1163
	2008	1339	1330	1320	1312	1300	1337	0	1148	1146
South Domed	**2004**	600	571	538	502	455	603	0	421	803
	2005	658	629	595	557	509	661	0	618	858
	2006	687	659	626	588	540	690	0	764	877
	2007	711	683	650	613	564	714	0	860	893
	2008	736	708	676	639	589	738	0	924	911

Table 3. Coastwide asymptotic fishery selectivity model rebuilding analysis: Input values.

Lingcod Coastwide-Asymptotic STAR Panel Final	
Created with Version 2.7b (August 2003)	
Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	No change
Number of fleets	4
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.12
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	12.41
Generation time (yrs)	13
Minimum Rebuild Time (from ydecl)	5
Maximum Rebuild Time (from yinit)	13
Selected rebuild time (yrs)	5
Year for rebuild	2009
Virgin Spawning Output (mt)	36967
Target Spawning Output (mt)	14787
Current Spawning Output - 2002 (mt)	9160
Spawning Output (ydecl) (mt)	4203
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2004
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

Table 4. Coastwide asymptotic fishery selectivity model rebuilding analysis: Output values and recruitments used to compute B_0.

			Summary table						40-10 Rule	ABC Rule
Fishing rate	0.1225	0.1195	0.116	0.1121	0.1077	0.1172	0	0	0
OY	1842.8	1799.5	1749.7	1693.2	1630.6	1766.7	0	1429.4	1820.3
Prob to rebuild by Tmax	50.0	60.0	70.0	80.1	90.0	66.7	100.0	79.4	55.7
Median time to rebuild (yrs)	5	4.4	3.8	3.5	3.1	4	1.4	3	4.7
Prob overfished after rebuild	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Median time to rebuild (yrs)	2009.0	2008.4	2007.8	2007.5	2007.1	2008.0	2005.4	2007.0	2008.7
Probability above current spawning outptut in 100 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability above current spawning outptut in 200 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability below 0.01B0 in 100 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Probability below 0.01B0 in 200 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Recruitments (Number of age 1 fish in thousands)	Year	Recruitment
	1972	2839
	1973	2807
	1974	3152
	1975	3107
	1976	3168
	1977	3093
	1978	3462
	1979	4180
	1980	3268
	1981	3002
	1982	2348
	1983	2978
	1984	3848
	1985	5837
	1986	3333
	1987	2349
	1988	2550
	1989	2777
	1990	2976
	1991	3126
	1992	1690
	1993	2372
	1994	2437
	1995	2661
	1996	2317
	1997	2107
	1998	2901
	1999	2517
	2000	3195
	2001	2999

Highlighted values are used to compute B0

Figure 1. Coastwide asymptotic fishery selectivity model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).

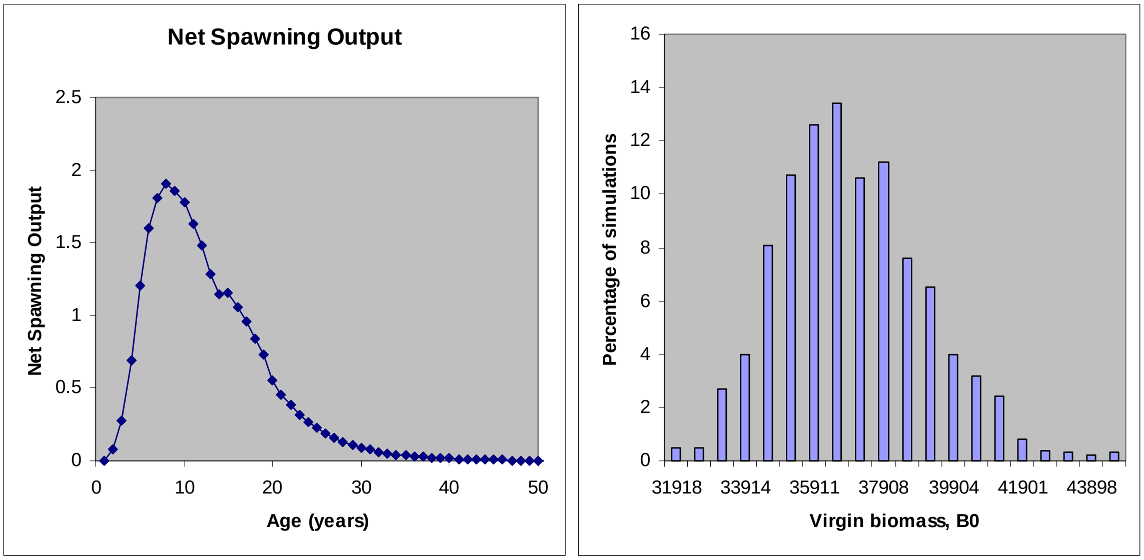


Figure 2. Coastwide asymptotic fishery selectivity model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).

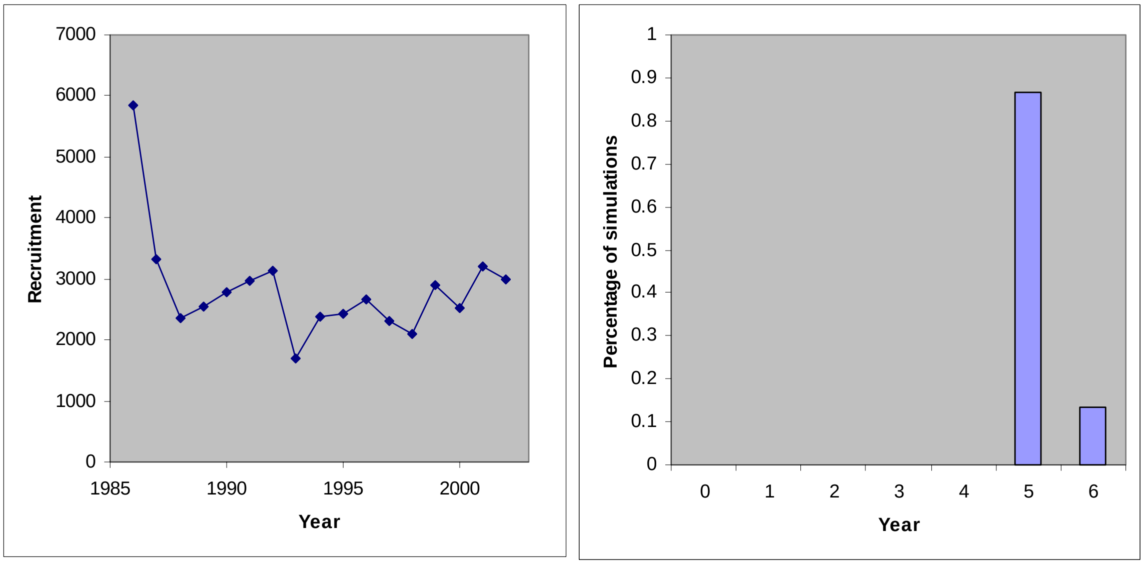


Figure 3. Coastwide asymptotic fishery selectivity model rebuilding analysis: Rebuilding trajectories showing probability above target (left) and catch (mt) (right) at selected P values.

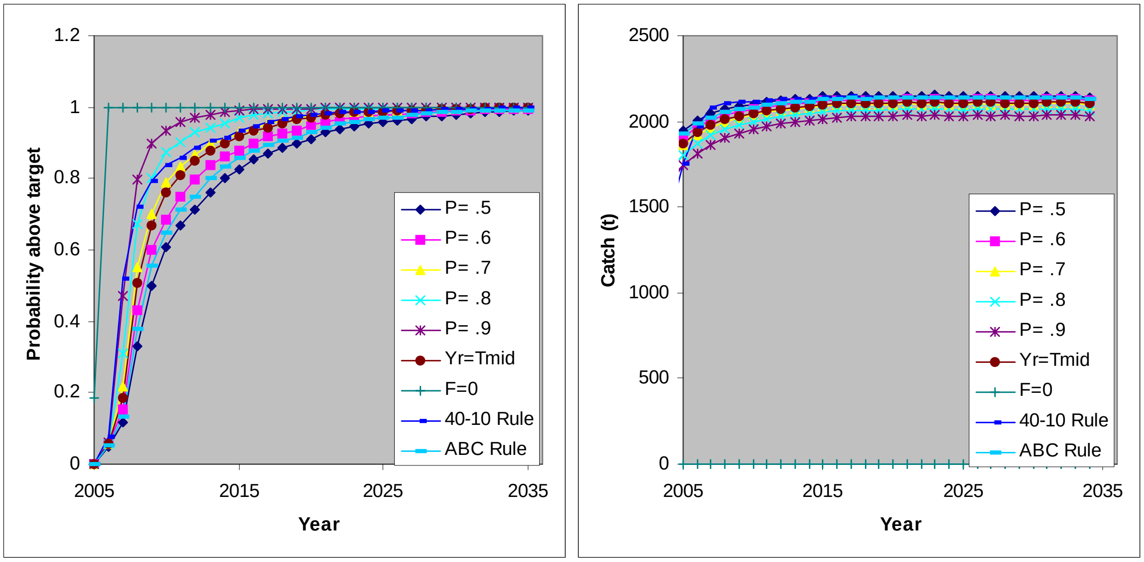


Table 5. Coastwide domed fishery selectivity model rebuilding analysis: Input values.

Lingcod Coastwide-Domed STAR Panel Final	
Created with Version 2.7b (August 2003)	
Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	No change
Number of fleets	4
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.18
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	11.77
Generation time (yrs)	12
Minimum Rebuild Time (from ydecl)	6
Maximum Rebuild Time (from yinit)	13
Selected rebuild time (yrs)	5
Year for rebuild	2009
Virgin Spawning Output (mt)	37115
Target Spawning Output (mt)	14846
Current Spawning Output - 2002 (mt)	8931
Spawning Output (ydecl) (mt)	4077
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2005
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

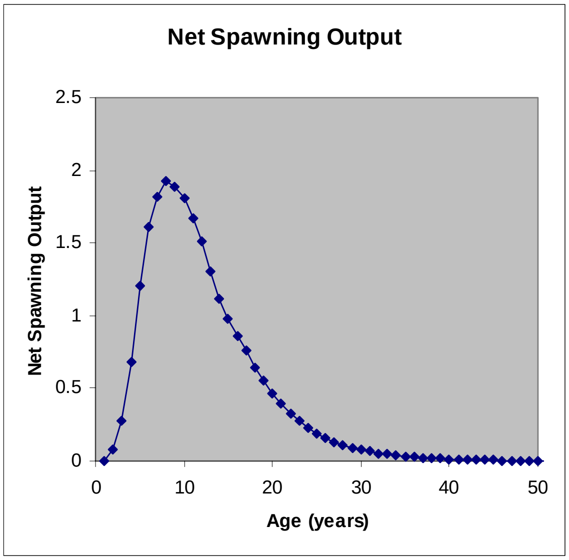
Table 6. Coastwide domed fishery selectivity model rebuilding analysis: Output values and recruitments used to compute B_0.

	Summary table							40-10 Rule	ABC Rule
Fishing rate	0.1856	0.1809	0.1764	0.1709	0.1646	0.1831	0	0	0
OY	2058.2	2009.3	1961.7	1904.8	1838.3	2032.3	0	1615.9	2040.7
Prob to rebuild by Tmax	49.9	60.0	69.9	80.1	89.9	55.3	100.0	80.3	53.2
Median time to rebuild (yrs)	5	4	3.6	3	2.7	4.4	0.5	2.7	4.7
Prob overfished after rebuild	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Median time to rebuild (yrs)	2009.0	2008.0	2007.6	2007.0	2006.7	2008.4	2004.5	2006.7	2008.7
Probability above current spawning outptut in 100 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability above current spawning outptut in 200 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability below 0.01B0 in 100 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Probability below 0.01B0 in 200 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Recruitments (Number of age 1 fish in thousands)	Year	Recruitment
	1972	3516
	1973	3359
	1974	3557
	1975	3967
	1976	4087
	1977	3490
	1978	3598
	1979	5104
	1980	3516
	1981	3015
	1982	2264
	1983	2935
	1984	3438
	1985	5505
	1986	3359
	1987	2554
	1988	2478
	1989	2568
	1990	2939
	1991	2991
	1992	1725
	1993	2646
	1994	2507
	1995	2719
	1996	2016
	1997	2289
	1998	2469
	1999	3437
	2000	3369
	2001	3201

Highlighted values are used to compute B0

Figure 4. Coastwide domed fishery selectivity model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).



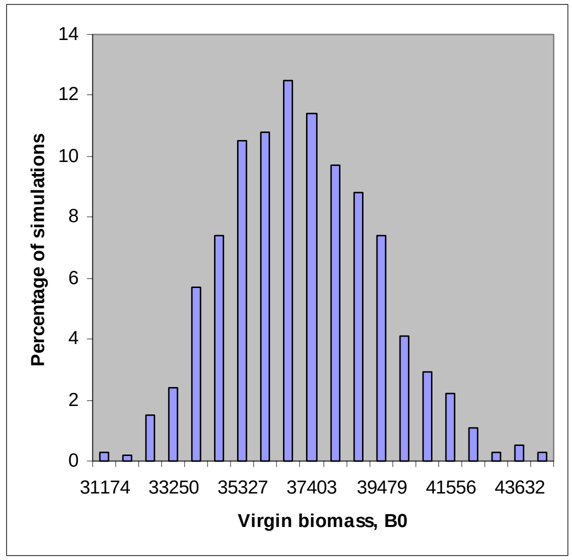


Figure 5. Coastwide domed fishery selectivity model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).

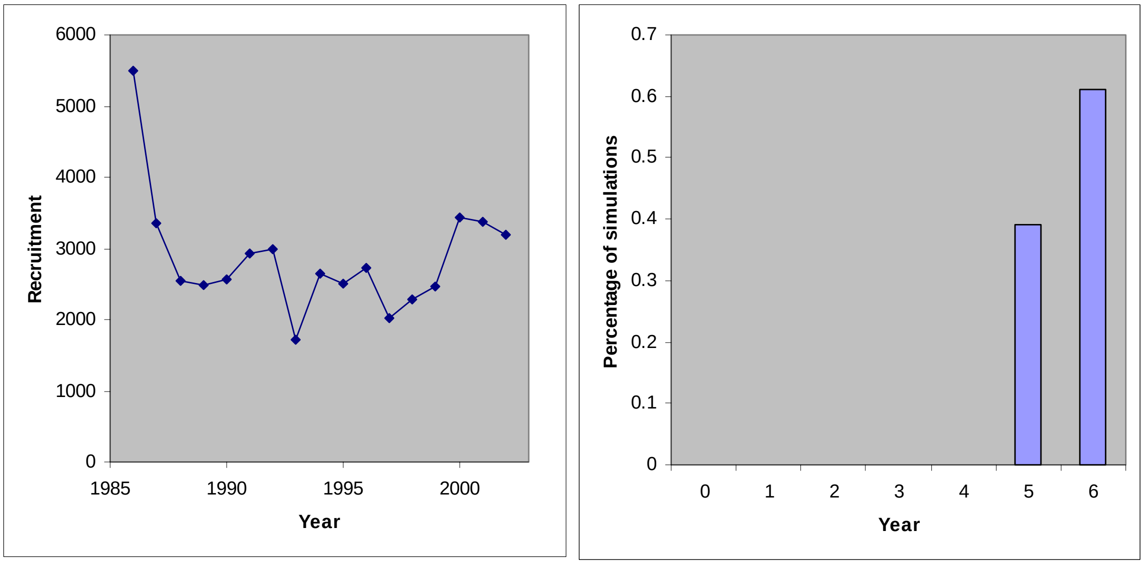
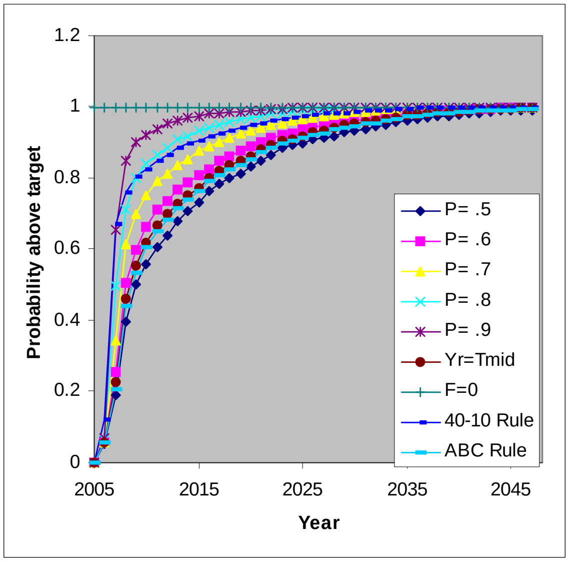
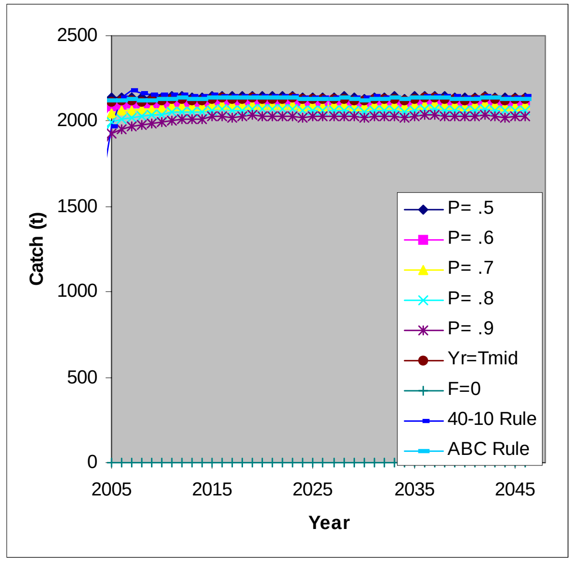


Figure 6. Coastwide domed fishery selectivity model rebuilding analysis: Rebuilding trajectories showing probability above target (left) and catch (mt) (right) at selected P values.





Lingcod

STAR Panel Meeting Report

NOAA/Northwest Fisheries Science Center
Seattle, Washington
September 15-19, 2003

STAR Panel
Han-Lin Lai, NOAA/Northwest Fisheries Science Center, PFMC SSC (Chair)
Chris Legault, NOAA/Northeast Fisheries Science Center (Rapporteur)
Mark Maunder, Inter-American Tropical Tuna Commission (CIE Reviewer)
David Smith, Primary Industries Research Victoria, Australia
Tony Smith, CSIRO Marine Research, Australia

PFMC
Tom Barnes, California Department of Fish and Game, PFMC GMT
Tom Ghio, PFMC GAP

STAT Team
Thomas Jagielo, Washington Department of Fish and Wildlife
Farron Wallace, Washington Department of Fish and Wildlife
Yuk Wing Cheng, Washington Department of Fish and Wildlife

Overview

The STAR Panel (hereafter the Panel) reviewed the assessment documents prepared by the STAT team for the lingcod fisheries. The entire STAT Team was available to present and discuss aspects of the report. This species was assessed previously in 1986 (coastal), 1994 (northern area), 1997 (northern area), 1999 (southern area) and 2000 (coastal).

This assessment treated the lingcod resource as two independent stocks; a northern stock (LCN: US-Vancouver, Columbia) and a southern stock (LCS: Eureka, Monterey, Conception). Both stocks were assessed using the multiple fleet age and sex structured model Coleraine, which also allows fitting length distributions. Both assessments utilized multiple tuning indices, the NMFS triennial surveys, trawl logbook CPUE, and in LCN only the WDFW tagging index (Table 1). The southern assessment was less well defined due to fewer data available, particularly the number of indices and years with catch at age.

The assessments were both sensitive to the levels of natural mortality rate (M) and steepness assumed. After considerable discussion and examination of many sensitivity analyses, the Panel agreed that steepness of 0.9 should be used as the base case in both LCN and LCS assessments. For LCN, the base case assessment resulted in current depletion of 29% while for the LCS current depletion is estimated to be 16%. The current assessments estimated depletions of 14% LCN and 9% LCS in 2000 compared to the 2000 assessments of 11% LCN and 14% LCS. This change in perception appears to be due to a combination of extension of the logbook indices back in time, extension of the NMFS triennial survey index forward in time, additional commercial and recreational catch at age data in recent years, and changes in the model structure.

Sensitivity analyses conducted by the STAT Team showed the level of depletion could vary widely due to changes in the natural mortality rate and the steepness parameter of the stock recruitment relationship. Neither of these parameters could be estimated by the model and had to be assumed but higher steepness was associated with better fit. Thus, different input assumptions lead to different results and management advice.

The consensus of the Panel is that the assessment has used the best available data and the analyses provide an adequate basis for Council decisions, if sufficient uncertainty in current depletion levels is considered. The Panel agreed that the stocks have been depleted and are now increasing; it is the level of decrease and subsequent increase that are not clearly defined, particularly for LCS.

The Panel commends the STAT Team for their cooperative spirit and willingness to respond to the Panel’s requests for additional analyses. The large number of runs conducted during the meeting greatly facilitated the Panel’s deliberations.

Requests made and comments to the STAT Team during the meeting

1. **Eliminate smoothing over years in the logbook CPUE index**. In the initial assessments the logbook index was estimated using a generalized additive model (GAM) that smoothed over years. This was thought to be inappropriate because the stock assessment model can be thought of as a smoother and so should receive year independent indices as input. The STAT Team initially conducted a GAM with years as factors, but could not estimate values for 1991 and 1997 due to missing variables in the dataset. The STAT Team then reanalyzed the logbook index using a generalized linear model (GLM) with years as factor, similar to the 2000 assessment, to address this request. The Panel agreed these GLM estimates provided a more appropriate index of abundance using the logbook CPUE data.
2. **Change years used in logbook CPUE index**. In the initial assessments the logbook data ranged from 1976 through 2002. Due to small sample sizes, the first two years of the LCS, but not the LCN, were dropped. Due to significant regulatory measured implemented in 1998, both series were truncated in 1997.
3. **Maintain consistency with the definition of water haul when forming the NMFS triennial index (Zimmermann et al. 2003[1])**. Although lingcod are a demersal species in general, they were not included in the list of species that determined water hauls in the NMFS triennial survey. The large change in the 1980 value when one tow was classified as a water haul demonstrates the responsiveness of the index to single tows with large catches. After much deliberation, the Panel agreed that consistency with the definition of water haul takes precedence when computing this index.
4. **Examine both the percent positive and density parts of the delta lognormal estimates for the logbook CPUE index**. The Panel initially had concerns regarding the large discrepancy between the raw and standardized catch rates, particularly in the early years. However, this appeared to be consistent with the data on proportion of positive tows.
5. **Report Canadian catches and results from their assessments**. Due to the artificial separation of a biological unit stock due to national boundaries it was thought that information from the Canadian stock could improve understanding of the LCN assessment.
6. **The fits of commercial catch at age in early years are not good for LCN**. The model predicts much younger catches than those observed in the first years of data. This means the model is predicting a more depleted stock than was present in those years, or else that the gear selectivities are incorrect for those years. Despite many sensitivity runs, there were no results that were able to fit these data at all.
7. **Convergence problems should always be noted when presenting results**. The apparent inconsistent responses seen in early sensitivity analyses were due to problems with convergence that were also not noted in the report. The STAT Team noted convergence problems in all later runs.

[1] Zimmermann, M., Wilkins, M.E., Weinberg, K.L., Lauth, R.R., and Shaw, F.R. 2003. Influence of improved performance monitoring on the consistency of a bottom trawl survey. ICES J. Mar. Sci. 60:818-826.

8. **The Panel requested a retrospective analysis that only included data up through 1999**. The STAT Team attempted this analysis but was unable to get the model to converge. However, the unconverged results were similar to the results using the full dataset.
9. **Compare dome with asymptotic selectivity patterns**. Although the parameter to cause dome selectivity could be estimated in the model, the STAR Panel requested sensitivity runs assuming asymptotic selectivity because there was difficulty in explaining how the dome pattern could be formed. The STAT Team provided a number of sensitivity runs with different combinations of allowed dome and assumed asymptotic by gear. Based on fit characteristics and lack of sensitivity to this specification, the Panel agreed to use the runs that allowed estimation of the parameter that causes a dome in both the commercial and recreational fisheries for both stocks. However, see Recommendations Item 13.
10. **Present management related statistics, such as depletion, when reporting sensitivity analysis results**. Initial tables of sensitivity results did not contain this information. The STAT Team provided this information for all runs conducted during the meeting.
11. **Correct "other" gear catch in US-Vancouver**. There was an error when generating the catch table of this gear type. This error has minor effects on the base runs. The STAT Team corrected this error in the subsequent runs.
12. **Modify sample sizes input for catch at age and length**. The multinomial-like method used to fit the catch at age data requires "effective" sample sizes as input, not "actual" sample sizes. The STAT Team produced runs that multiplied the initial sample sizes by 10% for input to the model in response to this request.
13. **Examine asymptotic and dome selectivity patterns applied by gender**. Due to differences in growth patterns, it was thought that one gender may be more susceptible to fishing at older ages than the other gender. This analysis was not possible due to limitations in the software used for the assessments.
14. **Provide summary tables of sensitivity analyses in hard copy form**. The STAT Team conducted an impressive number of sensitivity analyses during the meeting for which the Panel had trouble later recalling specific results. However, the results were only presented on screen because of the large number of runs conducted.

Technical merits and/or deficiencies of the assessment

The Panel appreciated the efforts of the STAT Team to transition the modeling from a flexible but stock specific approach to a tested and documented software package used in response to the recommendations of the 2000 STAR Panel. This should reduce the possibility of coding errors when conducting assessments. However, this standardized software does not eliminate the problem of poor data, especially in the LCS assessment, and reduces flexibility in representing the details of the fisheries. Results from a simple model, such as a production model or stock reduction analysis, would provide a check on the complex model results.

Areas of disagreement

There were no major disagreements between the STAR Panel and the STAT Team at the conclusion of the meeting.

Unresolved problems and major uncertainties

1. The influence on the LCN of the Canadian catches is not known. This could alter the interpretation of the status of the stock.
2. The strong dome selectivity patterns estimated by the model for the commercial and recreational fisheries, particularly for LCS, could not be easily explained based on biology, distribution, or gear effects.
3. It was reported to the Panel that both recreational and commercial fishers are seeing a lot more lingcod in recent years than they have seen previously. It is unclear whether this is due to a shift in fishing area due to management regulations, local abundance changes, or total abundance changes. However, recent increases in discarding suggest the possibility of recent good recruitment. Although the model results show an increasing trend in recent years, there are not signs of much higher recruitment. This apparent discrepancy needs to be explored further.
4. The incomplete split in biological parameters between LCN and LCS was noted. The two stocks have separate estimates of von Bertalanffy growth parameters and maturity ogives but the same parameter values for natural mortality, length weight relationship, and fecundity at age. In general, higher K values in the growth equation are associated with higher M values and fecundity at age is often related to weight at age.
5. The STAT Team was unable to reproduce the 2000 assessment due to structural differences in the models used in the two assessments. This was inevitable given the software used in response to recommendation by the previous STAR Panel.

Recommendations

The following recommendations are not given in priority order.

Data and monitoring issues

1. Estimation of discards in the recreational fisheries should be explored. The large estimates of fish caught recreationally but released alive means that these discards have the potential to be a large source of mortality. Factors to consider are the survival rate of discards and the age (or size) distribution of these discarded fish.
2. Observer data from the commercial fisheries should be used to estimate discards for this sector, and survival rates applied to the discards.
3. Appropriate biological parameters should be applied to the corresponding stock, particularly growth, mortality and fecundity. Data to support these estimates should be collected for both LCN and LCS.

4. Emphasis of collecting biological data should be placed on improving fishery age, length, and sex sample sizes and geographical coverage in both areas.
5. Check the validity of the early age composition data, which was inconsistent with later age composition data and could not be fitted by any model.
6. Indices should have year estimated as a factor, instead of smoothed, when GLM or GAM methods are applied.
7. Commercial trawl logbook CPUE data should be examined for trends in targeting or area fished to ensure the change in percent positive tows reflects change in population abundance. Investigate potential to develop a new index of abundance starting in 1998 using commercial logbook data.
8. Fishery independent information needs to be collected in the large areas that have recently been closed to both commercial and recreational fishing in order to document population level changes in abundance.
9. More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment. Surveys including nontrawlable areas should be conducted to address the issue of the habitat bias in trawl surveys.
10. The Panel endorsed the suggestion for a workshop to understand, analyze and interpret recreational CPUE data for all recreationally important species.
11. The Panel notes the importance of intercalibration of the NMFS triennial surveys conducted by the AFSC with the new NWFSC survey to ensure consistency in indices. This should be done before the next stock assessment.

Modelling and assessment issues

12. Changes from previous assessments in terms of data and model structure should be documented and attempts made to link the two results such that a clear understanding of the factors causing change in management parameters is apparent.
13. Determine reasonable expectations for the selectivity patterns in the commercial and recreational fisheries, through direct experimentation if possible, to reduce the large uncertainty in these parameters.
14. Do not use estimated CV for logbook CPUE index. The estimated coefficients of variation were thought to be unrealistically small (<6%) for use in assessment modeling and would impose too much emphasis on this index if used in the model. A better approach would be to estimate a factor that multiplies the estimated CVs so that a correct magnitude of uncertainty is used but year-to-year differences remain.
15. Projections should as far as practicable include all levels of uncertainty. The Panel agreed that the major uncertainties would be covered by projections of the base case (steepness of 0.9) and a sensitivity analysis using steepness set at 0.7.
16. Add recent management measures in the report. This information provides a context for understanding recent trends in catches and indices.

17. The Panel recommended that further exploration of the spatial structure of this fishery be undertaken, and that consideration be given in the future to the use of spatially explicit models.
18. The Panel recommended reporting convergence and other diagnostics on model runs as a matter of course and the reporting of CVs on management performance statistics.

Table 1. Data presented to the STAR Panel Meeting. Highlighted years are the data used in the base case. (*: Exclude water hauls; **: GLM is used to analyze this data; ***: Refer to STAT report)

LINGCOD	Northern Stock	Southern Stock
Catch Data		
Commercial	1973-2002	1973-2002
Recreational	1973-2002	1973-2002
Abundance Indices		
NMFS triennial surveys*	1977-2001	1977-2001
WDFW tagging	1986-1992	None
Trawl logbook CPUE**	1976-1997	1978-1997
Catch at Age		
Commercial	1979-2002	1992-1998; 2000-2002
Recreational	1980; 1986-2002	1992-1998; 2000-2002
NMFS Survey	1992, 1995, 1998, 2001	1995, 1998, 2001
WDFW tagging	1994-1997	None
Catch at Length		
Commercial	1975-1978	None
Recreational	1981-1983	None
NMFS Survey	1986, 1989	None
WDFW tagging	1986-1993	None
Data Presented but Not Used* **		
Catch data	1935-1972	1916-1972
WA-OSP CPUE	1990-2002	None
RecFIN CPUE: OR	1980-1989; 1993-2002	None
N. CA	None	1980-1989; 1996-2002
S. CA	None	1980-1981; 1983-1985; 1988-1989; 1994; 1996; 1998-2002

Status and Future Prospects for the Cabezon (*Scorpaenichthys marmoratus*) as Assessed in 2003

by

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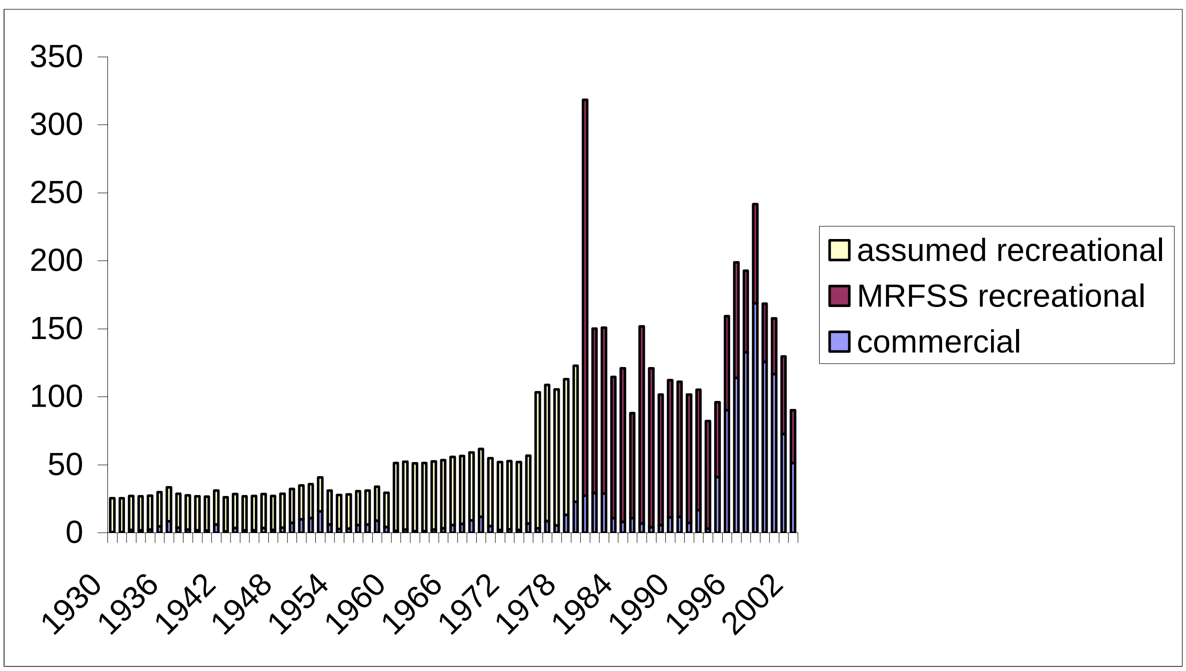
Executive Summary

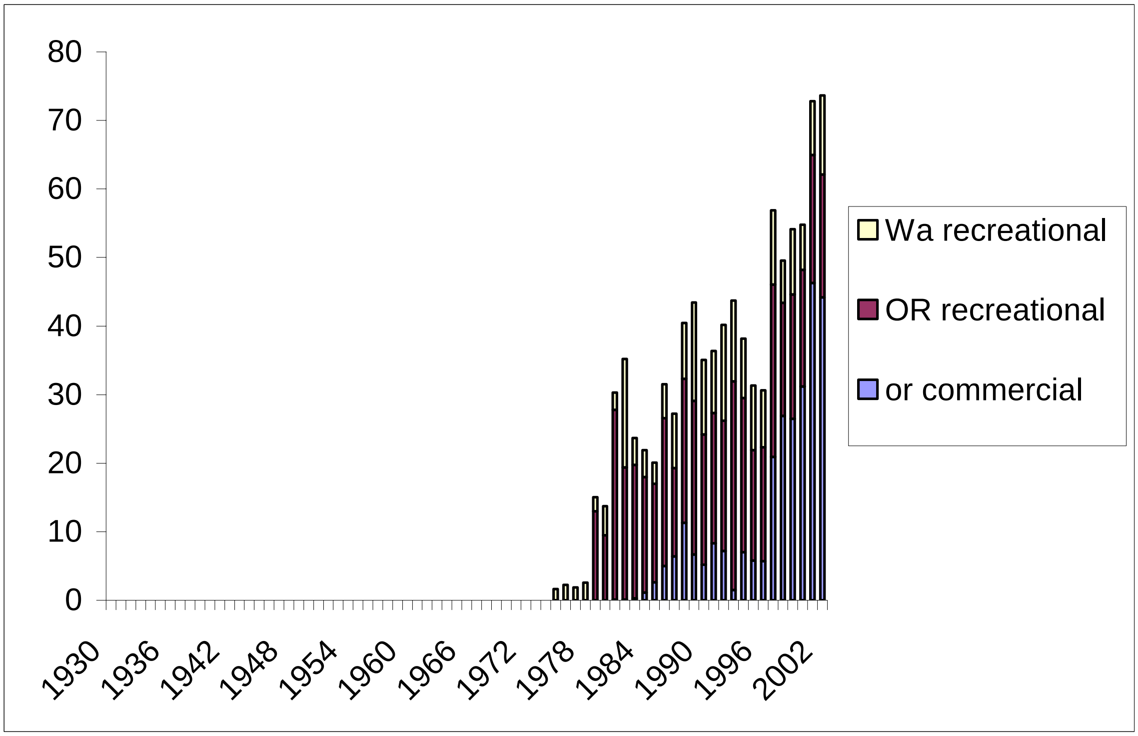
Stock

This is the first assessment pertaining to the status of cabezon (*Scorpaenichthys marmoratus*) on the west coast of the United States. Two stocks (north and south) were delineated for the purposes of this assessment at the Oregon-California border. This distinction was based on differences in the catch history, CPUE trends and biological parameters (mainly growth) between the two areas.

Catches

Cabezon removals were attributed to two fleets (commercial and recreational), but no distinctions among the gears employed were made. California recreational catch data were available from 1980 to 2002 and has historically been the predominant source of removals. California commercial catches were available from 1930 to 2002, but has become a major source of removals only in the last 10 years. Catches were assumed to increase over the years 1930 to 1979 because of the historically important contribution of recreational catch to the cabezon fishery. The sensitivity of the assessment results to the magnitude of this pre-1980 recreational catch was explored as part of the assessment. Catches by the Oregon commercial (1975-2002) and recreational (1975 to 2002) fisheries and Washington recreational fishery (1975 to 2002) were also available. Discard mortality was assumed to be negligible because cabezon can generally survive catch and release in the commercial nearshore fishery and cabezon have not been commonly sighted in the West Coast Observer Program.





Catch histories for California (top graph) and Oregon/Washington (bottom graph)

Year	California Commercial	California Recreational	Oregon Commercial	Oregon Recreational	Washington Recreational	California total	Ore/Wash total
1993	3	79	2	30	12	82	44
1994	41	55	7	23	9	96	38
1995	90	69	6	16	9	159	31
1996	114	85	6	17	8	199	31
1997	133	60	21	25	11	193	57
1998	169	73	27	16	6	242	50
1999	126	43	27	18	10	169	54
2000	117	41	31	17	7	158	55
2001	73	57	46	19	8	130	73
2002	51	39	44	18	12	90	74

Data and assessment

Seven potential indices of abundance (8 if the two CPFV indices are considered to be separate) were considered in this assessment: (1) California Logbook and Observer CPFV CPUE, (2) California RecFIN CPUE, (3) CalCOFI larval (southern population spawning) index, (4) Southern California Power Plant impingement (recruitment) index, (5) Oregon Recreational CPUE, (6) Washington Recreational CPUE, and (7) Alaska Fishery Science Center larval (northern population spawning) index. Each index was developed by fitting models to the proportion of non-zero records and the catch-rate (or whatever quantity is being measured) given that the catch was non-zero, and taking the product of the resultant estimates (delta method). In addition, catch length-composition data from each of the fisheries in both populations were available. This assessment is focused on the southern population (California) because it was determined that information for the northern stock was insufficient for population evaluation. For the southern stock, all indices (except the CPFV observer and CalCOFI larval index) and the length-composition data were included to fit an age- and sex-structured population dynamics model. The model uses maximum likelihood to estimate model parameters within the AD Model Builder ® (ADMB) non-linear minimization environment. Bayesian analyses using Markov Chain Monte Carlo methods were used to explore uncertainty in model outputs. An independent Stock Synthesis Model (Methot 2000) was constructed to verify the results obtained using the ADMB model.

Unresolved problems and major uncertainties

Several sources of uncertainty in the assessment were recognized and explored using sensitivity analyses. The inclusion and exclusion of indices proved to make little difference to the model outputs, although the reliability of each index is uncertain. Major uncertainties lie in the estimation of natural mortality (*M*) for each sex, the extent of variation in recruitment (σ_R^2), stock-recruitment parameters such as steepness (*h*), the correct number of years for which recruitment residuals are estimated, the size of the historical recreational catch, the effective sample size assigned to the catch length composition data, the length–at-age CVs, and the shape of the selectivity curve (asymptotic or domed). Additional uncertainty lies in the magnitude of the variability in the catchability coefficient and thus the extent of variation around each estimated abundance index value. For the northern stock (Oregon-Washington), the lack of informative data about changes in population abundance resulted in the STAT team abandoning formal modeling of that population.

Reference points

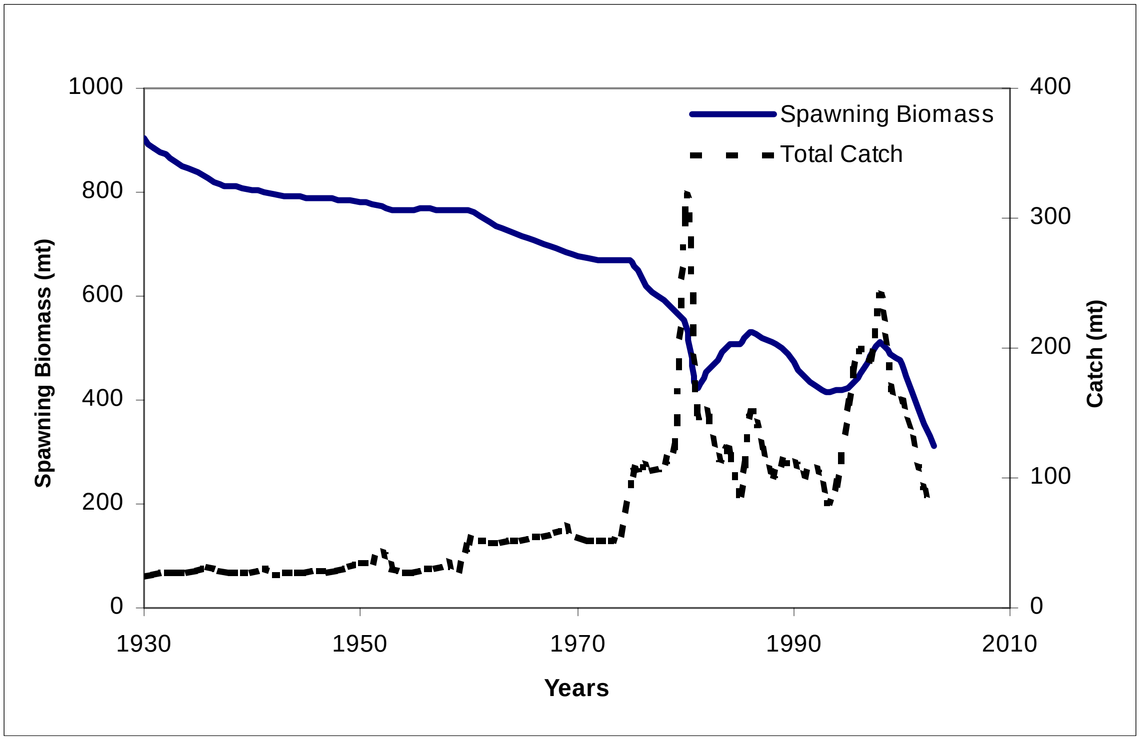
The current reproductive output of cabezon off the state of California is 34.7% of its unfished level. This is above the overfished threshold of 25%, but below the target of 40%. The median value of depletion from the posterior distribution however is above 40%. The target harvest rate is $F_{45\%}$=0.239. The state of California target harvest rate is $F_{50\%}$=0.197.

Stock biomass

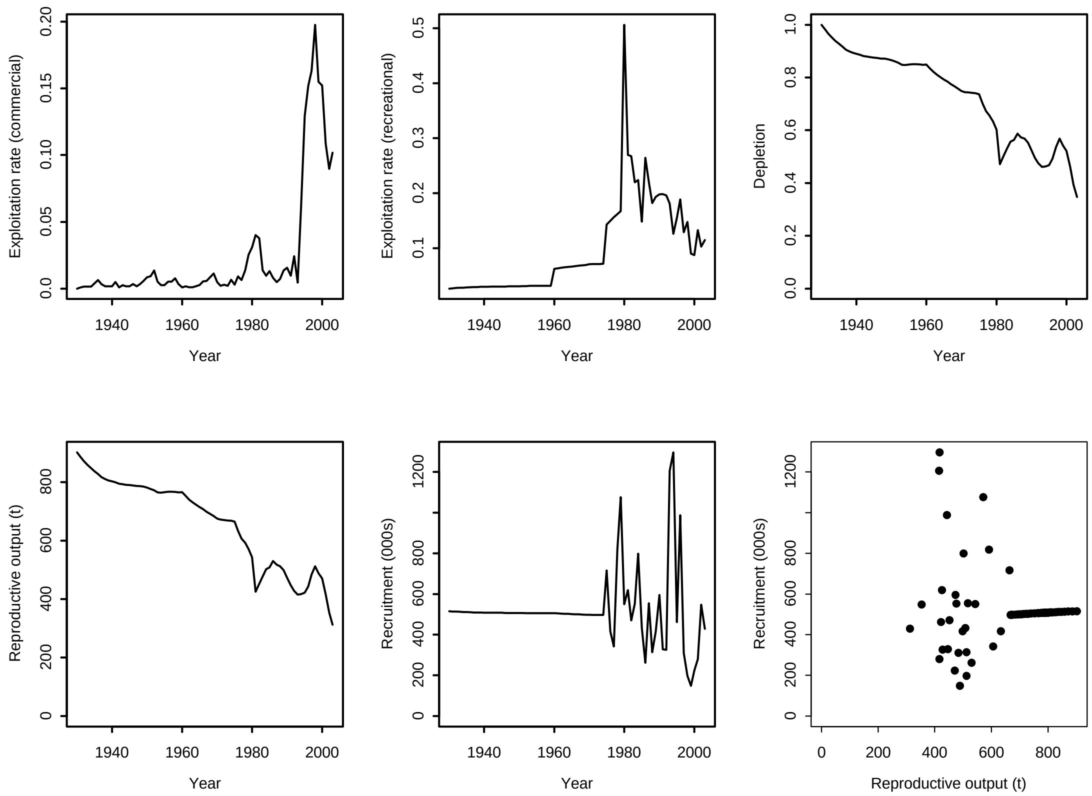
The estimated unfished reproductive output of the California cabezon resources is 902 mt, with an estimated reproductive output of 313 mt in 2003. This gives a depletion level of 34.7% for 2003.

Recruitment

A reparameterized Beverton-Holt equation with lognormal process error was used to characterize the spawner-recruitment relationship of cabezon. The steepness parameter was set to 0.7 and a likelihood profile was used to evaluate model outputs using steepness values from 0.2 to 1. Recruitment residuals were estimated for the years 1975 to 2002. Two major recruitment events are estimated to have occurred: one in the late 1970s and another in the early 1990s, both about twice the size of historical recruitment levels. The actual recruitment patterns are unclear because of a lack of information about year-specific recruitment.

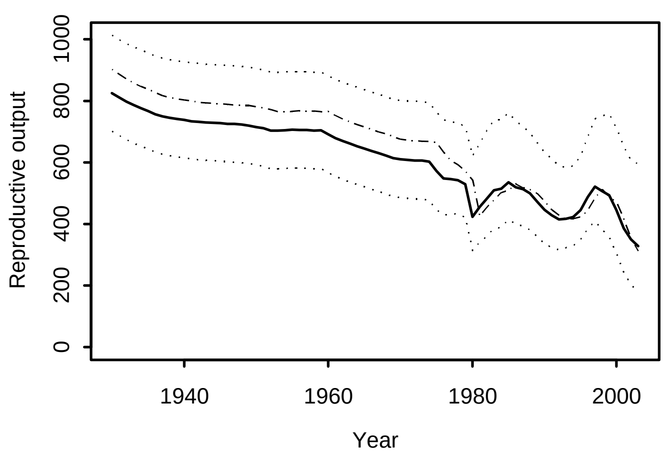


Year	Spawning Biomass	Recruitment	Total Catch
1930 (unfished)	902	515	25
1940	802	508	27
1950	781	507	35
1960	766	505	51
1970	675	497	55
1980	543	550	318
1990	473	595	111
1991	447	328	101
1992	428	326	106
1993	416	1205	82
1994	417	1296	96
1995	422	461	159
1996	443	987	199
1997	484	310	193
1998	512	197	242
1999	489	149	169
2000	471	223	158
2001	417	279	130
2002	354	547	90
2003	313	429	90



Exploitation status

The current reproductive output of the cabezon resource off California is estimated to be about 35% of its unfished level based on the base-case MPD and 42% based on the posterior median for the base-case analysis.



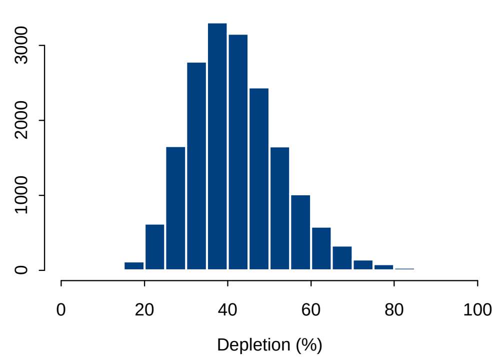
Posterior distributions (posterior medians and posterior 95% intervals) for the time-trajectory of reproductive output (1930-2003). The dashed lines are the MPD estimates of annual reproductive output.

Management performance

Few management regulations exist for cabezon. California imposed a 15-inch minimum size limit on retained cabezon in its recreational and commercial fisheries in 2001, an increase over the previous 14-inch size limit. Recreational bag limits have been 10 fish/day since 2000 in California. Oregon imposed a 16-inch commercial size limit and a 15-inch recreational size limit for cabezon in 2001. Oregon has a 10 fish/day bag limit for cabezon and greenling combined. California and Oregon are proposing slot limits for cabezon; cabezon must be within 15-22 inches in California and 15-19 inches in Oregon to be retained. There is no size limit in Washington and recreational fishers are limited to 15 bottom-type fishes daily. Commercial landings of cabezon are monitored as part of a mixed group called “Other Fish”. The coastwise ABC for this entire group of species was 14,700mt during 1999-2002 (5,200mt for the Eureka, Monterey and Conception INPFC areas and 9,500mt for Columbia and Vancouver INPFC areas).

Forecasts

Twenty-year yield projections were based on the combined posterior of nine Bayesian analyses (combinations of values for M of 0.2yr^{-1}, 0.25yr^{-1} and 0.3yr^{-1} and values for h of 0.5, 0.7 and 0.9; see below figure). Four control rules were considered: (1) 40-10, (2) $F_{45\%}$, (3) 60-20, and (4) $F_{50\%}$ (see below table). Two of the control rules are based on the Groundfish FMP (ABCs based on the “other groundfish” F_{MSY} proxy of $F_{45\%}$ and OYs based on the 40-10 adjustment for stocks below $0.4S_0$) and the other two control rules are based on California’s Nearshore FMP (ABCs based on a F_{MSY} proxy of $F_{50\%}$ and OYs based on a 60-20 adjustment for stocks below $0.6S_0$).



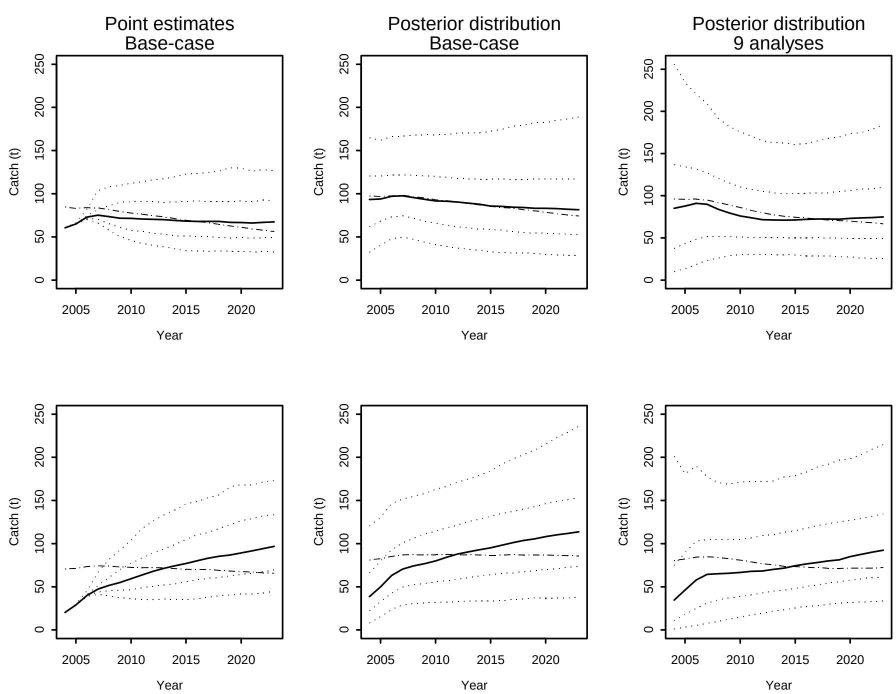
Posterior distribution for current depletion (i.e. S_{2003}/S_0) obtained by pooling the posterior distributions for the nine cases giving a weight of 1 to cases for which M=0.25yr^{-1} and 0.5 to cases for which M=0.2 yr^{-1} and M=0.3yr^{-1}.

Year	Posterior distribution (Nine analyses)			
	40-10 rule	$F_{45\%}$	60-20 rule	$F_{50\%}$
2004	85	96	35	80
2005	88	96	46	82
2006	91	96	58	84
2007	90	95	64	85
2008	84	92	65	84
2009	80	89	66	82
2010	76	86	66	81
2011	74	82	68	79
2012	72	80	68	77
2013	71	77	70	75
2014	71	76	72	74
2015	71	74	74	73
2016	72	74	76	72
2017	72	72	78	72
2018	72	71	80	71
2019	72	70	81	71
2020	73	70	85	72
2021	74	69	87	72
2022	74	68	90	72
2023	75	67	92	72

Decision table

Results are given below for three scenarios concerning the estimates on which the projections are based: (a) the MPD estimates (this is the basis for the bulk of projections presented to the Council in the past), (b) the posterior distribution for the base-case analysis, and (c) the posterior distribution for all nine cases combined. The widths of the 95% intervals generally increase with time.

Year	Point estimates (Base-case)				Posterior distribution (Base-case)				Posterior distribution (Nine analyses)			
	40-10 rule	$F_{45\%}$	60-20 rule	$F_{50\%}$	40-10 rule	$F_{45\%}$	60-20 rule	$F_{50\%}$	40-10 rule	$F_{45\%}$	60-20 rule	$F_{50\%}$
2004	61	85	20	71	93	97	39	81	85	96	35	80
2005	65	83	29	71	94	97	50	82	88	96	46	82
2006	73	84	40	73	97	98	63	85	91	96	58	84
2007	75	83	47	74	98	98	70	87	90	95	64	85
2008	74	82	52	74	96	96	74	87	84	92	65	84
2009	72	79	55	73	94	95	77	87	80	89	66	82
2010	71	78	59	72	92	93	80	87	76	86	66	81
2011	71	76	64	72	91	92	84	87	74	82	68	79
2012	70	75	68	72	90	90	88	87	72	80	68	77
2013	70	73	71	72	89	89	91	87	71	77	70	75
2014	69	71	74	71	88	87	93	87	71	76	72	74
2015	68	69	77	70	86	85	95	86	71	74	74	73
2016	68	68	80	70	85	84	98	87	72	74	76	72
2017	68	66	83	70	85	83	101	87	72	72	78	72
2018	68	64	85	69	84	81	104	87	72	71	80	71
2019	67	63	87	68	83	80	106	87	72	70	81	71
2020	67	61	89	67	83	78	108	87	73	70	85	72
2021	66	59	92	67	83	77	110	86	74	69	87	72
2022	67	58	94	66	82	75	112	86	74	68	90	72
2023	67	56	97	65	82	74	114	86	75	67	92	72



The above graph illustrates time-trajectories of yield. The solid lines are the median time-trajectories of 40-10 (upper panels) and 60-20 (lower panels) harvest, the dashed lines are F_{ABC} median time-trajectories of harvest, and the dotted lines and the 5th, 25th, 75th and 95th percentiles of 40-10 and 60-20 harvest.

Recommendations

1 Accurate accounting of removals, especially from recreational and live-fish fisheries: Fisheries primarily exploited by recreational and live-fish commercial fisheries are traditionally hard to monitor. More effort to monitor these fishery sectors may be necessary to accurately monitor fishing mortality.

2 A fishery-independent survey of cabezon population abundance: Cabezon primarily inhabit depths less 50m. Nearshore fishes, at this time, are not surveyed using fishery-independent methods. As fishing pressure builds in nearshore areas, a standardized and statistically-designed survey will be needed to adequately monitor population trends.

3 A study of the stock structure of cabezon: Cabezon along the west coast of the U.S were assumed to consist of two distinct biological populations (split at the California-Oregon border), but this assumption is based on very limited information. More work needs to be done to understand the stock structure of this and most other groundfish species.

4 Age validation/ age determination: Catch age-composition data were not available for this assessment. Accurate ageing is crucial to understand the population dynamics of a species, especially those for which there is limited survey information. Information on the age-structure of the catches for each fishery sector should substantially improve some aspects of the assessment.

5 A better understanding of the relationship between CPUE and population biomass: Changes in recreational CPUE are assumed to reflect changes in population biomass in a linearly proportional way. The results of the assessment would be severely in error if this assumption were substantially violated. Therefore, if future assessments depend on CPUE data, it is vital that the relationship between CPUE and population biomass be quantified. In principle, guidelines for dealing with this problem generically could be advanced through a workshop on methods and modeling approaches for the use of recreational data when developing indices of abundance.

6 A more standardized method of computing recreational CPUE. Recreational CPUE is becoming increasingly important as fishing effort moves into areas that have not been surveyed. Many decisions are necessary to use recreational information to develop CPUE indices. A more standardized method of developing these data would assist the development and review of assessments for those species that depend substantially on indices based on catch and effort information.

7 Effect of climate on cabezon: Several source of information in this assessment (e.g. the power-plant impingement index, the CalCOFI index and some length composition information) indicated that there was potentially good recruitment after 1999 (and before 1977 for the impingement data) whereas these same sources indicated that recruitment was very poor prior to 1999. This suggests that cabezon may be influenced by climatic/oceanic regimes. A better understanding of the relationship between cabezon population dynamics and climate would reduce the uncertainty of future assessments.

Purpose

This document describes the first assessment of the population status of cabezon (*Scorpaenichthys marmoratus*) on the west coast of the United States. The analyses are intended to provide information that will be of use by managers at both the state and federal levels. This document follows, to the extent possible given the available information, the Terms of Reference for stock assessments established by PFMC Scientific and Statistical Committee.

Several objectives are addressed in this document. First, the life history of cabezon is described and all the available data sources that were considered for use in the assessment are explained. The document only provides information for those data sources that were considered for use in the population modeling. Many other sources of information were considered but ultimately rejected, and for brevity they are not included in this document. Second, the assessment describes a population model built specifically for use in the assessment of cabezon status. Third, the assessment attempts to evaluate the assessment model through the use of an alternative model. The alternative model is used to evaluate and potentially validate the assessment results, but has not been put forward as a competing assessment.

This assessment differs from those performed for most other west coast groundfish species because of the lack of a dedicated fishery-independent biomass index. It consequently relies on indices of abundance based on recreational CPUE and information about larval abundance. Although no dedicated biomass indices exist for this species, these alternative data sources are viewed as sufficient for tuning the population dynamics model. Much uncertainty remains in regard to the assumption that changes in recreational CPUE are linearly proportional to changes in population size. There is no information on the age-structure of the catches. Therefore, although the model is age-structured, it is fit to length-composition data by converting the model-predicted catch age-compositions to catch size-compositions using a growth curve. The length frequency sample sizes are small and changes in length frequency distributions are not necessarily caused solely by changes in the age-structure and size-structure of the population. Nevertheless, although the results of this assessment are highly uncertain, this assessment is the best available for describing population changes and for providing management advice for cabezon and was considered to be of sufficient strength by the reviewers (STAR Panel) to be used for management.

Acronyms used in this document:

ABC – Allowable Biological Catch
AFSC – Alaska Fisheries Science Center
AIC – Akaike Information Criterion
CalCOFI - California Cooperative Oceanic Fisheries Investigation
CDF&G – California Department of Fish and Game
CPFV – Commercial Passenger Fishing Vessels
CPUE – Catch per unit of effort
CV – Coefficient of variation
FMP – Groundfish Fishery Management Plan
GLM – Generalized Linear Model
INPFC – International North Pacific Fishery Commission (spatial area units)
MCMC – Markov Chain Monte Carlo
MODE – Fishing Method (shore, private boat, charter boat)
MPD – Maximum of the posterior density function
MRFSS - Marine Recreational Fisheries Statistics Survey
NMFS – National Marine Fisheries Service
NWFSC – Northwest Fisheries Science Center
OBS – Ocean Boat Survey
ODF&W – Oregon Department of Fish and Wildlife
PFMC – Pacific Fishery Management Council
RecFIN – Recreational Fisheries Information Network
SWFSC – Southwest Fishery Science Center
WAVE – Bi-Monthly period
WDF&W- Washington Department of Fish and Wildlife
OY- Optimum Yield

INTRODUCTION

Very little is currently known about cabezon life history and even less is known about its population status. Cabezon are a member of the family Cottidae, which includes the sculpins. However, unlike most sculpins, cabezon grow to large size and are prized by both commercial and recreational fishers. Cabezon are currently managed as part of a nearshore complex of fishes that include several species of rockfishes and greenlings.

This is the first quantitative assessment of the population status of cabezon. Although the assessment considers the entire west coast of the continental United States, the data are very sparse, except for the state of California.

LIFE HISTORY

Distribution

Cabezon are distributed along the entire west coast of the continental United States (Figure 1), Canada and Alaska. They have been found as far south as central Baja California (Miller and Lea 1972) and as far north as Alaska (Quast 1968). Although cabezon are primarily a nearshore species (the majority of the recreational catch being inside of 15-20fm and approximately 99% within 30fm), they are nevertheless taken infrequently in depths that exceed 30 fm (Feder *et al.* 1974).

Species Associations

Cabezon is a member of a nearshore assemblage of fishes that include black-and-yellow rockfish, blue rockfish, brown rockfish, calico rockfish, china rockfish, copper rockfish, gopher rockfish, grass rockfish, kelp greenling and rock greenling, kelp rockfish, monkeyface prickleback, olive rockfish, quillback rockfish, California scorpionfish, California sheephead, and treefish. The population levels of most of these species have not yet been assessed, but their co-occurrence is indicative of the cabezon depth range.

Spawning and Early Life History

Cabezon are known to spawn in recesses of natural and manmade objects, and males are reported to show nest-guarding behavior (Garrison and Miller 1982). Spawning is protracted, and there appears to be a seasonal progression of spawning that begins off California in winter and proceeds northward to Washington by spring. Spawning off California peaks in January and February (O'Connell 1953) while spawning in Puget Sound (Washington State) occurs for up to 10 months (November-August), peaking in March-April. Laid eggs are sticky and adhere to the surface where laid. After hatching, the young of the year spend 3-4 months as pelagic larvae and juveniles. Settlement takes place after the young fish have attained 3-5 cm in length (Lauth 1987).

The number of eggs spawned appears to increase with fish size (weight or length) (O'Connell 1953, Lauth 1988). However, the actual relationship between age / size and number of eggs spawned is uncertain because cabezon may spawn more than once each year. Therefore, rather than attempting to determine this relationship, the reproductive output has, for this purposes of this assessment, been defined to be proportional to the product of maturity-at-age and body weight at the start of the year. Maturity ogives

(Figure 2; table 1) were estimated using the California Department of Fish and Game (CDF&G) visual inspection codes and ages provided by Joanna Grebel (Moss Landing Marine Laboratories), i.e.:

$$\phi_a = (1 + \exp(-1.56a + 4.1))^{-1} \qquad \text{age}$$
$$\phi_L = (1 + \exp(-0.7a + 25.7))^{-1} \qquad \text{length}$$

Females with gonads with early yolk stage eggs were assumed to be mature, although it is possible that some of these fish were maturing but not yet mature. This will lead to a more optimistic interpretation of the rate at which cabezon mature (younger and at smaller size)

Age and growth

Cabezon are among the largest of the cottids, attaining a length of nearly 1m and a weight in excess of 11 kg (Feder *et al.* 1974). Female cabezon are larger than males of the same age (Figure 3a). Little work has, however, been done on the relationship between age and length of cabezon. Joanna Grebel has recently concluded a study on age and growth of cabezon from California and her data form the basis for a growth curve for California cabezon (Grebel 2003). Ages were determined from a thin-section of the saggital otolith. The ages were all standardized to a 1 January birthdate to avoid bias caused by rapid growth during the first years of life and von Bertalanffy growth curves fitted to the resulting age-length data (Table 1). Partial "validation" of this growth curve was achieved by estimating the values for ℓ_∞ and κ from tag-recapture data (K. Karpov, CDF&G, pers. comm.) and setting t_0 so as to minimize the sums of squares of size at age from the combined sexes and the tag-recapture estimates. The ageing- and tagging-based growth curves do not appear to be in conflict (Figure 3b).

A von Bertalanffy growth curve for cabezon from Puget Sound, Washington was fitted by Lauth (1987). The age-length data reported by Lauth (1987) include very few young fish so these data were augmented by data on length-at-age for cabezon aged <2yr from the sample for California and the resultant data set fitted to sex-specific von Bertalanffy growth curves (Figure 3c). Cabezon in Oregon and Washington are estimated to reach larger size than those in California.

Weight-length relationships (both sexes combined; weight in g and length in cm) were determined for California and Oregon-Washington (Grebel 2003; Lauth 1987 respectively; Table 1):

$$W = 0.0089\, L^{3.19} \qquad \text{California}$$
$$W = 0.00684\, L^{3.16} \qquad \text{Oregon-Washington}$$

Natural Mortality (*M*)

Little is known about the natural mortality rate of cabezon. Cabezon currently reach an estimated age of 15 years (see Figure 3a) in California and of 17 years in Washington

(Figure 3c). These ages imply a natural mortality rate of approximately 0.25 yr^{-1} based upon maximum age methods for estimating *M* (Hoenig 1983; Royce 1972), but this value is highly uncertain.

HISTORY OF FISHERIES

The recreational sector has been the main source of cabezon removals until very recently. Cabezon have been a component of the catch in recreational fisheries for more than a century (Jordan and Everman 1898). The earliest modern commercial fishery information (O'Connell 1953) indicates that a small amount of cabezon was being sold in fish markets in the San Francisco area by the 1930s. However, it wasn't until the 1980s that a truly directed commercial fishery for cabezon was established.

The most significant change in the fishery for cabezon is likely the development of the live-fish commercial fishery that targets several species of nearshore fish including cabezon. This fishery started on the west coast in southern / central California in the late 1980s and spread northward in the late 1990s to Oregon (Starr *et al.* 2002). Fishermen routinely obtain much higher prices for fish brought back to markets alive. Cabezon are not subject to barotraumas because they lack a swim bladder and are usually found in shallow nearshore water. These traits make them an ideal target for both the live-fish and recreational fisheries. Gears that take cabezon include hook and line and pot/trap type gears, as they are successful at bringing up fish with relatively little damage. The live-fish fishery will continue to be an important contributor to the landings of cabezon, especially as the allowable catches of other marketable fish species are reduced.

Fisheries Management

Management of nearshore groundfish species is an area of active discussion. The Pacific Fishery Management Council (PFMC) and the National Marine Fisheries Service (NMFS) have management responsibility for all groundfish species included in the Groundfish Fishery Management Plan (FMP). Many nearshore species, including cabezon, that are included in this FMP also fall primarily within the 3-mile limit of states waters. States are currently seeking to be granted management authority over nearshore species by the PFMC.

Few management regulations exist for cabezon. California imposed a 15-inch minimum size limit on retained cabezon in its recreational and commercial fisheries in 2001, an increase over the previous 14-inch size limit. Recreational bag limits have been 10fish/day since 2000 in California. Oregon imposed a 16-inch commercial size limit and a 15-inch recreational size limit for cabezon in 2001 (see Appendix A for a complete list of California regulations). Oregon has a 10fish/day bag limit for cabezon and greenling combined. California and Oregon are proposing slot limits for cabezon; cabezon must be within 15-22 inches in California and 15-19 inches in Oregon to be retained. There is no size limit in Washington and recreational fishers are limited to 15 bottom-type fishes daily.

Commercial landings of cabezon are monitored as part of a mixed group called "Other Fish". This group of species includes sharks, skates, rays, grenadiers and other groundfish. This group has been defined historically as groundfish species that do not have directed or economically important fisheries. The coastwise ABC for this entire group of species was 14,700mt during 1999-2002 (5,200mt for the Eureka, Monterey and Conception INPFC areas and 9,500mt for Columbia and Vancouver INPFC areas).

DATA SOURCES INVESTIGATED

The data sources that were considered for use in the population modeling of cabezon are explored in the next section. Data for species managed by the Pacific Fishery Management Council are collected by both federal (or quasi-federal) and state agencies. This can complicate matters because multiple agencies may collect the same types of data. Where this occurs, the analyses below are based on those data that are most likely to be informative regarding changes in population size.

Removals

Whenever possible, removals were characterized as landed catch plus fish released and presumed dead. Historical catches (prior to 1980) were inferred from state reports or backward projections of later catches. Although cabezon are caught using a variety of pot and line type gears, all catches are assumed taken using a single gear type for the purposes of this assessment.

Recreational Catches

Given the nearshore depth-distribution of cabezon, it is not surprising that much of removals are due to the recreational sector (Table 2; Figure 4). Information on the activities of recreational fishermen has been collected by both state (CDF&G, ODF&W, and WDF&W) and federal (MRFSS) programs. The MRFSS program obtains effort information from a random-digit dialing protocol and catch/trip from intercept interviews. State run recreational sampling programs differ from the MRFSS program because effort is based upon exit counts of boats leaving recreational harbors. This type of exit count works well in the northern states because the number of ports is low and it is relatively easy to monitor these ports.

The RecFIN statistical subcommittee compared the state (only in Washington and Oregon) and MRFSS sampling programs and found that the state programs are likely to provide more accurate estimates of total removals. Therefore, the estimates of removals for this assessment are based on state estimates to the extent possible. It should be noted, however, that even in those states with state-sponsored recreational sampling programs, certain recreational activities are not monitored by the states (e.g. shore fishing). Thus MRFSS data are still needed to determine total removals for those activities. In addition, recreational catch from the MRFSS sampling program were not estimated during the years 1990-1993, so the estimates of the recreational catch in California for those years were calculated by linear interpolating between the catch for 1989 and that for 1994. The removals by the recreational catches by state are determined as follows:

1. Oregon: a combination of ODF&W (Don Bodenmiller, per. commn) OBS survey estimates of ocean boat catch plus the MRFSS estimates of shore and

inland marine catch. OBS collects information on the number of cabezon taken by recreational fishers. Biological sample information is used to determine the average weight of the fish caught annually and hence to compute removals in metric tons.

2. Washington: the estimated removals (metric tones) from 1990-2002 were taken from the state-sponsored ocean sampling program and the nearshore catch was estimated by MRFSS, which could be taken directly from the RecFIN website ((http://www.psmfc.org/recfin/). For years prior to 1990, removals were determined by adding the catches from state sampling in the ocean areas to the landings by shore fishermen estimated by MRFSS.

3. California: based solely on MRFSS estimates taken from the RecFIN website ((http://www.psmfc.org/recfin/ for the years 1980 to current. The total historical recreational catch is uncertain. Substantial catches are known to have occurred prior to 1979, because the catch (in numbers) reported in the CPFV logbooks was generally larger in late 1940s than during the 1980s. However, total removals due to the recreational sector cannot be determined because the logbooks only report a fraction (~10%) of the recreational catch in the more recent period (when there are estimates of all modes of recreational catch). For the purpose of this assessment, the catch is assumed to increase over time from 1930 to 1979; sensitivity analyses examine the impact of changing this assumption.

Estimates from the state and federal programs can sometimes differ greatly. In the case of Washington, for example, the MFRSS estimates for the total removals for 1980-2002 were twice those based on the state program, although the state program not accounting for shore-based fisheries causes some of the discrepancy. Estimates of recreational removals are therefore uncertain.

Commercial Catches

Estimates of commercial landings are obtained from fish tickets that detail the landed catch. Landed catches of cabezon are recorded in a specific cabezon category but also in a mixed-species category. Furthermore, this system has changed over time. The entire landing was assumed to be cabezon when the landing receipt identified the catch as nominal. For those landings brought to the dock as a mix of species, the species composition proportions determined from port samples were applied to the landing to estimate cabezon weight. This is a standard procedure carried out within the PacFIN database.

There are marked differences in the magnitude as well as the temporal pattern of the commercial take of cabezon in each of the three states (Table 2; Figure 4). Washington has never had a commercial fishery for cabezon. Oregon had a small commercial (relative to the recreational) fishery until the late 1990s when commercial landings increased dramatically due to development of the live-fish fishery in that state. California has a record of commercial catch that goes back to the 1920s and has by far the largest commercial removals of the three states. Commercial landings of cabezon in California reached a peak of over 150mt in 1998 and averaged more than 80mt since the mid 1990's

(Table 2). The live-fish fishery, which was first introduced into the U.S. west coast in California, was a primary driver for this increase in catch.

Discards

Discard mortality is assumed to be negligible for the purposes of this assessment because of the shallow habitat of this fish, its physiology, and its hardiness. The lack of any appreciable cabezon discard in the West Coast Observer Program (Lin-Lai, NWFSC, pers, commn) supports this assumption.

<u>Length Compositions</u>

Cabezon otoliths are not collected routinely during port sampling. Therefore, the only information on the structure of the catch is from length measurements. Sex is not recorded when sampling for length, so all of the catch length distributions considered in this assessment are sex-aggregated. Catch length compositions (Table 3; Figure 5) were developed for each state and fishery sector (see Table 4 for the numbers of fish and trips sampled).

The catch length compositions for each state and year from the recreational fisheries were obtained from the RecFIN website (RecFIN expands the sampled length proportions by port, mode (fishing activity) and wave (bi-monthly period) to estimate the proportion at length for the entire year.

The commercial catch length distributions for Oregon (1998-2002) are based on fish sampled by state port biologists. The sample size in the first two years is low (Table 4) because the Oregon commercial fishery had started only recently. No weighting of the length-frequency data for Oregon is needed (i.e. the raw length-frequency data are simply added together) because each cabezon sample typically made up the entire catch. The commercial length compositions for California were extracted from the CALCOM database. Commercial length samples are expanded using the standard routine at the port-gear-month level and then aggregated for the state.

<u>Indices of Abundance</u>

There is no standardized survey designed to estimate the abundance of cabezon along the U.S. west coast. All surveys presently used to provide biomass indices for groundfish populations are conducted at depths that are largely outside the depth preference of cabezon. Cabezon are caught so infrequently in the standardized trawl surveys that those data sources are not considered further. Therefore, in common with the assessment of yelloweye rockfish (Methot et al. 2002), this assessment is based on recreational CPUE data, larval abundance indices from standardized egg/larvae surveys (as possible index of reproductive output), and impingement rates of juvenile cabezon (considered as a possible index of recruitment).

Seven potential indices of abundance (eight if the two CPFV indices are considered separate indices) were developed by fitting models to the proportion of non-zero records and the catch-rate (or whatever quantity is being measured such as number of larvae impinged) given that the catch was non-zero, and taking the product of the resultant estimates (delta method). Table 5 summarizes the details of the sampling programs, the years for which data are available, the number of data points and the number of non-zero records for each data source. The proportion of non-zero records was modeled as a binomial variable while the catch-rate for non-zero records was modeled as a lognormal variable. The models were fitted using GLM and only main factor effects were considered (i.e. no interaction terms). A variety of alternative models were developed and these were weighted using AIC. Table 6 lists the AIC-based weights for the models considered. Other distributional assumptions (e.g. negative binomial, delta-gamma) were considered but these provided very similar indices. The results of the analyses are illustrated by plots of the average annual catch rate (no stratification) and the corresponding GLM-base estimates. The CVs are based on a bootstrapping methodology (MacCall per. comm.) using only the factors from the best fitting model. Index values for each data source are given in Table 7.

Recreational CPUE indices

Commercial Passenger Fishing Vessels (“CPFV Observer” and “CPFV Logbook”)

A recreational CPUE index was developed for California from the Commercial Passenger Fishing Vessel (CPFV) program (1988-98) operated by CDF&G. An observer was placed on some party fishing vessels and monitored location, depth and duration of fishing as well as the number of anglers and number of fish (by species) caught. Over 99% of all positive catches of cabezon were inside 30fm and for the analysis observations beyond 30fm were excluded. Factors available and considered for inclusion in the model include port complex (a proxy for latitude), and depth. AIC selected the full model (all factors; Table 6; Figure 6).

An alternative CPFV index (1960-2001) was constructed from data included the (self-reported) logbooks of the captains of the CPFV fleet (Figure 6). This data set included those trips with observers that were analyzed above, as well as many more trips. The data available were summarized by month and California block area; each record therefore contains at least one, but probably more than one, trip. The data were filtered to include only those trips (or collapsed trips) that caught nearshore species (but not necessarily cabezon). Factors considered in the models included season, latitude and depth.

Both CPFV CPUE indices include information from southern to northern California, although the majority of the data come from the central sections of the state. We chose to use the CPFV logbook series instead of the observer series in the assessment because: (a) some of the CPFV observer data series are included in the CPFV logbook data, and (b) the CPFV time series is longer. The two series indicated similar trends during the years they overlap (Figure 7a). Figure 7b depicts diagnostics for the CPFV logbook model.

California RecFIN

An alternative recreational CPUE index for California was developed using data collected by the MRFSS port samplers (Figure 8). These data were collected during the dockside intercepts used by the MRFSS program to estimate WAVE (bi-monthly period) and MODE (fishing type) specific CPUE that is later expanded by effort to get total recreational catch. Only shore and private boat fishing modes where fishing activities were targeting nearshore groundfish were included when developing CPUE indices to exclude the commercial party/charter vessels on which the CPFV Observer and CPFV

Logbook indices are based. Data were analyzed using factors such as MODE (private boat or shore) and season (spring, summer, fall and winter). A similar index was not developed for Oregon-Washington because shore-based angling is not as large a component of the recreational fisheries in the north compared to California.

Oregon Ocean Boat Survey
A recreational CPUE index was developed from data collected by ODF&W (1979-89 and 1999-2002; Figure 9). Similar to the RecFIN data, these data were obtained from angler interviews and intercepts. However, the data are not available at the individual trip level but rather grouped by trip-type (salmon, groundfish, etc.), port, and month. Factors considered were port and season (spring, summer, fall, and winter). Records that that did not involve trips targeted at groundfish were excluded when conducting the GLMs.

Washington Recreational Index
A recreational CPUE index was developed from data collected by WDF&W (1990-2002; Figure 10). The factors examined when fitting the GLMs were: port group (northern ports, middle coast ports, and Ilwaco), season (summer/winter), and vessel type (party/charter, private, Ilwaco). Records that that did not involve trips targeted at groundfish were excluded when conducting the GLMs.

Ichthyoplankton Indices
A spawning index was developed based on ichthyoplankton data. Cabezon larvae are initially neustonic and available (and readily identifiable) to planktonic sampling gears. The Southwest Fishery Science Center (SWFSC) and the Alaska Fisheries Science Center (AFSC) have conducted ichthyoplankton surveys off the west coast and developed databases with information on the abundance of cabezon larvae. Generally the size of fish collected during these studies is <15mm (pre-settlement) and therefore not thought to correlate well with recruitment to age-1. However, the abundance of this size group may relate (in a linearly proportional way) to the amount of reproductive output the year before the year of sampling. The possibility of developing an index using the Santa Cruz mid-water juvenile rockfish survey was investigated. However, cabezon are only a very small component of the catch in this survey (Steve Ralston, SWFSC, pers. comm.) so no attempt was made to develop an index of pre-settlement cabezon using these data.

CalCOFI
The SWFSC has conducted larval tows off California since 1950. Tows are generally made at stations from the Mexican border to roughly 36°N, so these data relate primarily to southern California. Surface and subsurface tows are made, but the subsurface tows catch few cabezon and are therefore excluded when developing the index. Surface tows made south of 31°N during June-September and west of 122°W are also excluded from the analyses due to few positive tows. The data for the years 1977, 1979, 1982 and 1983 were also excluded because of changes in survey methodology. The factors considered in the analyses where: day and night (day: between 6AM and 6PM), latitude (north and south of 34°N), longitude (east and west of 121°W) and month. The resultant index is shown in Figure 11.

AFSC Larval Index for Oregon and Washington.

The AFSC and the Soviet Pacific Research Institute conducted neustonic tows using a bongo-type net as part of a sampling program during 1980-87 (expect for 1986). This program operated from 39°N to 48°N, but the majority of tows (~85%) were north of 41°N so these data are assumed to pertain to the relative abundance of cabezon larvae for Oregon and Washington. Tows were conducted during all seasons and from 3-200 miles offshore. Larval cabezon were identified and counted whenever they were encountered. Factors that were measured at sea (or derived later by analysis) and evaluated for inclusion in the model were: time of day (day / night), latitude (south of 44°N / north of 44°N), longitude (west of 126°W / east of 126°W), distance from shore (<1000m from shore; >1000m from shore) and season (summer / winter). The resultant index is shown in Figure 12.

Power-plant Impingement

An index of recruitment was created using impingement data obtained from the Edison power plants in California (Figure 13). These data (catch in numbers per standardized flow volume) come from only the extreme southern California bight (33-34°N). The factors considered when developing the index were: station (some stations had multiple intake areas), and season (Dec-Feb, Mar-May, Jun-Aug, and Sept-Nov). This index is considered to pertain to recruitment rather than to reproductive output because the lengths of the fish impinged were primarily those of 0 and 1 year-old fish (Figure 14).

ASSESSMENT

Stock Structure

There is little direct information on the structure of cabezon stocks on the U.S. west coast. However, the indices of abundance for California and those for Washington exhibit substantially different trends (Figures 6-13), the growth curves developed for California and Washington differ markedly (Figure 3), and the fishing history for the 3 states is very different (Figure 4). Therefore, for the purposes of this assessment, cabezon are treated as two stocks divided at the Oregon-California border (Figure 1). This is consistent with assumptions made about stock structure in previous assessments where stock structure data were lacking (Williams et al. 1999; Crone et al. 1999; Jagielo et al. 2000). It also provides the states with the state-specific information needed to manage their fisheries.

Assessment Model

The present assessment is the first ever of the cabezon resource off the U.S. west coast, so there are no previous assessments of the resource against which to compare the assumptions that underlie the present assessment. The assessment framework is based on fitting an age- and sex-structured population dynamics model to the catch, abundance index and catch length-composition data.

The population dynamics model

The base-case variant of the population dynamics model (see Appendix B) is based on the following six key assumptions:

1. There are two fleets (commercial and recreational) that differ in terms of their (length-specific) selectivity patterns.

2. Selectivity is assumed to be asymptotic, constant over time, and related to length by a logistic function (domed-shaped selectivity is explored in a sensitivity analysis).
3. The catch is removed instantaneously in the middle of the year after half of natural mortality.
4. Recruitment is related to reproductive output by means of a Beverton-Holt stock-recruitment relationship with log-normally distributed process error.
5. Length-at-age is normally distributed about its expected value.
6. The estimates of catch-in-mass are known with negligible error (compared to that associated with the abundance index and the catch length-composition data)

As noted above, the assessment divides the cabezon resource at the Oregon-California border. The data for Oregon-Washington are very sparse so this assessment attempts to assess this area utilizing the results for California. In particular, the virgin reproductive output and the steepness of the stock-recruitment relationship for Oregon-Washington are assumed related to those for California. The constant of proportionality relating the virgin reproductive output for Oregon-Washington to that for California, *c* (see Equation B.3) is based on the ratio of the coast-wide nearshore rocky habitat in California to the total nearshore rocky habitat off the west coast. This approach to setting *c* assumes that cabezon density in a virgin state is proportional to the amount of rocky nearshore habitat.

Parameter estimation

The population dynamics model includes many parameters. However, the values for many of these are based on auxiliary information (Table 8). The base-case value for steepness (*h*) has been set equal to 0.7, as suggested by the STAR panel. The extent of variation in recruitment, σ_R^2, was arbitrarily set equal to 1.0. Similarly, the base-case value for the instantaneous rate of natural mortality was set to 0.25yr^{-1} and based on the life history of cabezon. Given the considerable uncertainty associated with the (assumed) base-case values for σ_R^2, and *M*, sensitivity tests examine the consequences of changing the values for these parameters.

The priors assigned to S_0, L_{50} and ΔL (Table 8) act as bounds for these quantities when conducting the analyses to find the values for the parameters that correspond to the maximum of the posterior density function (the MPD estimates). These priors were chosen to be “uninformative” over a relatively wide range.

The values for the parameters related to growth and fecundity are based on the results in Figures 2 and 3, and on the fit to the information on the relationship between length and mass. The values that determine the variability in length-at-age, σ^g, are computed by assuming the CV of length-at-age at age 1 is 0.14 and that at age 15 is 0.09. Although there are no studies aiming to estimate the variability of length-at-age for cabezon, there is an indication that the CV of length-at-age decreases linearly with age for many marine fishes (Erzini 1994). The only sample of length-at-age available for cabezon (Grebel 2003) indicated that the CV for age-0 females was 0.11 and for age-0 males was 0.14, and for age-10 was 0.01 for females and 0.09 for males. These values were based on small sample sizes (2 to 13 animals), therefore the upper limit for the CVs (0.14 and

0.09) were assumed and the value for age-10 was increased slightly and assumed to apply to age-15.

No attempt is made to estimate the recruitment residuals for the first year of the projection period (1930), nor those for some of the subsequent years. This is because the data are completely uninformative regarding the values for these parameters. The results of this assessment are based on estimating the recruitment residuals for 1975-2002. This selection is based on length composition and impingement data and its affect on the model is explored further in the sensitivity analyses.

The objective function minimized to find the MPD estimates for the model parameters includes contributions from the abundance index data (Table 7), the catch length-composition information (Table 3), and the priors (Appendix C).

The values for the constants of proportionality that relate the abundance indices to the model predictions (see Equations C.1, C.5, and C.8) are not included in the non-linear minimization search but are instead calculated analytically. The prior distributions for the logarithms of these parameters are assumed to be uniform because uniform on a log-scale is the uninformative prior for a scale parameter.

Two alternative approaches for dealing with the overall catchability variability scaling parameters were considered initially: (a) assuming them to be equal to 1 (i.e. assuming that the CVs computed for the abundance indices (Table 7) reflect the actual amount of variability of the indices about the true population trajectory), and (b) treating them as estimable parameters (with uniform priors; Equations C.2, C.6, and C.9). Neither of these two approaches is ideal because: (a) there are clear significant "runs" of residuals when these parameters are set equal to 1 which suggests that the CVs for the abundance indices from the bootstrapping exercise under-estimate the true extent of uncertainty, and (b) estimating the extent of additional variance is not ideal because it assumes that the discrepancy between the model and indices is due to the CVs being under-estimates whereas the actual reason is that the model of the population dynamics or that used to standardize the raw abundance index data excludes some key factors. All analyses were initially conducted for *both* approaches for dealing with the catchability variability scaling parameters. After consideration by the STAR panel, it was decided that the most appropriate base-case model included *estimation* of the catchability variability scaling parameters. All subsequent sensitivities presented refer to this base–case analysis.

The catch length-composition data were pooled into 44 length-classes, each of which has width 2cm (first length-class 6-7.9cm). The number of animals measured to construct the length-frequency distributions is substantial (Table 2). However, fits to length-frequency data usually exhibit substantial overdispersion relative to a multinomial distribution where the sample sizes are set to the number of animals measured. Therefore, for the purposes of the analyses of this document, the sample sizes are set to the "effective" number of animals measured (ω^d - see Equation C.12) using the approach developed by McAllister and Ianelli (1997). The results of preliminary analyses suggested setting the effective sample size to 60 for all years when fitting the California commercial lengths and 40 for all years when fitting the California recreational and Oregon length data sources. An effective sample size of 10 is more appropriate for the Washington recreational length-frequency information.

Evaluating convergence of the MCMC algorithm

The Metropolis-Hastings variant of the Markov-Chain Monte Carlo (MCMC) algorithm (Hastings 1970; Gilks *et al*. 1996; Gelman *et al.* 1995) with a multivariate normal jump function was used to sample 3,000 equally likely parameter vectors from the joint posterior density function. This sample implicitly accounts for correlation among the model parameters and considers uncertainty in all parameter dimensions simultaneously. Inference is based on samples generated by running 10,000,000 cycles of the MCMC algorithm, discarding the first 2,500,000 as a burn-in period and selecting every 2,500th parameter vector thereafter. The initial parameter vector was taken to be the vector of maximum posterior density (MPD) estimates. A potential problem with the MCMC algorithm is how to determine whether convergence to the actual posterior distribution has occurred; the selection of 10,000,000, 2,500,000 and 2,500 was based on generating a sample that showed no noteworthy signs of lack of convergence to the posterior distribution. We evaluated convergence by applying the diagnostic statistics developed by Geweke (1992), Heidelberger and Welch (1983), and Raftery and Lewis (1992) and by examining the extent of auto-correlation among the samples in the chain.

Model diagnostics

Figure 15 shows the fit to the base-case model (MPD estimates) for California only. Note that the model is fit to all California indices except the CPFV Observer and CalCOFI series. The former index is a not independent of the logbook series and is shorter (and hence less informative) and therefore was excluded. The latter index had too few positive tows and was deemed not to be useful by the STAR panel. The fit to the latter series in Figure 15 was therefore computed from the MPD estimates of population size and the maximum likelihood estimates for the catchability coefficient. Figures 16 and 17 show the fits of this model to the catch length-composition information and include the distributions for the annual effective sample sizes based on the approach of McAllister and Ianelli (1997).

The model tracks the changes in the CPFV Logbook index qualitatively but there are some notable systematic differences between the data and the model predictions (Figure 15). The wide confidence intervals for this series are indicative that the variability of this series as a measure of changes in biomass is high. Note that in the CPFV logbook data series the wide confidence intervals have expanded the y-axis causing the index to look flatter than it is (compare Figure 6).

The average values for the effective sample sizes in Figures 16 and 17 are close to the values assumed when fitting the population dynamics model (commercial: 60; recreational: 40).

Results

Base-case results: California

Figure 18 shows the MPD estimates of the time-trajectories of exploitation rate for the commercial and recreational sectors, reproductive output (in absolute terms and expressed relative to the virgin level), and recruitment. It also shows plots of recruitment against reproductive output.

The reproductive output of the cabezon resource off California is estimated to be 34.7% of its virgin level in 2003, and the current reproductive outputs is estimated to be 313 mt. Appendix D lists the MPD estimates of the numbers-at-age matrix. Results are not shown for all of the years between 1930 and 1965 in Appendix D because the lack of assessment data (abundance index and catch length-composition data) and the low catches over this period means that the age-structure only changes slowly from the pre-exploitation equilibrium age-structure.

Figure 19 shows the length- and age-specific selectivity ogives for the two fleets (commercial and recreational). Males are less selected than females for a given age because females are larger at age. Selectivity based on age and length suggests immature fish are not completely excluded from current and historical catch.

Figure 20 displays the changes over time in reproductive output and catch simultaneously. There appears to be a qualitative correlation between increased catches and downward changes in population size, particularly after catches greater than about 100 mt. This correlation is particularly apparent in the early 1980s when the catches by the recreational fishery are assumed to have increased and in the mid–to-late 90s when the commercial take increases.

Figure 21 illustrates the change in numbers at length in the starting (1930) and ending (2003) years of the assessment. Catch length composition data is used to fit the model, so it is important to assure the length information changes when the population goes from an unexploited to an exploited state. The biggest difference between the two years is the substantial loss of the larger and older size-classes in the exploited population.

A separate stock reduction analysis was performed in Stock Synthesis (Appendix E) using the same parameterization as the base case analyses. This less complex analysis was used to corroborate that the added complexity of the base-case model was justified. Results of the less complex stock reduction analysis were consistent with those from the base case assessment.

Base-case results: California and Oregon-Washington

Figure 22 shows the fits of the original two base-case models (MPD estimates) to the abundance index data for California and Oregon-Washington. Note that the model is fit only to the data for CPFV Logbook series and Oregon and Washington CPUE series. The two base–case models correspond to the fixing to 1 and estimating the catchability variability scaling parameters, respectively. The results for the remaining abundance series are computed from the MPD estimates of population size and the maximum likelihood estimates for the catchability coefficients. All of the catch length-composition information is included in the analysis. No recruitment residuals are estimated for the Oregon-Washington component of the population due to the sparseness of the data (i.e. the only additional parameters are those that define the selectivity curves for the commercial and recreational sectors).

The CPUE-based abundance indices for Oregon-Washington are essentially flat (or increasing) even though catches are increasing over time (Figure 22). Therefore, the model cannot fit these indices without implying biomass was not impacted by fishing. This leads to essentially infinite estimates of biomass for Oregon-Washington (and hence for California). The fits to the California data deteriorate markedly with the introduction of the data for Oregon-Washington.

Figure 23 presents model outputs for the component of the cabezon population off Oregon-Washington. The results in Figure 23 are based on setting S_0 for Oregon-Washington based on the estimate of S_0 for California and the value for c of 0.81. The only parameters specific to Oregon-Washington estimated to develop Figure 22 are the selectivity parameters for the commercial and recreational fisheries in this area. Note that recruitment is assumed to be constant for the calculations on which Figure 23 is based.

The results in Figure 23 suggest that the size of population in Oregon-Washington may be dropping rapidly. The quantitative results in Figure 23 are totally determined by the assumption c=0.81. However, the qualitative conclusions of this Figure are insensitive to changing the value of this parameter over a wide range. Furthermore, the only way to avoid the conclusion of rapidly declining population size is that c is much smaller than 0.81 (i.e. Oregon-Washington has an inherently higher density of cabezon given its habitat area).

The results in Figures 22 and 23 indicate therefore that it is premature at present to conduct an analytical assessment for cabezon off Oregon-Washington. The remaining results in this document pertain to the population off California only.

Comparison with Synthesis

A model of the dynamics of the California component of the population was constructed using length-based Stock Synthesis (Methot 2000) to compare outputs with the ADMB model. The specifications of the Synthesis assessment were based, to the extent possible, on those for the base-case analysis in which the catchability variability scaling parameters are set to 1. Figure 24(a) shows the MPD estimates of the time-trajectories of recruitment, fishing mortality for the commercial and recreational sectors, and reproductive output (in absolute terms and expressed relative to the virgin level), as well as recruitment plotted against reproductive output for an assessment of cabezon off California based on this application of Stock Synthesis. The results in Figure 24(a) are essentially identical to the corresponding ADMB-based outputs. The similarity of the model results validates the newer ADMB code, so all further analyses are conducted using the newer code.

Sensitivity analyses

The sensitivity analyses are based on the assessment for California only. Table 9 lists results (values for likelihood components, the current (2003) reproductive output and the ratio of the 2003 to the virgin reproductive output) for sensitivity tests for the assessment for California in which the weights assigned to the data sources included in the assessment are varied:

1 Drop the recreational catch length-composition data.

2 Double the weight assigned to the recreational catch length-composition data.
3 Drop the commercial catch length-composition data.
4 Double the weight assigned the commercial catch length-composition data.
5 Drop the Impingement index
6 Add the CalCOFI index
7 Drop the RecFIN index
8 Drop all indices (except CPFV Logbook data)
9 Drop all indices except the CPFV Observer data

Table 10 examines the sensitivity of the results to changing the values for M and σ_R^2. Table 11 explores the sensitivity of the results to changes in several model inputs including the first year for which a recruitment residual is estimated, the magnitude of historical (pre-1980) recreational catches, halving and doubling the effective sample size for the length-composition data, the assumed CVs for length-at-age, domed-shaped selectivity in the commercial fishery, and lowering the extremely high recreational catch (291 mt) in 1980 to 116 mt (calculated by averaging the catch from 1981 to 1983). In all cases, standard deviations for the depletion (taken from the normal approximation) are provided to characterize uncertainty.

Overall, the results indicate the model is not very sensitive to adding or removing the available data sources (Table 9). Only two cases are noteworthy: 1) the exclusion of the commercial catch length composition data, and 2) the use of the CPFV Observer data instead of the CPFV Logbook data. The CPFV Observer series was originally rejected as a potential index of abundance because it overlaps with the CPFV Logbook series and because it contains data for fewer years.

The results are sensitive to the value assumed for M (Table 10). Decreasing M from its base-case value of 0.25yr^{-1} to 0.2yr^{-1} leads to a more depleted resource and *vice versa*. Model results are less sensitive to changing the value assumed for σ_R^2, with a more depleted resource as σ_R^2 increases. The widest range of results occurs when σ_R^2 is held constant at the low value (0.36) and M is changed. Although estimated depletion fluctuates, the standard deviations do not greatly change.

Model outputs are generally weakly sensitive to most other parameter changes explored (Table 11). The sensitivity to the first year for which recruitment residuals are estimated is among the greatest; estimating recruitment starting in later years offers a less pessimistic view of resource depletion. The model is also sensitive to the assumption that length-at-age CVs change linearly with age, although this assumption seems biologically robust. Changes in historical catch, effective sample sizes for the catch length composition data, and domed-shaped rather than asymptotic selectivity in the commercial fishery (to mimic the live-fish fisheries choice of certain size classes) has little affect on the estimate of depletion, although there are some changes to the estimate of the absolute value of the reproductive output in 2003. Under all sensitivity runs, the standard deviations for depletions remained very similar, indicating no general increase in uncertainty with any of the parameter changes.

Figure 25 shows the likelihood profiles for steepness. The data are unable to distinguish between values for steepness from 0.4 to 1 although the data provide evidence against a low value for steepness. Figure 26 shows likelihood profiles for the logarithm of S_0. As expected, higher values for S_0 correspond to a less depleted resource and to a higher current reproductive output.

Bayesian analyses

Diagnostic statistics

Figure 27 summarizes the convergence statistics for three of the key model outputs (the objective function, the ratio of the reproductive output in 2003 to S_0, and the logarithm of S_0). The panels for each quantity show the trace, the posterior density function (estimated using a normal kernel density estimator), the correlation at different lags, the 50-point moving average against cycle number (dotted line in the rightmost panels), and the running mean and running 95% probability intervals (solid lines in the rightmost panels).

The convergence diagnostics in Figure 27 do not indicate any convergence problems. It is not feasible to produce figures summarizing the convergence statistics for all of the very many parameters of the model. However, examination of detailed results for the recruitment residuals and the estimates of reproductive output also do not provide evidence for convergence problems. Some of the recruitment residuals fail the Geweke test but none of estimates of reproductive output. The posterior median for current depletion (41.5%) is larger than the corresponding MPD estimate (34.7%) although the MPD estimate does lie well within the bulk of the posterior distribution for current depletion.

Bayesian results

Figure 28 shows the Bayesian posterior for the time-trajectory of reproductive output (1930-2003). The results shown are the posterior medians and the posterior 95% intervals as well as the MPD estimates. The posterior medians are virtually identical to the MPD estimates for the last years of the assessment period but are notably larger for the early (pre-data) years. The posterior 95% intervals for reproductive output are wide for all years of the assessment period confirming that the data are not highly informative about the absolute size of the biomass.

Projections and decision analysis

The forward projections are restricted to the assessment for California only given the poor fit of the model when it is fitted simultaneously to the data for California and Oregon-Washington (Figure 22). The forward projections were conducted using the software developed to implement the SSC Terms of Reference for rebuilding analyses (Version 2.7d - Punt, 2003) and were used to compute harvest levels for the next 20 years (2004-23). Results (e.g. Table 12) are shown for four alternative control rules. Two of the control rules are based on the Groundfish FMP (ABCs based on the “other groundfish” F_{MSY} proxy of $F_{45\%}$ and OYs based on the 40-10 adjustment for stocks below $0.4S_0$) and the other two control rules are based on California’s Nearshore Fishery Management Plan (ABCs based on a F_{MSY} proxy of $F_{50\%}$ and OYs based on a 60-20 adjustment for stocks below $0.6S_0$).

The cabezon STAR panel (see STAR Panel Report: Cabezon) recommended that projections be based on the posterior distributions from the Bayesian analysis. They noted that the base-case Bayesian analysis (e.g. Figure 28) ignores uncertainty in natural mortality, M, and stock-recruitment steepness, h, and consequently recommended that the projections be based on the results of nine Bayesian analyses (combinations of values for M of 0.2yr^{-1}, 0.25yr^{-1} and 0.3yr^{-1} and values for h of 0.5, 0.7 and 0.9). Furthermore, the STAR panel recommended that the six cases with M values of 0.2yr^{-1} and 0.3yr^{-1} be given half the weight assigned to the cases with M=0.25yr^{-1}.

Figure 29 shows diagnostic statistics for current depletion for each of the nine cases. There is no evidence in Figure 29 or in the detailed diagnostic statistics for convergence problems for any of the nine analyses. Figure 30 shows the implications of the nine analyses in terms of the posterior for current depletion. As expected from Table 10, current depletion gets larger (the assessment becomes more optimistic) when M and steepness are larger. Figure 31 shows the posterior for current depletion when the posteriors for the nine cases are pooled assigning weights of 0.5 for cases with M=0.2yr^{-1} and M=0.3yr^{-1} and 1 for cases with M=0.25yr^{-1}. As expected, the distribution for current depletion in Figure 31 is wider than any of the single distributions for current depletion on which it is based (Figure 30).

The technical specifications for the projections (see Appendix F for an example of an input file to the projection software) are as follows:

a) The virgin reproductive output for a simulation is set equal to the model-estimate of S_0 for that simulation.
b) Future recruitment is generated by sampling recruits / reproductive output ratios with replacement from those for 1975-2001. The more recent recruits/reproductive output ratios are ignored because they are likely to be very imprecise. Recruitment is generated by sampling recruits/reproductive output ratios rather than recruits because the latter exhibit a slight declining trend with time for the base-case analysis (Figure 32)[1].
c) The catch for 2003 is assumed to be 90t.
d) The split of the exploitation rate between the commercial and recreational sectors is assumed to be 50:50. This assumption is based on the exploitation rates in recent years, the base-case MPD estimates of which are 0.09 and 0.1 respectively for 2001.
e) The projections for the analyses based on the MPD estimates used 1,000 simulations while those for based on the posterior distribution used 1,000 alternative parameter vectors (the upper limit for version 2.7d of the projections software) and 5,000 simulations[2].

[1] It should be noted that the harvest levels for the first few years of the projection period will not be impacted markedly by this selection because recruitments not already included in the assessment only constitute a small fraction of the harvest for these years.

[2] Actually, the projections for nine-case analysis used 996 sets of parameters and 4,980 simulations to ensure that the weights assigned to each of the cases was maintained in the projections.

The results of the projections are shown in Figure 33 and Table 12. Results are shown for three scenarios concerning the estimates on which the projections are based: (a) the MPD estimates (this is the basis for the bulk of projections presented to the Council in the past), (b) the posterior distribution for the base-case analysis, and (c) the posterior distribution for all nine cases combined. Table 12 lists the median harvests for the four control rules and the three scenarios. Table 12 also indicates the harvest rates corresponding to $F_{45\%spr}$ and $F_{50\%spr}$ for the MPD estimates. Figure 33 shows the same information as Table 12, but also includes the 5^{th}, 25^{th}, 75^{th} and 95^{th} intervals for the harvest based on the 40-10 and 60-20 control rules to highlight the uncertainty associated with making projections of harvest for cabezon.

The projections for the 40-10 and 60-20 control rules based on the base-case posterior are the most optimistic in terms of medians (Table 12) while the projections for F_{ABC} are essentially identical for the two scenarios based on the results of the Bayesian analyses. The differences in harvest for the 40-10 and 60-20 rules between the two Bayesian scenarios occurs because the posterior for current depletion for the nine analyses scenario assigns higher probability to low depletion than the posterior for the base-case analysis (Figures 30 and 31). The projection results corresponding to the MPD estimates are less optimistic than those based on the posterior distributions primarily because of the differences in the estimates of current depletion.

The widths of the 95% intervals in Figure 33 generally increase with time (because unknown recruitment makes up an increasingly large proportion of the population with time) and as more uncertainty is added. For example, the harvest for 2004 based on the MPD estimates is estimated to have essentially no uncertainty (e.g. Figure 33, left panels) but the 95% intervals associated with the harvest for 2004 based on the nine analyses is 10-256*t* (40-10 rule) and 1-201*t* (60-20 rule).

The time-trajectories of harvest decline with time when F_{MSY} is assumed to be $F_{45\%}$. This occurs because the replacement fishing mortality is closer to $F_{55\%}$ rather than to $F_{45\%}$ (Figure 34), suggesting that $F_{45\%}$ may be a too aggressive fishing mortality for cabezon.

RESEARCH RECOMMENDATIONS

1 Accurate accounting of removals, especially from recreational and live-fish fisheries: Fisheries primarily exploited by recreational and live-fish commercial fisheries are traditionally hard to monitor. More effort to monitor these fishery sectors may be necessary to accurately monitor fishing mortality.

2 A fishery-independent survey of cabezon population abundance: Cabezon primarily inhabit depths less 50m. Nearshore fishes, at this time, are not surveyed using fishery-independent methods. As fishing pressure builds in nearshore areas, a standardized and statistically-designed survey will be needed to adequately monitor population trends.

3 A study of the stock structure of cabezon: Cabezon along the west coast of the U.S were assumed to consist of two distinct biological populations (split at the California-

Oregon border), but this assumption is based on very limited information. More work needs to be done to understand the stock structure of this and most other groundfish species.

4 Age validation/ age determination: Catch age-composition data were not available for this assessment. Accurate ageing is crucial to understand the population dynamics of a species, especially those for which there is limited survey information. Information on the age-structure of the catches for each fishery sector should substantially improve some aspects of the assessment.

5 A better understanding of the relationship between CPUE and population biomass: Changes in recreational CPUE are assumed to reflect changes in population biomass in a linearly proportional way. The results of the assessment would be severely in error if this assumption were substantially violated. Therefore, if future assessments depend on CPUE data, it is vital that the relationship between CPUE and population biomass be quantified. In principle, guidelines for dealing with this problem generically could be advanced through a workshop on methods and modeling approaches for the use of recreational data when developing indices of abundance.

6 A more standardized method of computing recreational CPUE. Recreational CPUE is becoming increasingly important as fishing effort moves into areas that have not been surveyed. Many decisions are necessary to use recreational information to develop CPUE indices. A more standardized method of developing these data would assist the development and review of assessments for those species that depend substantially on indices based on catch and effort information.

7 Effect of climate on cabezon: Several source of information in this assessment (e.g. the power-plant impingement index, the CalCOFI index and some length composition information) indicated that there was potentially good recruitment after 1999 (and before 1977 for the impingement data) whereas these same sources indicated that recruitment was very poor prior to 1999. This suggests that cabezon may be influenced by climatic/oceanic regimes. A better understanding of the relationship between cabezon population dynamics and climate would reduce the uncertainty of future assessments.

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Table 1. Biological parameters for cabezon. Values in parenthesis are the standard errors of the estimates.

A. Age and growth (VBGF) parameters						
	Parameter L_{∞}	95% C.I.	k	95% C.I.	t_0	95% C.I.
<u>North</u>						
Male	690.25	NA	0.241	NA	-1.23	NA
Female	740.87	NA	0.354	NA	0.84	NA
<u>South</u>						
Male	46.85 (2.50)	41.93 to 51.77	0.28 (0.07)	0.14 to 0.43	-1.19 (0.74)	-2.53 to 0.26
Female	62.12 (3.53)	55.18 to 69.07	0.18 (0.03)	0.12 to 0.24	-1.06 (0.39)	-1.82 to -0.29
Combined	56.78 (2.57)	51.73 to 61.83	0.20 (0.03)	0.14 to 0.26	-1.23 (0.38)	-1.98 to -0.49
B. Age and length maturity function parameters (combined sex and area)						
	a	b				
age (years)	-1.5754	4.0968				
length (cm)	-0.7433	25.7021				

Table 2. Removals in mt for each fishery and state.

Year	California Commercial	California Recreational	California[a] Inferred Rec	Oregon Commercial	Oregon Recreational	Washington Recreational	California total	Ore-Wash total
1930	0		25				25	0
1931	1		25				26	0
1932	2		25				27	0
1933	2		25				27	0
1934	2		25				27	0
1935	5		25				30	0
1936	8		25				33	0
1937	4		25				29	0
1938	2		25				27	0
1939	2		25				27	0
1940	2		25				27	0
1941	6		25				31	0
1942	1		25				26	0
1943	3		25				28	0
1944	2		25				27	0
1945	2		25				27	0
1946	4		25				29	0
1947	2		25				27	0
1948	4		25				29	0
1949	7		25				32	0
1950	10		25				35	0
1951	11		25				36	0
1952	16		25				41	0
1953	6		25				31	0
1954	3		25				28	0
1955	3		25				28	0
1956	6		25				31	0
1957	6		25				31	0
1958	9		25				34	0
1959	4		25				29	0
1960	1		50				51	0
1961	2		50				52	0
1962	1		50				51	0
1963	1		50				51	0
1964	2		50				52	0
1965	3		50				53	0
1966	6		50				56	0
1967	6		50				56	0
1968	9		50				59	0
1969	12		50				62	0
1970	5		50				55	0
1971	2		50				52	0
1972	3		50				53	0
1973	2		50				52	0
1974	7		50				57	0
1975	3		100	0	0	2	103	2
1976	9		100	0	0	2	109	2
1977	6		100	0	0	2	106	2
1978	13		100	0	0	3	113	3
1979	23		100	0	13	2	123	15
1980	27	291		0	9	4	318	14
1981	29	121		0	28	3	150	30
1982	29	122		0	19	16	151	35

1983	11	104	0	19	4	115	24
1984	8	113	1	17	4	121	22
1985	11	77	3	14	3	88	20
1986	7	145	5	22	5	152	32
1987	4	117	6	13	8	121	27
1988	6	96	11	21	8	102	40
1989	11	101	7	22	14	112	43
1990	12	99[b]	5	19	11	111	35
1991	7	94[b]	8	19	9	102	36
1992	17	89[b]	7	19	14	105	40
1993	3	79	2	30	12	82	44
1994	41	55	7	23	9	96	38
1995	90	69	6	16	9	159	31
1996	114	85	6	17	8	199	31
1997	133	60	21	25	11	193	57
1998	169	73	27	16	6	242	50
1999	126	43	27	18	10	169	54
2000	117	41	31	17	7	158	55
2001	73	57	46	19	8	130	73
2002	51	39	44	18	12	90	74

[a] This catch has been assumed
[b] Catch was estimated by linear interpolation between the values for 1989 and 1993.

Table 3 Catch length composition by state and fishery sector.

California

	by Commercial								by Recreational																			
cm	1995	1996	1997	1998	1999	2000	2001	2002	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
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	0.00	0.00	0.00	0.00	0.00	0.00
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
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
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	0.01	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
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	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.03
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.01	0.04	0.02	0.02	0.00	0.02	0.04	0.03	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00
26	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.03	0.00	0.01	0.03
28	0.05	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.16	0.00	0.03	0.02	0.01	0.04	0.06	0.00	0.02	0.01	0.00	0.02	0.02	0.01	0.01	0.01	0.03	0.00	0.01	0.00
30	0.08	0.11	0.01	0.03	0.00	0.00	0.00	0.00	0.11	0.06	0.16	0.06	0.02	0.04	0.04	0.04	0.00	0.06	0.03	0.01	0.02	0.02	0.02	0.01	0.05	0.00	0.02	0.00
32	0.15	0.16	0.03	0.09	0.00	0.00	0.00	0.00	0.05	0.06	0.03	0.07	0.03	0.04	0.10	0.02	0.00	0.04	0.01	0.04	0.04	0.04	0.06	0.02	0.08	0.03	0.02	0.01
34	0.08	0.14	0.06	0.12	0.01	0.02	0.01	0.00	0.03	0.06	0.08	0.05	0.05	0.05	0.06	0.00	0.00	0.04	0.05	0.03	0.13	0.07	0.08	0.04	0.08	0.00	0.01	0.01
36	0.12	0.13	0.16	0.17	0.15	0.18	0.05	0.00	0.10	0.08	0.08	0.08	0.03	0.06	0.07	0.09	0.06	0.07	0.09	0.07	0.11	0.13	0.11	0.25	0.13	0.04	0.02	0.12
38	0.06	0.10	0.14	0.20	0.22	0.19	0.18	0.17	0.03	0.05	0.08	0.09	0.08	0.08	0.09	0.03	0.05	0.04	0.09	0.07	0.09	0.15	0.13	0.05	0.10	0.07	0.01	0.00
40	0.07	0.06	0.12	0.12	0.18	0.17	0.22	0.21	0.06	0.11	0.10	0.13	0.19	0.09	0.04	0.09	0.07	0.20	0.12	0.11	0.06	0.10	0.13	0.17	0.10	0.05	0.03	0.17
42	0.10	0.04	0.15	0.10	0.13	0.12	0.18	0.09	0.03	0.06	0.09	0.06	0.04	0.06	0.05	0.09	0.05	0.04	0.14	0.16	0.13	0.12	0.15	0.17	0.12	0.08	0.09	0.20
44	0.05	0.05	0.07	0.06	0.10	0.09	0.15	0.13	0.04	0.06	0.04	0.10	0.11	0.11	0.06	0.14	0.10	0.11	0.13	0.09	0.07	0.10	0.10	0.06	0.07	0.10	0.08	0.06
46	0.10	0.04	0.06	0.03	0.07	0.08	0.10	0.08	0.06	0.08	0.10	0.08	0.03	0.05	0.10	0.11	0.12	0.04	0.11	0.07	0.11	0.06	0.04	0.14	0.09	0.06	0.11	0.12
48	0.02	0.04	0.07	0.03	0.04	0.04	0.05	0.11	0.04	0.08	0.06	0.06	0.17	0.06	0.06	0.05	0.15	0.05	0.03	0.05	0.07	0.03	0.06	0.02	0.01	0.07	0.13	0.08
50	0.04	0.03	0.02	0.02	0.03	0.03	0.02	0.06	0.02	0.06	0.02	0.02	0.06	0.03	0.07	0.04	0.08	0.01	0.04	0.03	0.01	0.05	0.05	0.02	0.04	0.09	0.15	0.00
52	0.01	0.02	0.04	0.01	0.02	0.02	0.02	0.05	0.03	0.06	0.02	0.03	0.07	0.06	0.04	0.08	0.02	0.05	0.04	0.03	0.04	0.03	0.02	0.02	0.03	0.10	0.09	0.06
54	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.04	0.02	0.03	0.03	0.03	0.03	0.05	0.05	0.07	0.07	0.03	0.01	0.01	0.02	0.04	0.02	0.01	0.00	0.09	0.12	0.04
56	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.04	0.06	0.02	0.02	0.03	0.02	0.01	0.08	0.07	0.08	0.03	0.03	0.02	0.01	0.00	0.01	0.01	0.01	0.04	0.01
58	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.02	0.04	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.01	0.05	0.00	0.01	0.02	0.00	0.00	0.04	0.03	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.01	0.03	0.03	0.02	0.00	0.01	0.01	0.01	0.00	0.01
62	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.00	0.05	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
66+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.03

Table 3 continued. Catch length composition by state and fishery sector.

Oregon

	by Commercial					by Recreational																			
cm	1998	1999	2000	2001	2002	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
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
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
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
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
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
16	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
18	0	0	0	0	0	8	1	1	0	0	6	0	0	0	0	1	2	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0
22	0	0	0	0	0	0	1	1	2	0	4	0	3	2	0	3	1	0	1	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	6	2	0	0	0	0	0
26	0	0	0	0	0	20	3	0	1	0	1	0	0	2	0	1	3	0	0	2	0	0	0	0	0
28	0	0	0	0	0	12	1	1	3	0	0	0	0	1	0	4	2	0	0	0	0	0	0	0	0
30	0	0	0	0	0	8	2	0	3	0	1	1	2	1	0	2	1	0	1	1	1	0	1	2	0
32	0	0	0	0	0	8	2	17	6	0	2	0	0	3	3	3	1	0	1	0	1	1	0	0	1
34	0	0	1	0	0	4	7	0	4	7	2	3	0	6	1	9	6	0	0	5	5	2	3	3	1
36	0	0	5	5	5	8	2	0	0	1	2	0	5	7	2	5	5	13	0	3	4	5	1	2	2
38	0	10	7	7	9	8	1	17	0	7	10	5	4	5	4	3	3	5	9	3	4	4	2	12	6
40	2	8	9	9	13	0	0	1	4	9	3	3	0	1	10	4	2	6	4	5	7	2	4	11	12
42	12	3	8	8	14	0	1	3	9	10	3	4	7	7	3	4	3	5	9	6	7	8	10	5	6
44	14	15	10	8	12	5	13	1	4	7	9	0	2	9	16	10	9	9	10	4	9	9	8	12	5
46	9	8	11	11	11	0	0	3	0	10	9	5	12	14	9	5	6	8	9	6	11	5	7	9	8
48	11	13	10	9	9	0	4	0	21	7	6	19	4	12	5	4	11	17	0	10	8	11	11	13	16
50	9	15	10	9	7	0	8	2	11	8	12	24	27	5	16	6	4	0	6	16	6	12	8	4	8
52	16	18	7	7	7	5	2	2	6	10	7	14	8	1	7	8	10	10	13	5	14	8	12	5	7
54	5	8	8	7	4	0	11	17	0	6	7	7	10	15	18	4	11	4	12	12	9	8	8	4	7
56	5	3	6	6	4	5	19	17	18	4	8	8	5	5	1	5	7	4	7	11	7	5	14	7	7
58	9	0	3	4	2	5	0	1	0	6	3	4	2	1	0	1	4	2	3	3	3	5	2	8	5
60	4	0	2	3	2	5	13	0	6	6	2	1	5	2	4	1	5	3	6	3	3	3	3	3	3
62	0	3	2	2	1	0	8	0	0	2	0	1	2	0	0	2	1	2	0	1	1	5	2	1	3
64	2	0	1	1	1	0	2	0	3	0	0	0	0	1	0	2	1	7	0	1	1	4	4	1	1
66	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	1	1	0	1
68	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	1	1	0	1
70	2	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
72	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
74	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
76+	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0

Table 3 continued. Catch length composition by state and fishery sector.

Washington

By Recreational

cm	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
6	0	0	0	0	0	0	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
10	0	0	0	0	0	0	0	0	0	0	0	0	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
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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
18	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	8	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	7	9	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	5	0	0	20	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
32	5	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0
34	5	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	2	0	4	0	0	0	0	0	0	0	4	0	0	0	14
38	5	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	4	12	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	5	0	0	0	6	6	0	5	0	14	0	0	0	0	17	4	0	14	0	14
44	7	24	8	0	6	6	0	5	0	0	0	0	0	14	17	25	0	0	0	0
46	4	24	10	20	6	3	0	8	9	0	0	0	0	0	0	4	10	7	33	0
48	2	12	0	0	19	3	0	0	0	0	0	0	0	0	0	11	10	0	0	0
50	5	3	28	0	0	6	0	12	9	0	0	0	0	0	0	0	0	14	17	0
52	2	0	13	40	0	6	0	0	0	0	0	0	0	29	17	0	20	0	0	0
54	1	0	5	0	25	12	0	14	16	14	0	0	0	0	0	12	10	0	0	0
56	6	0	10	0	0	3	0	5	3	0	0	0	0	0	0	10	10	14	17	0
58	3	12	0	0	12	0	0	9	3	0	0	0	0	14	0	10	10	0	0	14
60	4	0	2	0	0	0	0	8	13	14	0	0	0	14	17	6	10	21	17	29
62	9	0	2	0	6	6	0	5	10	14	0	0	0	0	0	10	10	0	17	14
64	6	0	8	20	6	6	0	23	0	14	0	0	0	0	17	0	0	7	0	0
66	0	0	0	0	6	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	6	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0
70	0	0	5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	7	0	0
72	0	0	0	0	0	3	0	0	0	14	0	0	0	14	0	0	0	7	0	0
74	0	0	0	0	0	3	0	0	0	0	0	0	0	14	17	0	0	0	0	14
76+	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4. Biological (length) sample size information

state	California		California		Oregon		Oregon		Washington	
sector	Commercial		Recreational		Commercial		Recreational		Recreational	
type	lengths		lengths		lengths		lengths		lengths	
	# samples	# trips	# samples	# trips	# samples	# trips	# samples	# trips	# samples	# trips
1980			483	468			104	101	119	117
1981			231	221			90	89	50	50
1982			303	292			135	133	50	50
1983			313	276			74.5	74	51	51
1984			242	228			106	106	53	53
1985			213	206			156	156	70	68
1986			284	284			150	150	31	31
1987			168	168			171	171	60	60
1988			136	136			202	202	43	43
1989			166	166			156	156	18	18
1990										
1991										
1992										
1993	30	15	317	306			221	221		
1994	9	7	184	178			244	244		
1995	206	84	194	186			100	100		
1996	1696	241	327	323			99	99	28	28
1997	904	131	162	159			375	375	14	14
1998	1345	148	235	226	5	57	217	217	43	43
1999	1479	191	208	207	6	40	220	220	42	42
2000	2500	340	122	121	116	866	185	185	24	24
2001	1080	163	197	197	132	1228	126	126	20	20
2002	251	35	122	124	172	1295	162	161	23	23

Table 5. Summary statistics for the data sources on which the indices are based.

Data source	Years	# obs	# positive
CA CPFV Observer CPUE	1988-98	4546	236
CA CPFV Logbook CPUE	1960-2001 except 1979	42577	16558
CA RecFIN CPUE	1980-2001 Except 1990-93	29849	2488
Oregon recreational CPUE	1979-87 &99-02	636	508
Washington Rec CPUE	1990-2001	44505	5712
AFSC larval survey	1980-1985 &1987	1170	174
CalCOFI Survey	1978-2002	2380	344
CA Power-Plant Impingement	1972-2002	6834	962

Table 6. AIC weights for the different models that were considered when developing the potential indices of abundance

model	% ZERO AIC	positive CPUE AIC	% ZERO AIC weights	positive CPUE AIC weights
CPFV OBSERVER				
year	1516.76	653.86	0.00	0.01
year port	1453.96	650.55	0.00	0.04
year port depth	1410.55	649.95	0.00	0.06
yr depth	1298.19	647.30	0.00	0.23
yr depth port	1271.96	645.16	1.00	0.66
CPFV LOGBOOK				
year	55835.82	64219.04	0.00	0.00
year season	55083.92	64000.57	0.00	0.00
year latitude	55641.67	61823.62	0.00	0.00
year depth	55290.08	64204.31	0.00	0.00
yr lat season	54767.92	61443.22	0.00	0.00
yr dep season	54572.67	63987.44	0.00	0.00
yr dep season latitude	53764.34	61204.37	1.00	1.00
RECFIN SHORE & PRIVATE BOAT				
year	17108.83	6745.07	0.00	0.00
year mode	17079.84	6680.41	0.65	0.06
year season	17107.71	6731.52	0.00	0.00
year mode season	17081.05	6674.85	0.35	0.94
CALCOFI LARVAL				
year 2	1929.86	1078.24	0.00	0.00
year day/night	1838.51	1069.41	0.00	0.00
year month	1905.78	1077.10	0.00	0.00
year longitude	1931.07	1080.08	0.00	0.00
year latitude	1868.80	1071.46	0.00	0.00
year day/night lat	1769.81	1057.76	1.00	1.00
CALIFORNIA POWER_PLANT				
year	5494.07	2904.42	0.00	0.00
year month	5607.46	3016.11	0.00	0.00
year season	4993.35	2682.41	0.00	0.00
year station	5380.96	2841.29	0.00	0.00
year season station	4881.64	2620.23	1.00	1.00
OREGON OCEAN BOAT SAMPLING (Recreational)				
year	652.38	1259.27	0.00	0.00
year port	619.23	1204.73	0.53	0.71
year season	653.60	1261.23	0.00	0.00
all	619.46	1206.57	0.47	0.29

AFSC OREGON WASHINGTON LARVAL				
year	984.87	452.49	0.00	0.00
year time	939.27	442.82	0.00	0.11
year season	984.42	451.99	0.00	0.00
year latitude	964.06	452.66	0.00	0.00
year longitude	902.53	453.25	0.00	0.00
yr long time	857.40	444.15	1.00	0.06
yr lat time	917.43	441.61	0.00	0.20
yr dist	919.26	447.70	0.00	0.01
year dist time	873.59	439.36	0.00	0.62

WASHINGTON OCEAN RECREATIONAL SAMPLING				
year	34050.96	14849.19	0.00	0.00
year port	30456.79	10269.39	0.72	0.65
year season	34038.07	14754.85	0.00	0.00
year port season	30458.66	10270.61	0.28	0.35
year vessel	33718.97	11899.46	0.00	0.00

Table 7. Estimated cabezon CPUE indices for each fishery in each area. The CV is the bootstrapped standard error CV associated with each years estimate

	CALIFORNIA					
	CPFV (Observer)		RecFIN		CPFV (logbook)	
Year	CPUE	CV	CPUE	CV	CPUE	CV
1960					4.07	0.12
1961					5.19	0.10
1962					8.17	0.10
1963					12.59	0.09
1964					14.10	0.08
1965					13.34	0.08
1966					14.19	0.08
1967					10.18	0.09
1968					5.71	0.09
1969					5.06	0.10
1970					6.64	0.09
1971					6.33	0.09
1972					10.33	0.08
1973					7.65	0.09
1974					8.17	0.08
1975					7.33	0.09
1976					6.72	0.08
1977					5.84	0.09
1978					8.91	0.09
1979						
1980			1.06	0.08	11.02	0.09
1981			0.94	0.11	5.49	0.10
1982			0.75	0.11	3.93	0.10
1983			0.95	0.10	4.41	0.10
1984			1.01	0.12	1.75	0.12
1985			0.85	0.12	2.16	0.12
1986			1.08	0.10	5.74	0.09
1987	4.92	0.69	1.06	0.13	7.71	0.09
1988	2.05	0.24	0.75	0.14	7.61	0.10
1989	1.73	0.26	1.44	0.15	10.00	0.08
1990	6.81	0.41			10.40	0.08
1991	1.76	0.40			8.06	0.09
1992	2.46	0.30			6.47	0.10
1993	1.02	0.36	0.90	0.08	3.51	0.11
1994	0.96	0.35	0.74	0.12	2.16	0.12
1995	1.25	0.29	1.05	0.13	2.88	0.11
1996	2.10	0.22	1.18	0.09	5.98	0.09
1997	1.37	0.28	0.82	0.14	5.01	0.08
1998	0.89	0.38	0.92	0.13	2.94	0.11
1999			0.74	0.12	2.76	0.10
2000			0.62	0.18	3.55	0.10
2001			0.86	0.17	5.34	0.10
2002						

Table 7 (continued)

	OREGON		WASHINGTON	
	Recreational		Recreational	
Year	CPUE	CV	CPUE	CV
1960.00				
1961.00				
1962.00				
1963.00				
1964.00				
1965.00				
1966.00				
1967.00				
1968.00				
1969.00				
1970.00				
1971.00				
1972.00				
1973.00				
1974.00				
1975.00				
1976.00				
1977.00				
1978.00				
1979.00	25.55	0.19		
1980.00	19.76	0.19		
1981.00	51.47	0.16		
1982.00	43.56	0.16		
1983.00	48.97	0.17		
1984.00	59.65	0.15		
1985.00	55.14	0.20		
1986.00	60.59	0.19		
1987.00	35.25	0.19		
1988.00				
1989.00				
1990.00			35.42	0.06
1991.00			38.04	0.06
1992.00			34.70	0.06
1993.00			32.68	0.06
1994.00			34.05	0.04
1995.00			35.17	0.05
1996.00			37.27	0.05
1997.00			42.20	0.05
1998.00			30.73	0.06
1999.00	67.44	0.13	33.79	0.07
2000.00	62.12	0.09	36.12	0.06
2001.00	56.63	0.10	52.41	0.06
2002.00	75.37	0.12		

Table 7 (continued)

Year	CalCOFI larval index (CA) CPUE	CV	AFSC larval index (north) CPUE	CV	S. CA Edison impingement index CPUE	CV
1972					13.57	0.22
1973					17.22	0.20
1974					6.52	0.18
1975					9.38	0.15
1976					7.12	0.16
1977					4.39	0.23
1978	63.18	0.70			3.31	0.21
1979					1.48	0.22
1980	100.16	0.48	23.63	0.23	1.70	0.20
1981	43.57	0.30	9.16	0.26	2.76	0.24
1982			4.25	0.41	2.30	0.26
1983			18.33	0.25	2.36	0.24
1984	39.44	0.28	12.29	0.36	2.46	0.22
1985	74.52	0.31	6.81	0.36	2.36	0.21
1986	29.46	0.34			1.58	0.24
1987	32.96	0.46	23.13	0.34	2.65	0.20
1988	31.43	0.30			1.04	0.34
1989	87.16	0.21			2.59	0.24
1990	44.32	0.50			1.73	0.26
1991	85.75	0.32			2.39	0.23
1992	16.66	0.67			1.51	0.24
1993	16.82	0.50			0.56	0.34
1994	16.66	0.58			0.80	0.36
1995	30.34	0.38			0.84	0.44
1996	33.24	0.35			0.76	0.43
1997	46.69	0.37			1.32	0.39
1998	3.16	0.29			0.77	0.41
1999	52.95	0.29			5.87	0.22
2000	40.23	0.36			4.26	0.32
2001	29.37	0.37			6.02	0.49
2002	112.91	0.34			8.27	0.29

Table 8. The parameters of the population dynamics model. The base-case values are given for those parameters that are pre-specified while the prior distributions are specified for the parameters that are estimated by fitting the model to the catch, abundance index, and catch length-composition data.

Parameter	Description	Prior distribution / Base-case value
$\ell n S_0$	Logarithm of the virgin reproductive output (both stocks)	Uniform [6, 31]
c	Proportion of S_0 in the southern area	Pre-specified; 0.81
h	Steepness of the stock-recruitment function	Pre-specified; 0.7
ε_t^p	Recruitment residuals	$N(0;\sigma_R^2)$
L_{50}	Length-at-50%-selectivity	Uniform [19cm, 70cm]
ΔL	Difference between length-at-50% and 95% selectivity	Uniform [1cm, 60cm]
x	Maximum age-class	Pre-specified; 15 yr
M	Instantaneous rate of natural mortality	Pre-specified; 0.25 yr^{-1}
f_a	Fecundity-at-age	Pre-specified; Figures 2 and 3
$w_a^{g,p}$	Weight-at-age	Pre-specified; Figure 3
$\phi_{l,a}^{g,p}$	The age-to-length transition matrix	Pre-specified; Figure 3
σ_R^2	Extent of variation in the deviations about the stock-recruitment relationship	Pre-specified; 1
$\bar{L}_a^{g,p}$	Mean length of a fish of sex *g*, age *a*, and population *p*	Pre-specified; Figure 3
σ_a^g	CV of the length of a fish of sex *g* and age *a*	Pre-specified; see text
y_1	First year considered in the analysis	1930
y_{rec}	First year for which a recruitment residual is estimated	1975
Δl	Width of each length-class	2cm
l_{min}	Midpoint of the first length-class	6cm
l_{max}	Midpoint of the last length-class	92cm
CV_{min}	CV of length-at-age for an animal of age 1	0.14
CV_{max}	CV of length-at-age for an animal of age *x*-1	0.09
m_1	Slope of the logistic maturity function	Pre-specified; -1.58
m_2	Intercept of the logistic maturity function	Pre-specified; 4.1

Table 9. Values for the likelihood components for the base-case analysis and the sensitivity tests that involve changing the data sources included in the assessment (- data source is ignored).

Trial	Base Case	1	2	3	4	5	6	7	8	9
Likelihood Components										
CPFV logbook CPUE	83.43	78.23	84.44	84.28	83.71	83.78	83.17	83.11	83.38	-
RecFIN CPUE `	17.44	19.96	17.94	14.18	19.40	17.22	18.00	-	-	-
CalCOFI larval tows	-	-	-	-	-	-	29.44	-	-	-
Impingement	58.78	56.27	59.20	56.86	59.94	-	58.71	58.14	-	-
Length Freq Comm.	64.22	59.27	68.99	-	114.38	62.88	63.94	61.61	60.37	59.78
Length Freq Rec.	182.59	-	355.67	177.15	187.14	182.35	182.74	183.37	182.64	181.92
CPFV observer CPUE	-	-	-	-	-	-	-	-	-	10.23
Penalties	7.60	8.91	7.64	5.66	9.57	8.24	7.57	7.75	8.43	8.42
TOTAL LIKELIHOOD	414.06	222.56	593.89	338.13	474.15	354.48	443.58	393.99	334.83	260.35
2003 reproductive output	313	295	376	583	272	282	324	339	309	435
%Depletion	34.7%	35.4%	39.5%	46.6%	33.4%	32.8%	35.6%	36.9%	35.4%	47.5%
(Std. Dev.)	(7.21)	(9.84)	(7.40)	(8.91)	(7.62)	(7.32)	(7.27)	(10.49)	(11.98)	(19.34)

Table 10. Results for sensitivity tests in which the (pre-specified) values for M and σ_R are varied.

σ_R^2	M	ℓnS_0	S (2003)	%Depletion (Std Dev.)	Likelihood
0.36	0.2	14.57	334	31.5% (6.10)	406.81
0.36	0.25	14.48	364	37.4% (6.98)	403.30
0.36	0.3	14.44	403	43.4% (7.97)	402.82
1	0.2	14.48	283	29.2% (6.28)	415.93
1	0.25	14.41	313	34.7% (7.21)	414.06
1	0.3	14.36	348	40.2% (8.26)	414.40
2.25	0.2	14.43	260	28.2 (6.39)	428.35
2.25	0.25	14.36	289	33.4% (7.32)	427.25
2.25	0.3	14.33	323	38.8% (8.38)	427.96

Table 11. Results for sensitivity tests in which changes are made to the first year for which a recruitment residual is estimated, the historical (pre-1980) recreational catches, the effective sample size of the recreational length frequencies, CVs assumed for length-at-age, and the form of the selectivity ogive.

	ℓnS_0	S (2003)	%Depletion (Std. Dev.)	Likelihood
Base Case	14.41	313	34.7% (7.21)	414.06
y_{rec}				
1965	14.37	295	33.9% (7.22)	414.30
1985	14.64	543	47.9% (8.16)	423.25
1995	14.64	482	42.2% (5.86)	439.96
Recreational catch series (pre-1980)				
Halved	14.33	309	37.2% (7.77)	415.21
Doubled	14.60	394	35.9%(7.58)	417.40
1980 Catch = 116mt (not 291 mt)	14.33	267	32.0% (7.22)	413.62
Effective sample size				
Halved	14.36	320	37.2% (7.49)	658.26
Doubled	14.48	338	34.8% (7.23)	288.97
Length at age CV (both sexes)				
0.05 (all ages)	14.70	603	49.6% (7.91)	411.39
0.2 (all ages)	14.12	141	20.5% (6.34)	434.93
0.2/0.05 (ages 1 and 15)	14.35	292	34.0% (7.62)	419.93
0.09/0.14 (ages 1 and 15)	14.39	276	31.1% (6.39)	410.18
Domed-shaped Commercial Selectivity	14.43	332	36.0% (7.43)	412.76

Table 12. Median harvest levels corresponding to four control rules for each of three scenarios.

Year	Point estimates (Base-case)				Posterior distribution (Base-case)				Posterior distribution (Nine analyses)			
	40-10 rule	$F_{45\%}$[a]	60-20 rule	$F_{50\%}$[b]	40-10 rule	$F_{45\%}$[c]	60-20 rule	$F_{50\%}$[c]	40-10 rule	$F_{45\%}$[c]	60-20 rule	$F_{50\%}$[c]
2004	61	85	20	71	93	97	39	81	85	96	35	80
2005	65	83	29	71	94	97	50	82	88	96	46	82
2006	73	84	40	73	97	98	63	85	91	96	58	84
2007	75	83	47	74	98	98	70	87	90	95	64	85
2008	74	82	52	74	96	96	74	87	84	92	65	84
2009	72	79	55	73	94	95	77	87	80	89	66	82
2010	71	78	59	72	92	93	80	87	76	86	66	81
2011	71	76	64	72	91	92	84	87	74	82	68	79
2012	70	75	68	72	90	90	88	87	72	80	68	77
2013	70	73	71	72	89	89	91	87	71	77	70	75
2014	69	71	74	71	88	87	93	87	71	76	72	74
2015	68	69	77	70	86	85	95	86	71	74	74	73
2016	68	68	80	70	85	84	98	87	72	74	76	72
2017	68	66	83	70	85	83	101	87	72	72	78	72
2018	68	64	85	69	84	81	104	87	72	71	80	71
2019	67	63	87	68	83	80	106	87	72	70	81	71
2020	67	61	89	67	83	78	108	87	73	70	85	72
2021	66	59	92	67	83	77	110	86	74	69	87	72
2022	67	58	94	66	82	75	112	86	74	68	90	72
2023	67	56	97	65	82	74	114	86	75	67	92	72

[a] $F_{45\%spr}$=0.239
[b] $F_{50\%spr}$=0.197
[c] Not given

Figure 1. A map of the assessment area that shows both state and INPFC boundaries.

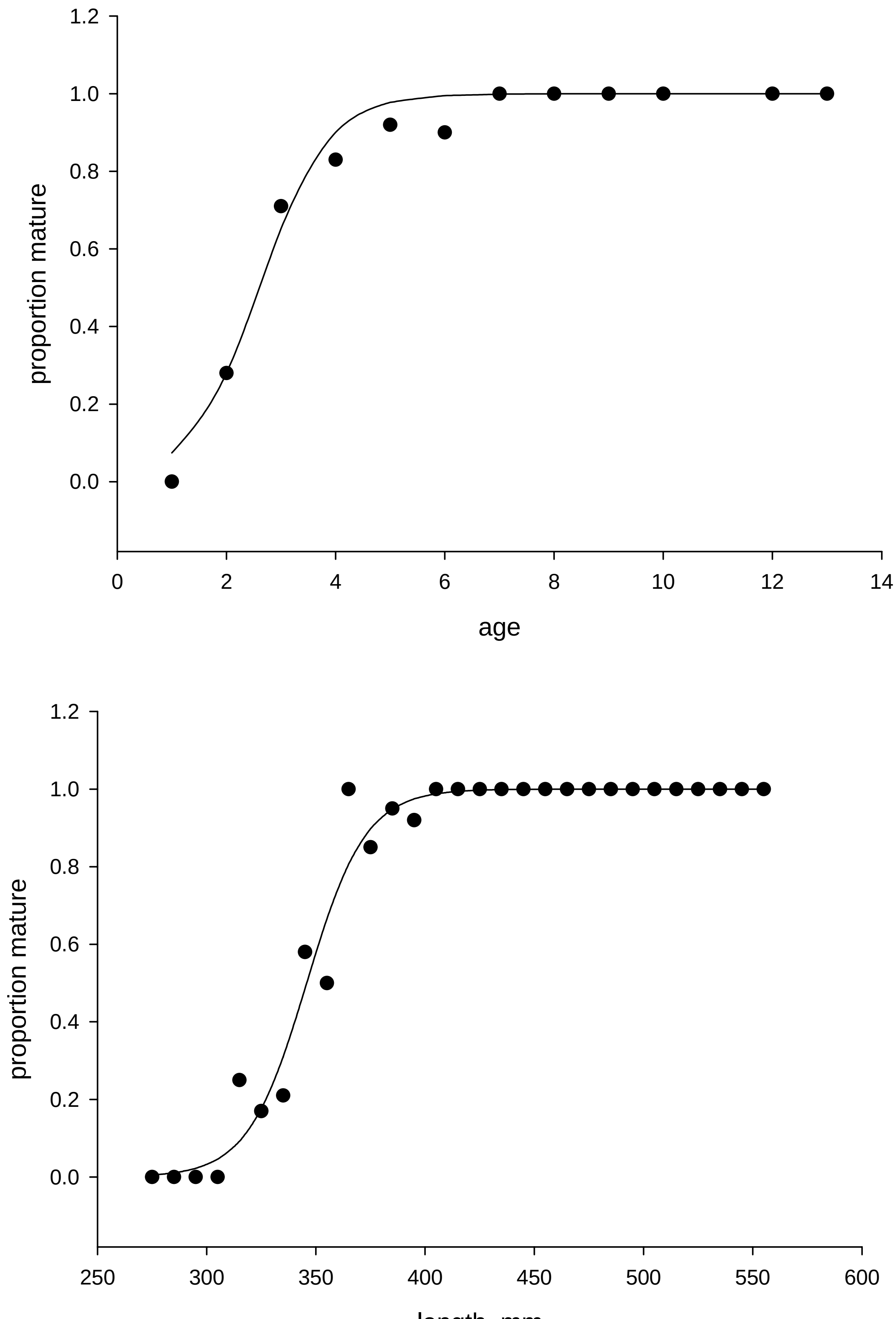


Figure 2. The maturity ogives of female cabezon by age and length.

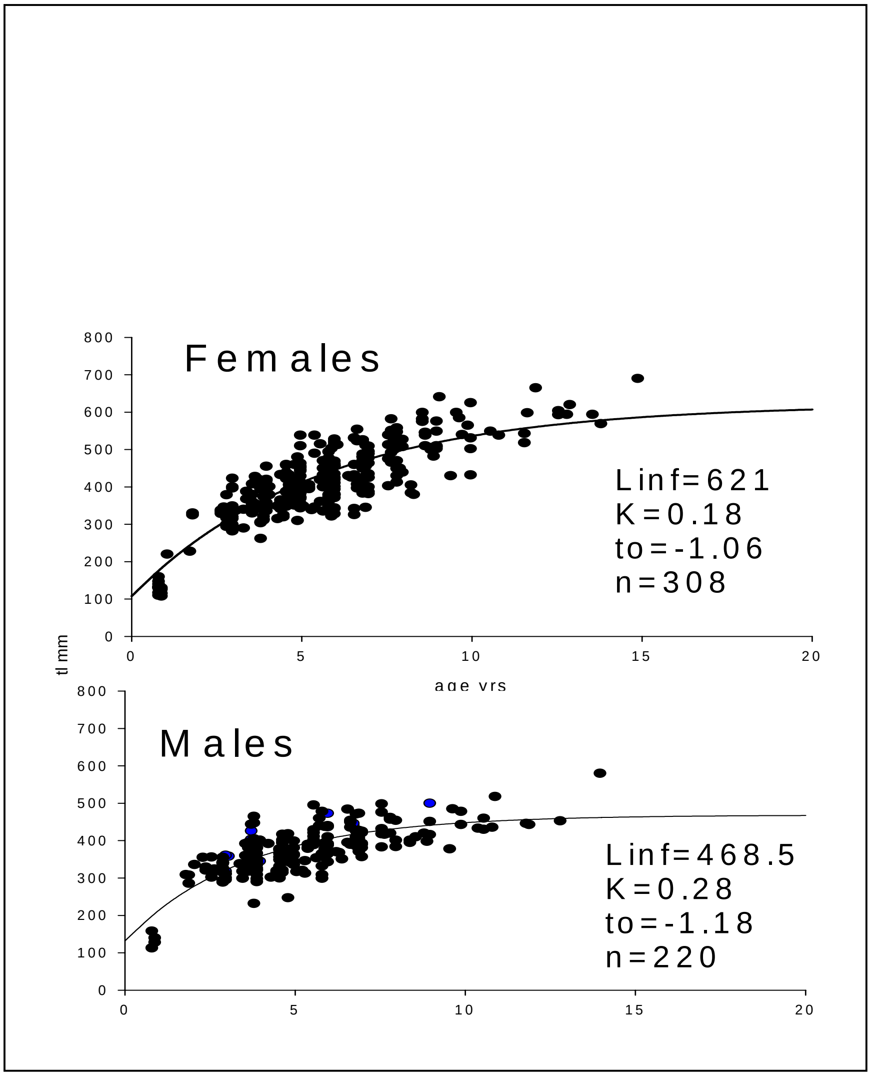


Figure 3a
Figure 3a. Von Bertalanffy growth curves for male and female cabezon from California (Grebel 2003).

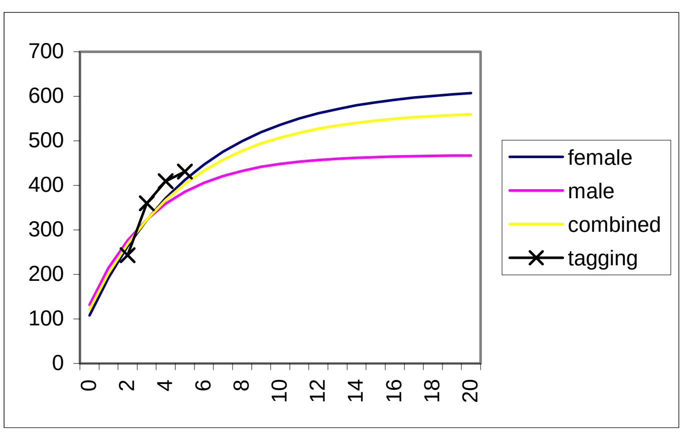


Figure 3b. Von Bertalanffy growth curves from California cabezon and that estimated from tag recapture information. Results are only shown for the tag-recapture based growth curve for lengths for which tag-recapture data are available.

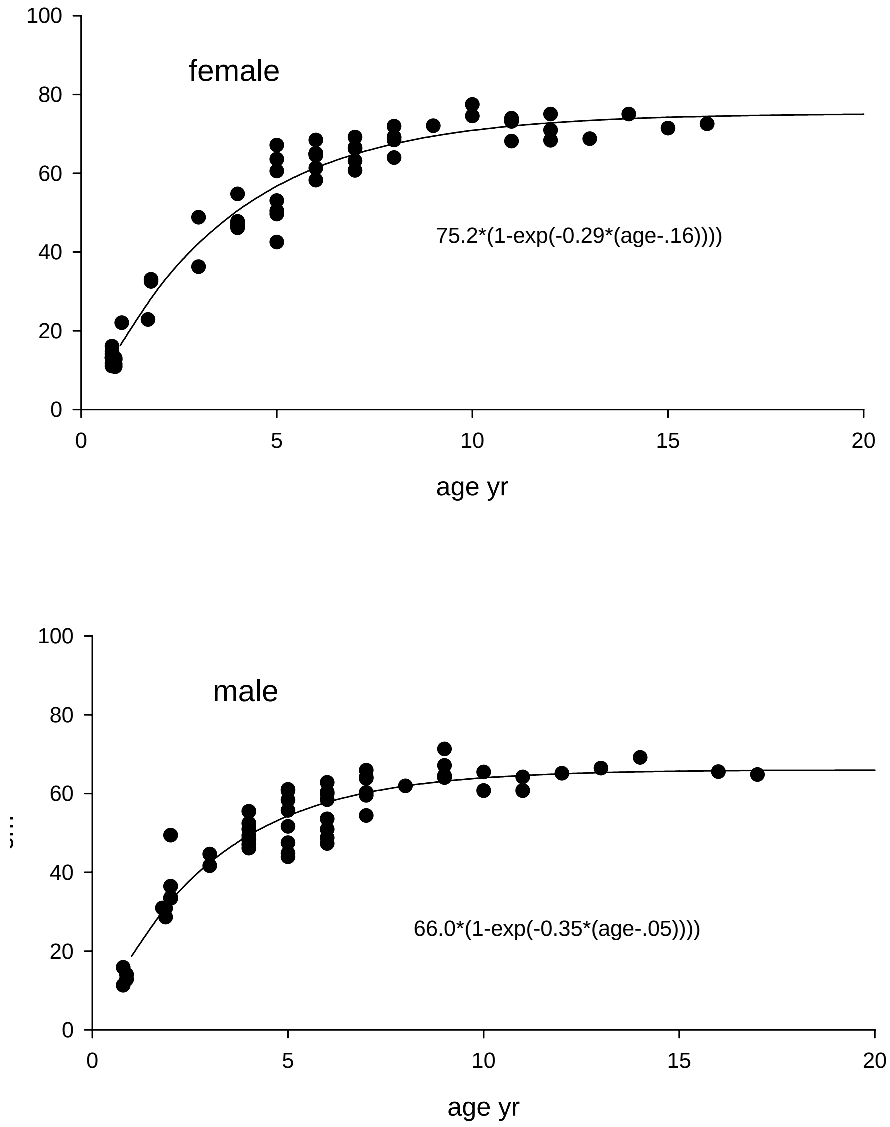
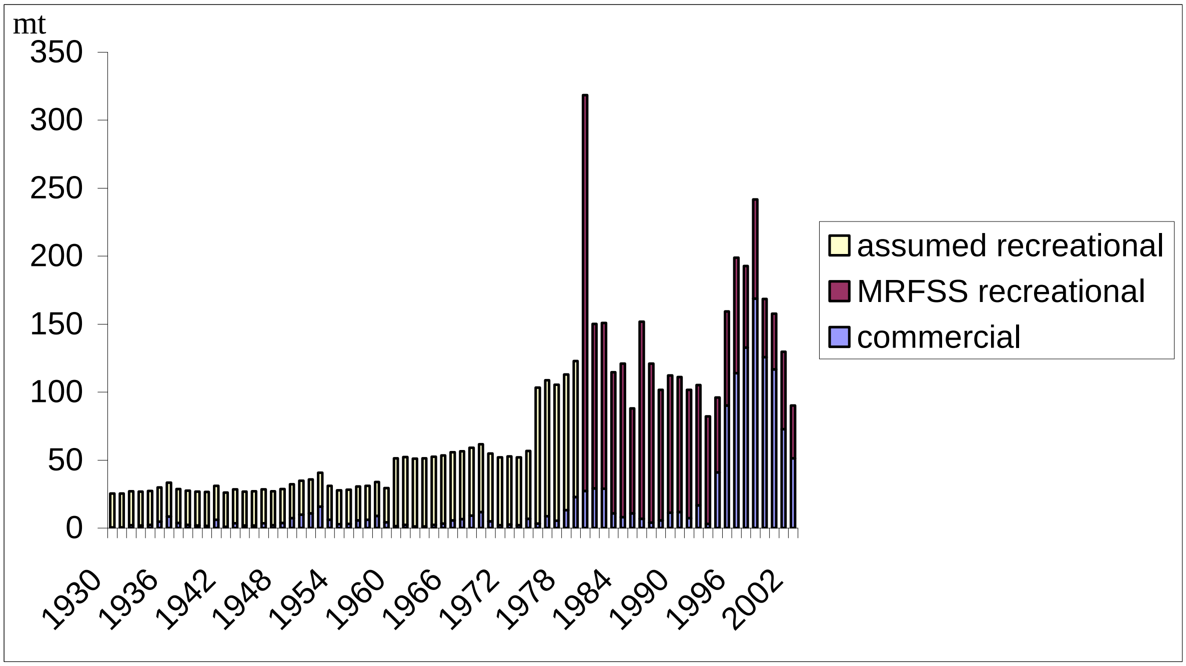


Figure 3c. Length-at-age relationships for cabezon in Puget Sound (Lauth 1987). All fish <2yrs are from California (Grebel 2003).



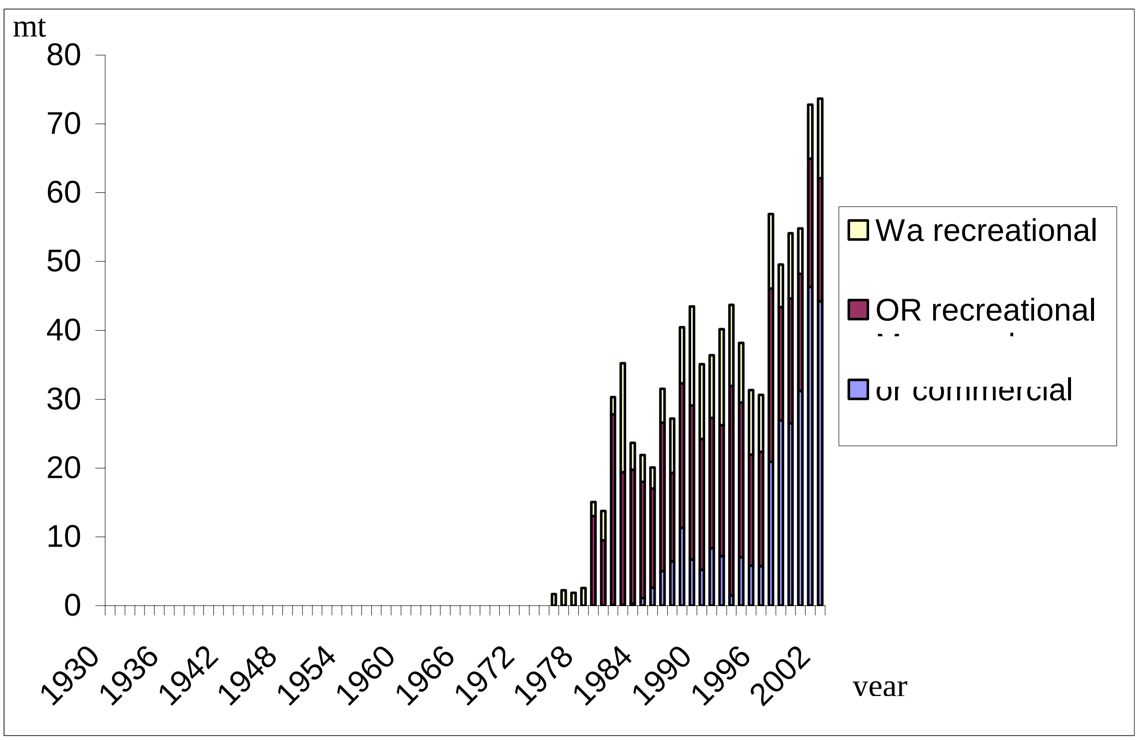


Figure 4. The cabezon removals by state and fishery sector used in the modeling. The removals for the recreational sector in California for the years prior to 1980 were inferred as outlined in the text.

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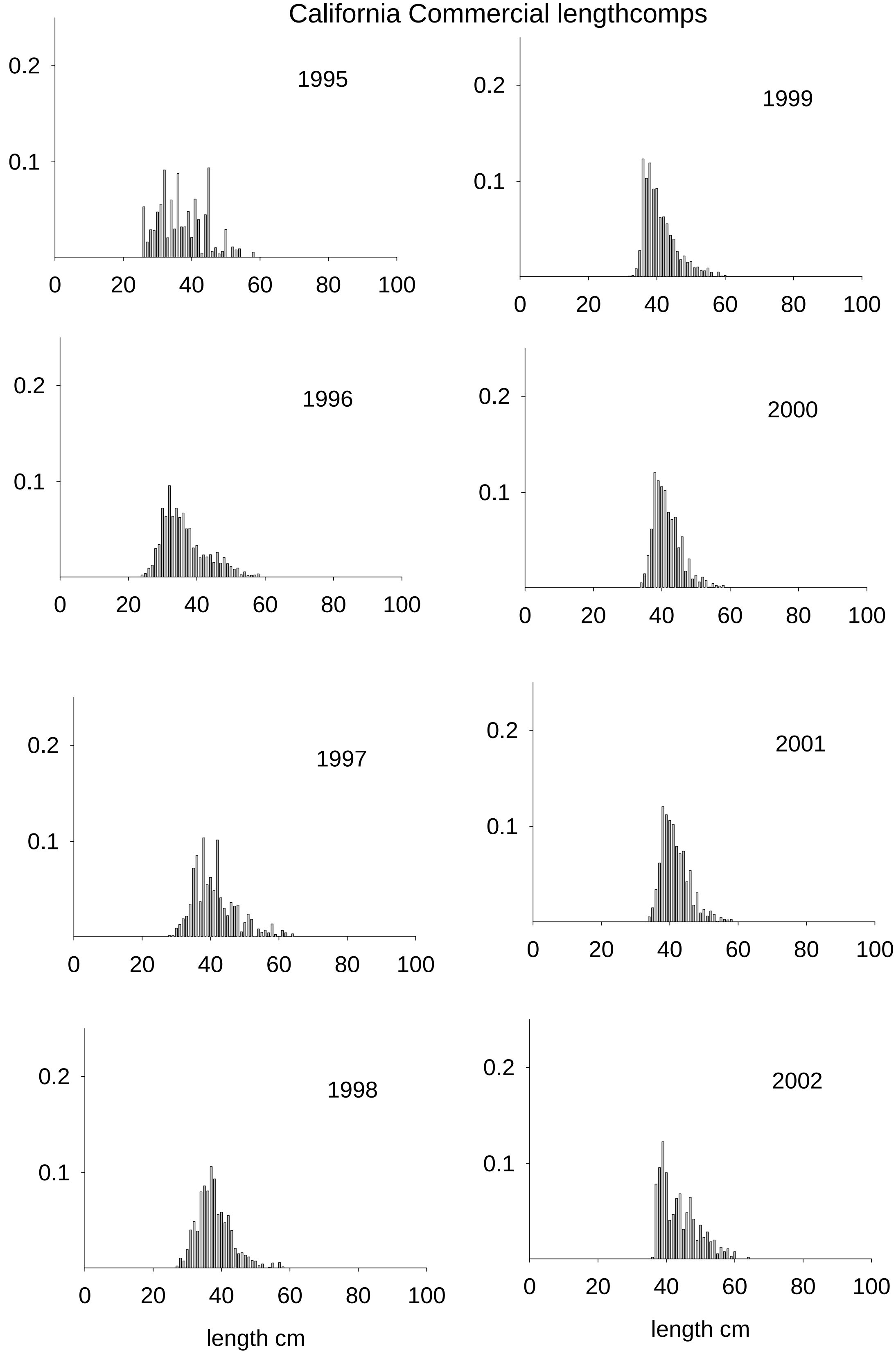
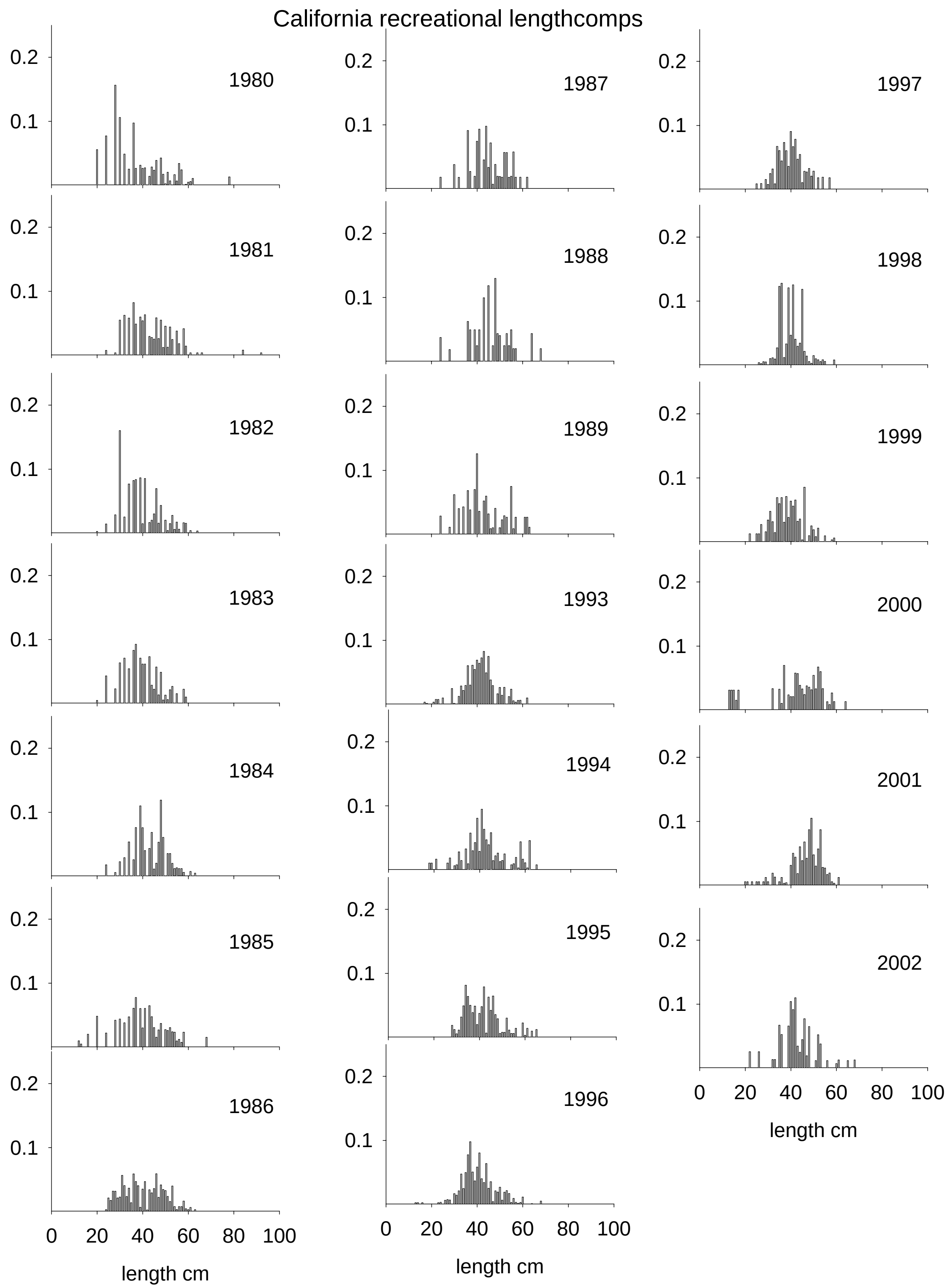
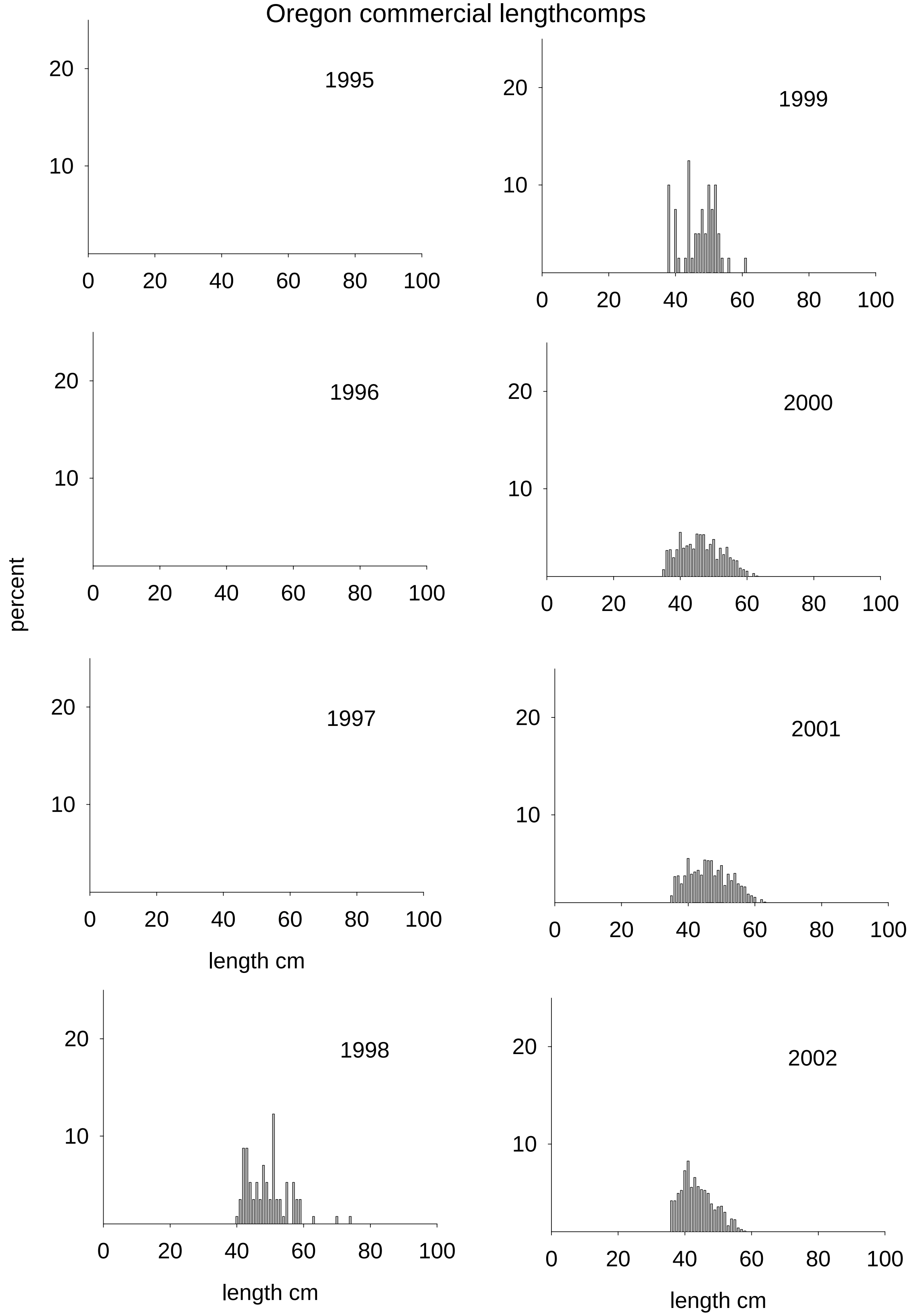
Figure 5. The following figures show the raw (i.e. un-binned) catch length frequency information by state and fishery sector. The order of information is commercial then recreational for California, Oregon and Washington.

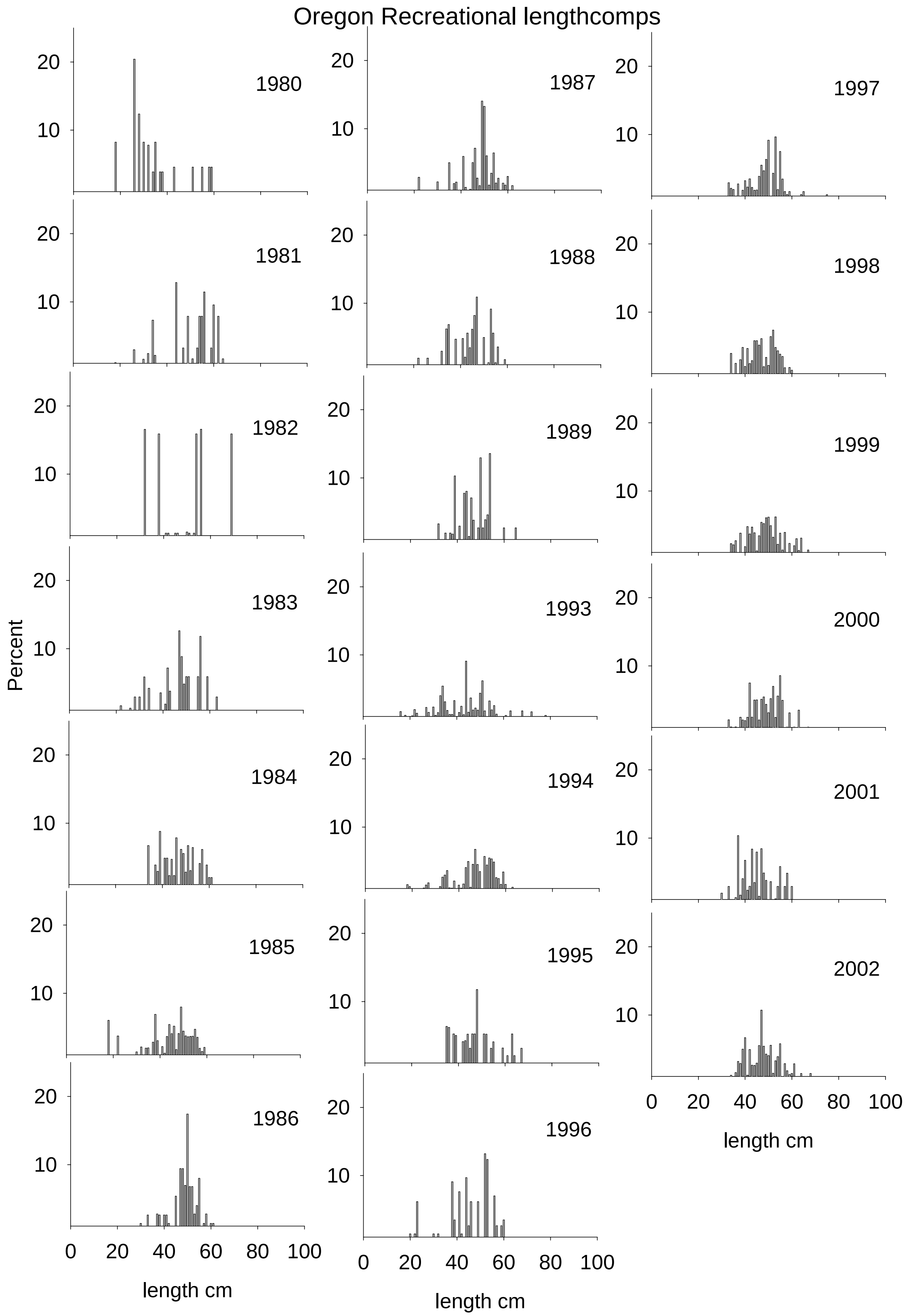
California Commercial lengthcomps




California recreational lengthcomps
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
0.2
0.1
0 20 40 60 80 100
length cm

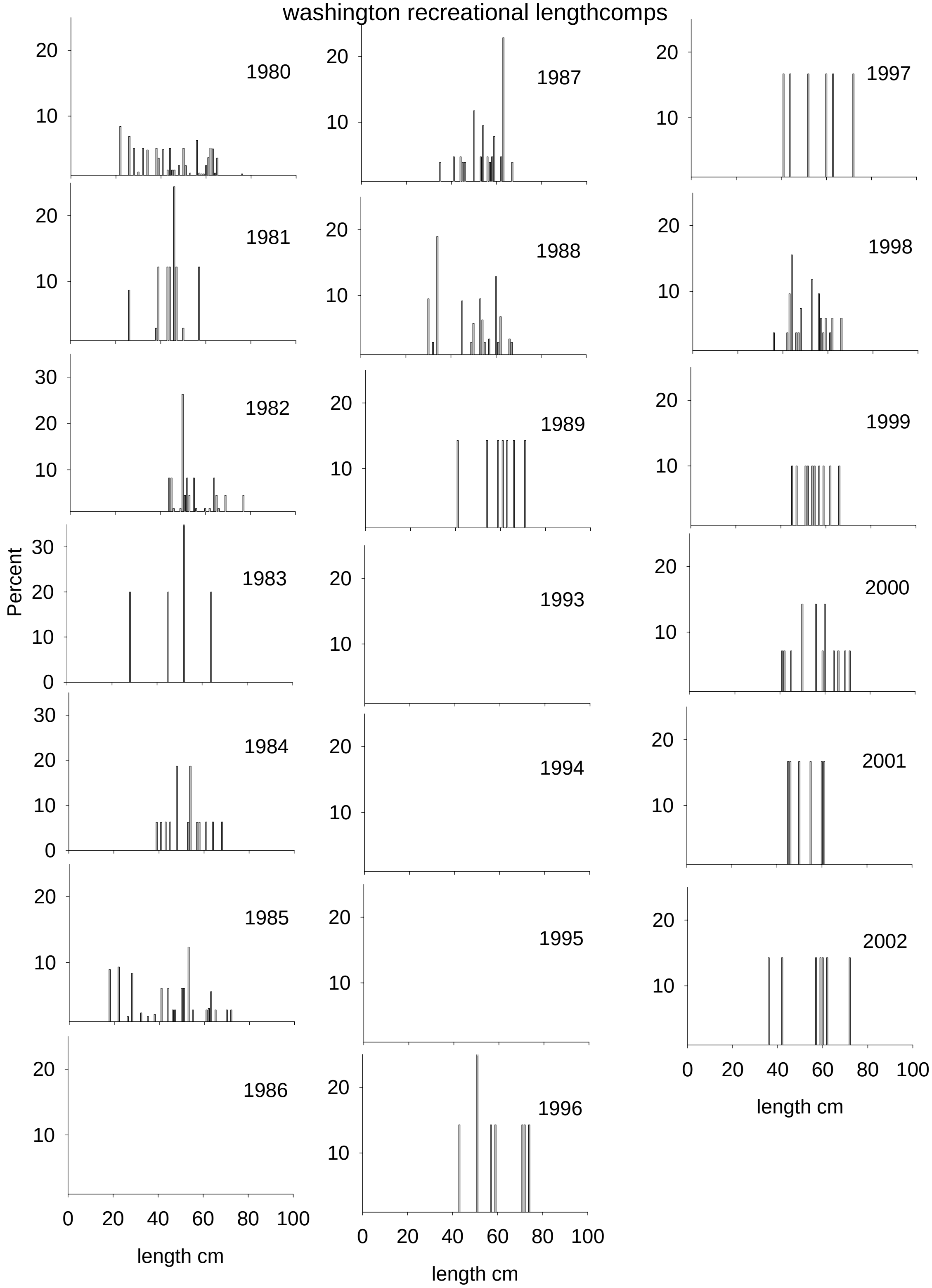
Oregon commercial lengthcomps





Oregon Recreational lengthcomps
Percent
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
20
10
0
20
40
60
80
100
length cm

washington recreational lengthcomps



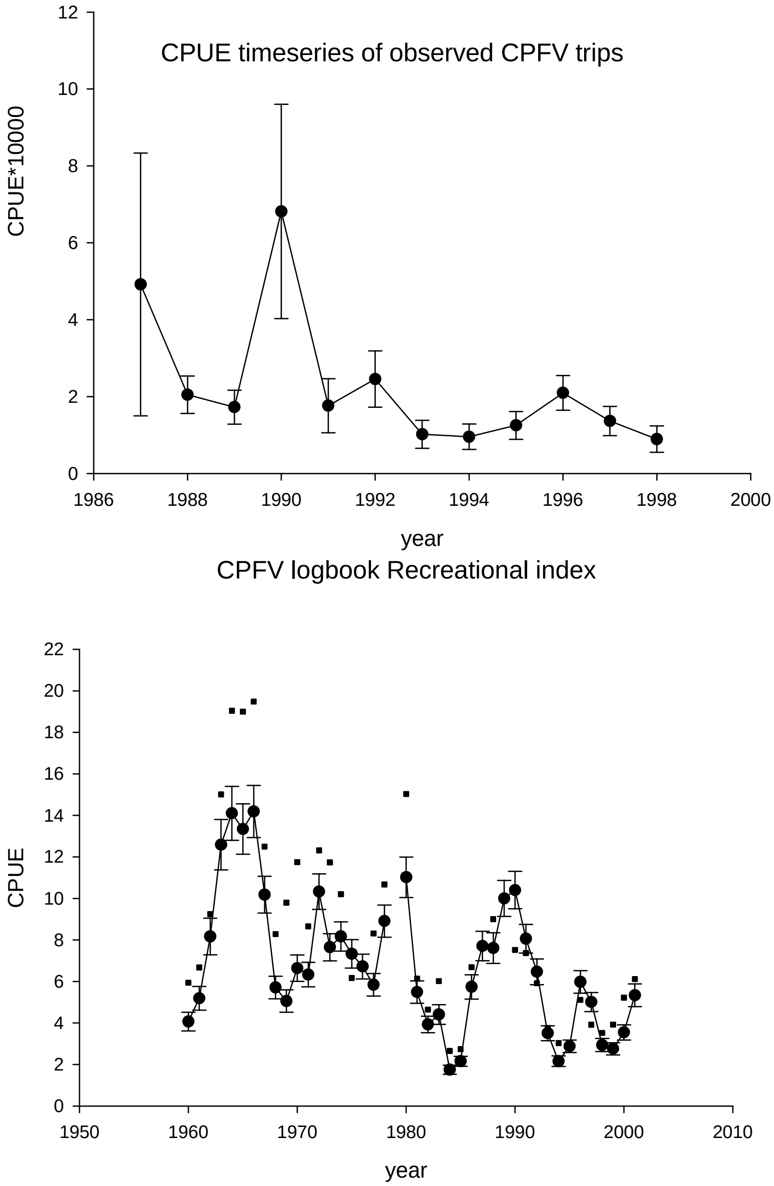


Figure 6. Recreational CPUE indices for the California CPFV fleet (CPFV Observer – upper panel; CPFV Logbook – lower panel). The GLM-based CPUE estimates are represented by connected circles; raw averages by the unconnected squares.

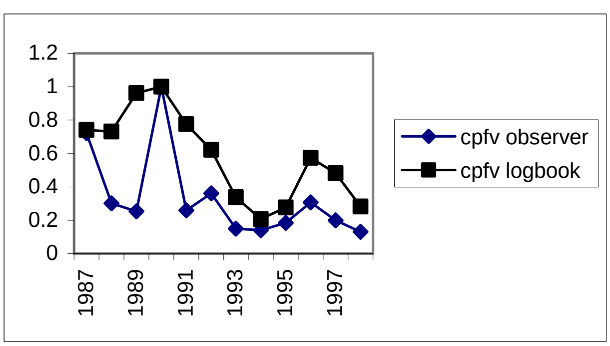
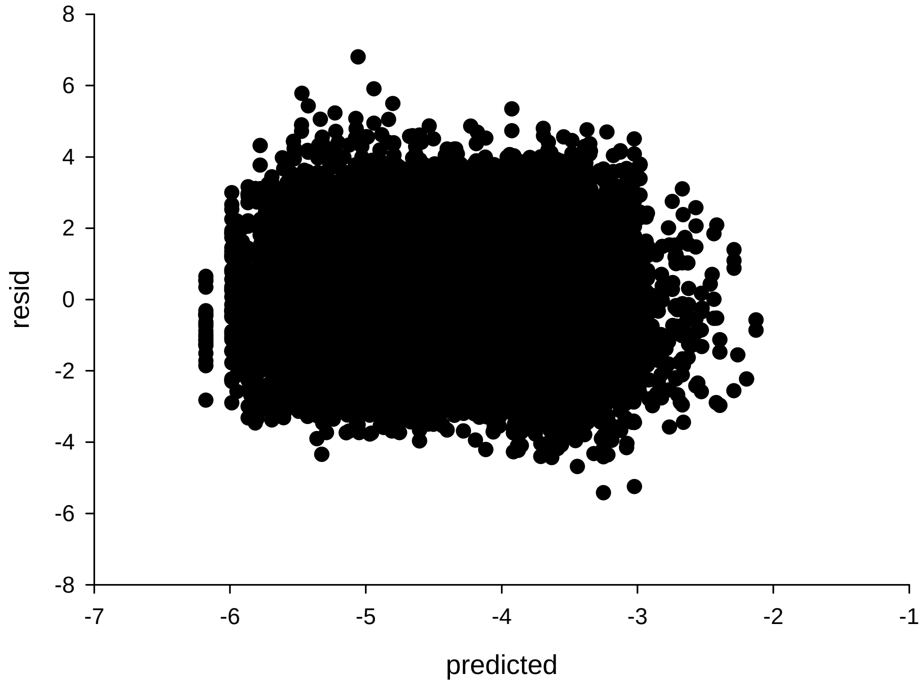


Figure 7a. Comparison of the CPFV observer and CPFV logbook indices.



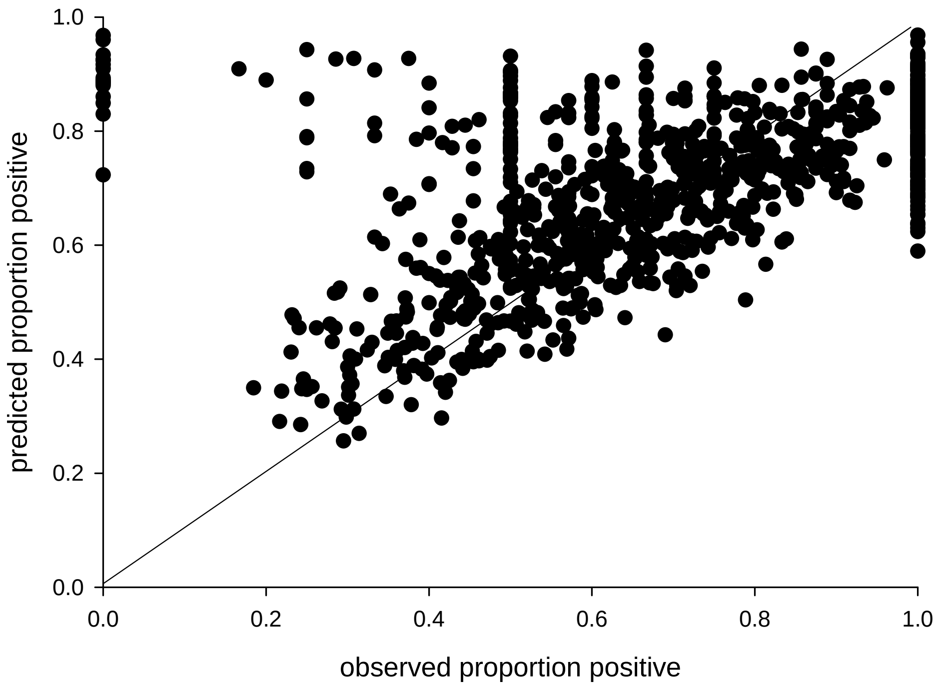


Figure 7b. Upper graph: Residuals plots of model estimates of the CPFV logbook positive tow CPUE; lower graph: observed and predicted percent of positive tows for each year-season-latitude combination.

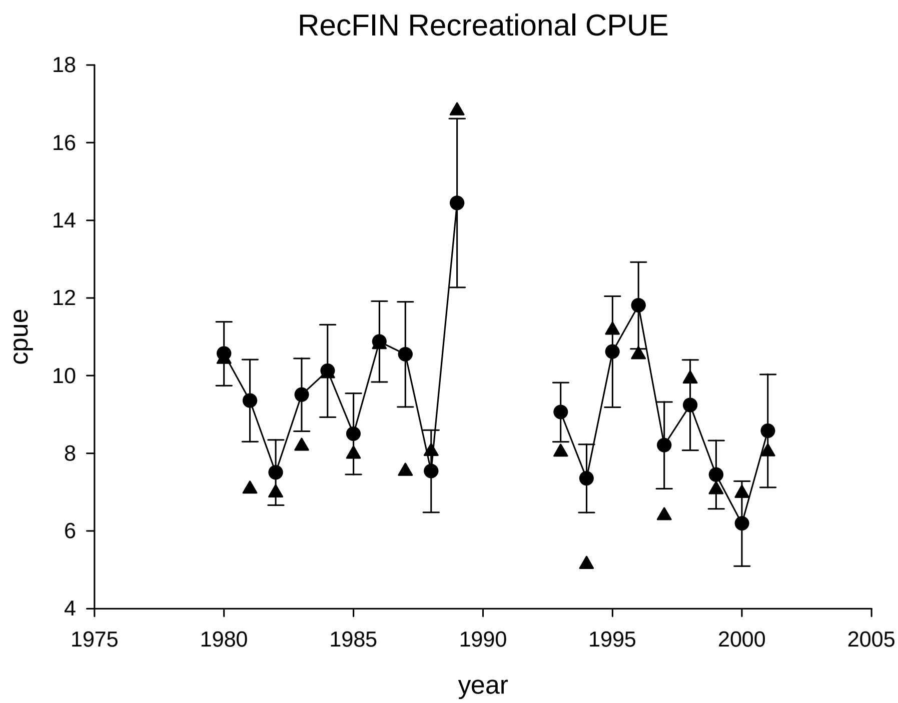


Figure 8. Recreational CPUE indices based on data for California shore and private boat anglers. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

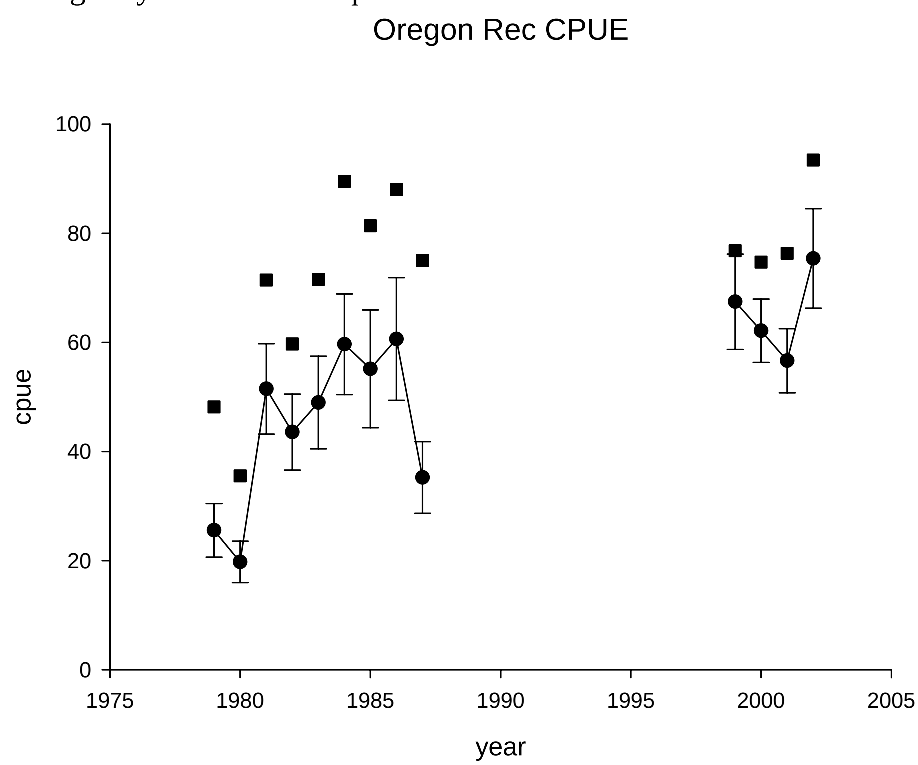


Figure 9. Recreational CPUE indices based on data from the Oregon ocean boat sampling program. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

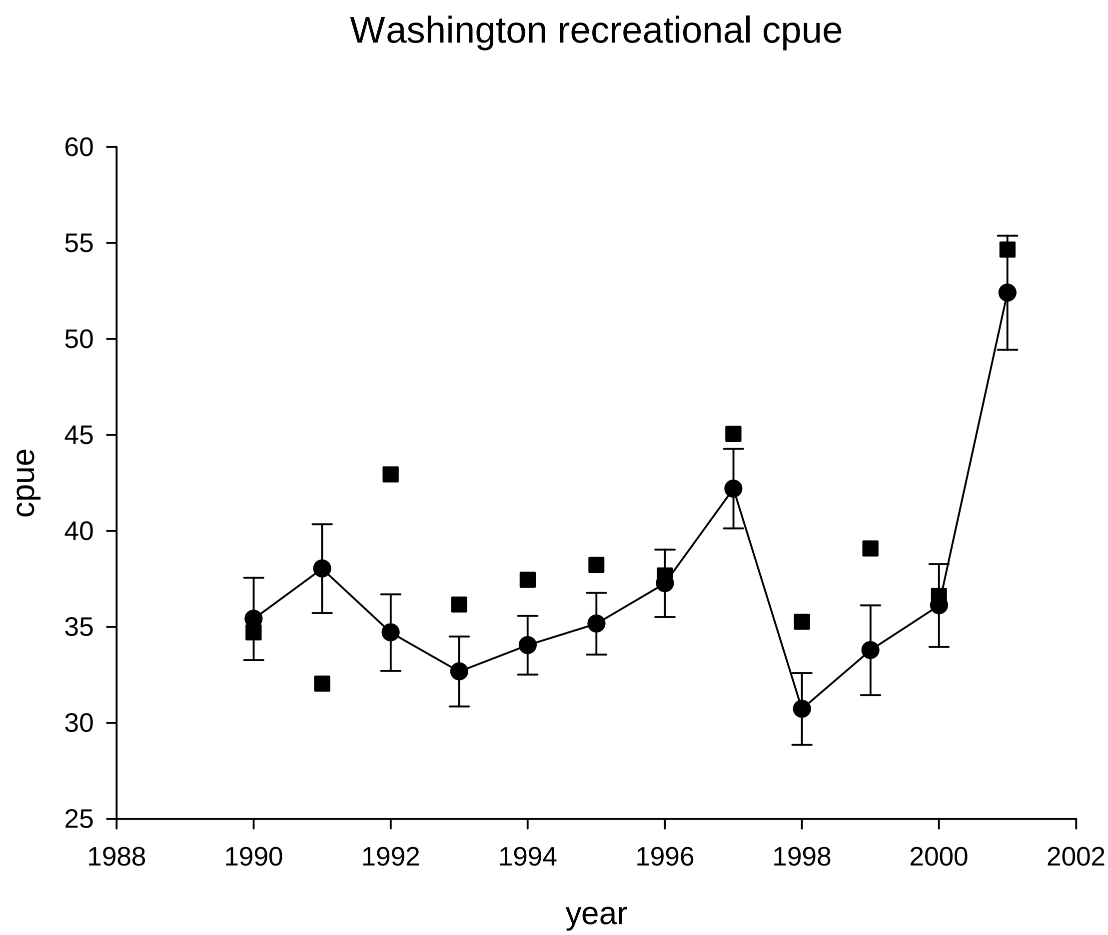


Figure 10. Recreational CPUE indices based on data for Washington state. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

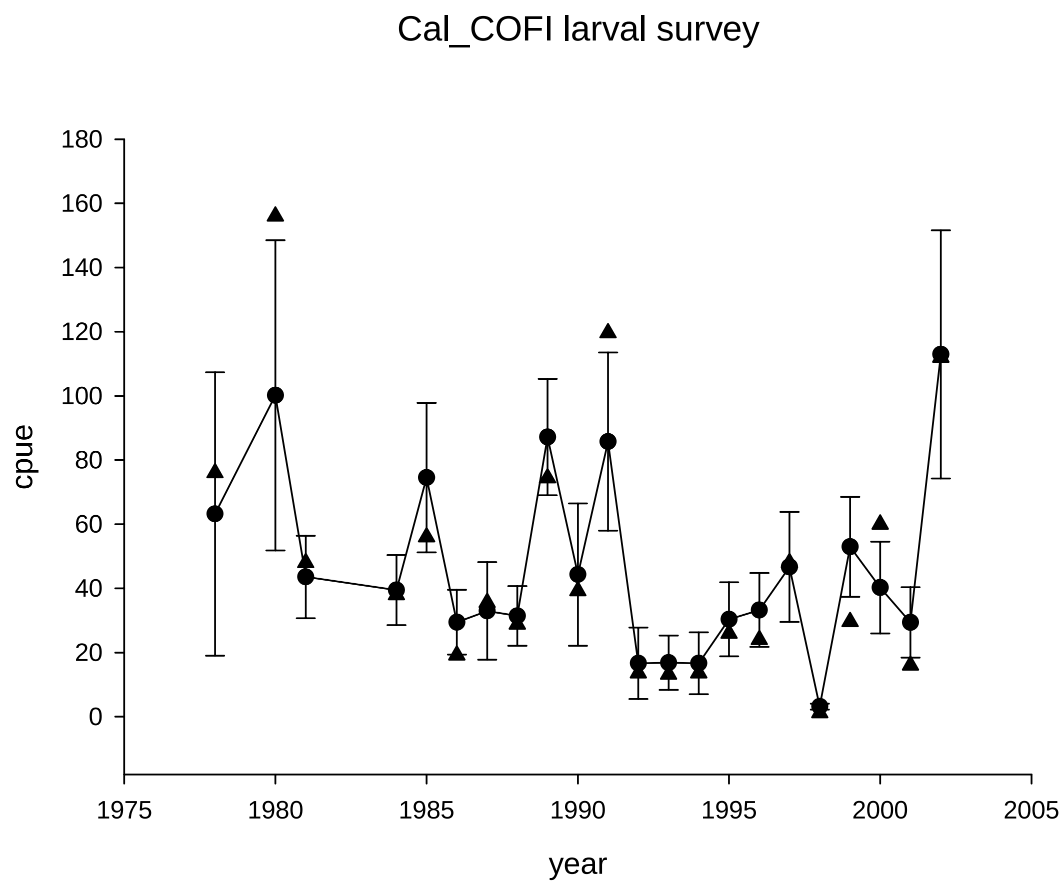


Figure 11. Index of reproductive output for southern California based on data from CalCOFI larval survey. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

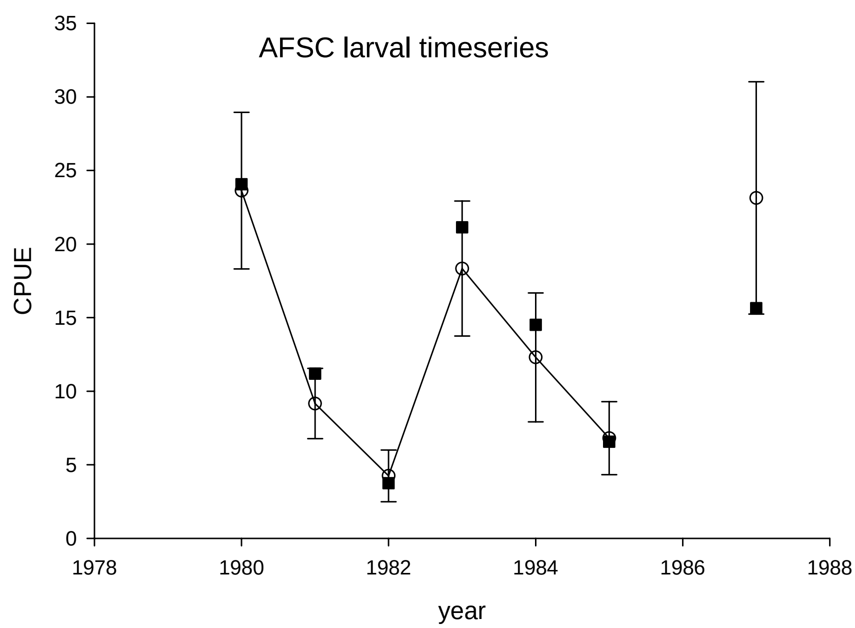


Figure 12. Index of reproductive output for Oregon and Washington based on data from the AFSC larval survey. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

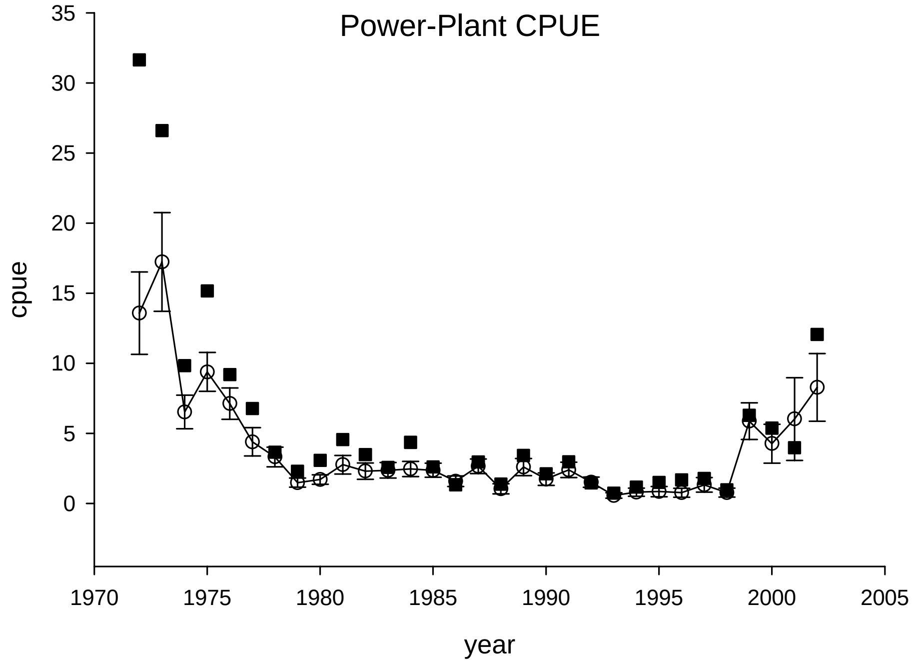


Figure 13. The timeseries of estimated CPUE from power-plant impingement data. The GLM-based CPUE estimates are represented by connected circles; raw averages by unconnected squares.

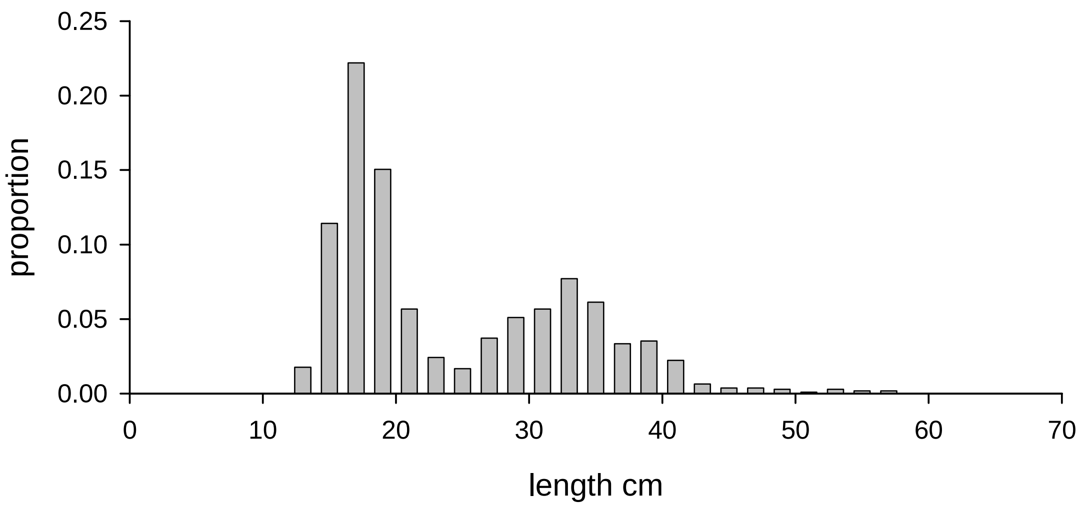


Figure 14. The raw length frequency of cabezon sampled in the power plants used to create the impingement time series depicted above.

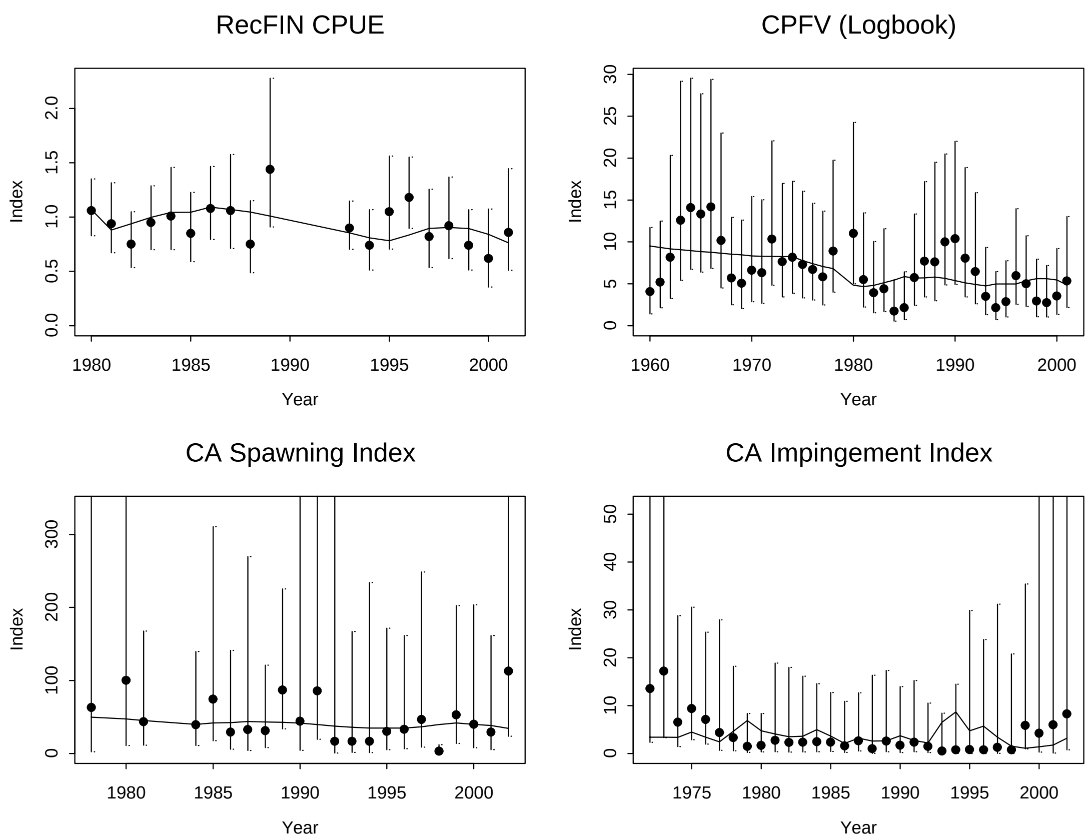


Figure 15. Observed (solid dots) and model-predicted (solid lines) abundance indices for cabezon off California.

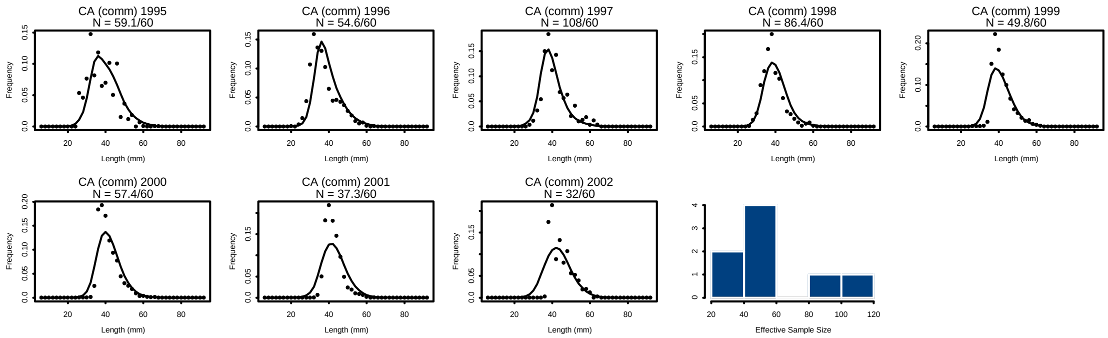


Figure 16. Observed (solid dots) and model-predicted (solid lines) commercial catch length-compositions for California. The annual effective sample sizes are shown in the form of histograms.

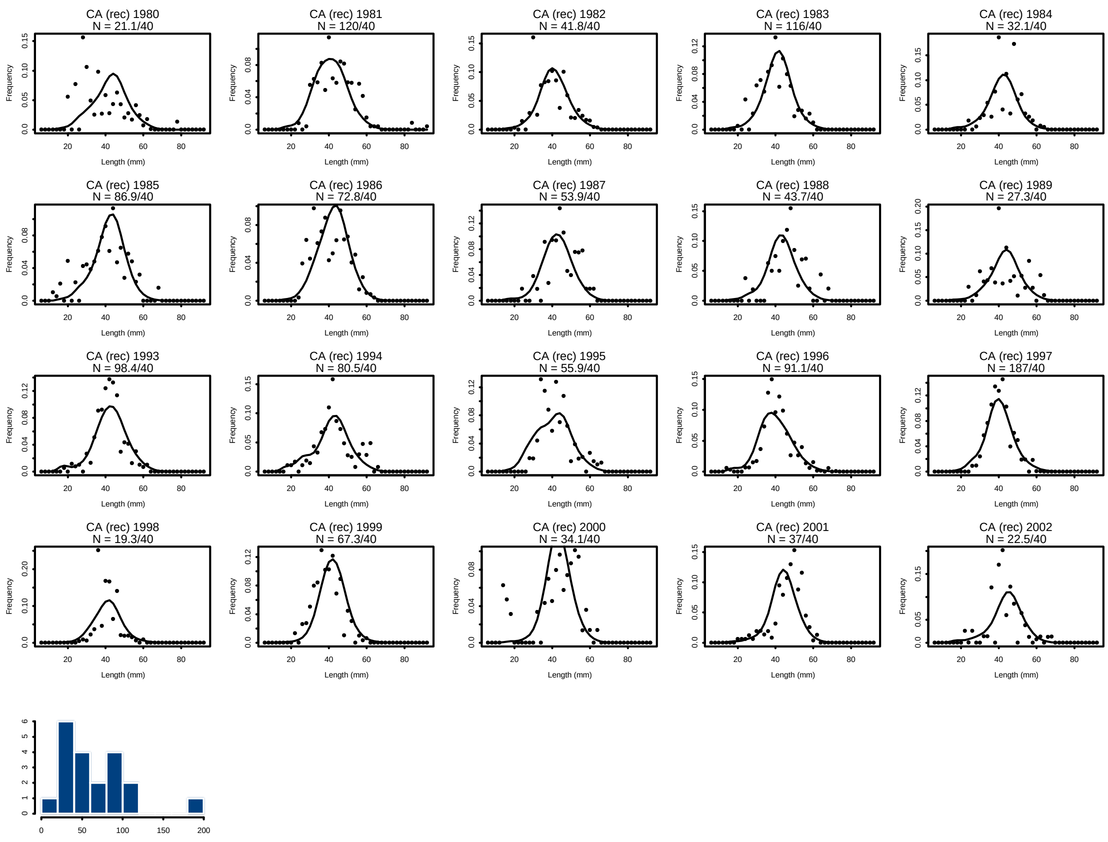


Figure 17. Observed (solid dots) and model-predicted (solid lines) recreational catch length-compositions for California. The annual effective sample sizes are shown in the form of histograms.

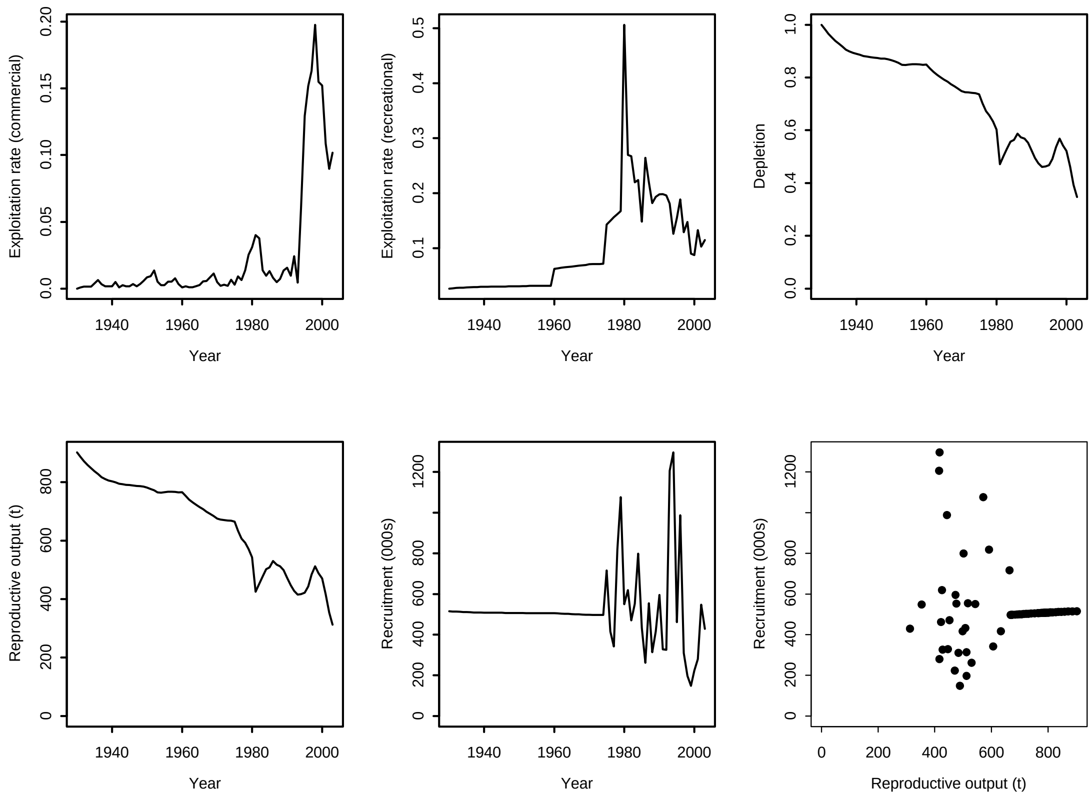


Figure 18. MPD time-trajectories of reproductive output and fishing mortality for cabezon off California.

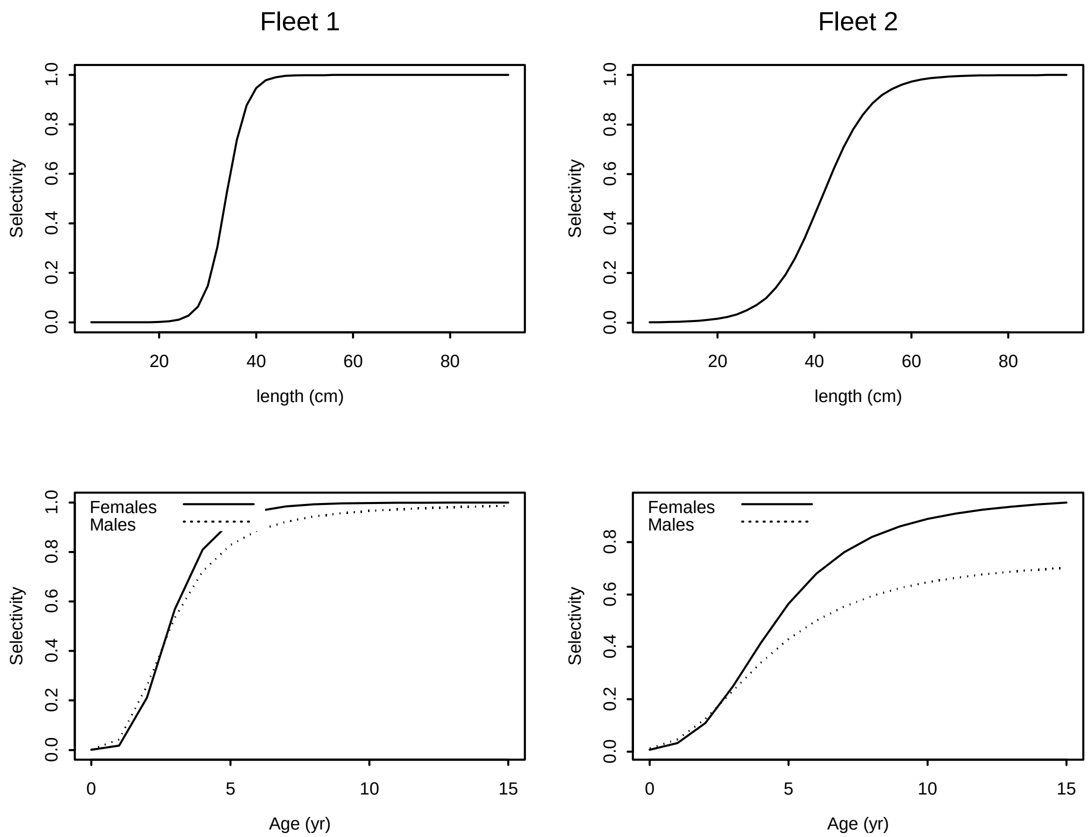


Figure 19. Cabezon length- and age-specific selectivity ogives for two fleets off California.

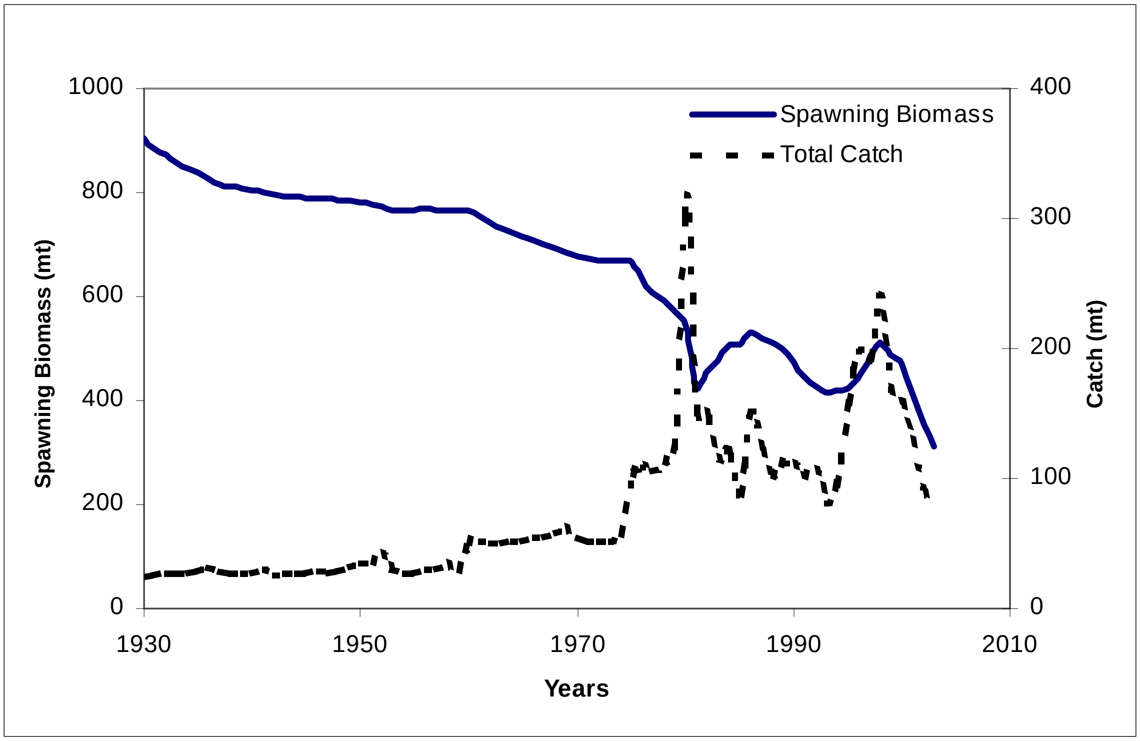


Figure 20. MPD time-trajectories of reproductive output and catch for the California population of cabezon.

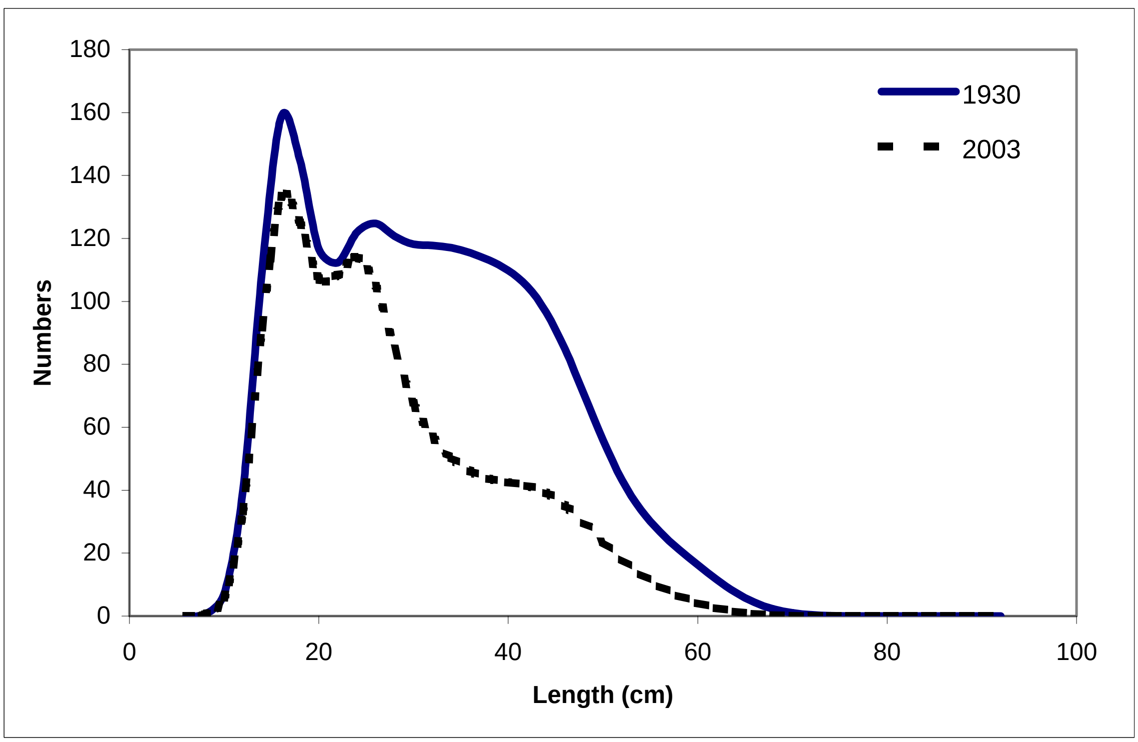
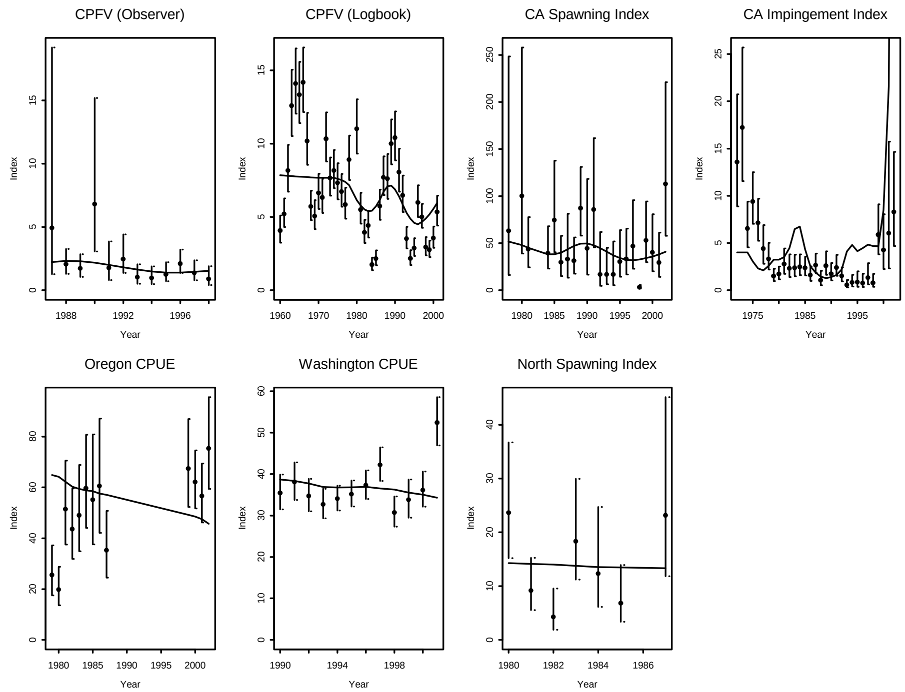


Figure 21. Numbers at length for two years for the California population of cabezon. Year 1930 represents an unexploited state whereas year 2003 represents the current exploited state.

(a) Catchability variability scaling parameters set equal to 1



(b) Catchability variability scaling parameters estimated

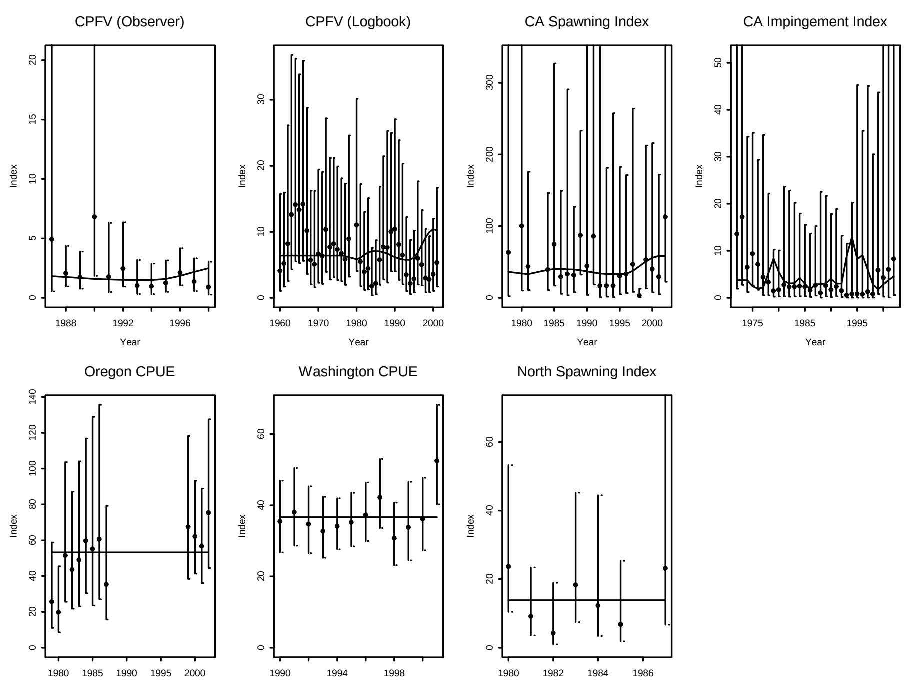
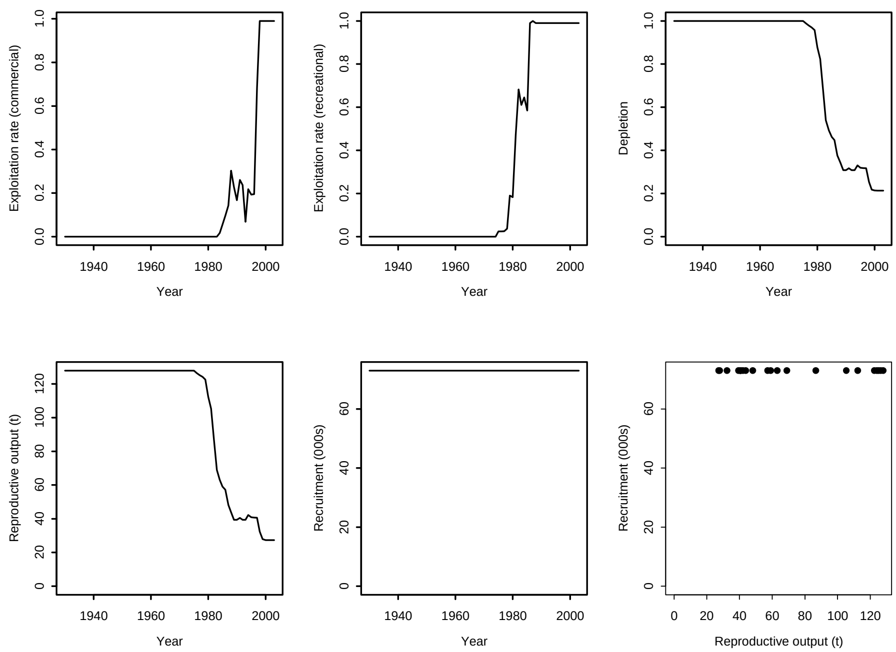


Figure 22. Observed (solid dots) and model-predicted (solid lines) abundance indices for cabezon off California and Oregon-Washington. Results are shown for the two base-case analyses. The confidence intervals in the lower panels include the impact of the estimates of the catchability variability scaling parameter factors.

(a) Catchability scaling parameters set equal to 1



(b) Catchability scaling parameters estimated

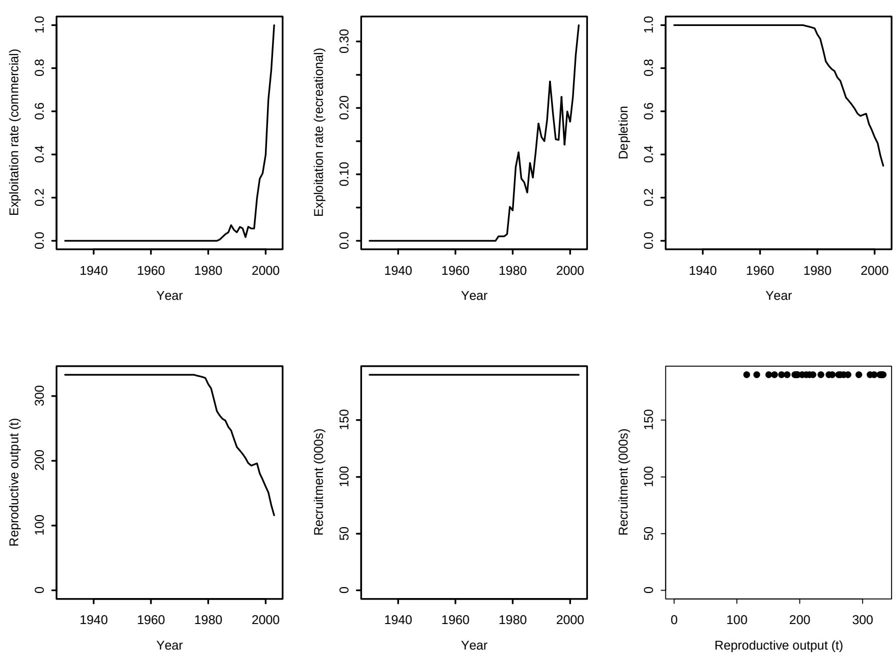


Figure 23. MPD time-trajectories of reproductive output and fishing mortality for the two base-case analyses of cabezon off Oregon-Washington.

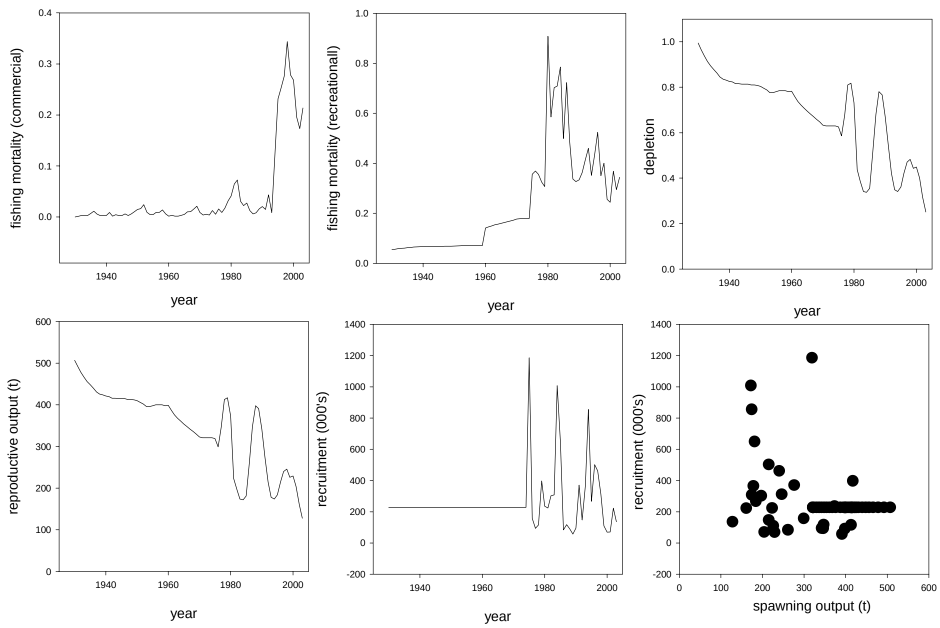


Figure 24a. MPD time-trajectories of reproductive output and fishing mortality for cabezon off California based on Stock Synthesis.

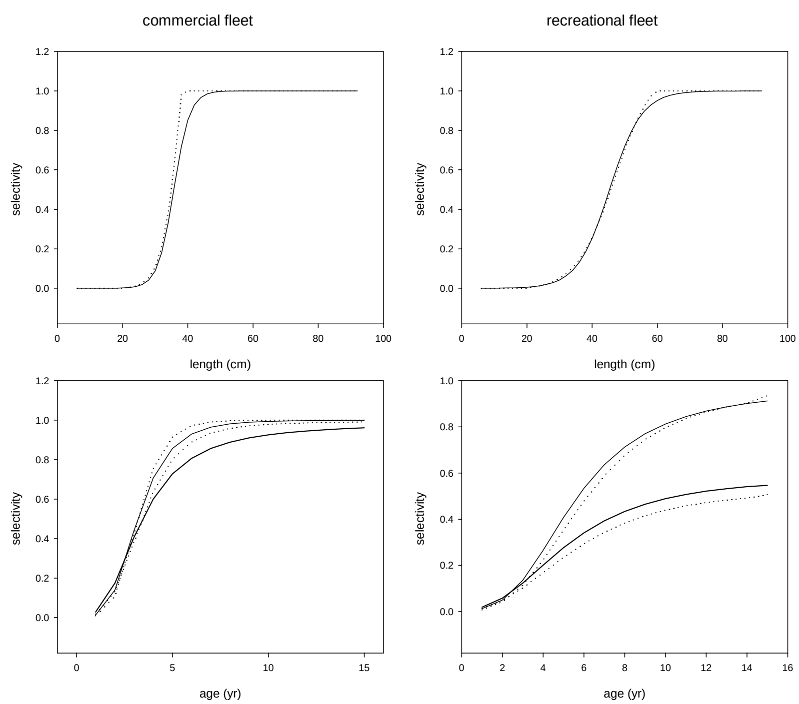


Figure 24b. Cabezon length- and age-specific selectivity ogives for two fleets off California. The base-case results from the ADMB model are shown by solid line; results from Synthesis are dotted lines.

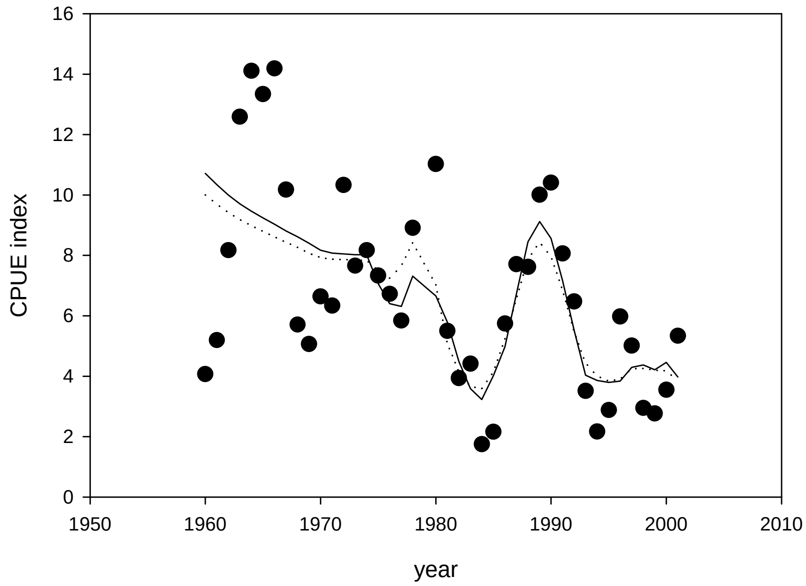


Figure 24c. Fits to the CPFV Logbook series. The base-case results are shown by the solid line; results from Synthesis by the dashed lines.

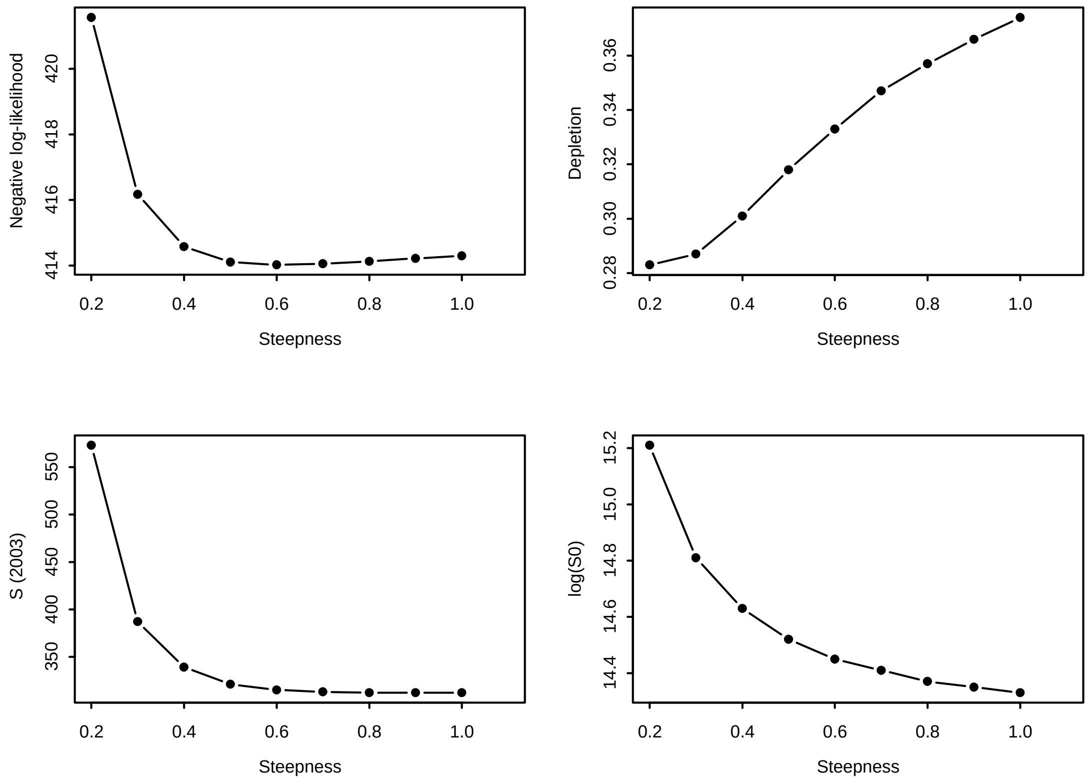


Figure 25. Results of likelihood profiles for steepness (h).

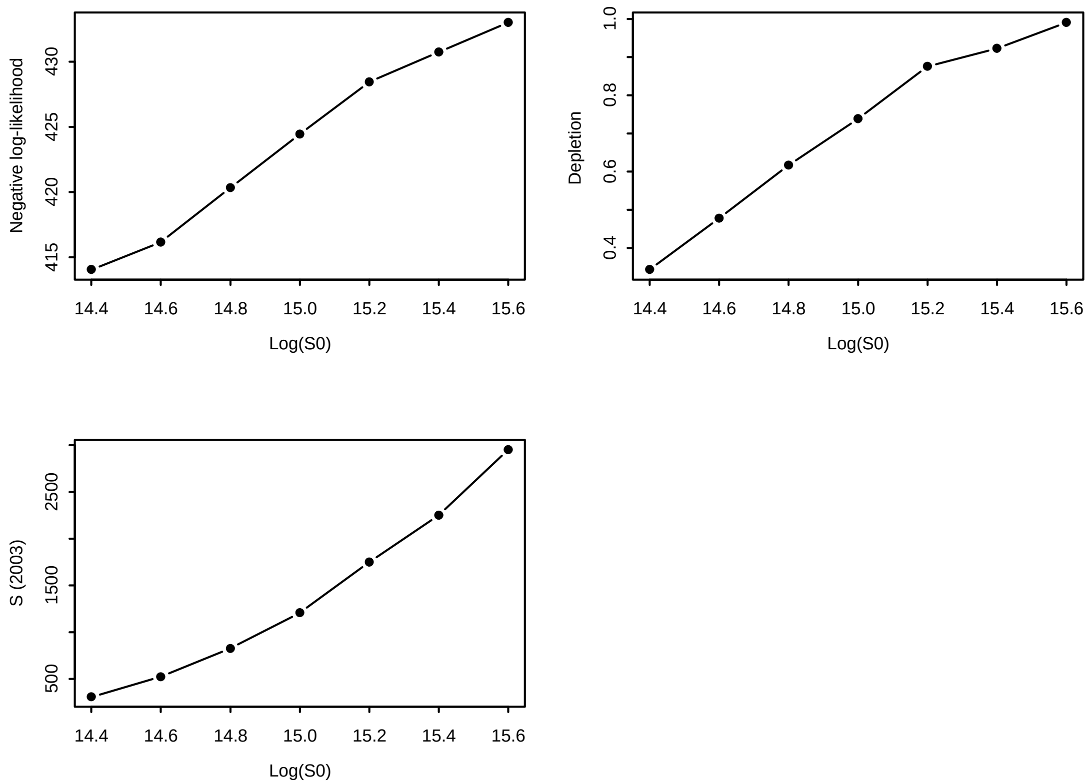


Figure 26. Results of likelihood profiles for $\ell n S_0$.

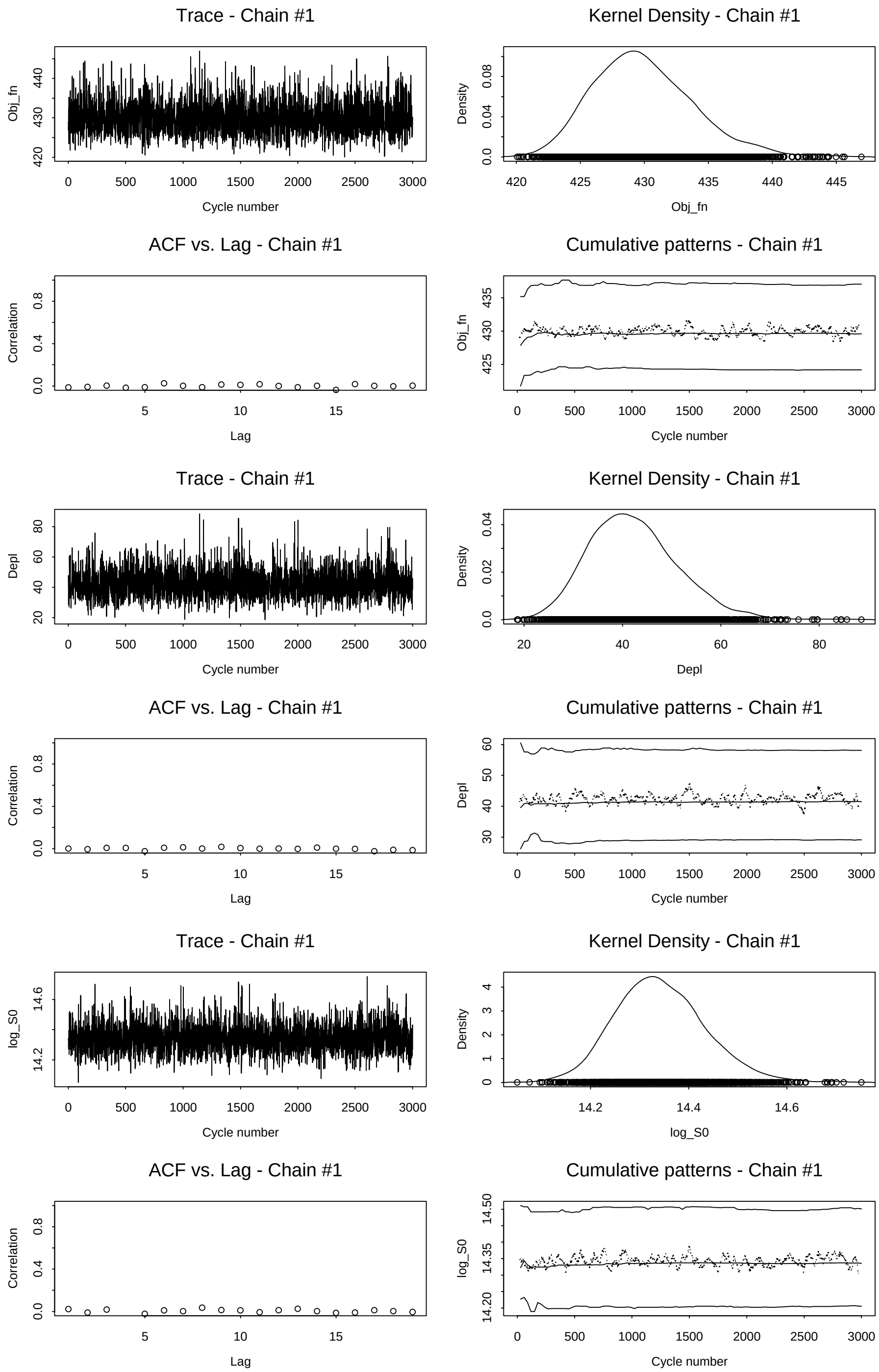


Figure 27. MCMC diagnostics for the objective function, current depletion and $\ell n S_0$.

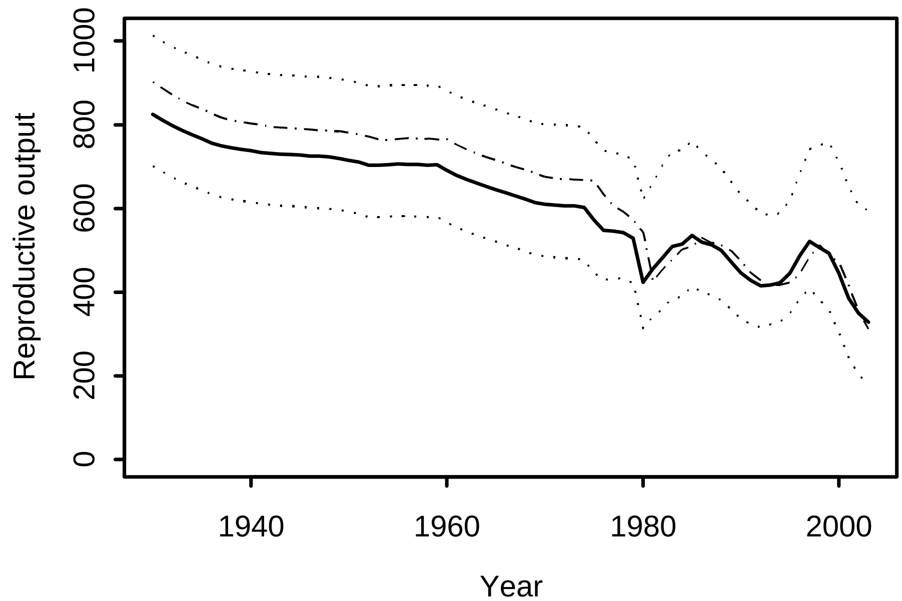
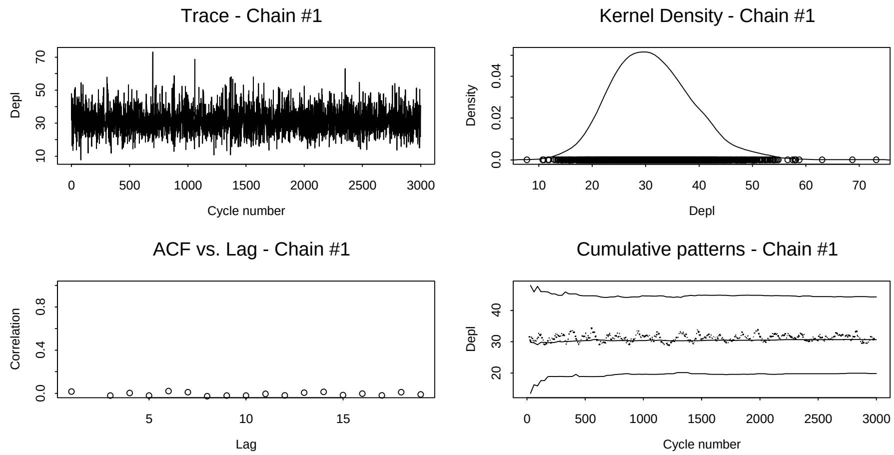
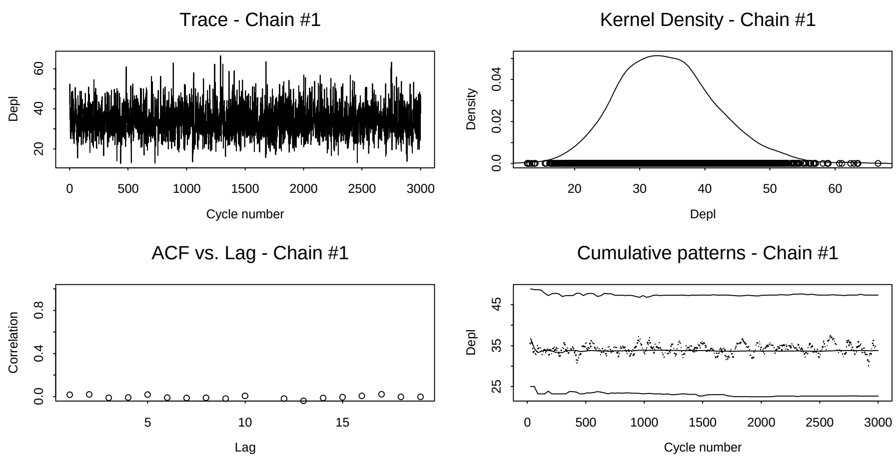


Figure 28. Posterior distributions (posterior medians and posterior 95% confidence intervals) for the time-trajectory of reproductive output (1930-2003). The dashed lines are the MPD estimates of annual reproductive output.

(a) M=0.2yr^{-1}; h=0.5



(b) M=0.2yr^{-1}; h=0.7



(c) M=0.2yr^{-1}; h=0.9

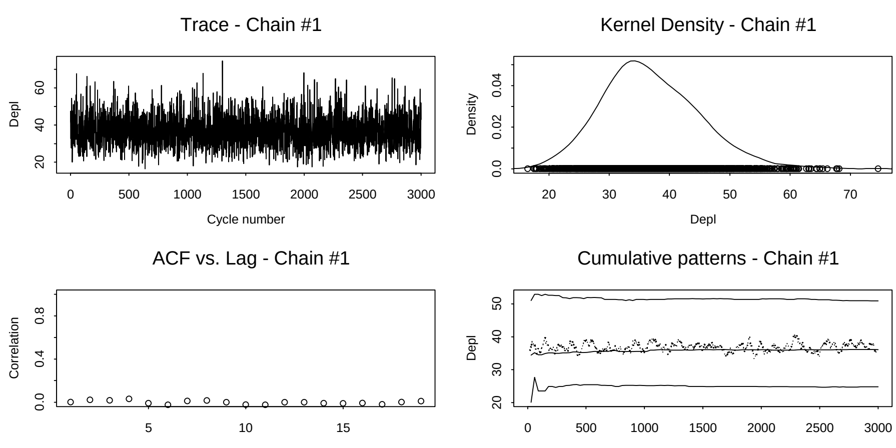
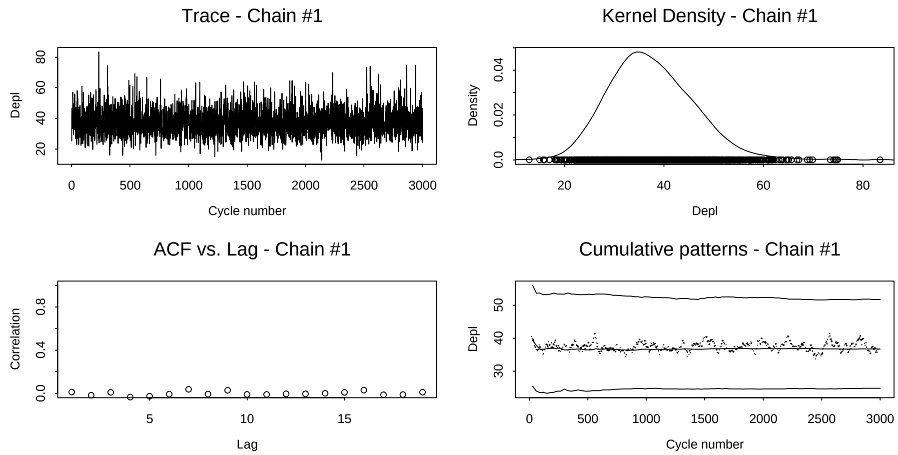


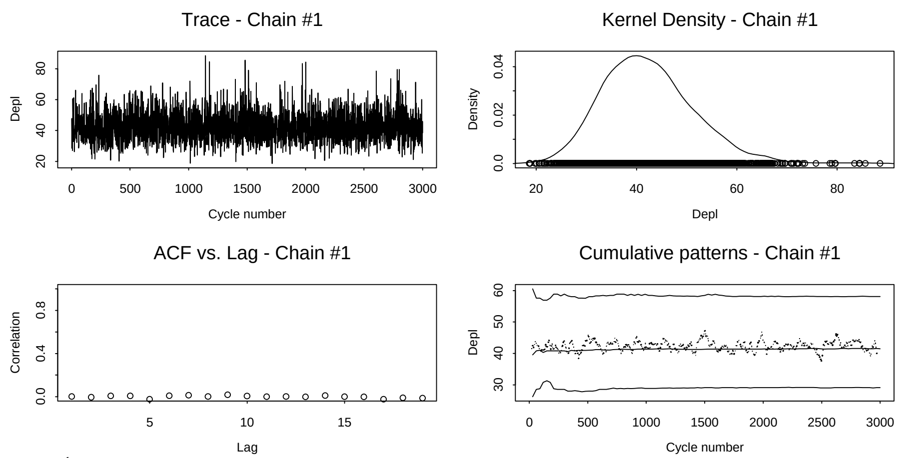
Figure 29: MCMC diagnostics for current depletion for each of the nine cases.

(Figure 29 Continued)

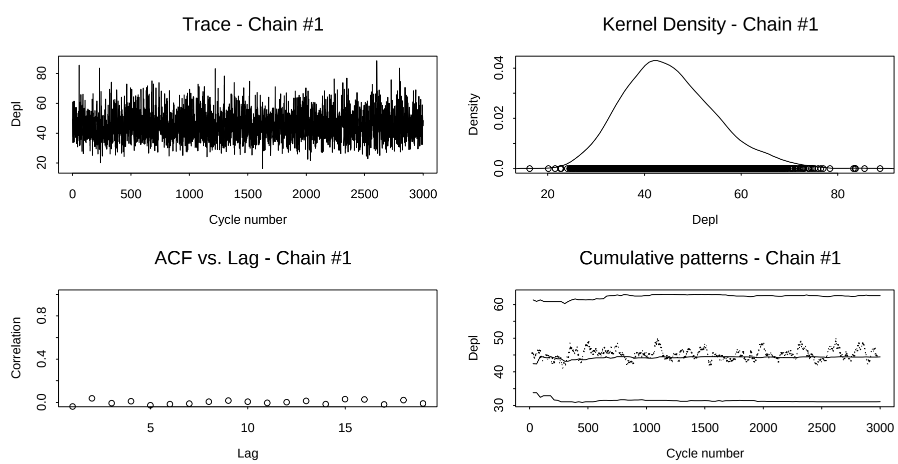
(d) M=0.25yr^{-1}; h=0.5



(e) M=0.25yr^{-1}; h=0.7 (Base-case)

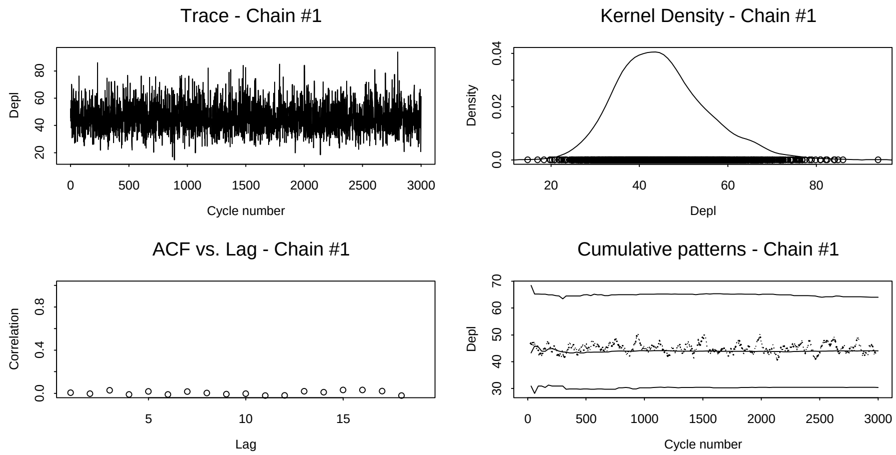


(f) M=0.25yr^{-1}; h=0.9

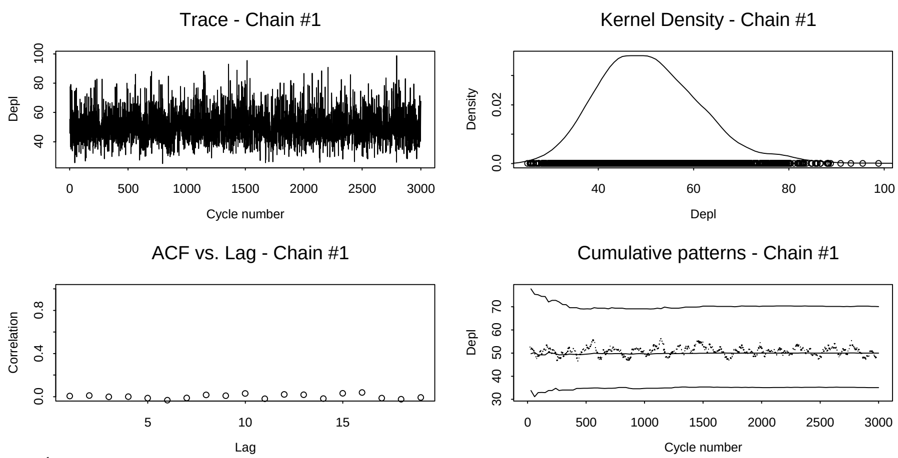


(Figure 29 Continued)

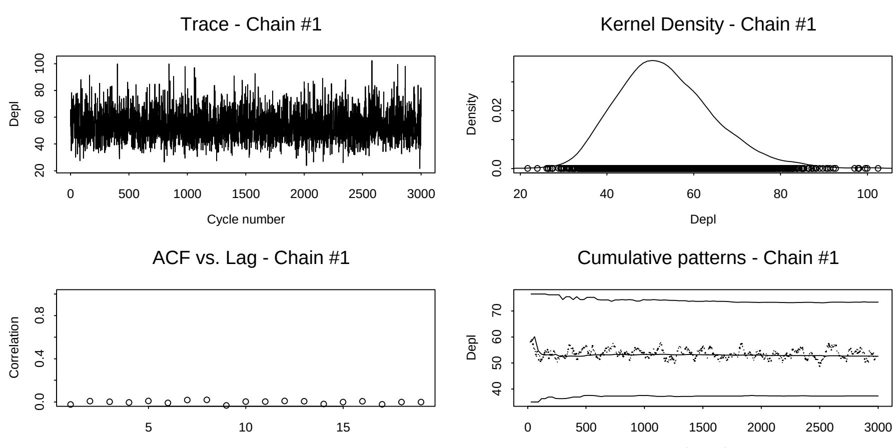
(g) M=0.3yr^{-1}; h=0.5



(h) M=0.3yr^{-1}; h=0.7



(i) M=0.3yr^{-1}; h=0.9



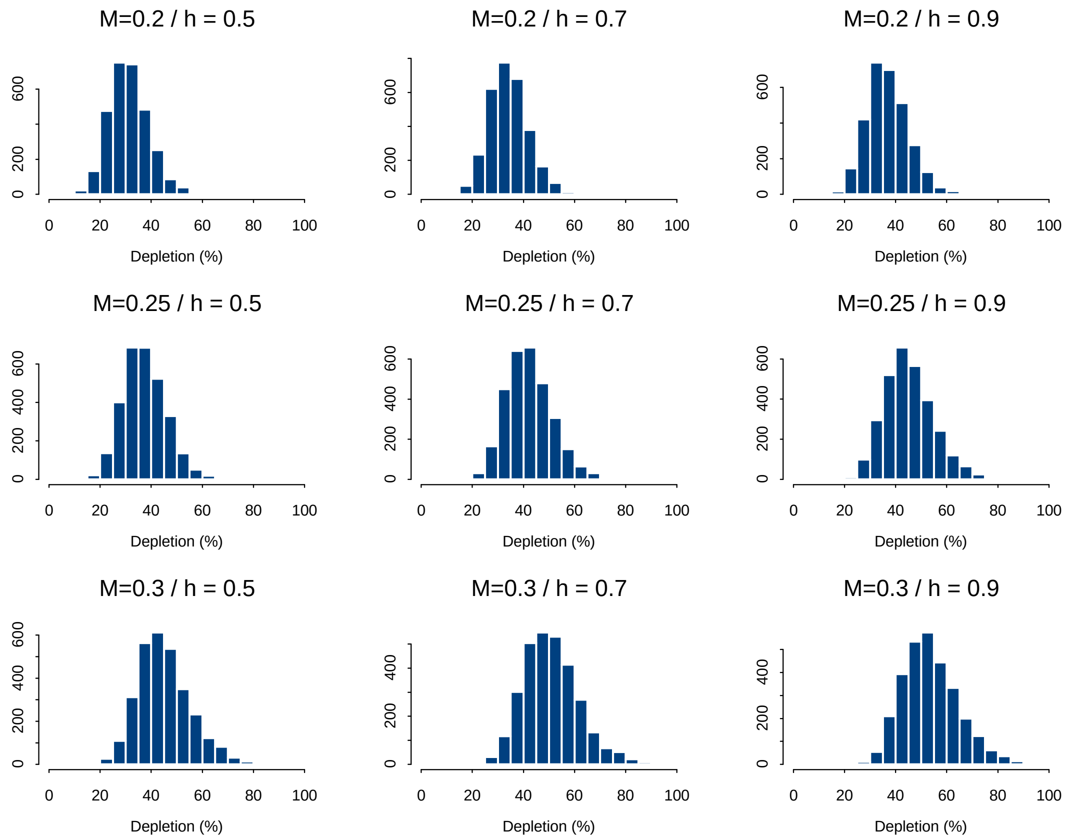


Figure 30: Posterior distributions for current depletion (i.e. S_{2003} / S_0) for each of the nine cases considered when conducting the projections.

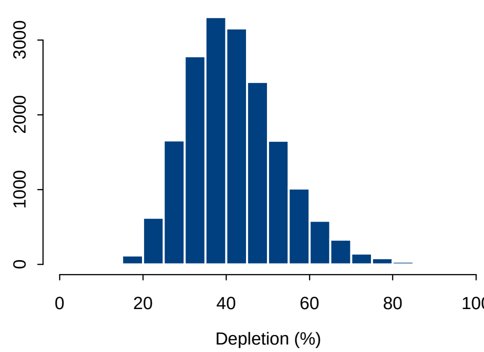


Figure 31: Posterior distribution for current depletion (i.e. S_{2003} / S_0) obtained by pooling the posterior distributions for the nine cases giving a weight of 1 to cases for which M=0.25yr^{-1} and 0.5 to cases for which M=0.2 yr^{-1} and M=0.3yr^{-1}.

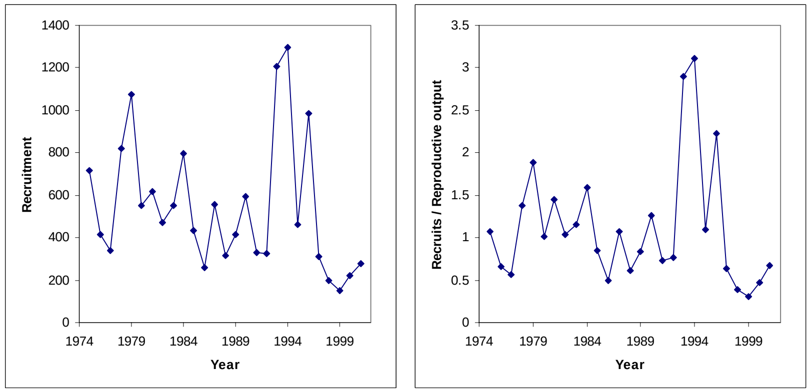


Figure 32. MPD time-trajectories of recruitment and recruits / reproductive output ratios for the base-case analysis.

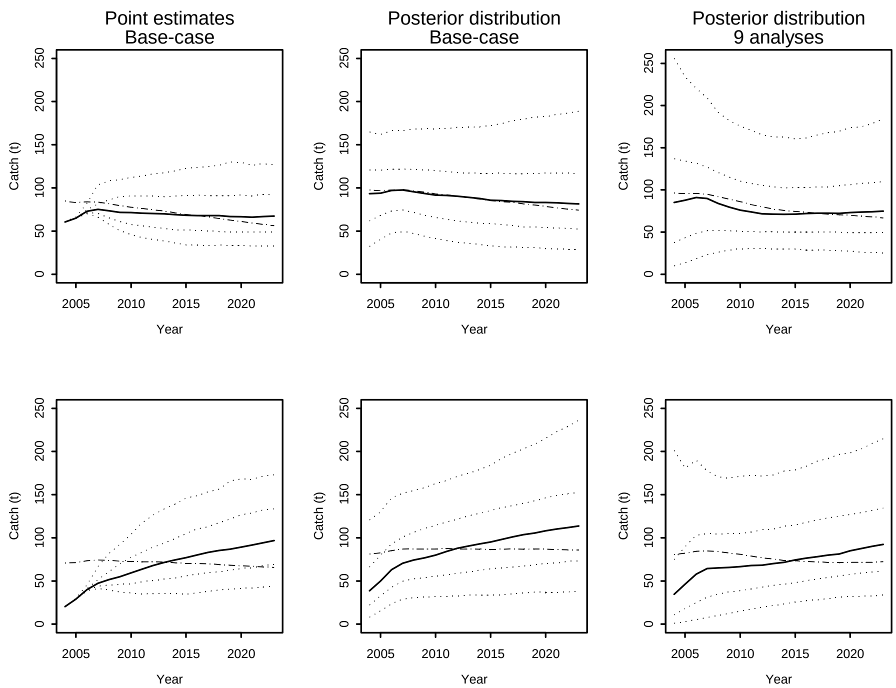


Figure 33 : Time-trajectories of yield. The solid lines are the median time-trajectories of 40-10 (upper panels) and 60-20 (lower panels) harvest, the dashed lines are F_{ABC} median time-trajectories of harvest, and the dotted lines and the 5$^{\mathrm{th}}$, 25$^{\mathrm{th}}$, 75$^{\mathrm{th}}$ and 95$^{\mathrm{th}}$ percentiles of 40-10 and 60-20 harvest. Results are shown for three scenarios (see text for details).

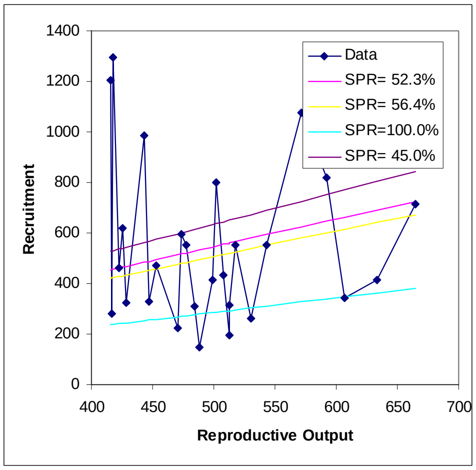


Figure 34. Recruitment versus reproductive output indicating various replacement lines.

Appendix A. Summary of California Nearshore Management Measures Affecting Cabezon

Year	Description	Effective Date
1999	Implement recreational and commercial size limit 14" total length	1/1/1999
Pre & 2000	Recreational Bag Limit of 10 fish w/in 20 fish aggregate	3/1/1984
2000	FGC fixes cabezon OY at 63,608 (40.3%) recreational; 94,398 (59.7%) commercial; Total = 158,006 pounds	12/30/1999
2001	Weekday closures - Commercial take prohibited Thursday thru Sunday	Jan-01
2001	Central and Southern Management Areas; recreational bag limit 10 fish; Recreational Fishery open year round; no depth restrictions, except no take in Cowcod Closure area in southern management area	1/1/2001
2001	Increase in size limit to 15" Total length recreational and commercial	Mar-01
2001	FGC fixes cabezon OY at 63,608 recreational; 94,398 commercial; Total OY = 178,728 pounds in emergency regulations	Sep-01
2002	Finfish traps required to have rigid five inch rings in entrance	1/8/2002
2002	FGC fixes cabezon OY at 84,330 (47.2%) recreational; 94,398 (52.8%) commercial; Total OY = 178,728 pounds reaffirming emergency action	2/4/2002
2003	Northern Rockfish and Lingcod Management Area; recreational bag limit remains at 10 fish; Open year round; No depth Restriction	1/3/2003
2003	FGC fixes cabezon OY at 118,300 (61%) recreational; 75,600 (39%) commercial; Total OY = 193,900 pounds	adopted by FGC 8/2/03; filed with OAL effective date pending

Appendix B: The Population Dynamics Model

Basic Dynamics

The population dynamics are assumed governed by:

$$N_{t+1,a}^{g,p}=\begin{cases} N_{t+1,0}^{g,p} & a=0 \\ (N_{t,a-1}^{g,p}\,e^{-M/2}-C_{t,a-1}^{g,p})e^{-M/2} & 1\le a<x \\ N_{t,x-1}^{g,p}\,e^{-M}-C_{t,x-1}^{g,p}\,e^{-M/2}+N_{t,x}^{g,p}\,e^{-M}-C_{t,x}^{g,p}\,e^{-M/2} & a=x \end{cases} \qquad \text{(B.1)}$$

where $N_{t,a}^{g,p}$ is the number of fish of age a and sex g (g=1 for females; g=2 for males) in population p (p=1 for south; p=2 for north) at the start of year t,

M is the instantaneous rate of natural mortality (assumed to be independent of sex, age, time, and population),

$C_{t,a}^{g,p}$ is the catch (in number) during year t of fish of age a, sex g and population p:

$$C_{t,a}^{g,p}=\sum_f C_{t,a}^{g,p,f}$$

$C_{t,a}^{g,p,f}$ is the catch (in number) by fleet f (commercial or recreational) during year t of fish of age a, sex g and population p, and

x is the maximum age considered (treated as a plus group, and assumed to be independent of sex, age, time, and population).

Births

The number of zero-year-olds in a given year depends on the reproductive output and an assumed stock-recruitment relationship. The total number of zero-year-olds in population p of sex g at the start of year t+1 is given by a stochastic Beverton-Holt model, reparameterized as in Francis (1992):

$$N_{t+1,0}^{g,p}=\frac{4\,h\,R_0^p\;S_{t+1}^p}{S_0^p(1-h)/2+(5h-1)S_{t+1}^p}\,e^{\varepsilon_{t+1}^p} \qquad \text{(B.2)}$$

where h is the steepness of the (Beverton-Holt) stock-recruitment relationship (assumed to be independent of population),

S_0^p is the reproductive output at pre-exploitation equilibrium for population p:

$$S_0^1=cS_0\,;\;\; S_0^2=(1-c)S_0 \qquad \text{(B.3)}$$

S_0 is the reproductive output at pre-exploitation equilibrium (both populations),

c is the fraction of the total unfished reproductive output that was in the southern area,

S_t^p is the reproductive output at the start of year t for population p:

$$S_t^p = \sum_{a=1}^{x} f_a \, N_{t,a}^{1,p} \tag{B.4}$$

f_a is a measure of the relative fecundity of an animal of age a (assumed to be independent of population),

$$f_a = w_a^{1,p} \frac{1}{1+\exp(m_2 + m_1 a)}$$

R_0^p is the number of zero-year-olds at pre-exploitation equilibrium in population p:

$$R_0^p = S_0^p \left\{ \sum_{a=1}^{x-1} f_a \, e^{-aM} + \frac{f_x \, e^{-xM}}{1-e^{-M}} \right\}^{-1} \tag{B.5}$$

ε_t^p is the logarithm of the ratio of the expected and actual number of zero-year-olds for year t and population p:

$$\varepsilon_t^p \sim N(0;\sigma_R^2)$$

σ_R is the standard deviation of ε_t^p.

Catches

The annual catches are assumed to be taken in a pulse in the middle of the year (after 50% of the natural mortality). The catch (in number) during year t of fish of age a, sex g and population p taken by fleet f is calculated from the total catch (in mass) for population p and fleet f during year t, $\tilde{C}_t^{p,f}$:

$$C_{t,a}^{g,p,f} = \frac{\tilde{C}_t^{p,f} \, N_{t,a}^{g,p} \, s_{a+0.5}^{g,p,f} \, e^{-M/2}}{\sum_g \sum_{a'=0}^{x} w_{a'+0.5}^{g,p} \, N_{t,a'}^{g,p} \, s_{a'+0.5}^{g,p,f} e^{-M/2}} \tag{B.6}$$

where $s_a^{g,p,f}$ is the selectivity of the gear of fleet f on fish of age a and sex g in population p (assumed to be independent of time):

$$s_{a+0.5}^{g,p,f} = \sum_{l=l_{\min}}^{l_{\max}} s_l^{g,p,f} \, \phi_{l,a+0.5}^{g,p} \tag{B.7}$$

$s_l^{g,p,f}$ is the selectivity of the gear of fleet *f* on fish of sex *g* in length-class *l* and population *p* (assumed to be independent of time), assumed to be of the logistic form:

$$s_l^{p,g,f} = \left\{1 + \exp\left(-\ell n 19 \frac{L_l - L_{50}^{p,f}}{\Delta L^{p,f}}\right)\right\}^{-1} \tag{B.8}$$

L_l is the mid-point of length-class *l*,

$L_{50}^{p,f}$ is the length-at-50%-selectivity for fleet *f* and population *p*,

$\Delta L^{p,f}$ is the difference between length-at-95%-selectivity and the length-at-50%-selectivity for fleet *f* and population *p*,

$l_{\min}$ is the first length-class,

$l_{\max}$ is the last length-class,

$w_a^{g,p}$ is the mass of a fish of age *a*, sex *g* and population *p*, and

$\phi_{l,a}^{g,p}$ is the probability that an individual of age *a*, sex *g* and population *p* is in length-class *l*.

The $\phi_{l,a}^{g,p}$ are computed by assuming that length-at-age is normally distributed about its expected value with a CV that depends on age and sex, i.e:

$$\phi_{l,a}^{g,p} = \int_{L_l - \Delta l/2}^{L_l + \Delta l/2} \frac{1}{\sqrt{2\pi}\sigma_a^g \, \bar{L}_a^{g,p}} e^{-\frac{(L - \bar{L}_a^{g,p})^2}{2(\sigma_a^g \bar{L}_a^{g,p})^2}} dL \tag{B.9}$$

where $\bar{L}_a^{g,p}$ is the mean length of a fish of sex *g*, age *a* and population *p* (based on the von Bertalanffy growth equation (Figure 3),

σ_a^g is the CV of the length of a fish of age *a* and sex *g*:

$$\sigma_a^g = CV_{\min} + \frac{(CV_{\max} - CV_{\min})(a-1)}{x-1}$$

$CV_{\min}$ is the CV of length-at-age for an animal of age 1,

$CV_{\max}$ is the CV of length-at-age for an animal of age *x*-1,

L_l is the midpoint of length-class *l*, and

Δl is the width of each length-class.

Initial conditions

Each population is assumed to be at its pre-exploitation equilibrium size at the start of 1930 (the assumed start of harvesting).

$$N_{t,a}^{p} = \begin{cases} R_0^p \, e^{-aM} & 0 \le a \le x-1 \\ R_0^p \, e^{-xM} / (1-e^{-M}) & a = x \end{cases} \tag{B.10}$$

where y_1 is the first year considered (1930).

Appendix C: The Likelihood Function

Indices of abundance

Catch-rate data

The contribution of the catch-rate data to the likelihood function is based on the assumption that the observed catch-rate data are lognormally distributed about their expected values:

$$I_t^p = q_c^p \, B_t^p \, e^{\eta_t^p} \qquad\qquad \eta_t^p \sim N(0;(\sigma_{c,t}^p)^2) \tag{C.1}$$

where I_t^p is the (standardized) catch-rate index for population p and year t,

q_c^p is the catchability coefficient for population p,

$\sigma_{c,t}^p$ is the standard deviation of the fluctuations in log(catchability):

$$\sigma_{c,t}^p = \sigma_c^p \, \tilde{\sigma}_{c,t}^p \tag{C.2}$$

$\tilde{\sigma}_{c,t}^p$ is the pre-specified CV of the catch-rate index for population p and year t (see Table 7),

σ_c^p is an overall catchability variability scaling factor for population p,

B_t^p is the exploitable biomass (in the middle of the year) corresponding to I_t^p:

$$B_t^p = \sum_g \sum_{a=0}^{x} w_a^{g,p} \, s_a^{g,p,f''} \, (N_{t,a}^{g,p} \, e^{-M/2} - C_{t,a}^{g,p}/2) \tag{C.3}$$

f'' is the fleet (commercial or recreational) to which the catch-rate index relates.

The negative of the log-likelihood function (ignoring constant terms) is:

$$-\ell\text{n}L = \sum_p \sum_t \left\{ \ell\text{n}\,\sigma_{c,t}^p + \frac{1}{2(\sigma_{c,t}^p)^2} \left[\ell\text{n}I_t^p - \ell\text{n}(q_c^p \, B_t^p) \right]^2 \right\} \tag{C.4}$$

where the summation over t is taken over all years for which catch-rates are available.

Spawning stock size index

The contribution of the indices of reproductive output to the likelihood function is based on the assumption that the observed indices are lognormally distributed about their expected values:

$$J_t^p = q_s^p \, S_{t-1}^p \, e^{\nu_t^p} \qquad\qquad \nu_t^p \sim N(0;(\sigma_{s,t}^p)^2) \tag{C.5}$$

where J_t^p is the index of reproductive output (males and females combined) for year t and population p,

q_s^p is the catchability coefficient for the index of reproductive output for population p,

$\sigma_{s,t}^p$ is the standard deviation of the fluctuations in log(catchability):

$$\sigma_{s,t}^p = \sigma_s^p \, \tilde{\sigma}_{s,t}^p \tag{C.6}$$

$\tilde{\sigma}_{s,t}^p$ is the pre-specified CV of the index of reproductive output for population p and year t, and

σ_s^p is an overall catchability variability scaling factor for population p.

The negative of the log-likelihood function (ignoring constant terms) is:

$$-\ell\mathrm{n}L = \sum_p \sum_t \left\{ \ell\mathrm{n}\,\sigma_{s,t}^p + \frac{1}{2(\sigma_{s,t}^p)^2} \left[\ell\mathrm{n}J_t^p - \ell\mathrm{n}(q_s^p \, S_t^p) \right]^2 \right\} \tag{C.7}$$

where the summation over t is taken over all years for which the reproductive output index data are available.

Recruitment index

The contribution of the juvenile impingement index to the likelihood function is based on the assumption that an observed index is lognormally distributed about its expected value:

$$K_t^p = q_K^p \, \tilde{N}_t^p \, e^{\upsilon_t^p} \qquad \upsilon_t^p \sim N(0;(\sigma_{K,t}^p)^2) \tag{C.8}$$

where K_t^p is the index of juvenile impingement for population p and year t,

q_K^p is the catchability coefficient for the index of juvenile abundance for population p,

$\sigma_{K,t}^p$ is the standard deviation of the fluctuations in log(catchability):

$$\sigma_{K,t}^p = \sigma_K^p \, \tilde{\sigma}_{K,t}^p \tag{C.9}$$

$\tilde{\sigma}_{K,t}^p$ is the pre-specified CV of the index of juvenile impingement for population p and year t,

σ_K^p is an overall catchability variability scaling factor for population p, and

$\tilde{N}_t^p$ is the number of juveniles expected to be vulnerable to impingement and hence that correspond to K_t^p:

$$\tilde{N}_t^p = \sum_g N_{t,0}^{g,p} + 0.5 \sum_g N_{t,1}^{g,p} \tag{C.10}$$

Note that all fish of age 0 are assumed to be vulnerable to impingement, but only half of the individuals of age 1.

The negative of the log-likelihood function (ignoring constant terms) is:

$$-\ell nL = \sum_p \sum_t \left\{ \ell n\, \sigma_{K,t}^p + \frac{1}{2(\sigma_{K,t}^p)^2} \left[\ell n K_t^p - \ell n(q_K^p\ \tilde{N}_t^p) \right]^2 \right\} \tag{C.11}$$

where the summation over t is taken over all years for which the juvenile impingement index is available.

Catch length-frequency
The contribution of the sex-aggregated catch-at-length data to the likelihood function is based on the assumption that the observed catch-at-length data are multinomially distributed:

$$-\ell nL = -\sum_d \omega^d \sum_t \sum_g \sum_{l=l_{\min}}^{l_{\max}} \rho_{t,l,d}^p\ \ell n(\hat{\rho}_{t,l}^p / \rho_{t,l,d}^p) \tag{C.12}$$

where $\hat{\rho}_{t,l}^{p,f}$ is the model estimate of the proportion of the catch (in number) of fish of population p caught by fleet f (data source d is assumed to be based on the catches by fleet f) during year t that is in length-class l:

$$\hat{\rho}_{t,l}^{p,f} = \frac{s_l^{g,p,f} \sum_g \sum_a \phi_{l,a+0.5}^{g,p}\ N_{t,a}^{g,p} e^{-M/2}}{\sum_{g'} \sum_{a'=0}^{x} C_{t,a'}^{g',p,f}} \tag{C.13}$$

$\rho_{t,l,d}^p$ is the observed fraction of the catch (in number) of fish of population p during year t that is in length-class l based on data-source d,

ω^d is a weighting factor (the effective sample size) for data source d.

Penalties and priors
Penalty on the recruitment residuals
The prior placed on the recruitment anomalies is implemented by adding the following penalty term to the objective function minimized to find the estimates for the model parameters:

$$P_1 = (2002 - y_{\text{rec}} + 1)\ell n\sigma_R + \frac{1}{2\sigma_R^2} \sum_p \left(\sum_{t=y_{\text{rec}}}^{2002} (\varepsilon_t^p + \sigma_R^2/2)^2 \right) \tag{C.14}$$

where y_{rec} is the first year for which a recruitment residual is estimated.

Appendix D-1: Numbers (in 1000s)-at-age matrix.

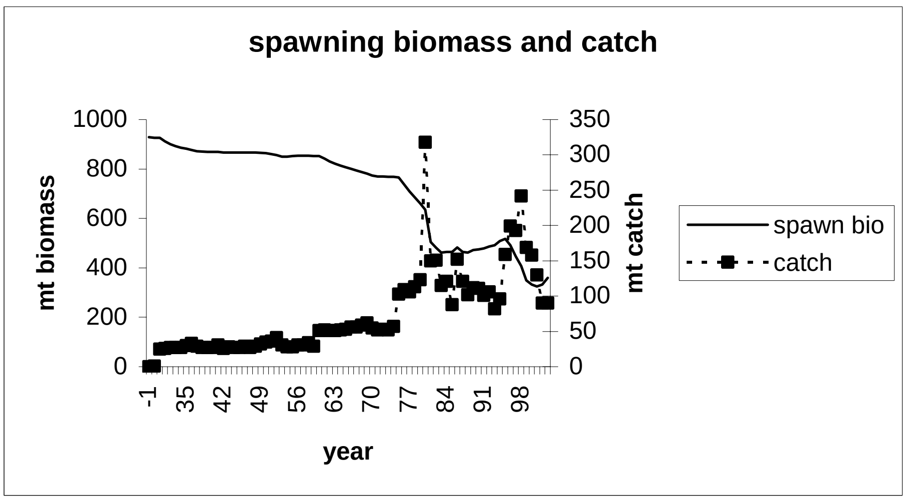
(a) Females

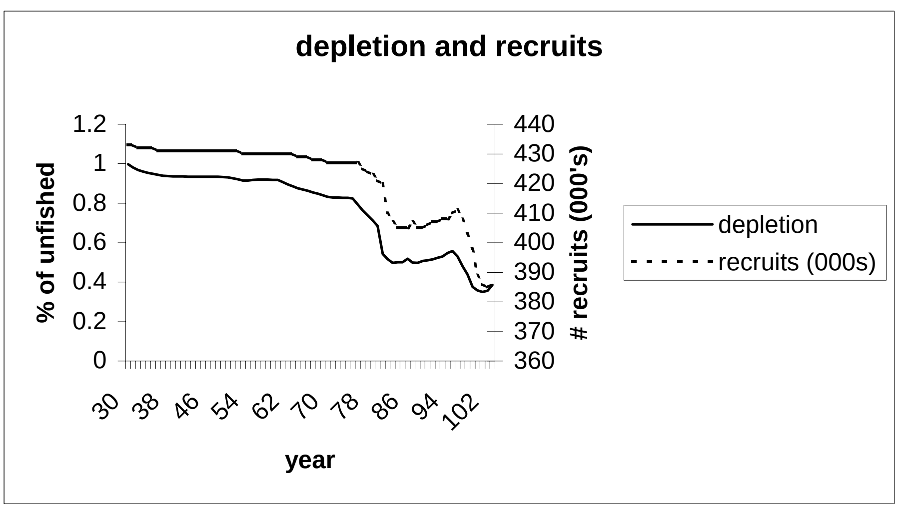
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1930	258	201	156	122	95	74	57	45	35	27	21	16	13	10	8	27
1940	254	198	154	120	93	71	54	41	32	24	18	14	10	8	6	21
1950	253	197	154	119	92	70	54	41	31	24	18	14	10	8	6	18
1960	253	197	153	119	92	70	53	40	31	23	17	13	10	7	6	17
1965	251	195	152	118	90	68	51	38	28	21	16	12	9	7	5	15
1966	250	195	152	117	90	68	51	38	28	21	15	11	9	6	5	14
1967	250	195	152	117	90	68	51	38	28	21	15	11	8	6	5	14
1968	249	194	151	117	89	68	51	38	28	20	15	11	8	6	4	13
1969	249	194	151	117	89	67	50	37	27	20	15	11	8	6	4	13
1970	249	194	151	116	89	67	50	37	27	20	15	11	8	6	4	12
1971	248	194	151	116	89	67	50	37	27	20	15	11	8	6	4	12
1972	248	193	150	116	89	67	50	37	27	20	14	11	8	6	4	12
1973	248	193	150	116	89	67	50	37	27	20	14	11	8	6	4	11
1974	248	193	150	116	89	67	50	37	27	20	14	10	8	6	4	11
1975	358	193	150	116	88	67	50	37	27	20	14	10	8	6	4	11
1976	208	278	150	115	87	65	48	35	25	19	13	10	7	5	4	10
1977	171	162	216	115	86	63	46	33	24	17	12	9	6	5	3	9
1978	409	133	125	165	85	62	44	32	22	16	12	8	6	4	3	8
1979	538	318	103	96	122	61	43	30	21	15	11	8	5	4	3	7
1980	275	418	246	78	70	87	42	29	20	14	10	7	5	3	2	6
1981	309	213	320	180	52	42	46	21	13	9	6	4	3	2	1	3
1982	236	240	165	240	128	35	26	28	12	8	5	3	2	1	1	3
1983	276	183	185	123	170	85	22	16	17	7	4	3	2	1	1	2
1984	399	215	142	141	90	119	57	14	10	10	4	3	2	1	1	2
1985	216	310	166	107	103	63	80	37	9	6	6	3	2	1	1	1
1986	131	168	240	127	80	74	44	55	26	6	4	4	2	1	1	1
1987	277	102	130	182	92	55	49	28	34	15	4	3	3	1	1	1
1988	157	216	78	99	133	65	37	32	18	22	10	2	2	2	1	1
1989	208	122	167	60	73	95	45	25	21	12	14	6	1	1	1	1
1990	297	162	94	127	44	52	65	30	17	14	8	9	4	1	1	1
1991	164	231	125	72	93	31	35	43	19	11	9	5	6	2	1	1
1992	163	128	179	95	53	66	21	23	28	13	7	6	3	4	2	1
1993	603	127	99	136	70	37	45	14	15	18	8	4	3	2	2	2
1994	648	469	98	75	101	50	26	30	9	10	12	5	3	2	1	2
1995	231	504	363	74	55	70	34	17	20	6	6	8	3	2	1	2
1996	494	179	390	270	51	35	44	20	10	12	3	4	4	2	1	2
1997	155	384	139	288	182	32	21	25	11	5	6	2	2	2	1	2
1998	98	121	297	103	196	116	19	12	14	6	3	3	1	1	1	1
1999	74	77	93	218	68	119	66	11	7	8	3	2	2	1	1	1
2000	111	58	59	69	151	44	75	41	6	4	5	2	1	1	0	1
2001	140	87	45	44	48	99	28	46	25	4	2	3	1	1	1	1
2002	273	109	67	34	31	32	63	18	28	15	2	1	2	1	0	1
2003	214	213	84	51	24	22	22	42	11	18	10	2	1	1	0	1
2004	209	167	165	63	36	16	14	14	26	7	11	6	1	1	1	1

(b) Males

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1930	258	201	156	122	95	74	57	45	35	27	21	16	13	10	8	27
1940	254	198	154	120	93	71	55	42	32	25	19	14	11	8	6	22
1950	253	197	153	119	92	71	54	41	32	24	18	14	11	8	6	20
1960	253	197	153	119	91	70	54	41	31	24	18	14	10	8	6	19
1965	251	195	152	117	90	69	52	39	30	22	17	13	10	7	5	17
1966	250	195	152	117	90	69	52	39	29	22	17	12	9	7	5	17
1967	250	195	151	117	90	68	52	39	29	22	16	12	9	7	5	16
1968	249	194	151	117	89	68	51	39	29	22	16	12	9	7	5	16
1969	249	194	151	116	89	68	51	38	29	21	16	12	9	7	5	15
1970	249	194	151	116	89	67	51	38	28	21	16	12	9	7	5	15
1971	248	193	150	116	89	67	50	38	28	21	16	12	9	6	5	15
1972	248	193	150	116	89	67	51	38	28	21	16	12	9	6	5	14
1973	248	193	150	116	89	67	51	38	28	21	16	12	9	6	5	14
1974	248	193	150	116	89	67	51	38	28	21	16	12	9	6	5	14
1975	358	193	150	116	88	67	51	38	28	21	16	12	9	6	5	14
1976	208	278	149	115	87	65	49	36	27	20	15	11	8	6	4	13
1977	171	162	215	114	86	64	47	35	26	19	14	10	8	6	4	12
1978	409	133	125	164	85	63	46	34	25	18	13	10	7	5	4	11
1979	538	318	103	95	122	62	45	33	24	17	12	9	7	5	4	10
1980	275	418	245	78	70	88	44	31	22	16	12	8	6	4	3	9
1981	309	213	317	178	52	44	52	25	17	12	8	6	4	3	2	6
1982	236	240	163	236	127	36	29	33	16	11	7	5	4	3	2	5
1983	276	183	184	122	169	87	24	19	21	10	7	4	3	2	2	4
1984	399	214	141	139	89	120	61	16	13	14	6	4	3	2	1	4
1985	216	310	165	106	102	64	84	42	11	9	9	4	3	2	1	3
1986	131	168	240	126	79	75	46	60	29	8	6	7	3	2	1	3
1987	277	101	129	180	92	56	51	31	39	19	5	4	4	2	1	3
1988	157	215	78	98	133	66	39	35	21	27	13	3	3	3	1	3
1989	208	122	166	59	73	96	47	28	25	14	18	9	2	2	2	3
1990	297	162	94	126	44	52	68	33	19	17	10	12	6	2	1	3
1991	164	231	125	71	93	31	37	47	22	13	11	7	8	4	1	3
1992	163	127	178	95	53	67	22	26	32	15	9	8	4	5	3	2
1993	603	127	98	134	69	38	47	15	17	22	10	6	5	3	4	3
1994	648	468	98	75	100	51	27	33	11	12	15	7	4	3	2	5
1995	231	504	362	74	55	71	35	18	22	7	8	10	5	3	2	4
1996	494	179	388	267	51	36	46	22	11	14	4	5	6	3	2	4
1997	155	384	137	283	182	33	22	28	13	7	8	2	3	3	2	3
1998	98	120	295	101	195	119	21	14	17	8	4	5	1	2	2	3
1999	74	77	92	214	68	122	72	12	8	9	4	2	3	1	1	3
2000	111	58	59	68	149	45	79	46	8	5	6	3	1	2	0	2
2001	140	87	45	44	48	100	29	51	29	5	3	4	2	1	1	2
2002	273	109	67	33	31	33	66	19	33	18	3	2	2	1	1	2
2003	214	213	84	50	24	22	22	45	13	22	12	2	1	1	1	1
2004	209	167	164	63	36	17	15	15	30	8	14	8	1	1	1	1

A stock reduction analysis was performed using stock synthesis to corroborate the results of the more complex base-case results used in the projections. Model components were the same as the base-case: steepness was fixed at 0.7, M=0.25, selectivity of both fisheries was assumed to be asymptotic and time-invariant. The major difference between the stock reduction analysis and the base-case model was that recruitment was not estimated but was instead constrained to the stock recruitment relationship, resulting in a less complex analysis. Ending spawning biomass was estimated at 359 mt with a depletion level of 38.6% (see figures below). These results indicate that catches above 150 mt resulted in stock decline but catches under 100 mt did not. These results are consistent with the more complex base-case model and verify that the addition of complexity had not caused a radical change in the description of the stock dynamics.





Appendix F. Example input file for the projection software.

#Title,,
Cabezon – base-case,,
Number of sexes,,
2,,
Age range to consider (minimum age; maximum age),,
0,15,
Number of fleets
2
First year of projection,,
2003,,
Year declared overfished
2003
Is the maximum age a plus-group (1=Yes;2=No),,
1,,
Generate future recruitments using historical recruitments (1), historical recruits/spawner (2), or a stock-recruitment (3)
2,,
Constant fishing mortality (1) or constant Catch (2) projections,,
1,,
Pre-specify the year of recovery (or -1) to ignore,,
-1,,
Fecundity-at-age,,,,,,,,,,,,,,,,,,,
0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
0 0.00825525 0.084551 0.376094 0.816357 1.23825 1.62711 1.99226 2.33286 2.64524 2.927 3.17753 3.39776 3.58955 3.75535 4.16801
Age specific information (Females then males) weight, selectivity
Females - Commerical
0.0522189 0.194185 0.428807 0.734307 1.08324 1.4505 1.81634 2.1668 2.49299 2.79008 3.05615 3.29134 3.49707 3.67554 3.82932 4.20998
0.000304952 0.0177052 0.211343 0.568303 0.809861 0.920338 0.965753 0.984496 0.992572 0.996243 0.998005 0.998892 0.99936 0.999616 0.999762 0.999847
Females - Recreational
0.0522189 0.194185 0.428807 0.734307 1.08324 1.4505 1.81634 2.1668 2.49299 2.79008 3.05615 3.29134 3.49707 3.67554 3.82932 4.20998
0.0069125 0.0326784 0.109161 0.249165 0.415607 0.564615 0.679191 0.761387 0.818976 0.859326 0.887936 0.908572 0.923744 0.935116 0.943798 0.950543
Males - Commerical
0.0846179 0.249546 0.467291 0.699729 0.920723 1.11653 1.28221 1.41811 1.52714 1.61327 1.68054 1.73263 1.77274 1.80346 1.82693 1.87009
0.00113472 0.0423843 0.258105 0.532868 0.721072 0.828066 0.887711 0.922203 0.943222 0.956738 0.965875 0.972335 0.977086 0.980702 0.983533 0.985802
Males - Recreational
0.0846179 0.249546 0.467291 0.699729 0.920723 1.11653 1.28221 1.41811 1.52714 1.61327 1.68054 1.73263 1.77274 1.80346 1.82693 1.87009

0.0113761 0.047042 0.124888 0.231785 0.339005 0.429636 0.500296 0.553596
0.593426 0.62325 0.645747 0.662886 0.676094 0.686398 0.694543 0.701072
M and initial age-structure
Females
0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
214.259 212.827 84.1825 50.6529 24.1601 21.5057 21.5282 41.7018 11.3941 18.3422
9.7127 1.51827 0.917558 1.03423 0.456564 0.792626
Males
0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
214.259 212.713 83.813 50.0912 23.9751 21.7142 22.3874 44.9633 12.8517 21.747
12.1504 2.00947 1.27609 1.49581 0.68603 1.38847
Initial age-structure
214.259 212.827 84.1825 50.6529 24.1601 21.5057 21.5282 41.7018 11.3941 18.3422
9.7127 1.51827 0.917558 1.03423 0.456564 0.792626
214.259 212.713 83.813 50.0912 23.9751 21.7142 22.3874 44.9633 12.8517 21.747
12.1504 2.00947 1.27609 1.49581 0.68603 1.38847
Year for Tmin Age-structure
2003
Number of simulations,,,,,,,,,,,,,,,,,,,,
1000,,,,,,,,,,,,,,,,,,,,
recruitment and biomass,,,,,,,,,,,,,,,,,,,,
Number of historical assessment years ,,,,,,,,,,,,,,,,,,,,
74,,,,,,,,,,,,,,,,,,,,
Historical data,,,,,,,,,,,,,,,,,,,,
year,recruitment,spawner,in B0,in R project,in R/S project,,,,,,,,,,,,,,,
1930 515.1 902.074 1 0 0
1931 514.112 886.178 0 0 0
1932 513.177 871.592 0 0 0
1933 512.306 858.379 0 0 0
1934 511.539 847.037 0 0 0
1935 510.869 837.355 0 0 0
1936 510.165 827.38 0 0 0
1937 509.422 817.073 0 0 0
1938 508.938 810.483 0 0 0
1939 508.612 806.103 0 0 0
1940 508.34 802.482 0 0 0
1941 508.112 799.458 0 0 0
1942 507.743 794.611 0 0 0
1943 507.639 793.256 0 0 0
1944 507.47 791.064 0 0 0
1945 507.369 789.763 0 0 0
1946 507.285 788.68 0 0 0
1947 507.125 786.617 0 0 0
1948 507.073 785.95 0 0 0
1949 506.941 784.266 0 0 0
1950 506.688 781.048 0 0 0

1951	506.322	776.441	0	0	0
1952	505.947	771.762	0	0	0
1953	505.378	764.765	0	0	0
1954	505.341	764.31	0	0	0
1955	505.468	765.863	0	0	0
1956	505.593	767.395	0	0	0
1957	505.567	767.075	0	0	0
1958	505.54	766.753	0	0	0
1959	505.375	764.731	0	0	0
1960	505.46	765.771	0	0	0
1961	504.386	752.824	0	0	0
1962	503.36	740.811	0	0	0
1963	502.494	730.935	0	0	0
1964	501.734	722.453	0	0	0
1965	501.016	714.596	0	0	0
1966	500.331	707.232	0	0	0
1967	499.562	699.128	0	0	0
1968	498.875	692.019	0	0	0
1969	498.097	684.115	0	0	0
1970	497.225	675.45	0	0	0
1971	496.851	671.781	0	0	0
1972	496.714	670.449	0	0	0
1973	496.551	668.87	0	0	0
1974	496.47	668.09	0	0	0
1975	715.791	664.606	0	1	1
1976	415.965	633.503	0	1	1
1977	341.413	606.598	0	1	1
1978	818.025	592.277	0	1	1
1979	1075.17	571.706	0	1	1
1980	550.025	543.359	0	1	1
1981	618.26	425.35	0	1	1
1982	471.084	452.717	0	1	1
1983	551.906	477.027	0	1	1
1984	797.987	502.123	0	1	1
1985	432.595	508.245	0	1	1
1986	261.172	530.102	0	1	1
1987	554.698	517.586	0	1	1
1988	313.835	512.639	0	1	1
1989	416.482	498.606	0	1	1
1990	594.625	473.311	0	1	1
1991	327.953	446.701	0	1	1
1992	325.914	428.094	0	1	1
1993	1205.27	415.955	0	1	1
1994	1296.31	417.373	0	1	1
1995	461.304	422.228	0	1	1
1996	987.152	443.313	0	1	1

1997 309.74 484.187 0 1 1
1998 196.956 512.305 0 1 1
1999 148.699 488.619 0 1 1
2000 222.676 470.761 0 1 1
2001 279.232 416.561 0 1 1
2002 546.954 354.102 0 0 0
2003 428.517 312.59 0 0 0
Number of years with pre-specified catches,,,,,
1,,,,,
catches for years with pre-specified catches,,
2003,90,
Number of future recruitments to override,,
0,,
Process for overiding (-1 for average otherwise index in data list),,
Which probability to product detailed results for (1=0.5; 2=0.6; etc.),,
8,,
Steepness,sigma-R,Auto-correlation
0.5,0.5,0.717
Target SPR rate (FMSY Proxy)
0.45
Target SPR information: Use (1=Yes) and power
0 20
Discount rate (for cumulative catch),,
0.1,,
Truncate the series when 0.4B0 is reached (1=Yes),,
0,,
Set F to FMSY once 0.4B0 is reached (1=Yes)
0
Percentage of FMSY which defines Ftarget
0.9
Maximum possible F for projection (-1 to set to FMSY)
2
Conduct MacCall transition policy (1=Yes)
0
Defintion of recovery (1=now only;2=now or before)
2
Results for rec probs by Tmax (1) or 0.5 prob for various Ttargets (2)
1
Definition of the "40-10" rule
10 40
Produce the risk-reward plots (1=Yes)
0
Calculate coefficients of variation (1=Yes)
0
Number of replicates to use
20

```
# Random number seed
-89102
# Conduct projections for multiple starting values (0=No;else yes)
0
# File with multiple parameter vectors
MCMC.STO
# Number of parameter vectors
100
# User-specific projection (1=Yes); Output replaced (1->6)
2 7 3 0.51
# Catches and Fs (Year; 1/2 (F or C); value); Final row is -1
2004 2 1000
2005 2  400
2010 1 0.05
2030 1 0.10
-1 -1 -1
# Split of Fs
2003 1 1
-1 1 1
```

Appendix G. ADMB code and input file.

```
//*******************************************************************
*******************
// Cabezon model
//   model by Punt, Minte-Vera, Cope, Piner
//   programmed by Carolina V. Minte-Vera using
//        AD Model Builder version 5.0.1 copyright (c) 1993 2000 Otter Research Ltd.
//        for Microsoft Visual C++ 6.0 compiler
//
// This is a two-sexes, two-population, two-fisheries (in each population) model fitted to
// length frequency data (sex-aggregated and separated by population),
// catch-rate indices (for both populations),
// spawning abundance indices (for both populations) and recruitment index (for
California)
// using Bayesian methods (MCMC). Catchabilities and sampling variances are set to
their MLEs.
//
// Additional features:
// 1) the model can be reduced to 1 population model, by changing the options in
// the cabezon.dat file. The population can be specified South = 1, North =2.
// 2) there is a debugging mode, that can be turn on/off in the cabezon.ctl file, no
parameter
// is estimated and the deterministic calculations are performed and can be checked
//
// The model is flexible to be increased to more
// then 2 populations and more then 2 sexes (or growth morphs) with minor
modifications.
//
// cabezon.dat has the data
// cabezon.ctl has the controls
// cabezon.pin has the initial values for the parameters
//
//  type cabezon -? to see the command line arguments
//
//*******************************************************************
*******************
//   May 21 2003: selectivity, size transition, initial conditions
//   May 24 2003: numbers at age, catch at age
//   May 27: recruitment
//   May 29: enter data,
//   May 30: predictions
//   June 01: likelihood
//   June 02: prior and penalties, report section
//   June 9-10: MLE for q and sigmas
//   June 11: replaced the initialization section for a pin file
```

```
//   June 24: corrections for sigma MLE
//   July 01-02: MLE for Q, MLE for sigma, likelihood
//   July 07-08: two fleets by population
//   July 10:  one vector of recruitment residuals by population
//   July 11: outputs for R, effective sample size for multinomial
//   July 17-18: options for one population
//   July 19-21: recruitment prior, double logistic
//   July 28: R graphs
//   August 07: the harvest rate and the catches depend on the weight at age at the middle
of the year
//           option to estimate or not the extra variability around the abundance indices
//
//TO DO:
//
//    use calculated effective sample size (neffective) for multinomial to re-weight the data
//
// ----------------------------------------------------------------------------
// Naming Conventions:
//
//  GENERAL:
//    styr, endyr begining year and ending year of model (catch data available)
//    pop         number of populations
//    gender      number of sexes
//    nages       number of age groups considered
//    nlength     number of length groups considered
//    rec         relative to recruitment
//
//  DATA SPECIFIC:
//    catch_bio   Observed catch biomass
//    com         Commercial fleet
//    rec         Recreational fleet
//
//    indices:
//    nyr         number of observations available to specific data set
//    yr          vector with the actual years where observations were made in specific data
set
//    obs         observed index
//    exp         expected values corresponding to the index (function of pop dynamic)
//    cv          observed CV, derived from bootstrap of observed values
//
//    cr          catch rate
//    sp          spawning biomass index
//    imp         impingment recruitment index
//
//    ca          California
//    or          Oregon
```

```
//    wa          Washingtn
//    nth         North Stock (OR + WA)
//
//    length frequencies:
//    lnyr        number of observations available to specific data set
//    lyr         actual years where observations were made in specific data set
//    ltrips      numbers of trips
//    langl       number of angler
//    lsamp       number of samples
//    lnb         number of bins
//    lbin        vector with the actual bins used
//    osc         observed size composition
//    esc         expected size composition
//
//    rec         recreational fisheries data
//
//*********************************************************************
****************
//
DATA_SECTION

  //*****************MODEL DIMENSIONS
**********************************************
  init_int styr  //start year of the model
  init_int endyr // end year of the model
  init_int pop   // number of populations
  init_int popID // if pop = 1, popID indicates which population to be assessed (1 -South,
2-North)
  init_int fleet // number of fleets (each one with a different selectivity function)
  init_int gender // number of genders
  ivector years(styr,endyr) // vector of the years of the model

   // prepare age vector
  init_int    nages // plus group
  ivector     age_vector(1,nages)
  !! for (a=1;a<=nages;a++) age_vector(a) = a;

  // prepare length vector
  init_int    nlength //number of length classes
  init_number len_start // firts length bin
  init_number len_step  // size of the length bins
  vector size_vector(1,nlength)  //vector with all length bins

 LOCAL_CALCS
  years(styr) = styr;
  for (i=styr+1;i<=endyr;i++) years(i)=years(i-1)+1; //year vector
```

```
  size_vector(1) = len_start;
  for (z=2;z<=nlength;z++)
   size_vector(z) = size_vector(z-1) + len_step;
 END_CALCS
  !!cout<<"nages "<<nages<<" nlength "<<nlength<<endl;

  //************BIOLOGICAL INFORMATION ************************
  // growth curve parameters, first population =1 south, then pop=2 north, females
gender=1, then males gender=2
  // Von Bertalanffy growth fumction reparametrized as Lmin, Lmax, K intead of Linf, t0
and K
  init_matrix Lmin(1,2,1,gender)//TO EXPAND FOR MORE THEN 2 POPULATIONS,
CHANGE 2 for pop,
  init_matrix Lmax(1,2,1,gender)//need to change the .DAT file also
  init_matrix K(1,2,1,gender)
  init_matrix CVLmin(1,2,1,gender)
  init_matrix CVLmax(1,2,1,gender)

   // Age-length keys for populations 1 and 2
  3darray age_length_pop1(1,gender,0,nages,1,nlength)
  3darray age_length_pop2(1,gender,0,nages,1,nlength)
  3darray Average_Size(1,pop,1,gender,0,nages);
  3darray Sd_Size(1,pop,1,gender,0,nages);


   // length-weight parameters, same for both genders and populations
  init_number WL_intercept
  init_number WL_slope
   // weight at age in kg, females then males
  init_3darray wt_input(1,2,1,gender,0,nages) //3d array: beginning of the year weight,
middle of the year weight, gender, ages
                                              //CHANGE FOR 1 POP, IF GROWTH
PARAMETERS CHANGE,
                                             // MODIFY HERE!this need to be changed when
setting a different nages

  matrix wt_age(1,gender,0,nages) //weight at the beginning of the year
  matrix wt_age_middle(1,gender,0,nages)//weight at the middle of the year

   // maturity-at-age parameters, same for both genders and populations
  init_number mat_intercept
  init_number mat_slope
  vector mat_age(0,nages)
   //relative fecundity at age, is the maturity times the weight-at-age for females
  vector fec(0,nages)
```

```
  //*******CATCH biomass, first south pop=1 then north pop = 2,
  // first commercial fleet=1, then recreational fleet =2
 init_matrix catch_bio1(1,fleet,styr,endyr)
 init_matrix catch_bio2(1,fleet,styr,endyr)
  3darray catch_bio(1,pop,1,fleet,styr,endyr) //CHANGE FOR 1 POP!!


//*********DATA*******************************************************
************
  // Catch rate index CA - CPFV(observer), Number of years, Year, value, CV,
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_ca
 init_ivector yr_cr_ca(1,nyr_cr_ca)
 init_vector  obs_cr_ca(1,nyr_cr_ca)
 init_vector  cv_cr_ca(1,nyr_cr_ca)

  // NOT USED Catch rate index CA - CPFV(logbook) first series, Number of years,
Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_ca2
 init_ivector yr_cr_ca2(1,nyr_cr_ca2)
 init_vector  obs_cr_ca2(1,nyr_cr_ca2)
 init_vector  cv_cr_ca2(1,nyr_cr_ca2)

  // NOT USED Catch rate index CA - CPFV(logbook) second series,  Number of years,
Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_ca3
 init_ivector yr_cr_ca3(1,nyr_cr_ca3)
 init_vector  obs_cr_ca3(1,nyr_cr_ca3)
 init_vector  cv_cr_ca3(1,nyr_cr_ca3)

  // Catch rate index CA - CPFV(logbook) all years, Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_ca4
 init_ivector yr_cr_ca4(1,nyr_cr_ca4)
 init_vector  obs_cr_ca4(1,nyr_cr_ca4)
 init_vector  cv_cr_ca4(1,nyr_cr_ca4)

  // Catch rate index Oregon, Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_or
 init_ivector yr_cr_or(1,nyr_cr_or)
 init_vector  obs_cr_or(1,nyr_cr_or)
```

```
 init_vector  cv_cr_or(1,nyr_cr_or)

  // Catch rate index Washington, Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_cr_wa
 init_ivector yr_cr_wa(1,nyr_cr_wa)
 init_vector  obs_cr_wa(1,nyr_cr_wa)
 init_vector  cv_cr_wa(1,nyr_cr_wa)

  // Spawning biomass index CA,  Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_sp_ca
 init_ivector yr_sp_ca(1,nyr_sp_ca)
 init_vector  obs_sp_ca(1,nyr_sp_ca)
 init_vector  cv_sp_ca(1,nyr_sp_ca)

  // Spawning biomass index North stock, Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_sp_nth
 init_ivector yr_sp_nth(1,nyr_sp_nth)
 init_vector  obs_sp_nth(1,nyr_sp_nth)
 init_vector  cv_sp_nth(1,nyr_sp_nth)

  // Impingement recruitment index CA, Number of years, Year, value, CV
  // and observed standard deviation computed from the CV and observed index
 init_int     nyr_imp_ca
 init_ivector yr_imp_ca(1,nyr_imp_ca)
 init_vector  obs_imp_ca(1,nyr_imp_ca)
 init_vector  cv_imp_ca(1,nyr_imp_ca)

  // Length frequencies, they get transformed in proportions in the Prelim_calcs section.
  // length frequency, California, commercial,Number of years, Year, number of trips,
number of samples
 init_int     lnyr_ca //number of years with data
 init_ivector lyr_ca(1,lnyr_ca) //actual years
 init_vector  ltrips_ca(1,lnyr_ca) //number of trips per year
 init_vector  lsamp_ca(1,lnyr_ca) //number of samples per year
 init_int     lnb_ca //number of length classes
 init_vector  lbin_ca(1,lnb_ca) //middle point of the length frequency bin
 init_matrix  osc_ca(1,lnyr_ca,1,lnb_ca) //matrix year*length with the length frequencies
 !! if(lnb_ca!=nlength) {cout<<"THE NUMBER OF LENGTH BINS FOR CA
("<<lnb_ca<<") DO NOT MATCH WITH THE MODEL "<<nlength<<endl;}

  // Length frequency, California, recreational, number of years, Year, number of anglers,
number of samples
 init_int     lnyr_carec
```

```
 init_ivector lyr_carec(1,lnyr_carec)
 init_vector  langl_carec(1,lnyr_carec)
 init_vector  lsamp_carec(1,lnyr_carec)
 init_int     lnb_carec
 init_vector  lbin_carec(1,lnb_carec)
 init_matrix  osc_carec(1,lnyr_carec,1,lnb_carec)
 !! if(lnb_carec!=nlength) {cout<<"THE NUMBER OF LENGTH BINS FOR CAREC
DO NOT MATCH WITH THE MODEL"<<endl;}

  // length frequency, Oregon, commercial
 init_int     lnyr_or
 init_ivector lyr_or(1,lnyr_or)
 init_vector  ltrips_or(1,lnyr_or)
 init_vector  lsamp_or(1,lnyr_or)
 init_int     lnb_or
 init_vector  lbin_or(1,lnb_or)
 init_matrix  osc_or(1,lnyr_or,1,lnb_or)
 !! if(lnb_or!=nlength) {cout<<"THE NUMBER OF LENGTH BINS FOR OR DO NOT
MATCH WITH THE MODEL"<<endl;}

  // length frequency, Oregon, recreational, Number of years, Year, number of trips,
number of samples
 init_int     lnyr_orrec
 init_ivector lyr_orrec(1,lnyr_orrec)
 init_vector  ltrips_orrec(1,lnyr_orrec)
 init_vector  lsamp_orrec(1,lnyr_orrec)
 init_int     lnb_orrec
 init_vector  lbin_orrec(1,lnb_orrec)
 init_matrix  osc_orrec(1,lnyr_orrec,1,lnb_orrec)
 !! if(lnb_orrec!=nlength) {cout<<"THE NUMBER OF LENGTH BINS FOR ORREC
DO NOT MATCH WITH THE MODEL"<<endl;}

  // length frequency, Washington, recreational, Number of years, Year, number of trips,
number of samples
 init_int     lnyr_warec
 init_ivector lyr_warec(1,lnyr_warec)
 init_vector  ltrips_warec(1,lnyr_warec)
 init_vector  lsamp_warec(1,lnyr_warec)
 init_int     lnb_warec
 init_vector  lbin_warec(1,lnb_warec)
 init_matrix  osc_warec(1,lnyr_warec,1,lnb_warec)
 !! if(lnb_warec!=nlength) {cout<<"THE NUMBER OF LENGTH BINS FOR WAREC
DO NOT MATCH WITH THE MODEL"<<endl;}

 ivector maxindx_nsamples(1,5);
```

```
 LOCAL_CALCS //this will allow to define a ragged array
  maxindx_nsamples(1) = lnyr_ca;
  maxindx_nsamples(2) = lnyr_carec;
  maxindx_nsamples(3) = lnyr_or;
  maxindx_nsamples(4) = lnyr_orrec;
  maxindx_nsamples(5) = lnyr_warec;
 END_CALCS
  matrix nsamples(1,5,1,maxindx_nsamples) //Effective sample size for multinomial,
ragged array

  //End of file indicator
  init_int endoffile
  !!cout<<"If you see 999, we got to the end of the data imput sucessfully!
"<<endoffile<<endl;



//********CONTROLS****************************************************
****************
  //  Lets change the main datafile to a control data file for
  //  specifying controls over the estimation (range of parameters, weights of data sets,
  //  switch on and off data sets,etc.
 LOCAL_CALCS
   ad_comm::change_datafile_name("cabezon.ctl");
 END_CALCS
  init_int dummy;//dummy==1 turns off all parameters, makes determinitic projections
  int phase_dummy;

  init_int project_from_external_recs; // takes the values in ssrecs.ctl and uses them as
recruitment values

  //estimate the extra the variability around the observed abundance indices
  //(see Equation B.2, overall catchability scaling factor) yes==1, no==0
  init_int do_var;
  // 3 controls: Lower_limit, Upper_limit, phase_of_estimation
  init_number low_M;       init_number upp_M;       init_int phase_M;
  init_number low_ln_S0;   init_number upp_ln_S0;   init_int phase_ln_S0;
  init_number low_h;       init_number upp_h;       init_int phase_h;
  init_number low_c;       init_number upp_c;       init_int phase_c;
  init_number low_s2age;   init_number upp_s2age;   init_int phase_s2age;
  //Recruitment residuals:
  // 5 controls: start_year, end year,Lower_limit, Upper_limit, phase_of_estimation
          //South
  init_int start_rec; init_int end_rec;   init_number low_rec;   init_number upp_rec;
init_int phase_rec;
          //North
```

```
  init_int start_rec2; init_int end_rec2;   init_number low_rec2;   init_number upp_rec2;
init_int phase_rec2;

  ivector maxindx_priorrec(1,pop);
  ivector minindx_priorrec(1,pop);

 LOCAL_CALCS //this will allow to define a ragged array for recruitment prior
  if(pop==1)
   { //one population
    if(popID==1) {minindx_priorrec(1) = start_rec;  maxindx_priorrec(1) = end_rec;}
    if(popID==2) {minindx_priorrec(1) = start_rec2; maxindx_priorrec(1) = end_rec2;}
   }
  else
   {    //two populations
    maxindx_priorrec(1) = end_rec;
    maxindx_priorrec(2) = end_rec2;
    minindx_priorrec(1) = start_rec;
    minindx_priorrec(2) = start_rec2;
   }
 END_CALCS

  //Selectivity switch, 1 - logistic, 2 - double logistic
  //South Commercial SC, South Recreational SR, North Commercial NC, North
Recreational NR
  init_int switchSC; init_int switchSR; init_int switchNC; init_int switchNR;
  //Selectivity, option 1 - logistic
  // 3 controls: Lower_limit, Upper_limit, phase_of_estimation
  init_number low_Len50_S_com;   init_number upp_Len50_S_com;   init_int
phase_Len50_S_com;
  init_number low_LenDiff_S_com; init_number upp_LenDiff_S_com; init_int
phase_LenDiff_S_com;
  init_number low_Len50_S_rec;   init_number upp_Len50_S_rec;   init_int
phase_Len50_S_rec;
  init_number low_LenDiff_S_rec; init_number upp_LenDiff_S_rec; init_int
phase_LenDiff_S_rec;
  init_number low_Len50_N_com;   init_number upp_Len50_N_com;   init_int
phase_Len50_N_com;
  init_number low_LenDiff_N_com; init_number upp_LenDiff_N_com; init_int
phase_LenDiff_N_com;
  init_number low_Len50_N_rec;   init_number upp_Len50_N_rec;   init_int
phase_Len50_N_rec;
  init_number low_LenDiff_N_rec; init_number upp_LenDiff_N_rec; init_int
phase_LenDiff_N_rec;

  //Selectivity, option 2 - double logistic, stock synthesis parametrization
```

```
  init_int ph_sel_peak1;   init_int ph_sel_peak2;   init_int ph_sel_peak3;   init_int
ph_sel_peak4;   // phase for the ascending  peak synthesis sel option
  init_int ph_sel_init1;   init_int ph_sel_init2;   init_int ph_sel_init3;   init_int
ph_sel_init4;   // phase for the ascending init value synthesis sel option
  init_int ph_sel_infl1;   init_int ph_sel_infl2;   init_int ph_sel_infl3;   init_int
ph_sel_infl4;   // phase for the ascending inflection point synthesis sel option
  init_int ph_sel_slope1;  init_int ph_sel_slope2;  init_int ph_sel_slope3;  init_int
ph_sel_slope4;  // phase for the ascending slope synthesis sel option
  init_int ph_sel_final1;  init_int ph_sel_final2;  init_int ph_sel_final3;  init_int
ph_sel_final4;  // phase for the descending final value synthesis sel option
  init_int ph_sel_infl2_1; init_int ph_sel_infl2_2; init_int ph_sel_infl2_3; init_int
ph_sel_infl2_4; // phase for the descending inflection synthesis sel option
  init_int ph_sel_slope2_1;init_int ph_sel_slope2_2;init_int ph_sel_slope2_3;init_int
ph_sel_slope2_4;// phase for the descending slope synthesis sel option

  !!cout<<phase_ln_S0<<endl;

  //CHANGE this does not need to be integer
  init_vector surv_lambda(1,9)
  init_vector length_lambda(1,5)
  init_number lambda_rec
  init_ivector effective(1,5)// switch to use 0 - number of trips or number of anglers or  1
to use number of samples,
                  // or another value that will then be used as the effective sample size for all
the
                  // years...
  init_int Do_rec_Bias;
  !!cout << Do_rec_Bias << endl;

   //effective sample size for multinomial, maximum index for each row of the ragged
array "nsamples"
 LOCAL_CALCS
   if (effective(1) == 0)
    nsamples(1) =  ltrips_ca;
   else if (effective(1) == -1)
    nsamples(1) = lsamp_ca;
   else
    nsamples(1) = effective(1);
   if (effective(2) == 0)
    nsamples(2) =  langl_carec;
   else if (effective(2) == -1)
    nsamples(2) = lsamp_carec;
   else
    nsamples(2) = effective(2);
   if (effective(3) == 0)
    nsamples(3) =  ltrips_or;
```

```
  else if (effective(3) == -1)
   nsamples(3) = lsamp_or;
  else
   nsamples(3) = effective(3);
  if (effective(4) == 0)
   nsamples(4) =  ltrips_orrec;
  else if (effective(4) == -1)
   nsamples(4) = lsamp_orrec;
  else
   nsamples(4) = effective(4);
  if (effective(5) == 0)
   nsamples(5) =  ltrips_warec;
  else if (effective(1) == -1)
   nsamples(5) = lsamp_warec;
  else
   nsamples(5) = effective(5);

 if (switchSC == 1)
  { ph_sel_peak1 = -1; ph_sel_init1 = -1; ph_sel_infl1 = -1; ph_sel_slope1 = -1;
ph_sel_final1 = -1; ph_sel_infl2_1 = -1; ph_sel_slope2_1 = -1; }
 if (switchSC == 2)
  { phase_Len50_S_com = -1; phase_LenDiff_S_com = -1; }
 if (switchSR == 1)
  { ph_sel_peak2 = -1; ph_sel_init2 = -1; ph_sel_infl2 = -1; ph_sel_slope2 = -1;
ph_sel_final2 = -1; ph_sel_infl2_2 = -1; ph_sel_slope2_2 = -1; }
 if (switchSR == 2)
  { phase_Len50_S_rec = -1; phase_LenDiff_S_rec = -1; }
 if (switchNC == 1)
  { ph_sel_peak3 = -1; ph_sel_init3 = -1; ph_sel_infl3 = -1; ph_sel_slope3 = -1;
ph_sel_final3 = -1; ph_sel_infl2_3 = -1; ph_sel_slope2_3 = -1; }
 if (switchNC == 2)
  { phase_Len50_N_com = -1; phase_LenDiff_N_com = -1; }
 if (switchNR == 1)
  { ph_sel_peak4 = -1; ph_sel_init4 = -1; ph_sel_infl4 = -1; ph_sel_slope4 = -1;
ph_sel_final4 = -1; ph_sel_infl2_4 = -1; ph_sel_slope2_4 = -1; }
 if (switchNR == 2)
  { phase_Len50_N_rec = -1; phase_LenDiff_N_rec = -1; }


 //Turn off all the parameters if debbuging is on.
 if (dummy==1 || project_from_external_recs==1)
 {
  phase_dummy = 1;
  phase_Len50_S_com  =-1; phase_Len50_S_rec  =-1; phase_Len50_N_com  =-1;
phase_Len50_N_rec  =-1;
```

```
   phase_LenDiff_S_com=-1; phase_LenDiff_S_rec=-1; phase_LenDiff_N_com=-1;
phase_LenDiff_N_rec=-1;
   ph_sel_peak1      =-1; ph_sel_peak2      =-1; ph_sel_peak3      =-1; ph_sel_peak4 =-1;
   ph_sel_init1      =-1; ph_sel_init2      =-1; ph_sel_init3      =-1; ph_sel_init4 =-1;
   ph_sel_infl1      =-1; ph_sel_infl2      =-1; ph_sel_infl3      =-1; ph_sel_infl4 =-1;
   ph_sel_slope1     =-1; ph_sel_slope2     =-1; ph_sel_slope3     =-1; ph_sel_slope4 =-1;
   ph_sel_final1     =-1; ph_sel_final2     =-1; ph_sel_final3     =-1; ph_sel_final4 =-1;
   ph_sel_infl2_1    =-1; ph_sel_infl2_2    =-1; ph_sel_infl2_3    =-1; ph_sel_infl2_4 =-
1;
   ph_sel_slope2_1   =-1; ph_sel_slope2_2   =-1; ph_sel_slope2_3   =-1;
ph_sel_slope2_4 =-1;
   phase_M           =-6; phase_ln_S0       =-1; phase_h           =-5; phase_c=-6;
   phase_s2age       =-6; phase_rec         =-3; phase_rec2        =-3;
  }

  //Turn off the dummy_par is the debugging is off, o/w the hessian will have a 0
  if (dummy==0)  phase_dummy=-1;
  if (project_from_external_recs==1) phase_dummy=1;

  cout<<"phase_ln_S0: "<<phase_ln_S0<<endl;

  //Assessment of one population at a time only
  // Special features for South
  if (pop==1 && popID==1)
   {
    phase_rec2=-5;phase_c = -6;
    phase_Len50_N_com=-3;  phase_LenDiff_N_com=-4; phase_Len50_N_rec=-3;
phase_LenDiff_N_rec=-4;
    ph_sel_peak3     =-1;  ph_sel_peak4           =-1;
    ph_sel_init3     =-1;  ph_sel_init4     =-1;
    ph_sel_infl3     =-1;  ph_sel_infl4     =-1;
    ph_sel_slope3    =-1;  ph_sel_slope4   =-1;
    ph_sel_final3    =-1;  ph_sel_final4   =-1;
    ph_sel_infl2_3   =-1;  ph_sel_infl2_4  =-1;
    ph_sel_slope2_3  =-1;  ph_sel_slope2_4 =-1;
    surv_lambda(5)   = 0;  surv_lambda(6)  = 0;    surv_lambda(8) = 0;
    length_lambda(3) = 0; length_lambda(4) = 0;  length_lambda(5) = 0;
   }

  // Special features for North
  if (pop==1 && popID==2)
   {
    phase_c = -6; phase_rec=-5;
    phase_Len50_S_com=-3; phase_LenDiff_S_com=-4; phase_Len50_S_rec=-3;
phase_LenDiff_S_rec=-4;
    ph_sel_peak1     =-1; ph_sel_peak2          =-1;
```

```
   ph_sel_init1     =-1; ph_sel_init2    =-1;
   ph_sel_infl1     =-1; ph_sel_infl2    =-1;
   ph_sel_slope1    =-1; ph_sel_slope2          =-1;
   ph_sel_final1    =-1; ph_sel_final2 =-1;
   ph_sel_infl2_1   =-1; ph_sel_infl2_2 =-1;
   ph_sel_slope2_1  =-1; ph_sel_slope2_2 =-1;
   surv_lambda(1)   = 0; surv_lambda(2) = 0;    surv_lambda(3) = 0;
   surv_lambda(4)   = 0; surv_lambda(7) = 0;    surv_lambda(9) = 0;
   length_lambda(1) = 0;  length_lambda(2)= 0;
  }
 END_CALCS
  //!!cout<<"controls"<<start_rec<<","<<low_rec","<<upp_rec<<","<<phase_rec<<endl;

  init_int fim // end of file indicator
  !!cout<<"If you see 999, we got to the end of the control file sucessfully!
"<<fim<<endl;

 //HERE: new, read in SS recruitment just to check the projections

 LOCAL_CALCS
   if (project_from_external_recs==1)
    ad_comm::change_datafile_name("ssrecs.ctl");
 END_CALCS
 !! if (project_from_external_recs==1)
 init_vector ssrecs(styr,endyr)


//*********COUNTERS*****************************************************
****************
  // All counters are declared globally (here) in this version
  int z // counters for size
  int l
  int g // counter for gender
  int a // counter for ages
  int p // counter for populations
  int t // counter for time
  int i
  int j
  int f // counter for fleet

 //
*=============================================================
===========*


PARAMETER_SECTION
```

```
  // remember: init_bounded_number(lower limit, upper limit, phase of estimation)
  // Dummy parameter for debugging (if dummy== 1, then turn all the parameters off)
  init_number dummy_par(phase_dummy)

   //recruitment and initial conditions
  init_bounded_number M(low_M,upp_M,phase_M)
  init_bounded_number ln_S0(low_ln_S0,upp_ln_S0,phase_ln_S0)
  init_bounded_number h_steep(low_h,upp_h,phase_h)
  init_bounded_number c(low_c,upp_c,phase_c)
  init_bounded_number sigmasq_rec(low_s2age,upp_s2age,phase_s2age)
  init_bounded_dev_vector rec_dev1(start_rec,end_rec,low_rec,upp_rec,phase_rec) //
recruitrment residuals population 1
  init_bounded_dev_vector rec_dev2(start_rec2,end_rec2,low_rec2,upp_rec2,phase_rec2)
// recruitment residuals population 2

  number S0
  vector S0_pop(1,pop)
  vector R0_pop(1,pop)
  matrix log_R0_pop(1,pop,1,gender)
  matrix Spbio(1,pop,styr,endyr)        //Spawning biomass
  matrix exp_rec(1,pop,minindx_priorrec,maxindx_priorrec) //expected value for
recruitment (deterministic)
  matrix pred_rec(1,pop,minindx_priorrec,maxindx_priorrec) //predicted value for
recruitment (stochastic)

  //likelihood profile numbers
  likeprof_number S0_lprof
  //likeprof_number h_steep_lprof

  4darray natage(styr,endyr,1,pop,1,gender,0,nages)
  5darray catage(styr,endyr,1,pop,1,fleet,1,gender,0,nages) // 5 dimensions!
  4darray catage_tot(styr,endyr,1,pop,1,gender,0,nages)//sum the catches for all fleets
  3darray Hrate(1,pop,1,fleet,styr,endyr) //Harvest Rate for each fleet

  // selectivity  option 1, sel at length by population and fleet, logistic -
  // South Commercial
  init_bounded_number
Len50_S_com(low_Len50_S_com,upp_Len50_S_com,phase_Len50_S_com)
  init_bounded_number
LenDiff_S_com(low_LenDiff_S_com,upp_LenDiff_S_com,phase_LenDiff_S_com)
  // South Recreational
  init_bounded_number
Len50_S_rec(low_Len50_S_rec,upp_Len50_S_rec,phase_Len50_S_rec)
  init_bounded_number
LenDiff_S_rec(low_LenDiff_S_rec,upp_LenDiff_S_rec,phase_LenDiff_S_rec)
  // North Commercial
```

```
  init_bounded_number
Len50_N_com(low_Len50_N_com,upp_Len50_N_com,phase_Len50_N_com)
  init_bounded_number
LenDiff_N_com(low_LenDiff_N_com,upp_LenDiff_N_com,phase_LenDiff_N_com)
  // North Recreational
  init_bounded_number
Len50_N_rec(low_Len50_N_rec,upp_Len50_N_rec,phase_Len50_N_rec)
  init_bounded_number
LenDiff_N_rec(low_LenDiff_N_rec,upp_LenDiff_N_rec,phase_LenDiff_N_rec)

  //selectivity option 2 - sel at length double logistic, stock synthesis parametrizatin
  // South Commercial SC
  init_bounded_number  sel_peak_SC(1,nlength,ph_sel_peak1);
  init_bounded_number  sel_init_SC(0.000001,1,ph_sel_init1);
  init_bounded_number  sel_infl_SC(1,nlength,ph_sel_infl1);
  init_number          sel_slope_SC(ph_sel_slope1);
  init_bounded_number  sel_final_SC(0.000001,1,ph_sel_final1);
  init_bounded_number  sel_infl2_SC(1,nlength,ph_sel_infl2_1);
  init_number          sel_slope2_SC(ph_sel_slope2_1);
  //South Recreational SR
  init_bounded_number  sel_peak_SR(1,nlength,ph_sel_peak2);
  init_bounded_number  sel_init_SR(0.000001,1,ph_sel_init2);
  init_bounded_number  sel_infl_SR(1,nlength,ph_sel_infl2);
  init_number          sel_slope_SR(ph_sel_slope2);
  init_bounded_number  sel_final_SR(0.000001,1,ph_sel_final2);
  init_bounded_number  sel_infl2_SR(1,nlength,ph_sel_infl2_2);
  init_number          sel_slope2_SR(ph_sel_slope2_2);
  //North Commercial NC
  init_bounded_number  sel_peak_NC(1,nlength,ph_sel_peak3);
  init_bounded_number  sel_init_NC(0.000001,1,ph_sel_init3);
  init_bounded_number  sel_infl_NC(1,nlength,ph_sel_infl3);
  init_number          sel_slope_NC(ph_sel_slope3);
  init_bounded_number  sel_final_NC(0.000001,1,ph_sel_final3);
  init_bounded_number  sel_infl2_NC(1,nlength,ph_sel_infl2_3);
  init_number          sel_slope2_NC(ph_sel_slope2_3);
  //North REcreational NR
  init_bounded_number  sel_peak_NR(1,nlength,ph_sel_peak4);
  init_bounded_number  sel_init_NR(0.000001,1,ph_sel_init4);
  init_bounded_number  sel_infl_NR(1,nlength,ph_sel_infl4);
  init_number          sel_slope_NR(ph_sel_slope4);
  init_bounded_number  sel_final_NR(0.000001,1,ph_sel_final4);
  init_bounded_number  sel_infl2_NR(1,nlength,ph_sel_infl2_4);
  init_number          sel_slope2_NR(ph_sel_slope2_4);


  // Selectivity-related parameters
```

```
  3darray sel(1,pop,1,fleet,1,nlength)
  4darray sel_age(1,pop,1,fleet,1,gender,0,nages) //selectivity at age= multiplication of the
age_length_key by the selectivity at length
  4darray sel_wt_age(1,pop,1,fleet,1,gender,0,nages) // multiplication of sel at age and
weigth at age

  //catchabilities and observation error variances

  // Q and sigmas - we are going to calculate the MLE' fo those, no need to declared them
as init parameters
  // one q and sigma for each data set
  number    log_q_cr_ca
  number    log_q_cr_ca2
  number    log_q_cr_ca3
  number    log_q_cr_ca4
  number    log_q_cr_or
  number    log_q_cr_wa
  number    log_q_sp_ca
  number    log_q_sp_nth
  number    log_q_imp_ca

  // this is only the estimable part of the variability of q
  //(see Equation B.2, overall catchability scaling factor)
  number    s2_cr_ca
  number    s2_cr_ca2
  number    s2_cr_ca3
  number    s2_cr_ca4
  number    s2_cr_or
  number    s2_cr_wa
  number    s2_sp_ca
  number    s2_sp_nth
  number    s2_imp_ca

   // this is the parameter times the observed variability , Equation B.2
   // standard deviation of the fluctuations in log(catchability)
  vector sd_cr_ca(1,nyr_cr_ca)
  vector sd_cr_ca2(1,nyr_cr_ca2)
  vector sd_cr_ca3(1,nyr_cr_ca3)
  vector sd_cr_ca4(1,nyr_cr_ca4)
  vector sd_cr_or(1,nyr_cr_or)
  vector sd_cr_wa(1,nyr_cr_wa)
  vector sd_sp_ca(1,nyr_sp_ca)
  vector sd_sp_nth(1,nyr_sp_nth)
  vector sd_imp_ca(1,nyr_imp_ca)
```

```
    //expected values for each index
  vector exp_cr_ca(1,nyr_cr_ca)
  vector exp_cr_ca2(1,nyr_cr_ca2)
  vector exp_cr_ca3(1,nyr_cr_ca3)
  vector exp_cr_ca4(1,nyr_cr_ca4)
  vector exp_cr_or(1,nyr_cr_or)
  vector exp_cr_wa(1,nyr_cr_wa)
  vector exp_sp_ca(1,nyr_sp_ca)
  vector exp_sp_nth(1,nyr_sp_nth)
  vector exp_imp_ca(1,nyr_imp_ca)

  // Expected length-frequency, the length dimension is the SAME as the model AND
  // the same as in the data if so specified, otherwise an error will be produced ("array out
of bounds")
  //  when calculating the likelihood we pick the right values
  matrix esc_ca(1,lnyr_ca,1,nlength)
  matrix esc_carec(1,lnyr_carec,1,nlength)
  matrix esc_or(1,lnyr_or,1,nlength)
  matrix esc_orrec(1,lnyr_orrec,1,nlength)
  matrix esc_warec(1,lnyr_warec,1,nlength)

  matrix neffective(1,5,1,maxindx_nsamples) //Estimated effective sample size for
multinomial, ragged array
                                            //See McAllister & Ianelli 1997 Appendix 2 for
derivation

  vector offset(1,5) // Compute OFFSET for multinomial (i.e, value for the multinonial
function
          // for a perfect fit, or observed length frequency equal expected length
frequency

  vector surv_like(1,9) // likelihood of the indices
  vector length_like(1,5)  // likelihood of the length-frequency data
  number prior_rec
  number CrashPen;

  objective_function_value obj_fun
  !!cout<<"end of parameter section"<<endl;

  sdreport_number Depl;

//
*==================================================================
===========*

PRELIMINARY_CALCS_SECTION
```

```
 //Reset
//This will guarantee that the vectors are set = 0  at the beginning of the run
catch_bio.initialize();age_length_pop1.initialize();age_length_pop2.initialize();
wt_age.initialize();wt_age_middle.initialize();mat_age.initialize(); offset.initialize();

//CATCHES
  //one population
if (pop==1 && popID==1 ) //South
     catch_bio(1) = catch_bio1;
if (pop==1 && popID==2 ) //North
     catch_bio(1) = catch_bio2;
if (pop==2)
    { catch_bio(1) = catch_bio1;
      catch_bio(2) = catch_bio2;}
 //GROWTH
for (g=1;g<=gender;g++)
 {
   age_length_pop1(g) =
SizeTrans(Lmin(1,g),Lmax(1,g),K(1,g),CVLmin(1,g),CVLmax(1,g),1);// 0 means
beginning of the year length
   age_length_pop2(g) =
SizeTrans(Lmin(2,g),Lmax(2,g),K(2,g),CVLmin(2,g),CVLmax(2,g),1); // 1 means
middle of the year
 }

// wt_input(1) is beginning of the year weight, wt_input(2) is middle of the year weight,
from age 0 to nages
for (g=1;g<=gender;g++)
 for (a=0;a<=nages;a++)
  {wt_age(g,a) = wt_input(1,g,a);
   wt_age_middle(g,a)=wt_input(2,g,a);}

// MATURITY at age is being calculated from the parameters provided in the data input
mat_age(0)=0;
for (a=1;a<=nages;a++)
 mat_age(a)= 1/(1 + mfexp(mat_intercept + (mat_slope*age_vector(a))));

// relative FECUNDITY age, is the product of the maturity at age and the weight at age
//for the females (g=1) at the beginning pf the year
fec = elem_prod(wt_age(1),mat_age);

// Compute OFFSET for multinomial (i.e, value for the multinonial function for a
perfect fit, osc=esc)---------
for (i=1; i <= lnyr_ca; i++)
{ osc_ca(i)=osc_ca(i)/sum(osc_ca(i));
   offset(1) -= nsamples(1,i) *(osc_ca(i))*log(0.0001+osc_ca(i)); }
```

```
  for (i=1; i <= lnyr_carec; i++)
  { osc_carec(i)=osc_carec(i)/sum(osc_carec(i));
     offset(2) -= nsamples(2,i) *(osc_carec(i))*log(0.0001+osc_carec(i)); }

  for (i=1; i <= lnyr_or; i++)
  { osc_or(i)=osc_or(i)/sum(osc_or(i));
     offset(3) -= nsamples(3,i) *(osc_or(i))*log(0.0001+osc_or(i)); }

  for (i=1; i <= lnyr_orrec; i++)
  { osc_orrec(i)=osc_orrec(i)/sum(osc_orrec(i));
     offset(4) -= nsamples(4,i) *(osc_orrec(i))*log(0.0001+osc_orrec(i)); }

  for (i=1; i <= lnyr_warec; i++)
  { osc_warec(i)=osc_warec(i)/sum(osc_warec(i));
     offset(5) -= nsamples(5,i) *(osc_warec(i))*log(0.0001+osc_warec(i)); }

  cout << "offset" << endl << offset << endl;
  if (dummy==1)
     {cout<<endl<<endl<<endl<<"Debugging is on, no parameters are being
estimated"<<endl;
      cout<<"model being projected using pin file values"<<endl<<endl<<endl;}
  else
     {cout<<endl<<endl<<endl<<"Estimating...please wait..."<<endl;
      if (do_var==0) cout<<endl<<"Please note: extra variability around observations is not
been estimated"<<endl;}

//
*=============================================================
===========*

PROCEDURE_SECTION

  // Reset the crash penalty
  CrashPen = 0;

  // selectivity does not change over time, it can be compute only once in each iteration
  get_selectivity(); // cout<<"end of get selectivity"<<endl;

  get_initial_conditions(); // cout<<"end of get initial conditions"<<endl;

  get_numbers_at_age();  //cout<<"end of get numbers at age"<<endl;

   //compute the penalty used for the recruitment residuals
  get_recruitment_prior();   // cout<<"end of get recruitment prior"<<endl;
```

```
 // compute the expected values for the indices and the length frequency
 // compute likelihood functions and include all  in the obj_fun
 get_predictions();
 evaluate_the_objective_function();

 Depl = Spbio(1,2003)/Spbio(1,styr)*100;


 if (mceval_phase())
  {
   cout << obj_fun << " " << Depl << " " << ln_S0 << " ";
   cout << Len50_S_com << " " << LenDiff_S_com << " " << Len50_S_rec << " " <<
LenDiff_S_rec << " "
        << Len50_N_com << " " << LenDiff_N_com << " " << Len50_N_rec << " " <<
LenDiff_N_rec << " ";
   cout  << rec_dev1 << " ";
   if (pop==2) cout << rec_dev2 << " ";
   if (pop==1) cout << Spbio(1) << endl;
   if (pop==2) cout << Spbio(1) << " " << Spbio(2) << endl;
  }


//==============================================================
==========================

FUNCTION get_recruitment_prior
 dvariable chi,tmp;

 //The recruitment prior is assumed to be a lognormal pdf with expected
 // value equal to the deterministic stock-recruitment curve
 chi = 0;
 for (p=1;p<=pop;p++)
  if ((p==1 && phase_rec > 0) || (p==2 && phase_rec2 > 0))
   for (i=minindx_priorrec(p);i<=maxindx_priorrec(p);i++)
    {
     if (Do_rec_Bias==1)
      tmp = log( (exp_rec(p,i)+1e-8)/(pred_rec(p,i)+1e-8)) + sigmasq_rec/2;
     else
      tmp = log( (exp_rec(p,i)+1e-8)/(pred_rec(p,i)+1e-8));
     chi += square(tmp)/(2*sigmasq_rec) + log(sqrt(sigmasq_rec));
    }
 prior_rec = chi;

 if (!last_phase() ) // Recruitment variability: EARLY PHASES ONLY
  {
   if(pop==2 || popID==1) prior_rec += 1. * norm2(rec_dev1);//South
```

```
   if(pop==2 || popID==2) prior_rec += 1. * norm2(rec_dev2);//North
  }

  // Adjust to weight
  prior_rec *= lambda_rec ;

//=============================================================
=====================

FUNCTION get_numbers_at_age
  dvariable vul_bio=0.0;                       // Vulnerable biomass
  dvariable harvest_rate=0.0;                   // Harvest rate
  dvariable Spaw_bio=0.0;                       // Spawning biomass
  dvariable Recruits=0.0;                      // Age0 Recruits

  // Reset variables
  catage.initialize();  catage_tot.initialize();
  //h_steep_lprof = h_steep; //for likelihood profile

  //loop over populations
  for (p=1;p<=pop;p++)
   {
    //loop over time
    for (t=styr;t<=endyr-1;t++)
     {

      //loop over fleets
      //In this loop get the harvest rate and catch at age --------------------------------------
      catage_tot(t,p)=0.0;
      for (f=1;f<=fleet;f++)
       {
        harvest_rate = 0.0; //reset
           if (catch_bio(p,f,t) > 0)
         {
          // vul_bio for each fleet, need this to calculate the harvest rate (Equation B.6)
          vul_bio = 0.0;
          for (g=1;g<=gender;g++)
           vul_bio += (natage(t,p,g)*mfexp(-M/2))*sel_wt_age(p,f,g);//HERE: I inserted "*
mfexp(-M/2)"

          // Compute the harvest rate and store it
          if (vul_bio > catch_bio(p,f,t))
            harvest_rate = catch_bio(p,f,t)/vul_bio;
          else
            {
             harvest_rate = 0.99 ;
```

```
            CrashPen += 100;
           }
         Hrate(p,f,t) = harvest_rate;

         // Compute the predicted catch at age
         for (g=1;g<=gender;g++)
          {
           catage(t,p,f,g) = harvest_rate* elem_prod( (natage(t,p,g)*mfexp(-M/2) )
,sel_age(p,f,g));//HERE: I inserted "* mfexp(-M/2)"
           for (a=1;a<=nages;a++)
            if (catage(t,p,f,g,a)<=0.0) {catage(t,p,f,g,a) = 0.0;}  // avoid negative catches
           catage_tot(t,p,g) += catage(t,p,f,g);                  //catch at age for all fleets, this is
summing the two fleets
          }
        }
           else
        Hrate(p,f,t) = 0.0;

       } //end fleet loop

      // Update the dynamics------------------------------------------------------------------------
      for (g=1;g<=gender;g++)
       {
        // Recruitment (by gender)
        natage(t+1,p,g,0) = 0;

        // the rest of the ages (Equation A.1)
        for (a=1;a<nages;a++)
         natage(t+1,p,g,a) = natage(t,p,g,a-1)*mfexp(-M)-catage_tot(t,p,g,a-1)*mfexp(-
M/2);

        // plus group (Equation A.1)
        natage(t+1,p,g,nages) = natage(t,p,g,nages-1)*mfexp(-M) - catage_tot(t,p,g,nages-
1)*mfexp(-M/2);
        natage(t+1,p,g,nages) += natage(t,p,g,nages)*mfexp(-M) -
catage_tot(t,p,g,nages)*mfexp(-M/2);

        // now make sure all numbers at age are above 0
        for (a=0;a<=nages;a++)
         if (natage(t+1,p,g,a)<=0.0) {natage(t+1,p,g,a) = 0.0;}
       }

      // Compute the spawning biomass (males and females)-------------------------------------
----
      Spaw_bio = 0.0;
      Spaw_bio = fec*natage(t+1,p,1); // + fec*natage(t+1,p,2);   //no males
```

```
     if (Spaw_bio < 0.0) {Spaw_bio= 0.0;}
     Spbio(p,t+1) = Spaw_bio;                    //store it for the report

     // Compute recruitment-----------------------------------------------------------------------
     // deterministic
     if (project_from_external_recs==1) Recruits=ssrecs(t);
     else
     Recruits =  (4*h_steep*R0_pop(p)*Spaw_bio) / ((S0_pop(p)/gender)*(1-
h_steep)+(5*h_steep-1)*Spaw_bio) ; //deterministic

     // add stochastics bits and store the quantities we need for the recruitment prior
     if ( (pop == 2 && p == 1) || pop == 1 && popID == 1)
      if (t+1 >= start_rec && t+1 <=end_rec)
        {
         exp_rec(p,t+1)  = Recruits;               //store deterministic
         Recruits = Recruits*mfexp(rec_dev1(t+1));
         pred_rec(p,t+1) = Recruits;               //store stochastic
        }

      if ( (pop == 2 && p == 2) || pop == 1 && popID == 2)
       if (t+1 >= start_rec2 && t+1 <= end_rec2)
        {
         exp_rec(p,t+1)  = Recruits;
         Recruits = Recruits*mfexp(rec_dev2(t+1));
         pred_rec(p,t+1) = Recruits;
        }

     // Recruitment (by gender)
     for (g=1;g<=gender;g++)
      natage(t+1,p,g,0) =  Recruits/gender;

    } //close time loop
  } //close population loop

//==============================================================
===================

FUNCTION get_selectivity
  int Ip;

  //Reset variables
  sel.initialize(); sel_age.initialize();sel_wt_age.initialize();

  //----------------------------Selectivity at length------------------------------
    // South options
  if(pop==2 || popID == 1)
```

```
 {
  if (switchSC==1) //logistic
   sel(1,1) = 1/(1+mfexp(-log(19)*(size_vector-Len50_S_com)/LenDiff_S_com));
  else           //double logistic
   sel(1,1) = DoubLogistic(sel_peak_SC, sel_init_SC,sel_infl_SC,
                          sel_slope_SC, sel_final_SC,sel_infl2_SC,sel_slope2_SC);
  if (switchSR==1)
   sel(1,2) = 1/(1+mfexp(-log(19)*(size_vector-Len50_S_rec)/LenDiff_S_rec));
  else
   sel(1,2) = DoubLogistic(sel_peak_SR, sel_init_SR,sel_infl_SR,
                          sel_slope_SR, sel_final_SR,sel_infl2_SR,sel_slope2_SR);
 }

if(pop==2 || popID == 2)
 {
  if (pop==1) Ip = 1; else Ip = 2;

  if (switchNC==1) //logistic
   sel(Ip,1) = 1/(1+mfexp(-log(19)*(size_vector-Len50_N_com)/LenDiff_N_com));
  else          //double logistic
   sel(Ip,1) = DoubLogistic(sel_peak_NC, sel_init_NC,sel_infl_NC,
                          sel_slope_NC, sel_final_NC,sel_infl2_NC,sel_slope2_NC);
  if (switchNR==1)
   sel(Ip,2) = 1/(1+mfexp(-log(19)*(size_vector-Len50_N_rec)/LenDiff_N_rec));
  else
   sel(Ip,2) = DoubLogistic(sel_peak_NR, sel_init_NR,sel_infl_NR,
                          sel_slope_NR, sel_final_NR,sel_infl2_NR,sel_slope2_NR);
 }

//--------------Selectivity at age, is the selectivity at length times the Age-Length Key
//  sel_wt_age is the selectivity at age times the weight at age at the middle of the year
if (pop==2 || popID == 1)
 {
  for (f=1;f<=fleet;f++)
   for(g=1;g<=gender;g++)
    {
     for (a=0;a<=nages;a++)
      sel_age(1,f,g,a)= sel(1,f)*age_length_pop1(g,a);
     sel_wt_age(1,f,g) = elem_prod(sel_age(1,f,g), wt_age_middle(g));
    }
 }
if (pop==2 || popID == 2)
 {
  if (pop==1) Ip = 1; else Ip = 2;

  for (f=1;f<=fleet;f++)
```

```
    for(g=1;g<=gender;g++)
     {
      for (a=0;a<=nages;a++)
       sel_age(Ip,f,g,a)= sel(Ip,f)*age_length_pop2(g,a);
      sel_wt_age(Ip,f,g) = elem_prod(sel_age(Ip,f,g), wt_age_middle(g));
     }
  }

//=============================================================
=======

FUNCTION get_initial_conditions
  dvariable sum_fec=0.0;

  // reset
  S0_pop.initialize(); natage.initialize();
  //Virgin_Recruitment (by population)
  S0 = mfexp(ln_S0);

  S0_lprof = S0; //for likelihood profile

  if(pop == 1) // assessment of one population
    S0_pop(1) = S0;
  else          // assessment of two populations
    { S0_pop(1) = c*S0; S0_pop(2) = (1-c)*S0; }

  //Calculate R0 from S0 and fecundity at age
  for (p=1;p<=pop;p++)
   {
    sum_fec = fec(nages)*mfexp(-M*double(nages))/(1-mfexp(-M));
    for (a=1;a<nages;a++)
     sum_fec  += fec(a)*mfexp(-M*double(age_vector(a)));
    R0_pop(p) = S0_pop(p)/sum_fec;
    Spbio(p,styr) = S0_pop(p)/gender;
   }

  //Allocate half of the recruitment for each gender
  for (g=1;g<=gender;g++)
   {
    for (p=1;p<=pop;p++)
     if (R0_pop(p) > 0)
      log_R0_pop(p,g)= log (R0_pop(p)/gender);
     else
      log_R0_pop(p,g) = 0.0;
   }
```

```
  //Initial age structure
  for (p=1;p<=pop;p++)
   for (g=1;g<=gender;g++)
   {
    if(project_from_external_recs==1)  {
     natage(styr,p,g,0) =ssrecs(styr)/2;
     for (j=1;j<=nages-1;j++)
      natage(styr,p,g,j) =  (ssrecs(styr)/2)*mfexp(-M*double(j));
     natage(styr,p,g,nages) =( (ssrecs(styr)/2) * mfexp(-M*double(nages)) )/(1-mfexp(-
M));}

    else {
     natage(styr,p,g,0) = mfexp(log_R0_pop(p,g));
     for (j=1;j<=nages-1;j++)
      natage(styr,p,g,j) = mfexp(log_R0_pop(p,g)-M*double(j));
     natage(styr,p,g,nages) = (mfexp(log_R0_pop(p,g)-M*double(nages)))/(1-mfexp(-
M));}
   }

//
==========================================================
===============

FUNCTION get_predictions
  int iyr,Ip;

  // Clear the effective population size
  neffective.initialize();

  //--------------SOUTH--------<><-------<><---------
  if(pop==2 || popID==1)
  { // SEE HERE ----------- predictions for abundance indices -----------------

   //catch-rate data (CA)
   log_q_cr_ca = 0;
   for (i=1;i<=nyr_cr_ca;i++)
    {
     exp_cr_ca(i)  = 0.0;
     for (g=1;g<=gender;g++)
      exp_cr_ca(i) += sel_wt_age(1,1,g) * ( mfexp(-M/2)* natage(yr_cr_ca(i),1,g) -
catage(yr_cr_ca(i),1,1,g) );
     if (exp_cr_ca(i)<=0) exp_cr_ca(i)= 0.001;
     log_q_cr_ca += log(obs_cr_ca(i)/exp_cr_ca(i))/square(cv_cr_ca(i));
    }
   // MLE for ln(q) and sigma
   log_q_cr_ca /= sum( pow(cv_cr_ca, -2) );
```

```
  if (do_var==1){
    s2_cr_ca    = sum( pow( elem_div( (log(obs_cr_ca) -log(exp_cr_ca) - log_q_cr_ca) ,
cv_cr_ca) , 2) );
    s2_cr_ca    = sqrt (s2_cr_ca/nyr_cr_ca);
    sd_cr_ca    = s2_cr_ca * cv_cr_ca ;}
   else sd_cr_ca    =  cv_cr_ca;

  // Catch-rate data (CA4)
  log_q_cr_ca4 = 0;
  for (i=1;i<=nyr_cr_ca4;i++)
   {
    exp_cr_ca4(i)  = 0.0;
    for (g=1;g<=gender;g++)
     exp_cr_ca4(i) += sel_wt_age(1,2,g) * ( (mfexp(-M/2)* natage(yr_cr_ca4(i),1,g)) -
catage(yr_cr_ca4(i),1,2,g) );
    if (exp_cr_ca4(i)<=0) exp_cr_ca4(i)= 0.001;
    log_q_cr_ca4 += log(obs_cr_ca4(i)/exp_cr_ca4(i))/square(cv_cr_ca4(i));
   }
  // MLE for ln(q) and sigma
  log_q_cr_ca4 /= sum( pow(cv_cr_ca4, -2) );
  if (do_var==1){
    s2_cr_ca4    = sum( pow( elem_div( (log(obs_cr_ca4) - log(exp_cr_ca4) -
log_q_cr_ca4) , cv_cr_ca4) , 2) );
    s2_cr_ca4    = sqrt (s2_cr_ca4/nyr_cr_ca4);
    sd_cr_ca4    = s2_cr_ca4 * cv_cr_ca4 ; }
  else sd_cr_ca4    = cv_cr_ca4 ;

  // spawning stock size indices, ATTENTION: the index in year t is proportional to the
spawning stock size in year t-1, Equation B.7
  log_q_sp_ca = 0;
  for (i=1;i<=nyr_sp_ca;i++)
   {
    exp_sp_ca(i)  = 0.0;
    for (g=1;g<=gender;g++)
     exp_sp_ca(i) +=fec*natage((yr_sp_ca(i)-1),1,g);
    if (exp_sp_ca(i) <=0 ) exp_sp_ca(i)= 0.001;
    log_q_sp_ca += log(obs_sp_ca(i)/exp_sp_ca(i))/square(cv_sp_ca(i));
   }
  // MLE for ln(q) and sigma
  log_q_sp_ca /= sum( pow(cv_sp_ca, -2) ) ;
  if (do_var==1){
    s2_sp_ca    = sum( pow( elem_div( (log(obs_sp_ca) -log(exp_sp_ca) - log_q_sp_ca) ,
cv_sp_ca) , 2) );
    s2_sp_ca    = sqrt (s2_sp_ca / nyr_sp_ca);
    sd_sp_ca    = s2_sp_ca*cv_sp_ca ; }
  else sd_sp_ca    = cv_sp_ca ;
```

```
//recruitment index
log_q_imp_ca = 0;
for (i=1;i<=nyr_imp_ca;i++)
 {
  exp_imp_ca(i)  = 0.0;
  for (g=1;g<=gender;g++)
   exp_imp_ca(i) += natage(yr_imp_ca(i),1,g,0) + ( 0.5 * natage(yr_imp_ca(i),1,g,1) ) ;
  if (exp_imp_ca(i)<=0) exp_imp_ca(i)= 0.001;
  log_q_imp_ca += log(obs_imp_ca(i)/exp_imp_ca(i))/square(cv_imp_ca(i));
 }
// MLE for ln(q) and sigma
log_q_imp_ca /= sum( pow(cv_imp_ca, -2) ) ;
if (do_var==1){
  s2_imp_ca    = sum( pow( elem_div( (log(obs_imp_ca) -log(exp_imp_ca) -
log_q_imp_ca) , cv_imp_ca) , 2) );
  s2_imp_ca    = sqrt (s2_imp_ca / nyr_imp_ca);
  sd_imp_ca    = s2_imp_ca * cv_imp_ca ; }
else sd_imp_ca    = cv_imp_ca ;

//---------------predictions for length frequency----------------------
// California Commercial
for (i=1;i<=lnyr_ca;i++) //loop over years
 {  // get the year we need the predicted value for
  iyr = lyr_ca(i);
  esc_ca(i) = 0;
  for (l=1;l<=nlength;l++)
   {
    for (g=1;g<=gender;g++)
     for (j=0;j<=nages;j++)
      esc_ca(i,l) += natage(iyr,1,g,j)*age_length_pop1(g,j,l);
    esc_ca(i,l) *= sel(1,1,l);
    if (esc_ca(i,l) <= 0) esc_ca(i,l)= 0.00001;
   }
  esc_ca(i)  = esc_ca(i) / sum(esc_ca(i));
  neffective(1,i)  = sum(elem_prod(esc_ca(i),(1-esc_ca(i))));
  neffective(1,i) /= sum(elem_prod((osc_ca(i)-esc_ca(i)),(osc_ca(i)-esc_ca(i))));
 }

// California Recreational
for (i=1;i<=lnyr_carec;i++)
 {
  iyr=lyr_carec(i);
  esc_carec(i) = 0;
  for (l=1;l<=nlength;l++)
   {
```

```
      for (g=1;g<=gender;g++)
       for (j=0;j<=nages;j++)
        esc_carec(i,l) += natage(iyr,1,g,j)*age_length_pop1(g,j,l);
      esc_carec(i,l) *= sel(1,2,l);
      if (esc_carec(i,l) <= 0) esc_carec(i,l)= 0.00001;
     }
    esc_carec(i)  = esc_carec(i) / sum(esc_carec(i));
    neffective(2,i)  = sum(elem_prod(esc_carec(i),(1-esc_carec(i))));
    neffective(2,i) /= sum(elem_prod((osc_carec(i)-esc_carec(i)),(osc_carec(i)-
esc_carec(i))));
   }
  } //-------------end of South---<><-----------------------------------------


  //--------------NORTH--------<><-------<><---------
  if(pop==2 || popID==2)
  {

   if (pop==1) Ip = 1; else Ip = 2;

   // Catch-rate data (OR)
   log_q_cr_or = 0;
   for (i=1;i<=nyr_cr_or;i++)
    {
     exp_cr_or(i)  = 0.0;
     for (g=1;g<=gender;g++)
      exp_cr_or(i) += sel_wt_age(Ip,2,g) * ( (mfexp(-M/2)* natage(yr_cr_or(i),Ip,g)) -
catage(yr_cr_or(i),Ip,2,g) );
     if (exp_cr_or(i)<=0) exp_cr_or(i)= 0.001;//make sure there is no negative values or 0 s
     log_q_cr_or += log(obs_cr_or(i)/exp_cr_or(i))/square(cv_cr_or(i));
    }
   // MLE for ln(q) and sigma
   log_q_cr_or /= sum( pow(cv_cr_or, -2) ) ;
   if (do_var==1){
   s2_cr_or    = sum( pow( elem_div( (log(obs_cr_or) -log(exp_cr_or) - log_q_cr_or) ,
cv_cr_or) , 2) );
   s2_cr_or    = sqrt (s2_cr_or / nyr_cr_or);
   sd_cr_or    = s2_cr_or * cv_cr_or ; }
   else sd_cr_or    = cv_cr_or ;

   // Catch-rate data (WA)
   log_q_cr_wa = 0;
   for (i=1;i<=nyr_cr_wa;i++)
    {
     exp_cr_wa(i)  = 0.0;
     for (g=1;g<=gender;g++)
```

```
      exp_cr_wa(i) += sel_wt_age(Ip,2,g) * ( (mfexp(-M/2)* natage(yr_cr_wa(i),Ip,g)) -
catage(yr_cr_wa(i),Ip,2,g) );
     if (exp_cr_wa(i)<=0) exp_cr_wa(i)= 0.001;//make sure there is no negative values or 0
s
     log_q_cr_wa += log(obs_cr_wa(i)/exp_cr_wa(i))/square(cv_cr_wa(i));
    }
   // MLE for ln(q) and sigma
   log_q_cr_wa /= sum( pow(cv_cr_wa, -2) ) ;
   if (do_var==1){
     s2_cr_wa    = sum( pow( elem_div( (log(obs_cr_wa) -log(exp_cr_wa) - log_q_cr_wa)
, cv_cr_wa) , 2) );
     s2_cr_wa    = sqrt (s2_cr_wa/nyr_cr_wa);
     sd_cr_wa    = s2_cr_wa * cv_cr_wa ; }
   else sd_cr_wa    = cv_cr_wa ;

   // Spawning stock index (north)
   log_q_sp_nth = 0;
   for (i=1;i<=nyr_sp_nth;i++)
    {
     exp_sp_nth(i)  = 0.0;
     for (g=1;g<=gender;g++)
      exp_sp_nth(i) +=fec*natage((yr_sp_nth(i)-1),Ip,g);
     if (exp_sp_nth(i)<=0) exp_sp_nth(i)= 0.001;
     log_q_sp_nth += log(obs_sp_nth(i)/exp_sp_nth(i))/square(cv_sp_nth(i));
    }
   // MLE for ln(q) and sigma
   log_q_sp_nth /= sum( pow(cv_sp_nth, -2) ) ;
   if (do_var==1){
     s2_sp_nth    = sum( pow( elem_div( (log(obs_sp_nth) -log(exp_sp_nth) -
log_q_sp_nth) , cv_sp_nth) , 2) );
     s2_sp_nth    = sqrt (s2_sp_nth / nyr_sp_nth);
     sd_sp_nth    = s2_sp_nth * cv_sp_nth ;}
   else sd_sp_nth    = cv_sp_nth;

   //---------Predictions for length frequency---------
   // Oregon Commercial
   for (i=1;i<=lnyr_or;i++)
    {
     iyr=lyr_or(i);
     esc_or(i) = 0;
     for (l=1;l<=nlength;l++)
      {
       for (g=1;g<=gender;g++)
        for (j=0;j<=nages;j++)
         esc_or(i,l) += natage(iyr,Ip,g,j)*age_length_pop2(g,j,l);
       esc_or(i,l) *= sel(Ip,1,l);
```

```
      if (esc_or(i,l) <= 0) esc_or(i,l)= 0.00001;
     }
    esc_or(i)  = esc_or(i) / sum(esc_or(i));
    neffective(3,i)  = sum(elem_prod(esc_or(i),(1-esc_or(i))));
    neffective(3,i) /= sum(elem_prod((osc_or(i)-esc_or(i)),(osc_or(i)-esc_or(i))));
   }

  // Oregon Recreational
  for (i=1;i<=lnyr_orrec;i++)
   {
    iyr=lyr_orrec(i);
    esc_orrec(i) = 0;
    for (l=1;l<=nlength;l++)
     {
      for (g=1;g<=gender;g++)
       for (j=0;j<=nages;j++)
        esc_orrec(i,l) += natage(iyr,Ip,g,j)*age_length_pop2(g,j,l);
      esc_orrec(i,l) *= sel(Ip,2,l);
      if (esc_orrec(i,l) <= 0) esc_orrec(i,l)= 0.00001;
     }
    esc_orrec(i)  = esc_orrec(i) / sum(esc_orrec(i));
    neffective(4,i)  = sum(elem_prod(esc_orrec(i),(1-esc_orrec(i))));
    neffective(4,i) /= sum(elem_prod((osc_orrec(i)-esc_orrec(i)),(osc_orrec(i)-
esc_orrec(i))));
   }

  // Washington Recreational
  for (i=1;i<=lnyr_warec;i++)
   {
    iyr=lyr_warec(i);
    esc_warec(i) = 0;
    for (l=1;l<=nlength;l++)
     {
      for (g=1;g<=gender;g++)
       for (j=0;j<=nages;j++)
        esc_warec(i,l) += natage(iyr,Ip,g,j)*age_length_pop2(g,j,l);
      esc_warec(i,l) *= sel(Ip,2,l);
      if (esc_warec(i,l) <= 0) esc_warec(i,l)= 0.00001;
     }
    esc_warec(i)  = esc_warec(i) / sum(esc_warec(i));
    neffective(5,i)  = sum(elem_prod(esc_warec(i),(1-esc_warec(i))));
    neffective(5,i) /= sum(elem_prod((osc_warec(i)-esc_warec(i)),(osc_warec(i)-
esc_warec(i))));
   }

 }//------------------end of North---:->-----------------------------------
```

```
//=================================================================
===========================

FUNCTION evaluate_the_objective_function

  //reset
  surv_like.initialize();   length_like.initialize();


  //----------------LIKELIHOODS------------------------------------

  // Fit to indices (lognormal)
  // catch-rate data, spawning biomass index, recruitment index
  if (do_var==1) //loglikelihood using MLE of s2
  {
   if (pop==2 || popID == 1) {
    surv_like(1) = nyr_cr_ca  * log(s2_cr_ca)  + (nyr_cr_ca  / 2);
    surv_like(4) = nyr_cr_ca4 * log(s2_cr_ca4) + (nyr_cr_ca4 / 2);
    surv_like(7) = nyr_sp_ca  * log(s2_sp_ca)  + (nyr_sp_ca  / 2);
    surv_like(9) = nyr_imp_ca * log(s2_imp_ca) + (nyr_imp_ca / 2); }
  if (pop==2 || popID == 2) {
    surv_like(5) = nyr_cr_or  * log(s2_cr_or)  + (nyr_cr_or  / 2);
    surv_like(6) = nyr_cr_wa  * log(s2_cr_wa)  + (nyr_cr_wa  / 2);
    surv_like(8) = nyr_sp_nth * log(s2_sp_nth) + (nyr_sp_nth / 2); }
  }
  else //loglikelihood assuming s2 is 1, i.e. there is no extra variance in the observations
  {
   if (pop==2 || popID == 1) {
    surv_like(1) =( sum( pow( elem_div( (log(obs_cr_ca) -log(exp_cr_ca) - log_q_cr_ca) ,
cv_cr_ca) , 2) ) ) / 2;
    surv_like(4) =( sum( pow( elem_div( (log(obs_cr_ca4) - log(exp_cr_ca4) -
log_q_cr_ca4) , cv_cr_ca4) , 2) ) ) / 2;
    surv_like(7) =( sum( pow( elem_div( (log(obs_sp_ca) -log(exp_sp_ca) - log_q_sp_ca)
, cv_sp_ca) , 2) ) ) / 2;
    surv_like(9) =( sum( pow( elem_div( (log(obs_imp_ca) -log(exp_imp_ca) -
log_q_imp_ca) , cv_imp_ca) , 2) ) ) /2 ;
   }
   if (pop==2 || popID == 2) {
    surv_like(5) = ( sum( pow( elem_div( (log(obs_cr_or) -log(exp_cr_or) - log_q_cr_or) ,
cv_cr_or) , 2) ) ) / 2;
    surv_like(6) =( sum( pow( elem_div( (log(obs_cr_wa) -log(exp_cr_wa) -
log_q_cr_wa) , cv_cr_wa) , 2) ) ) / 2;
    surv_like(8) =( sum( pow( elem_div( (log(obs_sp_nth) -log(exp_sp_nth) -
log_q_sp_nth) , cv_sp_nth) , 2) ) )/ 2;
   }
```

```
  }

  //cout<<"surv_like:"<<endl<<elem_prod(surv_lambda,surv_like)<<endl;
  //catch length frequency (multinomial)

  // more matrix calculations,  elem_prod( osc_ca , log(esc_ca + 0.001) ) is a matrix
  // rowsum( elem_prod( osc_ca , log(esc_ca + 0.001) ) ) is a vector
  // nsamples(1) is a vector too.
  // so...vector * vector is a scalar

  if (pop==2 || popID == 1)
   { length_like(1) = - ( nsamples(1) * rowsum( elem_prod( osc_ca , log(esc_ca + 0.001) )
) );
     length_like(1) -=offset(1); }

  if (pop==2 || popID == 1)
   { length_like(2) = - ( nsamples(2) * rowsum( elem_prod( osc_carec , log(esc_carec +
0.001) ) ) );
      length_like(2) -=offset(2); }

  if (pop==2 || popID == 2)
   { length_like(3) = - ( nsamples(3) * rowsum( elem_prod( osc_or , log(esc_or + 0.001) )
) );
     length_like(3) -=offset(3); }

  if (pop==2 || popID == 2)
   { length_like(4) = - ( nsamples(4) * rowsum( elem_prod( osc_orrec , log(esc_orrec +
0.001) ) ) );
     length_like(4) -=offset(4); }

  if (pop==2 || popID == 2)
   { length_like(5) = - ( nsamples(5) * rowsum( elem_prod( osc_warec , log(esc_warec +
0.001) ) ) );
     length_like(5) -=offset(5); }

  if (dummy == 1) //debugging mode, turn off all parameters
   obj_fun= dummy_par*dummy_par;
  else
  {
   obj_fun = 0;
   obj_fun += sum(elem_prod(surv_lambda,surv_like)); //Lambdas are controls that turns
on (when > 1) and off (0) the data set,
   obj_fun += sum(elem_prod(length_lambda,length_like));//and specify the weight that
each data set will have, the values of lambda should be specified in the Control file

   obj_fun += prior_rec;
```

```
   obj_fun += CrashPen;
   if (!mceval_phase()) cout << obj_fun << endl;
//   cout << surv_like << endl;
//   cout << length_like << endl;
  }

//
*=================================================================
===========*

REPORT_SECTION

  report << "Catches used" << endl;
  report << catch_bio << endl;

   //Number and catch at age for quick look
  report << "Estimated numbers of fish " << endl;
    for (p=1;p<=pop;p++)
     for (g=1;g<=gender;g++)
      {report << "Population "<<p<<" gender "<<g<<endl;
       report << "Age "<<"0 "<<age_vector <<endl;
       for (i=styr;i<=endyr;i++)
        report <<i<<" "<< natage(i,p,g) << endl;}
   report <<endl<< "Estimated catch at age " << endl;
    for (p=1;p<=pop;p++)
     for (g=1;g<=gender;g++)
      for (f=1;f<=fleet;f++)
       {report << "Population "<<p<<" fleet "<<f<<" gender "<<g<<endl;
        report << "Age "<<"0 "<<age_vector <<endl;
        for (i=styr;i<=endyr;i++)
         report <<i<<" "<<catage(i,p,f,g)  << endl;}
   report <<endl<< "Estimated total catch at age " << endl;
    for (p=1;p<=pop;p++)
     for (g=1;g<=gender;g++)
      {report << "Population "<<p<<" gender "<<g<<endl;
      report << "Age "<<"0 "<<age_vector <<endl;
      for (i=styr;i<=endyr;i++)
       report <<i<<" "<<catage_tot(i,p,g)  << endl;}

  //---------.dat files---------------------------
  // Abundance index information
  ofstream out1("ind.dat");
  out1<<"index"<<" "<<"year"<<" "<<"obs"<<" "<<"exp"<<" "<<"CV"<<endl;
  if (pop == 2 || popID == 1) abund_South(out1);
  if (pop == 2 || popID == 2) abund_North(out1);
```

```
  // Length-frequency information
  ofstream out2("lf.dat");
  out2<<"dataset"<<" "<<"year"<<" "<<"effectiveN"<<" "<<"length"<<" "<<"obs"<<"
"<<"exp"<<endl;
  if (pop == 2 || popID == 1) lf_South(out2);
  if (pop == 2 || popID == 2) lf_North(out2);

  report << " " << endl;
  report << fec << endl;
  report << wt_age_middle << endl;
  for (p=1;p<=pop;p++)
   {
   report << sel_age(p) << endl;
   for (t=styr;t<endyr;t++)
     report<< t << " " << 2*natage(t,p,1,0)/1000 << " " << Spbio(p,t)/1000 << " 0 0 0" <<
endl;
   for (i=0;i<= nages;i++) report << natage(endyr-1,p,1,i)/1000 << " "; report << endl;
   for (i=0;i<= nages;i++) report << natage(endyr-1,p,2,i)/1000 << " "; report << endl;

   }

  //Likelihood components
  ofstream out3("like.dat");
  like(out3);

  //Trajectories
  ofstream out4("traj.dat");
  trajectories(out4);

  //Selectivity at length
  ofstream out5("selL.dat");
  selL(out5);

  //Selectivity at age
  ofstream out6("selA.dat");
  selA(out6);

  // Growth stuff
  cout << "Here" << endl;
  ofstream out7("Size.dat");
  out7 << pop << " " << gender << " " << nages << " " << nlength << endl;
  for (p=1;p<=pop;p++)
   for (g=1;g<=gender;g++)
    for (j=1;j<=nlength;j++)
     {
      out7 << size_vector(j) << " ";
```

```
      for (i=0;i<=nages;i++)
       {
        if (p==1) out7 << age_length_pop1(g,i,j) << " " ;
        if (p==2) out7 << age_length_pop2(g,i,j) << " " ;
       }
      out7 << endl;
     }

   // Number and catch at age for R graphs
   ofstream out8("dynamic.dat");
   for(p=1;p<=pop;p++)
      report_dynamic(out8,p);

    //MLE for q and s2
    ofstream out9("mle.dat");
    if (do_var==1){//report MLE for sigma only if we are estimating it
           if (pop==2 || popID == 1) out9<<"s2_cr_ca " <<s2_cr_ca<<endl;
           if (pop==2 || popID == 1) out9<<"s2_cr_ca4 " <<s2_cr_ca4<<endl;
           if (pop==2 || popID == 2) out9<<"s2_cr_or " <<s2_cr_or<<endl;
           if (pop==2 || popID == 2) out9<<"s2_cr_wa " <<s2_cr_wa<<endl;
           if (pop==2 || popID == 1) out9<<"s2_sp_ca " <<s2_sp_ca<<endl;
           if (pop==2 || popID == 2) out9<<"s2_sp_nth " <<s2_sp_nth<<endl;
           if (pop==2 || popID == 1) out9<<"s2_imp_ca " <<s2_imp_ca<<endl;
    }

    if (pop==2 || popID == 1) out9<<"log_q_cr_ca " <<log_q_cr_ca<<endl;
    if (pop==2 || popID == 1) out9<<"log_q_cr_ca4 " <<log_q_cr_ca4<<endl;
    if (pop==2 || popID == 2) out9<<"log_q_cr_or " <<log_q_cr_or<<endl;
    if (pop==2 || popID == 2) out9<<"log_q_cr_wa " <<log_q_cr_wa<<endl;
    if (pop==2 || popID == 1) out9<<"log_q_sp_ca " <<log_q_sp_ca<<endl;
    if (pop==2 || popID == 2) out9<<"log_q_sp_nth " <<log_q_sp_nth<<endl;
    if (pop==2 || popID == 1) out9<<"log_q_imp_ca " <<log_q_imp_ca<<endl;

//--------------------------------------------------------------------------------------------------
FUNCTION void report_dynamic(ofstream& file, int& p)

   file <<"Pop"<<" "<<"gender"<<" "<<"year"<<" "<<"age"<<" "<<"N"<<"
"<<"Ccom"<<" "<<"Crec"<<" "<<"Ctot"<<endl;
   for(g=1;g<=gender;g++)
    for (i=styr;i<=endyr;i++)
     for (a=0;a<=nages;a++)
      file <<p<<" "<<g<<" "<<i<<" "<<a<<" "<<natage(i,p,g,a)<<"
"<<catage(i,p,1,g,a)<<" "<<catage(i,p,2,g,a)<<" "<<catage_tot(i,p,g,a)<<endl;
   file << " " << endl;
   file << natage << endl;
```

```
//------------------------------------------------------------------------------------------

FUNCTION void like(ofstream& file)//output likelihood components

  file << "Likelihood components " <<endl;
  file <<" indices "<<endl<<elem_prod(surv_like,surv_lambda)<<endl;
  file <<" length frequency "<<elem_prod(length_like,length_lambda)<<endl;
  file <<" penalties "<<prior_rec<< " " << CrashPen <<endl;

//------------------------------------------------------------------------------------------

FUNCTION void selA(ofstream& file)

  file<<"pop"<<" "<<"fleet"<<" "<<"sex"<<" "<<"age"<<" "<<"selA"<<endl;
  for(p=1;p<=pop;p++)
   for(f=1;f<=fleet;f++)
    for(g=1;g<=gender;g++)
     for(a=0;a<=nages;a++)
      file<<p<<" "<<f<<" "<<g<<" "<<a<<" "<<sel_age(p,f,g,a)<<endl;

//------------------------------------------------------------------------------------------

FUNCTION void selL(ofstream& file)

  file<<"pop"<<" "<<"fleet"<<" "<<"size"<<" "<<"selL"<<endl;
  for(p=1;p<=pop;p++)
   for(f=1;f<=fleet;f++)
    for(l=1;l<=nlength;l++)
     file<<p<<" "<<f<<" "<<size_vector(l)<<" "<<sel(p,f,l)<<endl;

//------------------------------------------------------------------------------------------

FUNCTION void trajectories(ofstream& file)

  file<<"pop"<<" "<<"year"<<" "<<"depletion"<<" "<<"spaw_bio"<<" ";
  file<<"recruit"<<" "<<"hrate_com"<<" "<<"hrate_rec"<<endl;

  for (p=1;p<=pop;p++)
   for (t=styr;t<endyr;t++)
    {
     file<<p<<" "<<t<<" "<<(2*Spbio(p,t)/S0_pop(p))<<" "<<Spbio(p,t);
     file<<" "<<2*natage(t,p,1,0)<<" "<<Hrate(p,1,t)<<" "<<Hrate(p,2,t)<<endl;
    }

//------------------------------------------------------------------------------------------
```

```
FUNCTION void lf_North(ofstream& out2)//output length frequencies for the North

  for(t=1;t<=lnyr_or;t++)
   for(l=1;l<=nlength;l++)
    {
     out2<<"lf3"<<" "<<lyr_or(t)<<" "<<nsamples(3,t)<<" "<<neffective(3,t)<<" ";
     out2<<size_vector(l)<<" "<<osc_or(t,l)<<" "<<esc_or(t,l)<<endl;
    }

  for(t=1;t<=lnyr_orrec;t++)
   for(l=1;l<=nlength;l++)
    {
     out2<<"lf4"<<" "<<lyr_orrec(t)<<" "<<nsamples(4,t)<<" "<<neffective(4,t)<<" ";
     out2<<size_vector(l)<<" "<<osc_orrec(t,l)<<" "<<esc_orrec(t,l)<<endl;
    }

  for(t=1;t<=lnyr_warec;t++)
   for(l=1;l<=nlength;l++)
    {
     out2<<"lf5"<<" "<<lyr_warec(t)<<" "<<nsamples(5,t)<<" "<<neffective(5,t)<<" ";
     out2<<size_vector(l)<<" "<<osc_warec(t,l)<<" "<<esc_warec(t,l)<<endl;
    }

//------------------------------------------------------------------------------------------

FUNCTION void lf_South(ofstream& out2)//output length frequencies for the South

  for(t=1;t<=lnyr_ca;t++)
   for(l=1;l<=nlength;l++)
    {
     out2<<"lf1"<<" "<<lyr_ca(t)<<" "<<nsamples(1,t)<<" "<<neffective(1,t)<<" ";
     out2<<size_vector(l)<<" "<<osc_ca(t,l)<<" "<<esc_ca(t,l)<<endl;
    }

  for(t=1;t<=lnyr_carec;t++)
   for(l=1;l<=nlength;l++)
    {
     out2<<"lf2"<<" "<<lyr_carec(t)<<" "<<nsamples(2,t)<<" "<<neffective(2,t)<<" ";
     out2<<size_vector(l)<<" "<<osc_carec(t,l)<<" "<<esc_carec(t,l)<<endl;
    }

//------------------------------------------------------------------------------------------

FUNCTION void abund_South(ofstream& out1)

  for (t=1;t<=nyr_cr_ca;t++)
```

```
    out1<<"I1"<<" "<<yr_cr_ca(t)<<" "<<obs_cr_ca(t)<<"
"<<mfexp(log_q_cr_ca)*exp_cr_ca(t)<<" "<<sd_cr_ca(t)<<endl;

   for (t=1;t<=nyr_cr_ca4;t++)
    out1<<"I2"<<" "<<yr_cr_ca4(t)<<" "<<obs_cr_ca4(t)<<"
"<<mfexp(log_q_cr_ca4)*exp_cr_ca4(t)<<" "<<sd_cr_ca4(t)<<endl;

   for (t=1;t<=nyr_sp_ca;t++)
    out1<<"I5"<<" "<<yr_sp_ca(t)<<" "<<obs_sp_ca(t)<<"
"<<mfexp(log_q_sp_ca)*exp_sp_ca(t)<<" "<<sd_sp_ca(t)<<endl;

   for (t=1;t<=nyr_imp_ca;t++)
    out1<<"I7"<<" "<<yr_imp_ca(t)<<" "<<obs_imp_ca(t)<<"
"<<mfexp(log_q_imp_ca)*exp_imp_ca(t)<<" "<<sd_imp_ca(t)<<endl;

//-------------------------------------------------------------------------------------------

FUNCTION void abund_North(ofstream& out1)

   for (t=1;t<=nyr_cr_or;t++)
    out1<<"I3"<<" "<<yr_cr_or(t)<<" "<<obs_cr_or(t)<<"
"<<mfexp(log_q_cr_or)*exp_cr_or(t)<<" "<<sd_cr_or(t)<<endl;

   for (t=1;t<=nyr_cr_wa;t++)
    out1<<"I4"<<" "<<yr_cr_wa(t)<<" "<<obs_cr_wa(t)<<"
"<<mfexp(log_q_cr_wa)*exp_cr_wa(t)<<" "<<sd_cr_wa(t)<<endl;

   for (t=1;t<=nyr_sp_nth;t++)
    out1<<"I6"<<" "<<yr_sp_nth(t)<<" "<<obs_sp_nth(t)<<"
"<<mfexp(log_q_sp_nth)*exp_sp_nth(t)<<" "<<sd_sp_nth(t) << endl;

//
*=============================================================
=======================*
//
*=============================================================
=======================*

RUNTIME_SECTION
  maximum_function_evaluations 1000 1000 1000 2000;
  convergence_criteria 0.01,0.01,0.01,1e-7;

//
*=============================================================
========================*
```

```
//
*====================================================================
=========================*

TOP_OF_MAIN_SECTION
  arrmblsize = 5000000;
  gradient_structure::set_GRADSTACK_BUFFER_SIZE(56000);
  gradient_structure::set_CMPDIF_BUFFER_SIZE(1500000);
  gradient_structure::set_MAX_NVAR_OFFSET(500);
  gradient_structure::set_NUM_DEPENDENT_VARIABLES(500);
  time(&start); //this is to see how long it takes to run
  cout<<endl<<"Start time : "<<ctime(&start)<<endl;

//
*====================================================================
=========================*

GLOBALS_SECTION
  #include <admodel.h>
  #include <time.h>
  time_t start,finish;
  long hour,minute,second;
  double elapsed_time;

//--------------------------------------------------------------------------------

FUNCTION dmatrix SizeTrans(_CONST double& Lbeg,_CONST double&
Lmax,_CONST double& K,_CONST double& CVLmin,_CONST double&
CVLmax,_CONST int& m)
  {
   RETURN_ARRAYS_INCREMENT(); //Need this statement because the function
   // m is a switch, if m==0, the function will calculate the length transition for the
beginning of the year,
   //                    if m==1, the function will calculate it for the middle of the year;
   dmatrix Size_Trans(0,nages,1,nlength);
   dvector Average_Size(0,nages);
   dvector Sd(0,nages);
   double age;
   for (i=0; i<=nages;i++)
    {
     //first calculate average values...
     if(m==0) age=double(i);//beginning of the year
     else age=double(i)+0.5;//middle of the year
     Average_Size(i) = Lmax + (Lbeg - Lmax) * mfexp (- K * (age-1));
     Sd(i)= (CVLmin+(age-1)*(CVLmax-CVLmin)/(nages-1))*Average_Size(i);
```

```
    //...then calculate the distribution arround those values
    // first bin, note: need to standarize before using cumd_norm;
    Size_Trans(i,1)=((size_vector(1)+(size_vector(2)-size_vector(1))/2)-
Average_Size(i))/Sd(i);
    Size_Trans(i,1)=cumd_norm(Size_Trans(i,1));

    //other bins but the last;
    for (j=2;j<=nlength-1;j++)
     {
      Size_Trans(i,j)= 0;
      Size_Trans(i,j)= cumd_norm(((size_vector(j)+(size_vector(j+1)-size_vector(j))/2)-
Average_Size(i))/Sd(i));
      Size_Trans(i,j)-= cumd_norm(((size_vector(j)-(size_vector(j)-size_vector(j-1))/2)-
Average_Size(i))/Sd(i));
     }
    //last bin;
    Size_Trans(i,nlength)= 1 - cumd_norm(((size_vector(nlength)-(size_vector(nlength)-
size_vector(nlength-1))/2)-Average_Size(i))/Sd(i));
   }

  RETURN_ARRAYS_DECREMENT(); // Need this to decrement the stack increment
                  // caused by RETURN_ARRAYS_INCREMENT();
  return(Size_Trans);

  }

//--------------------------------------------------------------------------------
//SEE if we have any problem because I didn't declare the arguments to be _CONST
//According to Jim this may cause the arguments to be changed within the function
// But there is a limit to the number of strings I can pass, so if I include the _CONST will
exceed the limit

FUNCTION dvar_vector DoubLogistic(dvariable& pk,dvariable& in,dvariable&
infl,dvariable& sl,dvariable& fin,dvariable& infl2,dvariable& sl2)
  {
  //This code is based on POP model (from Ian J. Stewart, SAFS-UW)
  RETURN_ARRAYS_INCREMENT(); //Need this statement because the function
  dvar_vector sel_at_length(1,nlength);

  for (j=1; j<=nlength; j++)  //calculate the value over length bins
         {
          if (double(j) < pk) // ascending limb
          {
            sel_at_length(j)= in +
                    (1 - in)/((1 / (1 + (mfexp(-1 * sl * (pk - infl))))) -
                 (1 / (1 + (mfexp(-1 * sl * (1 - infl)))))) *
```

```
               ((1/(1+mfexp(-1*sl*(size_vector(j)-infl)))) -
                    (1 / (1 + (mfexp(-1 * sl * (1 - infl))))));
           }
           else
           {
              if (double(j) > (pk + 1)) // descending limb
              {
                 sel_at_length(j) = 1 +
                       (fin - 1)/((1 / (1 + (mfexp(-1 * sl2 * (size_vector(nlength) - infl2))))) -
                    (1 / (1 + (mfexp(-1 * sl2 * ((pk+1) - infl2)))))) *
                    ((1/(1+mfexp(-1*sl2*(size_vector(j)-infl2)))) -
                       (1 / (1 + (mfexp(-1 * sl2 * ((pk+1) - infl2))))));
              }
              else // between the peaks
              {
                    sel_at_length(j) = 1.0;
              };
         };
       };

  RETURN_ARRAYS_DECREMENT(); // Need this to decrement the stack increment
                   // caused by RETURN_ARRAYS_INCREMENT();
  return(sel_at_length);
  }

//*============================================================
=========================*=/

FINAL_SECTION
  //Calculates how long is taking to run
  // this code is based on the Widow Rockfish model (from Erik H. Williams, NMFS-
Santa Cruz)
  time(&finish);
  elapsed_time = difftime(finish,start);
  hour = long(elapsed_time)/3600;
  minute = long(elapsed_time)%3600/60;
  second = (long(elapsed_time)%3600)%60;
  cout<<endl<<endl<<"starting time: "<<ctime(&start);
  cout<<"finishing time: "<<ctime(&finish);
  cout<<"This run took: ";
  cout<<hour<<" hours, "<<minute<<" minutes, "<<second<<"
seconds."<<endl<<endl<<endl;
```

Cabezon

STAR Panel Meeting Report

NOAA/Northwest Fisheries Science Center
Seattle, Washington
September 15-19, 2003

STAR Panel
Han-Lin Lai, NOAA/Northwest Fisheries Science Center, PFMC SSC (Chair)
Chris Legault, NOAA/Northeast Fisheries Science Center
Mark Maunder, Inter-American Tropical Tuna Commission (CIE Reviewer)
David Smith, Primary Industries Research Victoria, Australia
Tony Smith, CSIRO Marine Research, Australia (Rapporteur)

PFMC
Tom Barnes, California Department of Fish and Game, PFMC GMT
Tom Ghio, PFMC GAP

STAT Team
Kevin Piner, NOAA/Northwest Fisheries Science Center
Jason Cope, University of Washington, School of Aquatic and Fishery Sciences
Carolina Minte-Vera, University of Washington, School of Aquatic and Fishery Sciences
Andre Punt, University of Washington, School of Aquatic and Fishery Sciences

Overview

The STAR Panel (hereafter the Panel) reviewed the draft assessment report for cabezon (*Scorpaenichthys marmoratus*) prepared by the STAT Team and dated September 5, 2003. The entire STAT Team was available to present and discuss aspects of the report. This assessment represents the first quantitative assessment for cabezon, and the first for any of the inshore groundfish species under the PFMC FMP.

Considerable effort had gone into compiling the relevant data and information for this species (Table 1). Nonetheless, the STAT Team stressed the limited amount of data and the uncertainties in the data, and the lack of critical biological information on the species and stocks. For this assessment, two stocks are assumed for the west coast of the US – a northern stock (Washington and Oregon) and a southern stock (California). There is a lot less data for the northern "stock" and the Panel agreed with the STAT Team that the model results for this stock were implausible. The assessment therefore focuses on the status of the southern stock.

A feature of this assessment is that there is no dedicated fishery independent biomass index for this species or any inshore species. The assessment examined several time series of potential abundance indices, including recreational catch rates, larval surveys (CalCOFI), and "impingement" data (a possible index for recruitment). The assessment also used commercial and recreational length composition data. There is considerable uncertainty in all data series, particularly pre-1980 catches (especially recreational). The assessment model is a two-fleet age and sex structured catch at length model with variable recruitment about a Beverton-Holt stock recruitment relationship. Results were presented for two base cases and a range of sensitivity analyses (to uncertainties in data inputs and fixed model parameters). Maximum Posterior Density (MPD) estimates were presented for the sensitivity analyses, and Bayesian results only for the base cases. Results for the base cases were checked by running the model using two independently derived sets of software.

Both base case models involved fitting to recreational CPUE derived from Commercial Passenger Fishing Vessel logbooks ("CPFV Logbook") and recreational and commercial catch length composition. Base Case A assumed a fixed CV for the CPUE index, while Base Case B estimated the CV scaling parameter. Neither model fitted the data particularly well, but the fit to the CPUE index for Base Case A was not consistent with the assumed confidence intervals for the index. Biomass estimates for Base Case B were more uncertain, but estimates of depletion for Base Case B were less sensitive to data and model assumptions. Base Case B estimated the stock to be less depleted than Base Case A.

For the reasons given above, the Panel asked the STAT Team to re-run and present results for a new Base Case which was a modification of the original Base Case B. The new Base Case involved the addition of two times series of abundance indices (RecFIN CPUE and the CA Impingement Index), a differential weighting on commercial and recreational length composition data, and setting the stock recruitment steepness parameter to 0.7. A similar set of sensitivity analyses was run for this new Base Case.

The MPD results for the new Base Case were intermediate between the previous Base Cases in terms of level of depletion in 2003 (35% with a standard deviation of 7%), and in general showed less sensitivity to data and assumptions. The greatest sensitivities were to pre-specified values of natural mortality and stock recruitment steepness. The assessment was also sensitive to one of the values for the CV on length at age. The previous high sensitivity to the pre 1980 recreational catch levels was greatly reduced. Initial diagnostics for the Bayesian analysis supported their use in the projections.

The Panel agreed that the new Base Case model could be used for stock projections and as a basis for management decisions about the Californian fisheries. The Panel reiterated the considerable uncertainties in the data and biological information on which this assessment was based, but considered that (with the inclusion of several key uncertainties in the projections, outlined below in recommendations) it represented the best available science for the purpose of providing management advice.

Given the uncertainties, the Panel has provided a list of key recommendations for future research and monitoring for this fishery.

The Panel commended the STAT Team for their efforts in putting together this first assessment for cabezon, and thanked them for their cooperation and assistance during the course of the meeting.

Additional analyses requested by the STAR Panel

1. **Discussion of gear and market selectivity led to the suggestion that a sensitivity test be run to use of dome shaped selectivity (decline at 4 lbs, to half at maximum age).** This change resulted in a worse fit overall to the data, and so was not included in the new Base Case.
2. **Discussion of differences by sex in growth led to the suggestion to test the effect of sex dependent natural mortality (0.2 female, 0.3 male).** This could only be tested using Stock Synthesis software, and the results were not significantly different from the Base Case.
3. **Variability in recruitment was discussed, including the possibility of "regime shift" effects (perhaps evident in impingement data, and thought to occur for some other species along the coast).** It was agreed that high sigma R could capture this effect (if it was present), The Panel suggested reducing steepness to 0.7 (from 1) for the new Base Case, in line with results from meta-analyses.
4. **There was evidence in the preliminary results of differences between commercial and recreational length composition data in effective sample size.** It was suggested that the new Base Case use effective sample sizes of 60 for commercial and 40 for recreational data.

5. **The Panel requested a sensitivity test to the use of increasing CV of length at age in the growth model, for the sake of completeness.** The results were not qualitatively different from the sensitivity tests already conducted.
6. **A request was made to present (for the Base Case runs) a single figure with time series for catch, reproductive output, and recruitment.**
7. **The Panel discussed the large recreational catch in 1980 (approximately double adjacent catches), and its possible validity. The Panel requested a sensitivity test to reducing the large recreational catch in 1980 to the average of catches in 1981 to 1983.** This resulted in a slightly more depleted stock. The Panel examined the catch by fishing mode, and found no basis to reject the 1980 data. It was therefore included in the new Base Case.
8. **The Panel requested the presentation of CVs on output parameters (especially management related quantities such as level of depletion) in output diagnostics.** This was found to be useful in comparing apparent differences in levels of depletion between different scenarios.
9. **The Panel and the meeting discussed the use of the various abundance time series in the new Base Case. The Panel recommended including RecFIN CPUE, and the CA Impingement Index in the Base Case (as well as the CPFV logbook CPUE), but not including the CalCOFI data and the CPFV observer CPUE.** This was based on generally including rather than excluding data, but noting concerns about sample size, including two indices based on the same data source, and representativeness of the data.
10. **The Panel recommended incorporating "model" uncertainty in projections by combining separate posteriors using combinations of fixed levels for steepness and natural mortality.** Due to time constraints, the full set of Bayesian analyses could not be completed during the meeting.
11. **In addition to yield projections based on NMFS decision rules, the Panel requested yield projections based on the decision rule specified in the CA Nearshore Fishery Management Plan (yield at $F_{50\%}$, adjusted using a 60-20 precautionary reduction).** No yield calculations were available for review at the meeting.

Comments on technical issues and remedies

Technical issues were mainly dealt with in the specific requests to the STAT Team, and to some extent in the recommendations for future research. The Panel specifically noted and endorsed the value of conducting and comparing assessments of different levels of complexity, and using independently coded software.

Areas of disagreement

There were no areas of disagreement between the STAR Panel and the STAT Team.

Unresolved problems and major uncertainties

The Panel noted the following unresolved problems and uncertainties:

1. The lack of a credible assessment for the northern stock.
2. Major uncertainties in historical catch levels.
3. Problems with trends in residuals for the fits to the CPUE data.
4. Lack of fishery independent abundance data for this species.
5. Lack of age data for this species.
6. Uncertainties about stock structure, although the panel noted that studies are underway.
7. Different trends in catch rates along the coast.
8. The current ADMB model does not allow for sex specific M.
9. The habitat ratio scalar between the northern and southern areas is highly uncertain. However the Panel questioned the usefulness of this approach, due to inconsistencies in assumptions about productivity versus carrying capacity between areas.

Recommendations

The following recommendations are not given in priority order.

Data and monitoring issues

1. The Panel considered that the highest priority for monitoring is the development of a fishery independent index of abundance for inshore species. Various survey methods should be considered, including use of trap and hook and line gears. In addition, the Panel recommended consideration of a coast wide tagging study for cabezon. Such a study would potentially provide not only an index of abundance, but also additional biological information on growth, movement and stock structure. The Panel strongly endorsed a joint science / industry survey and tagging study.
2. The Panel endorsed the recommendation in the STAT report that improved and accurate accounting of removals for both commercial and recreational sectors was essential to sound assessment. This should include better reporting of location of fishing. Techniques such as electronic card swiping at point of landing could be considered for the commercial sector.
3. The Panel suggested that further investigation of the unusually high estimate of the 1980 recreational catch be undertaken, for example by comparing the catches in the same and adjoining years for other inshore species. This uncertainty was not resolved in this meeting.
4. The Panel noted the potential value of sampling the sex ratio of the catch, but also noted the difficulty of doing so given that the commercial fishery is mainly a live fishery.
5. The Panel endorsed the suggestion for a workshop to understand, analyze and interpret recreational CPUE data, particularly for nearshore species.

Modelling and assessment issues

6. With regard to calculating yield projections in 2003, the Panel recommended incorporating "model" uncertainty in projections by combining separate posteriors using combinations of fixed levels for steepness and natural mortality. The values recommended were (suggested weights shown in square brackets): M = 0.2 [0.25], 0.25 [0.5] and 0.3 [0.25]; h = 0.5, 0.7, 0.9 with equal weighting for the values of steepness. In the longer term, the Panel recommended including such parameter uncertainty directly in the Bayesian analysis.
7. The Panel endorsed the value of using multiple assessment packages and models (including simple "production" models and SRA) in undertaking stock assessments. The Panel noted and endorsed the suggestion to develop an ADModel Builder version of Stock Synthesis. The Panel was encouraged by the PhD proposal by Jason Cope incorporating the testing of harvest strategies using a wide range of assessment models. The Panel strongly endorsed the approach in this dissertation to evaluate strategies for assessing and managing low information species, and asked for cooperation by agencies in providing data for this study.
8. Noting the (surprising) sensitivity of the cabezon assessment to uncertainty in the CV for length at age, the Panel recommended that this issue be explored in the context of this assessment and others which rely substantially on fitting to length-frequency data.
9. The Panel recommended that further exploration of the spatial structure of this fishery be undertaken, and that consideration be given in the future to the use of spatially explicit models.
10. The Panel suggested that the implications of regime shifts and environmental variability for assessments and management reference points be examined.
11. The Panel endorsed the presentation and use of the range of diagnostics for the Bayesian analyses, and the reporting of CVs on management performance statistics.
12. The Panel suggested that the possibility of sex specific natural mortality should be investigated.

Table 1. Data presented to the STAR Panel Meeting. Highlighted years are the data used in the base case. (*: no assessment undertaken for the northern stock due to data limitations; **: assumed; ***: assume equal to 2002)

CABEZON	**Northern Stock***	**Southern Stock**
Catch Data		
Commercial	1975-2002	1930-2002, 2003***
Recreational	1975-2002	1930-1979**; 1980-2002; 2003 ***
Abundance Indices		
CPFV observer	None	1987-1998
CPFV logbook	None	1960-1978; 1980-2001
RecFIN	None	1980-1989; 1993-2001
OR Ocean boat survey	1979-1987; 1999-2002	None
WA Ocean Sampling	1990-2001	None
CalCOFI	None	1979-2002
AFSC WA&OR larval index	1980-1985; 1987	None
Power plant Impingement	None	1972-2002
Catch at Length (sex-aggregated)		
Commercial	OR: 1998-2002	1995-2002
Recreational	OR+WA: 1980-2002	1980-1989; 1993-2002

Addendum to "Assessment of Lingcod for the Pacific Fishery Management Council in 2003" Prepared February 1, 2004

Addendum: February 1, 2004

Response to November 2003 SSC review.

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STAT Team response to November 2003 SSC review

At the November, 2003 Council meeting, the SSC noted that a parameter specifying recruitment variability appeared to be mis-specified in both the LCN (northern) and LCS (southern) models. Upon investigation, the STAT team confirmed that this was in fact the case. In the LCN model, the "log rec dev" parameter was set at 0.20 (Appendix I; Table 4, Page 4). In the LCS model, this parameter was set at 0.30 (Appendix I; Table 4, Page 30). The SSC indicated that, if possible, this parameter should be set at a higher value to allow for a greater range of recruitment variability in the models.

Following the November Council meeting, the STAT team evaluated the LCN and LCS model responses to increasing the "log rec dev" parameter. For both LCN and LCS, the model was able to converge at higher values up to log rec dev = 0.50. At higher values, model performance became unstable and convergence was problematic. The STAT team also noted that, for both LCN and LCS, total likelihoods showed better model fits at values of log rec dev = 0.50, when compared to the original base model. Based on the SSC suggestions and these results, the STAT team changed this parameter accordingly and produced revised model output and rebuilding analysis results in this Addendum (Tables 1-10; Figures 1-10).

The STAT team notes that the revised LCN model indicates relatively strong 1999 year class recruitment. Evidence for this recruitment is most apparent in the NMFS trawl survey catch-at-age data. Survey selectivities became more asymptotic in the revised model, while fishery selectivities were little changed. The overall likelihood is higher for the revised model, which resulted from better fits to the catch-at-age and catch-at-length data sets.

The total likelihood of the revised LCS model also improved modestly. Sport fishery selectivity became notably more dome-shaped in the revised model.

The SSC also noted that it would be preferable to compute the "coastwide" rebuilding analysis as the sum of out puts from separate northern and southern rebuilding analyses, rather than from an analysis generated from pooled inputs. This suggestion was adopted and is relected in the rebuilding analysis results given in Tables 5 and 6.

Table 1. Coleraine output file for the northern area (LCN) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

B0	27024
Depletion	0.31
Spawning Biomass 2003	**8477.42**
Input File	**sigma50.txt**
Likelihoods	
Trawl Logbook CPUE	5.8
Com Catch-At-Age	-1956.8
Rec Catch-At-Age	-1551.5
Com Catch-At-Length	-829.3
Rec Catch-At-Length	-655.9
NMFS Trawl Survey	2.6
WDFW Tag Survey	2.8
NMFS Survey Catch-At-Age	-328.9
WDFW Survey Catch-At-Age	-355.7
NMFS Survey Catch-At-Length	-318.8
WDFW Survey Catch-At-Length	-1622
	0
	0.0
Penalties: B-H Recruitment	**30.6**
Total Likelihood:	**-7577.2**
Parameters	
R0	2036.1
h	0.9
M Females	0.18
M Males	0.32
Rinit	1
Uinit Females	0.09
Uinit Males	0.09
Init Plus Grp Resid Females	1
Init Plus Grp Resid Males	1.00
Selectivity - Full Com	4.00
Selectivity - Full Rec	4.00
Selectivity - Left Side Com	-11.23
Selectivity - Left Side Rec	-15.00
Selectivity - Right Side Com	15.00
Selectivity - Right Side Rec	2.33369
Selectivity - Full - Yr Error Com	0
Selectivity - Full - Yr Error Rec	0
Selectivity - Left - Yr Error Com	0
Selectivity - Left - Yr Error Rec	0
Selectivity - Right - Yr Error Com	0
Selectivity - Right - Yr Error Rec	0.00
Trawl Logbook CPUE - log(q)	-6.69
Trawl Logbook CPUE - q Yr Error	0.00
Trawl Logbook CPUE q	0.00
NMFS Trawl Survey q	-0.33
WDFW Tag Survey q	4.90
Selectivity - Full NMFS Survey	4.21
Selectivity - Full WDFW Survey	7.59
Selectivity - Left NMFS Survey	-0.29
Selectivity - Left WDFW Survey	-0.64
Selectivity - Right NMFS Survey	5.74
Selectivity - Right WDFW Survey	15.00
Log Initial Age Comp Dev	0.0000
Log Rec Dev	-1.21788

Table 2. Coleraine output for the northern area (LCN) base model. Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	2.0361e+003	8.6640e+001
2	log_RecDev	-1.2179e+000	3.7409e-001
3	log_RecDev	-1.5518e+000	3.1961e-001
4	log_RecDev	-7.1743e-002	3.0898e-001
5	log_RecDev	-1.3627e+000	3.3319e-001
6	log_RecDev	-1.4095e+000	2.9256e-001
7	log_RecDev	4.1032e-001	1.5383e-001
8	log_RecDev	-8.5215e-001	3.3386e-001
9	log_RecDev	7.9378e-001	1.5053e-001
10	log_RecDev	-5.2725e-001	3.5798e-001
11	log_RecDev	4.0885e-001	2.2770e-001
12	log_RecDev	-7.2629e-001	2.3883e-001
13	log_RecDev	1.7764e-001	1.5985e-001
14	log_RecDev	-6.4471e-001	2.7610e-001
15	log_RecDev	9.5618e-001	8.5450e-002
16	log_RecDev	-2.5518e-001	2.3288e-001
17	log_RecDev	-7.7266e-001	2.2383e-001
18	log_RecDev	-4.1704e-001	1.5373e-001
19	log_RecDev	1.2682e-001	1.3990e-001
20	log_RecDev	3.3164e-002	1.2109e-001
21	log_RecDev	6.6010e-002	1.5125e-001
22	log_RecDev	-2.2342e-001	2.0164e-001
23	log_RecDev	1.6101e-001	1.5600e-001
24	log_RecDev	4.1759e-001	2.2013e-001
25	log_RecDev	3.0089e-001	2.2978e-001
26	log_RecDev	-2.9711e-001	2.9106e-001
27	log_RecDev	-7.1149e-002	2.6565e-001
28	log_RecDev	1.8178e-001	3.1577e-001
29	log_RecDev	1.5356e+000	4.1326e-001
30	log_RecDev	4.6543e-002	5.1515e-001
31	log_RecDev	0.0000e+000	5.0000e-001
32	log_RecDev	0.0000e+000	5.0000e-001
33	Sfullest	4.0010e+000	9.5637e-002
34	Sfullest	4.0009e+000	6.5244e-005
35	Sfulldelta	1.9008e-003	1.8184e-001
36	Sfulldelta	-8.6686e-004	1.4982e-004
37	log_varLest	-1.1228e+001	1.9133e+002
38	log_varLest	-1.5000e+001	3.0920e-002
39	log_varRest	1.5000e+001	2.9662e-001
40	log_varRest	2.3337e+000	3.5075e-001
41	log_qCPUE	-6.6899e+000	5.6349e-002
42	log_qsurvey	-3.2617e-001	1.4273e-001
43	log_qsurvey	4.9037e+000	5.8869e-002
44	surveySfullest	4.2092e+000	4.2826e-001
45	surveySfullest	7.5877e+000	1.1925e-001
46	surveySfulldeltaest	-1.3340e+000	1.9595e-001
47	surveySfulldeltaest	-5.0000e+000	9.6011e-006
48	log_surveyvarL	-2.9390e-001	7.0048e-001
49	log_surveyvarL	-6.4231e-001	2.3196e-001
50	log_surveyvarR	5.7386e+000	2.2170e+000
51	log_surveyvarR	1.4997e+001	1.3808e+001

Figure 1. Coleraine output for the northern area (LCN) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

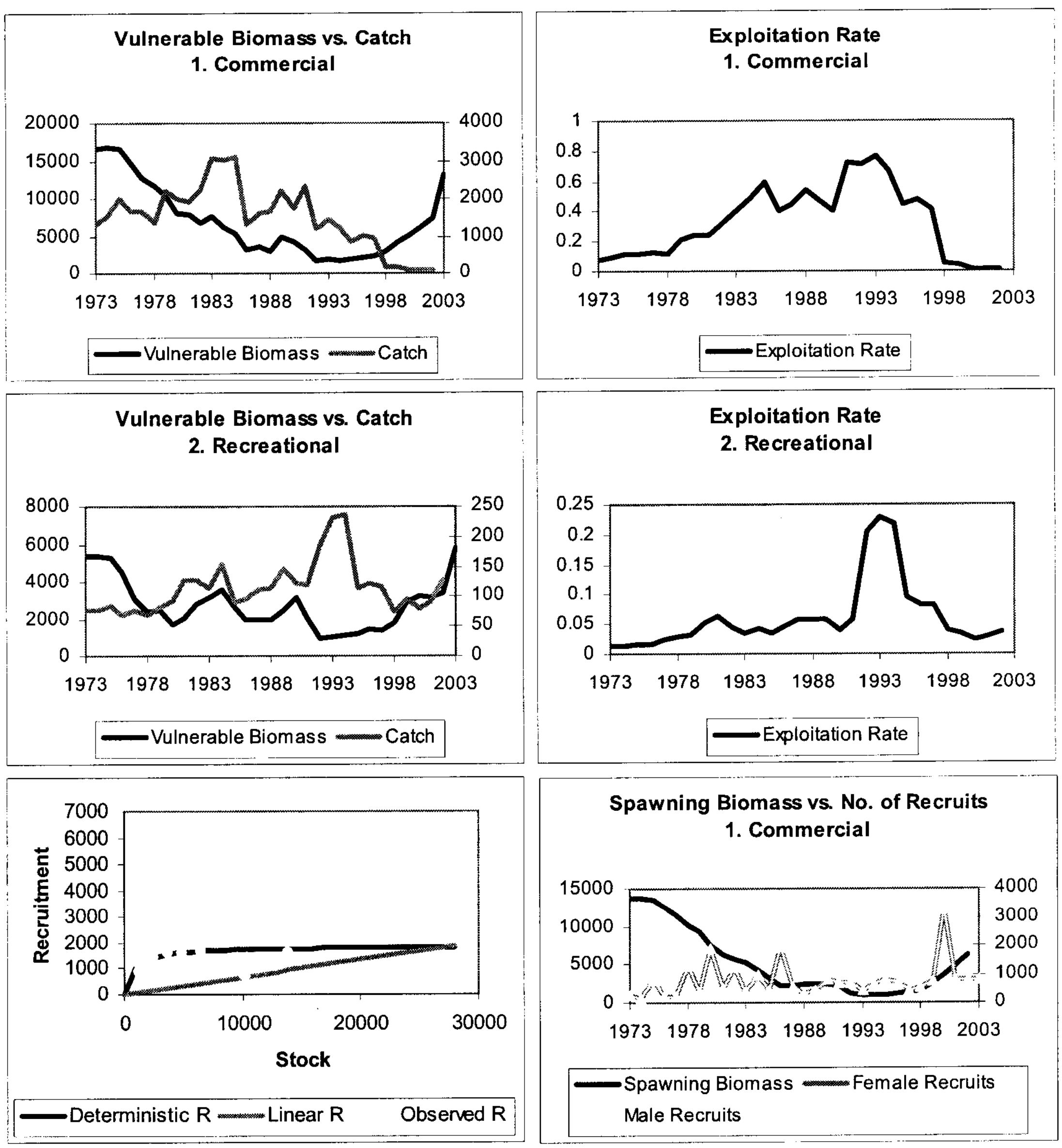


Figure 2. Coleraine output for the northern area (LCN) base model: Estimated selectivity for the commercial fishery, recreational fishery, NMFS trawl survey, and WDFW tagging survey.

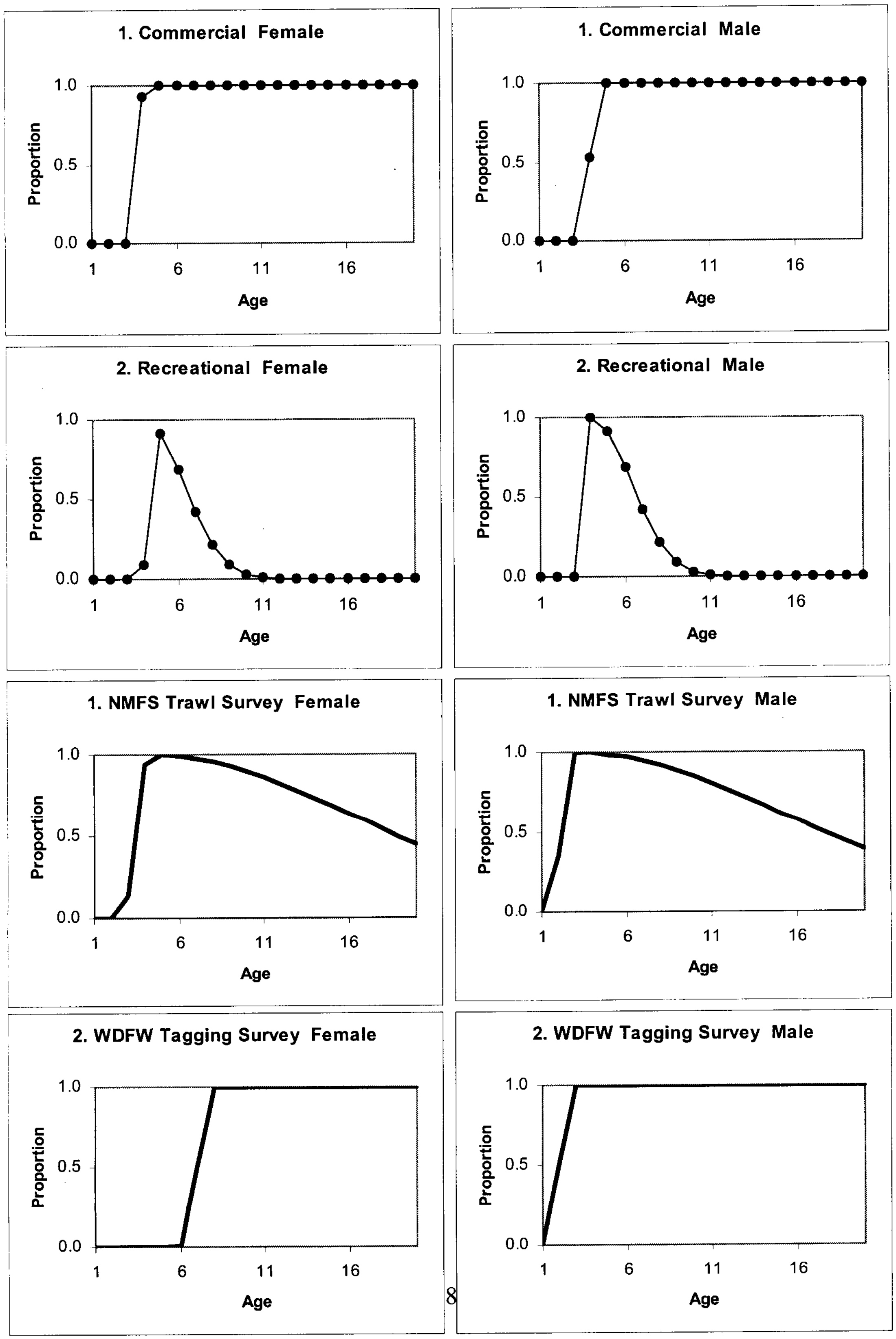


Figure 3. Coleraine output for the northern area (LCN) base model: Model fits to indices of abundance; NMFS trawl survey, WDFW tagging survey, and trawl logbook.

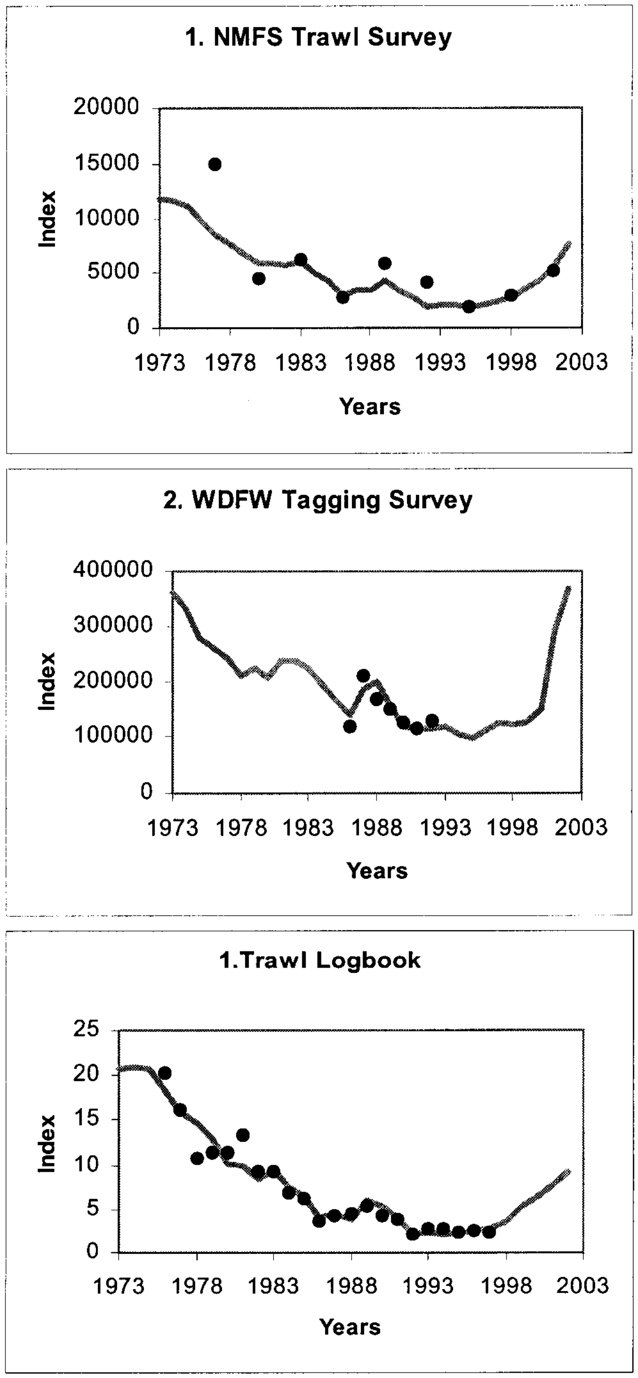


Table 3. Coleraine output for the southern area (LCS) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

File Path	D:\WDFW\
B0	25603
Depletion	0.18
Spawning Biomass 2003	**4481.9**
Input File	sigma50.tx
Likelihoods	
Trawl Logbook CPUE	4.19773
Com Catch-At-Age	-904.405
Rec Catch-At-Age	-944.468
	0
	0
NMFS Trawl Survey	10.8456
NMFS Survey Catch-At-Age	-286.324
	0
	0
Penalties: B-H Recruitment	9.51935
Total Likelihood:	**-2110.6**
Parameters	
R0	2286.7
h	0.9
M Females	0.18
M Males	0.32
Rinit	1
Uinit Females	0.07
Uinit Males	0.07
Init Plus Grp Resid Females	1
Init Plus Grp Resid Males	1
Selectivity - Full Com	3.12727
Selectivity - Full Rec	4.38449
Selectivity - Left Side Com	-1.9787
Selectivity - Left Side Rec	-1.60574
Selectivity - Right Side Com	1.31206
Selectivity - Right Side Rec	4.42149
Selectivity - Full - Yr Error Com	0
Selectivity - Full - Yr Error Rec	0
Selectivity - Left - Yr Error Com	0
Selectivity - Left - Yr Error Rec	0
Selectivity - Right - Yr Error Com	0
Selectivity - Right - Yr Error Rec	0
Trawl Logbook CPUE - log(q)	-6.03306
Trawl Logbook CPUE - q Yr Error	0
Trawl Logbook CPUE q	0.002398
NMFS Trawl Survey q	-1.25573
Selectivity - Full NMFS Survey	2
Selectivity - Left NMFS Survey	1
Selectivity - Right NMFS Survey	4
Log Initial Age Comp Dev	0
Log Rec Dev	0.222296

Table 4. Coleraine output for the northern area (LCS) base model: Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	2.2867e+003	1.3872e+002
2	log_RecDev	2.2230e-001	5.0204e-001
3	log_RecDev	6.6042e-002	4.6453e-001
4	log_RecDev	-8.5741e-002	4.1796e-001
5	log_RecDev	4.0889e-001	4.2767e-001
6	log_RecDev	5.6450e-001	3.7490e-001
7	log_RecDev	-1.6706e-002	3.9797e-001
8	log_RecDev	9.4838e-002	3.9870e-001
9	log_RecDev	5.0688e-001	3.3235e-001
10	log_RecDev	1.7577e-001	3.4492e-001
11	log_RecDev	-5.2751e-001	3.4803e-001
12	log_RecDev	-6.5988e-001	3.3002e-001
13	log_RecDev	-2.3102e-001	3.2852e-001
14	log_RecDev	1.5183e-001	3.3258e-001
15	log_RecDev	2.5469e-001	3.6218e-001
16	log_RecDev	3.8168e-001	3.2427e-001
17	log_RecDev	-1.3165e-001	3.7575e-001
18	log_RecDev	-2.1135e-001	2.4985e-001
19	log_RecDev	-5.0610e-001	1.2877e-001
20	log_RecDev	-1.1010e-001	1.4778e-001
21	log_RecDev	6.1601e-002	1.3935e-001
22	log_RecDev	-9.3462e-001	2.6014e-001
23	log_RecDev	7.7540e-002	1.7060e-001
24	log_RecDev	-3.3040e-001	2.4518e-001
25	log_RecDev	1.6243e-001	2.1778e-001
26	log_RecDev	-6.6863e-001	3.1835e-001
27	log_RecDev	-4.0311e-001	2.4642e-001
28	log_RecDev	-8.2802e-001	3.0370e-001
29	log_RecDev	4.3989e-001	2.8968e-001
30	log_RecDev	2.7769e-001	3.1538e-001
31	log_RecDev	1.1781e-006	5.0000e-001
32	log_RecDev	0.0000e+000	5.0000e-001
33	Sfullest	3.1273e+000	9.4028e-002
34	Sfullest	4.3845e+000	2.9536e-001
35	Sfulldelta	6.1394e-001	2.8249e-001
36	Sfulldelta	-7.5257e-002	9.2465e-002
37	log_varLest	-1.9787e+000	9.8804e-001
38	log_varLest	-1.6057e+000	1.4612e+000
39	log_varRest	1.3121e+000	3.1038e-001
40	log_varRest	4.4215e+000	5.0895e-001
41	log_qCPUE	-6.0331e+000	9.9451e-002
42	log_qsurvey	-1.2557e+000	1.0768e-001

Figure 4. Coleraine output for the southern area (LCS) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

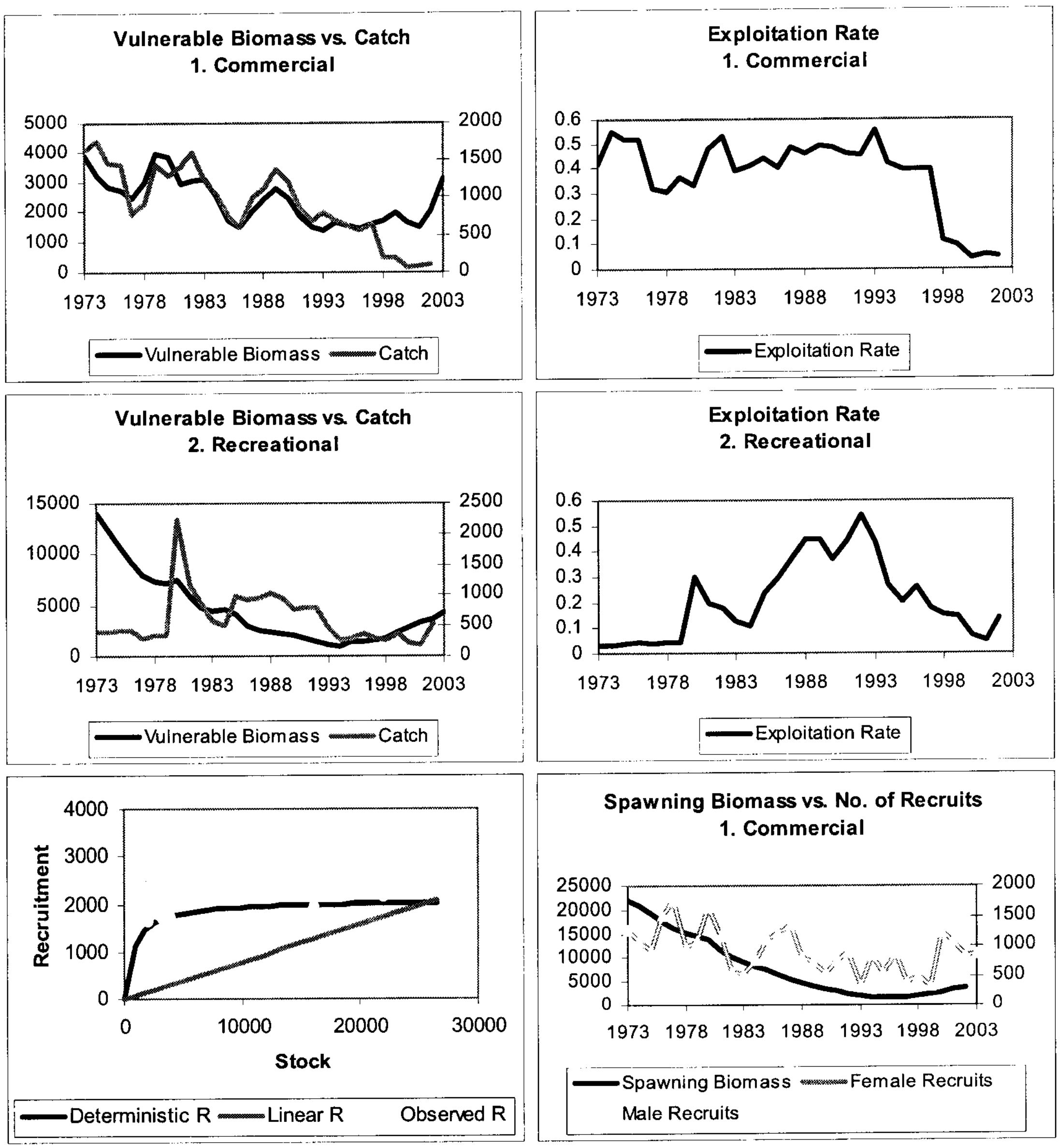


Figure 5. Coleraine output for the southern area (LCS) base model: Estimated selectivity for the commercial fishery, recreational fishery, and NMFS trawl survey.

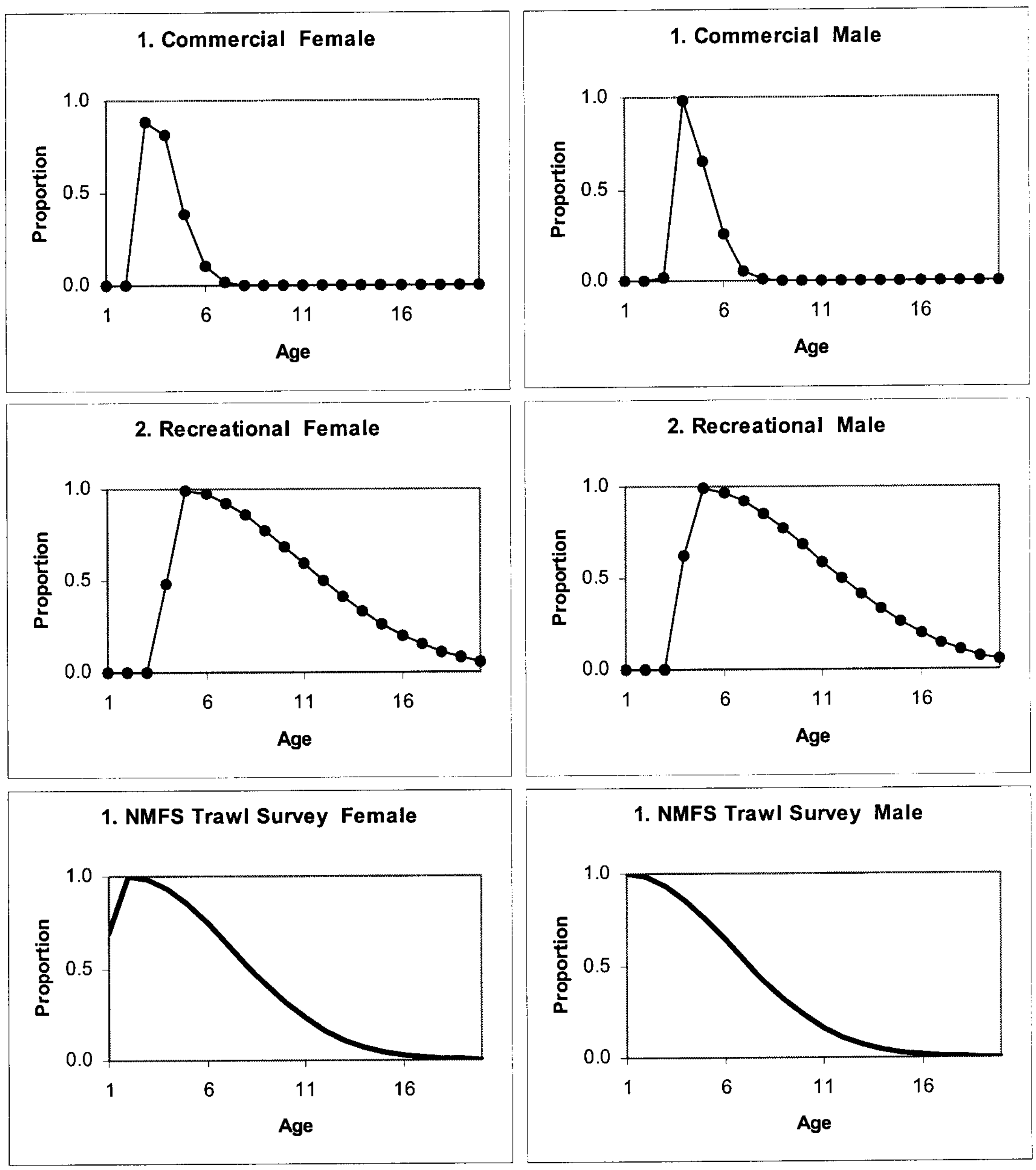
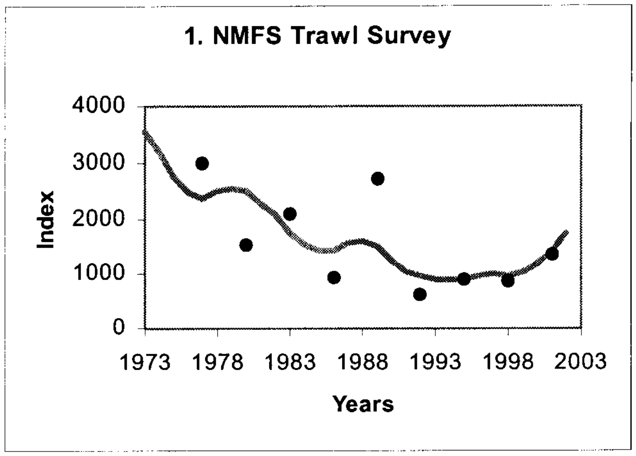


Figure 6. Coleraine output for the southern area (LCS) base model: Model fits to indices of abundance; NMFS trawl survey and trawl logbook.



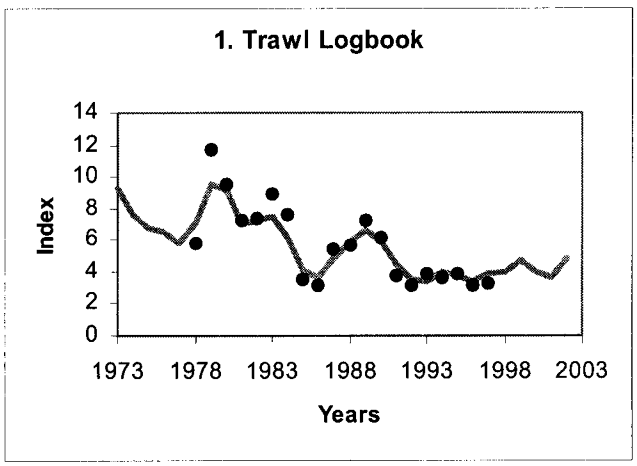


Table 5. Management reference points derived from the 2003 lingcod stock assessment (Jagielo et al. 2003; Addundum February 1, 2004). The final model allowed for domed fishery selectivity. Rebuilding projection input files were constructed for LCN (northern) and LCS (southern) area model data separately. Coastwide values are the sum of LCN and LCS.

	Coastwide	Northern	Southern
FMSY proxy		0.18	0.24
FMSY SPR / SPR(F=0)		0.45	0.45
Virgin SPR		13.27	11.20
Virgin Spawning Output (mt)	41071	20801	20270
Target Spawning Output (mt)	16428	8321	8108
Current (2002) Spawning Output (mt)	10261	6376	3885
Depletion ($SpBio_{2002}/SpBio_{Virgin}$)	0.25	0.31	0.19
Spawning Output (ydecl) (mt)	4935	2597	2338

Table 6. Projected yield (mt) under the model allowing for domed fishery selectivity. Yields are shown for probability of recovery values ranging from P=0.5 to P=0.9, and for the 40-10 and ABC rules.

Model	Year	P= .5	P= .6	P= .7	P= .8	P= .9	Yr=Tmid	F=0	40-10 Rule	ABC Rule
Coastwide	2004	2825	2781	2732	2680	2609	2815	0	2674	3091
	2005	2677	2636	2588	2538	2467	2668	0	2694	2922
	2006	2497	2459	2414	2367	2299	2489	0	2618	2716
	2007	2339	2303	2261	2216	2150	2331	0	2511	2540
	2008	2250	2216	2175	2132	2069	2243	0	2437	2438
North	2004	2055	2055	2055	2055	2055	2055	0	2055	2055
	2005	1874	1874	1874	1874	1874	1874	0	1874	1874
	2006	1694	1694	1694	1694	1694	1694	0	1694	1694
	2007	1540	1540	1540	1540	1540	1540	0	1540	1540
	2008	1451	1451	1451	1451	1451	1451	0	1451	1451
South	2004	769	726	676	625	554	760	0	618	1036
	2005	804	762	714	664	594	795	0	821	1048
	2006	803	764	719	672	605	794	0	924	1021
	2007	799	763	721	675	610	791	0	971	1000
	2008	800	765	725	682	618	792	0	987	987

Table 7. LCN (northern) model rebuilding analysis: Input values.

Lingcod North-Feb04	
Created with Version 2.7b (August 2003)	
Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	Set F to FMSY when above target
Number of fleets	2
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.18
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	13.27
Generation time	13
Minimum Rebuild Time (from ydecl)	5
Maximum Rebuild Time (from yinit)	13
Selected rebuild time	5
Year for rebuild	2009
Virgin Spawning Output	20801
Target Spawning Output	8321
Current Spawning Output	6376
Spawning Output (ydecl)	2597
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2004
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

Table 8. LCN (northern) model rebuilding analysis: Output values and recruitments used to compute B_0.

		Summary table						**40-10 Rule**	**ABC Rule**
Fishing rate	0.18	0.18	0.17	0.17	0.16	0.18	0	0	0
OY	2037	1991	1939	1873	1835	2017	0	1616	2041
Prob to rebuild by Tmax	50	60	70	80	90	54	100	76	50
Median time to rebuild	5	4	4	3	3	5	1	3	5
Prob overfished after rebuild	0	0	0	0	0	0	0	0	0
Median time to rebuild (yrs)	2009	2008	2008	2007	2007	2009	2005	2007	2009
Probability above current spawning outptut in 100 years	100	100	100	100	100	100	100	100	100
Probability above current spawning outptut in 200 years	100	100	100	100	100	100	100	100	100
Probability below 0.01B0 in 100 years	0	0	0	0	0	0	0	0	0
Probability below 0.01B0 in 200 years	0	0	0	0	0	0	0	0	0

Recruitments used to compute

Year	Recruitment
1972	531.62
1973	370.84
1974	1629.31
1975	447.53
1976	425.28
1977	2610.38
1978	732.79
1979	3773.36
1980	990.13
1981	2481.48
1982	788.29
1983	1921.27
1984	822.99
1985	3902.1
1986	1059.48
1987	638.59
1988	915.27
1989	1597.01
1990	1440.2
1991	1451.96
1992	900.99
1993	1273.07
1994	1591.85
1995	1425.21
1996	855.34
1997	1117.22
1998	1523.83
1999	6616.18
2000	1591.16
2001	1593.16

Highlighted values are used to compute B0

Figure 7. LCN (northern) model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).

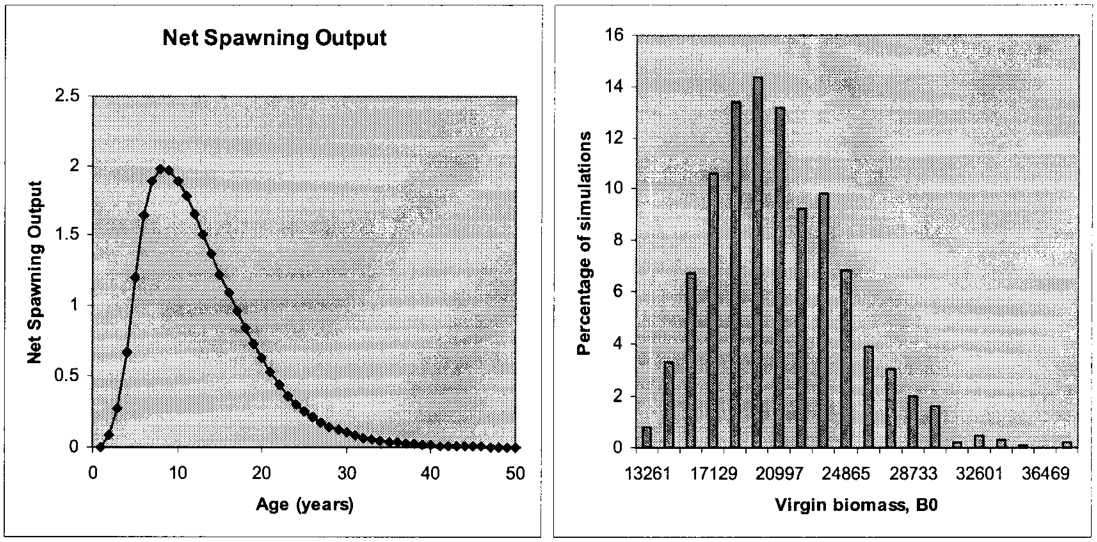
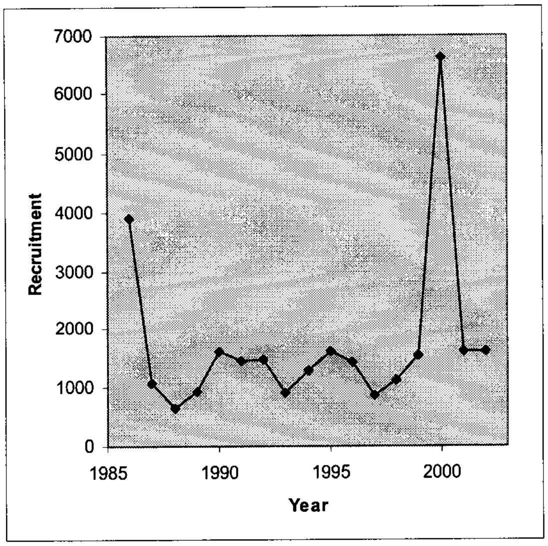


Figure 8. LCN (northern) model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).



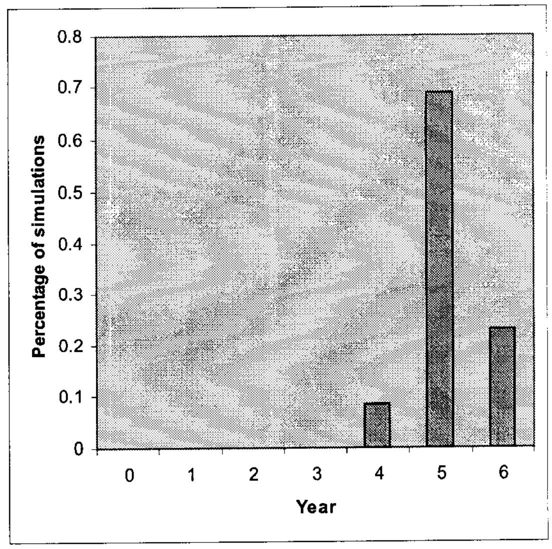


Table 9. LCS (southern) model rebuilding analysis: Input values.

Lingcod South-Feb 04

Created with Version 2.7b (August 2003)

Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	No change
Number of fleets	2
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.24
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	11.20
Generation time	12
Minimum Rebuild Time (from ydecl)	7
Maximum Rebuild Time (from yinit)	14
Selected rebuild time	5
Year for rebuild	2009
Virgin Spawning Output	20270
Target Spawning Output	8108
Current Spawning Output	3885
Spawning Output (ydecl)	2338
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2006
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

Table 10. LCS (southern) model rebuilding analysis: Output values and recruitments used to compute B_0.

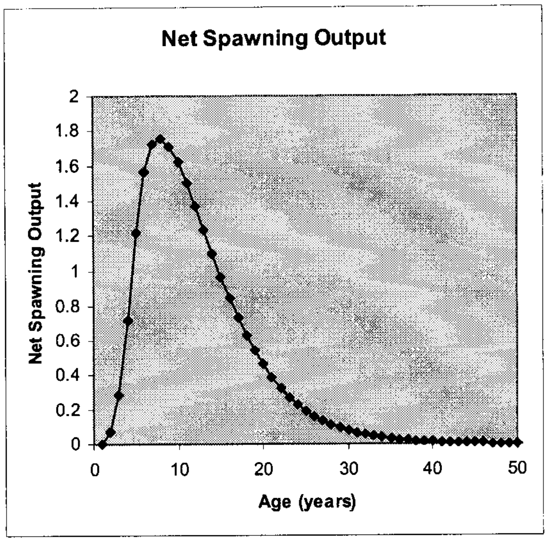
		Summary table						40-10 Rule	ABC Rule
Fishing rate	0.17	0.16	0.15	0.14	0.12	0.17	0	0	0
OY	769	726	676	625	554	760	0	618	1036
Prob to rebuild by Tmax	50	60	70	80	90	52	100	26	4
Median time to rebuild	5	5	4	4	3	5	2	9	21
Prob overfished after rebuild	0	0	0	0	0	0	0	0	0
Median time to rebuild (yrs)	2009	2009	2008	2008	2007	2009	2006	2013	2025
Probability above current spawning outptut in 100 years	100	100	100	100	100	100	100	100	100
Probability above current spawning outptut in 200 years	100	100	100	100	100	100	100	100	100
Probability below 0.01B0 in 100 years	0	0	0	0	0	0	0	0	0
Probability below 0.01B0 in 200 years	0	0	0	0	0	0	0	0	0

Recruitments used to compute

Highlighted values are used to compute B0

Year	Recruitment
1972	2146
1973	1840
1974	3010
1975	3505
1976	1953
1977	2177
1978	3280
1979	2349
1980	1152
1981	1001
1982	1524
1983	2218
1984	2438
1985	2728
1986	1608
1987	1458
1988	1064
1989	1539
1990	1774
1991	630
1992	1654
1993	1061
1994	1735
1995	761
1996	994
1997	660
1998	2455
1999	2156
2000	1693
2001	1747

Figure 9. LCS (southen) model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).



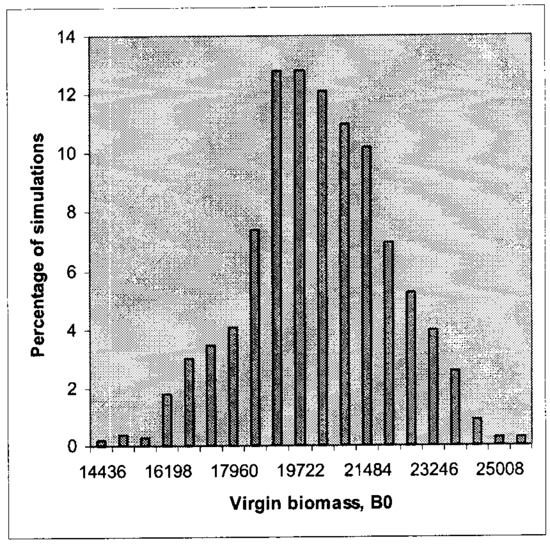
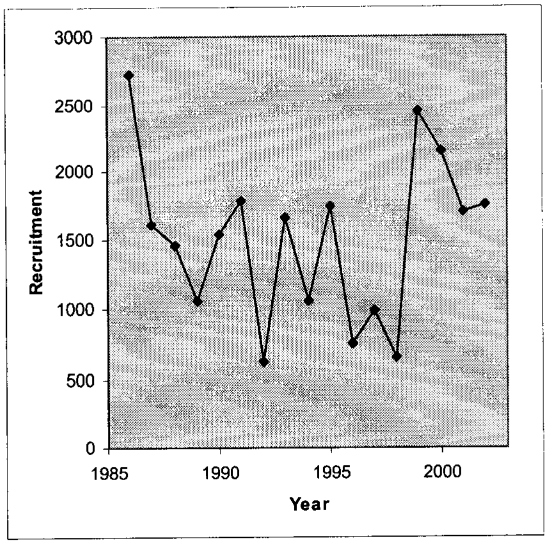
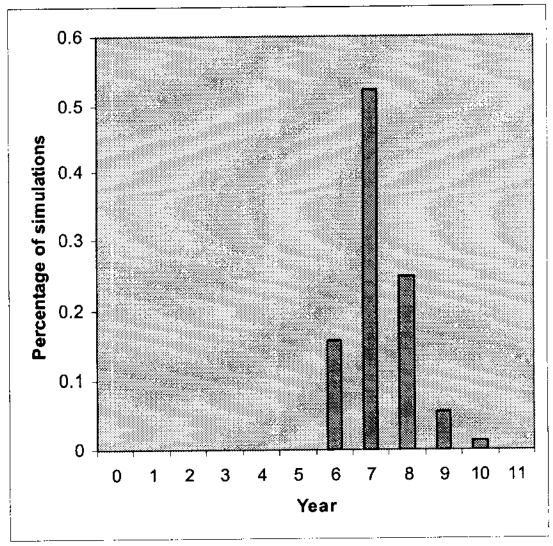


Figure 10. LCS (southern) model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).





SSC Requests from the November PFMC meeting.

INTRODUCTION

This document was prepared in response to requests made by the Scientific and Statistical Committee (SSC) of the Pacific Fishery Management Council regarding the recent stock assessment of cabezon (Cope et al., 2003). There were two requests to the Statistical Team:

1) re-analyze the data on which the CPFV logbook CPUE index is based to include data for the years prior to 1960 (the start of this CPUE series in the present assessment), and
2) re-examine the time-series of historical recreational catches using the CPFV logbook data and other published and unpublished information to estimate catches back to 1930.

This document shows the results of those analyses (including the effects on the outputs of the base case model of Cope et al. (2003)) and discusses the merits and disadvantages of the additional analyses. Within this document we use 'old' to refer to the assessment specifications and results from Cope et al. (2003) and 'new' to refer to the results from the analyses requested by the SSC.

METHODS

Analyze CPFV logbook CPUE index

Three alternative CPFV logbook CPUE series were derived using the same methods as described in the assessment document, except for the following differences:

1. Data prior to 1960 were used. Three alternative CPUE indices were developed (1936-present, 1947 present, and 1957-present).
2. The effort prior to 1960 was converted from angler hours to numbers of anglers using a linear relationship based on data for 1960-65 (linear regression, r^2=0.92, slope=0.0162, intercept =36.95). The uncertainty about this relationship was, however, not carried forward into the variance estimates for the CPUE indices.

Analysis of Recreational Catch Prior to 1980

A new time-series of recreational catches (1930-79; **Table 1.SSC**) was derived primarily from the ratio of the reported numbers of cabezon in the CPFV logbooks to the total recreational catch, as suggested to the STAT team by Dr Kevin Hill (pers. Comm. Kevin Hill, NMFS SWFSC), i.e.:

$$C_y^N = \sum_a \frac{C_y^{CPFV,N,a}}{P_y^{CPFV,a}} \tag{1}$$

where C_y^N is the recreational catch (in numbers) for year y ($1947 \le y \le 1979$),

$C_y^{CPFV,N,a}$ is the catch (in numbers) by the CPFV fleet in area a (southern and northern California) during year y, and

$P_y^{CPFV,a}$ is the fraction that the catch by the CPFV fleet represents of the total recreational catch in area a during year y.

The CPFV catches were taken from the CPFV logbooks and yearly summaries (Kevin Hill, SWFSC, pers. comm.). The catches for the years 1930-47 were taken from O'Connell (1953) assuming that the weight of an average fish in the catch is 1 kg.

Values for $P_y^{CPFV,a}$ are not available for all years unlike the values for $C_y^{CPFV,N,a}$. Therefore, the values for $P_y^{CPFV,a}$ are calculated for two time periods (1947-69 and 1970-79) as follows:

- 1947-69: 0.789 shore, 0.079 CPFV, and 0.132 private boat (northern California) and 0.549 shore, 0.254 CPFV, and 0.198 private boat (southern California; Miller and Gotshall 1965; Karpov et al. 1995; Pinkas et al. 1968).
- 1970-79: 0.522 shore, 0.041 CPFV, and 0.437 private boat (northern California) and 0.242 shore, 0.122 CPFV, and 0.636 private boat (southern California); based on average catch per mode from RecFIN (1980-89).
- The average weight of an individual fish (1947-79) was assumed to be: 0.85kg shore, 1.97 CPFV and 1.57 kg private boat (Northern California) and 0.76kg shore, 0.8kg CPFV and 0.93kg private boat (Southern California).

RESULTS and DISCUSSION

New CPUE Series

For the years after 1959, the "new" CPUE indices are virtually identical to the "old" CPUE indices (**Figure 1.SSC**). The CPUE indices for the years prior to 1959 are almost independent of the first year of the analysis (1936, 1947, or 1957) although there are some differences in the coefficients of variation estimated using bootstrapping (**Table 2.SSC**). CPUE increases from 1936 to a maximum in 1955 and drops off rapidly thereafter (**Figure 1.SSC; Table 2.SSC**). The CPUE indices for the years prior to 1957 are based solely on catches reported from south of Pt. Conception; i.e. the data before 1957 are highly unbalanced. It should also be noted that effort was recorded differently before and after 1960 (angler hours prior to 1960 and angler days and number of anglers thereafter).

The STAT team has some concern regarding the validity of the data prior to the change in the effort measure in 1960. Cabezon show a marked decline in numbers of fish caught after 1957 (**Figure 2.SSC**) resulting in a dramatic drop in CPUE. This same trend is seen not just in cabezon, but also across all rockfishes and all fishes in the CPFV data. It seems highly unlikely that all fish would show similar dramatic decreases in reported catch even as effort increased (**Figure 3.SSC**). This drop is possibly a result of differences in reporting practices or of CPFV fishing behavior. Further research should be conducted to investigate this. The STAT team also notes that the CPUE shows what appears to be an anomalous spike during the 1950s, something that is inconsistent with the dynamics of this fairly long-lived animal.

New Historical Recreational Catch

The "new" historical catch differs substantially from that used in the assessment (**Figure 4.SSC**). The largest differences between the "new" catch series (based on the CPFV catches and the split of the total recreational catch among fishing modes) and "old" catch series (based on the assumption of increasing recreational catch through time) occur during the 1950s when very large catches (and indeed all fish) were reported in the CPFV logbooks. The "new" catch series produced the two 5-year periods with the largest average catches over the entire time-series, even though total recreational effort increased from the 1950's to the 1980's (**Figure 5.SSC**). We also note here that no statistical sampling program was used to estimate catch prior to 1980 and no verified samples were reported prior to 1980. We also note that the CPFV logbook estimates for 1980-99 are poor predictors of total recreational catch over the same period (linear regression, r^2=0.27). This is likely because the CPFV fleet generally fishes outside cabezon habitat (deeper) and catches of cabezon are most likely influenced by the years when the CPFV fleet moved inshore (documented in the CPFV observer fleet). Further work in the area of historical catch is clearly warranted.

Modeling Results.

The modeling results (using the base-case model configuration of Cope et al. (2003) and based on maximum likelihood rather than Bayesian methods) were largely unaffected by the changes to the CPFV logbook CPUE and to the historical recreational catch (**Table 3.SSC**). The range of depletion levels (32.2% [CPUE 1947-present and old recreational catch] to 34.6% [New recreational catch and CPUE 1936-present] are very slightly less than that for the original base-case model (34.7%). However, the original base-case estimate of spawning biomass in 2003 (313 t) is bounded by the values from the sensitivity tests (282 t [CPUE 1947-present and old recreational catch] to 353 t [New recreational catch and CPUE 1937-present]). The estimates of 2004 OY ($F_{45\%}$ and 40-10 adjusted) were most affected by the changes to the catch and CPUE series, primarily because both the depletion level and the 2003 spawning biomass impact the calculation of these estimates.

CONCLUSIONS

There is little difference between the new modeling results (**Table 3.SSC**) and the assessment results from Cope et al. (2003), especially when the overall uncertainty of the modeling is considered. The STAT team notes that the effects of the new catch series on the model results were largely already indicated in the original assessment document through the sensitivity analyses conducted. The effect of a different CPUE series was not evaluated in the original assessment document, but is relatively small. Regardless of the data combinations used, the impression of stock status is very consistent.

The question of which version of the data to use in a base-case assessment is, however, difficult to address. This is because expert judgment must be used as (unfortunately) almost no actual sampling was done prior to the 1980s and therefore the data available are self-reported and unverified. In developing the original assessment model, the STAT team debated whether the CPFV catch series should be used as a basis to estimate total recreational catches (i.e. the basis for the "new" catch series) but rejected this because:

a) producing the largest catches without any sampling to verify this was judged by the STAT team to be questionable;
b) the reported catch by the CPFV fleet is only a small proportion of the total recreational catch so using this as a basis for extrapolation is questionable as minor reporting errors may be magnified substantially;
c) the CPFV catch is a very poor predictor of the total recreational catch in recent years raising the question why it should be considered to be a good predictor of this catch in the past; and
d) the assumption that recreational catches should increase through time reflecting the increasing recreational fishing effort (**Figure 5.SSC**) was judged more plausible.

In relation to the question of how to deal with the CPFV logbook CPUE series, the STAT team still believes that ignoring the data prior to 1960 is the most scientifically defensible approach, primarily because of the change in how effort is reported from 1960, the unusual peak in catch in the late 1950s of all species and our inability to account for the added variance due to effort conversion prior to 1960.

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Table 1.SSC. Estimates of new and old California cabezon recreational catch.

		Rrecreational Catch (f)						
year	new	old	year	new	old	year	new	old
1930	1	25	1961	25	50	1992	88.7	88.7
1931	2	25	1962	35	50	1993	79	79
1932	3	25	1963	74	50	1994	55	55
1933	3	25	1964	44	50	1995	69	69
1934	5	25	1965	58	50	1996	85	85
1935	5	25	1966	75	50	1997	60	60
1936	9	25	1967	38	50	1998	73	73
1937	9	25	1968	34	50	1999	43	43
1938	18	25	1969	35	50	2000	41	41
1939	9	25	1970	124	50	2001	57	57
1940	12	25	1971	69	50	2002	39	39
1941	11	25	1972	234	50			
1942	11	25	1973	149	50			
1943	11	25	1974	130	50			
1944	11	25	1975	78	100			
1945	11	25	1976	116	100			
1946	11	25	1977	118	100			
1947	108	25	1978	191	100			
1948	164	25	1979	81	100			
1949	149	25	1980	291	291			
1950	179	25	1981	121	121			
1951	208	25	1982	122	122			
1952	107	25	1983	104	104			
1953	75	25	1984	113	113			
1954	54	25	1985	77	77			
1955	49	25	1986	145	145			
1956	110	25	1987	117	117			
1957	98	25	1988	96	96			
1958	68	25	1989	101	101			
1959	54	25	1990	99.3	99.3			
1960	25	50	1991	94.3	94.3			

Table 2.SSC. Estimates of new CPFV CPUE for 1936-, 1947- and 1957-present.

series	1936-		1947-		1957-	
year	cpue	cv	cpue	cv	cpue	cv
1936	8.13	0.33				
1937	3.88	0.30				
1938	7.81	0.29				
1939	3.77	0.24				
1940	3.35	0.27				
1947	3.35	0.19	3.35	0.19		
1948	5.68	0.16	5.67	0.16		
1949	5.52	0.16	5.52	0.16		
1950	7.10	0.16	7.10	0.16		
1951	6.62	0.14	6.61	0.14		
1952	8.55	0.15	8.54	0.15		
1953	11.63	0.14	11.62	0.14		
1954	25.61	0.12	25.59	0.12		
1955	29.37	0.13	29.34	0.13		
1956	39.85	0.11	39.81	0.11		
1957	21.45	0.09	21.44	0.09	22.00	0.09
1958	13.01	0.10	13.01	0.10	13.37	0.09
1959	5.95	0.10	5.95	0.10	6.15	0.11
1960	3.77	0.11	3.76	0.11	3.91	0.12
1961	4.81	0.11	4.81	0.11	4.99	0.09
1962	7.59	0.11	7.59	0.11	7.87	0.12
1963	11.72	0.09	11.73	0.09	12.13	0.08
1964	13.15	0.09	13.15	0.09	13.61	0.10
1965	12.53	0.09	12.54	0.09	12.88	0.09
1966	13.36	0.08	13.36	0.08	13.71	0.08
1967	9.58	0.09	9.58	0.09	9.83	0.09
1968	5.34	0.10	5.34	0.10	5.51	0.09
1969	4.76	0.10	4.75	0.10	4.89	0.11
1970	6.22	0.10	6.22	0.10	6.41	0.09
1971	5.96	0.10	5.95	0.10	6.12	0.11
1972	9.73	0.08	9.73	0.08	9.97	0.08
1973	7.20	0.09	7.19	0.09	7.38	0.10
1974	7.66	0.09	7.66	0.09	7.87	0.09
1975	6.93	0.09	6.92	0.09	7.08	0.09
1976	6.31	0.09	6.31	0.09	6.49	0.08
1977	5.45	0.10	5.45	0.10	5.63	0.10
1978	8.36	0.09	8.36	0.09	8.60	0.09
1980	7.01	0.10	7.01	0.10	7.22	0.08
1981	5.16	0.09	5.15	0.09	5.30	0.09
1982	3.66	0.11	3.66	0.11	3.79	0.10
1983	4.13	0.11	4.12	0.11	4.26	0.10
1984	1.62	0.13	1.62	0.13	1.68	0.13
1985	1.97	0.11	1.98	0.11	2.08	0.11
1986	5.34	0.10	5.34	0.10	5.55	0.09
1987	7.20	0.10	7.20	0.10	7.46	0.09
1988	7.08	0.09	7.09	0.09	7.34	0.08
1989	9.38	0.10	9.38	0.10	9.68	0.08
1990	9.70	0.09	9.70	0.09	10.06	0.08
1991	7.51	0.09	7.51	0.09	7.80	0.10
1992	6.01	0.09	6.02	0.09	6.24	0.09
1993	3.28	0.10	3.28	0.10	3.40	0.11
1994	2.04	0.11	2.04	0.11	2.11	0.13
1995	2.74	0.11	2.74	0.11	2.81	0.10
1996	5.67	0.09	5.67	0.09	5.80	0.09
1997	4.72	0.09	4.72	0.09	4.85	0.09
1998	2.76	0.11	2.76	0.11	2.85	0.10
1999	2.60	0.11	2.60	0.11	2.67	0.11
2000	3.43	0.10	3.42	0.10	3.53	0.11
2001	5.15	0.11	5.14	0.11	5.26	0.11

Table 3.SSC. Selected Model outputs from all sensitivities done to the inclusion of new data series. The old model results are given and labeled as Base Case.

Trial	$\ln S_0$	S_{2003} (t)	Depletion	ABC	40-10 adjusted
New catch	14,51	341	34.0%	98.1	74.1
CPFV CPUE Index					
Old catch + 1936-	14.38	286	32.5%	77.5	50.1
Old catch + 1947-	14.38	282	32.2%	76.4	48.5
Old catch + 1957-	14.39	294	33.2%	79.7	53.2
New Catch + CPUE index					
New catch & 1936-	14.53	353	34.6%	103.5	82.5
New catch & 1947-	14.52	337	33.4%	98.7	74.5
New catch & 1957-	14.51	331	33.1%	96.3	70.9
Base Case	14.41	313	34.7%	84.5	60.5

Note:
$\ln S_0$ is natural log of intial stock size
S_{2003} is spawning stock biomass in 2003
Depletion is S2003/initial spawing stock size
ABC results from the application of an F45%
40-10 adjusted is the F45% rate adjusted by the 40-10 rule

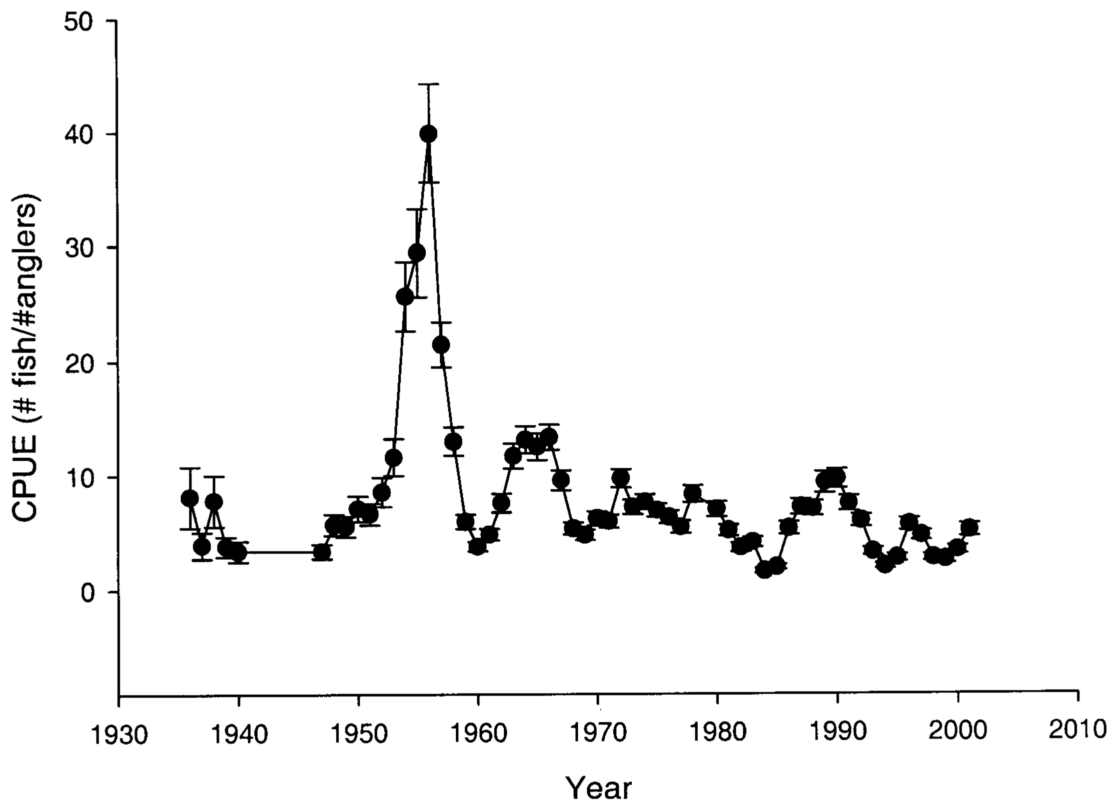


Figure 1.SSC. Plot of the CPFV recreational CPUE series. Errors bars are ± S.E.

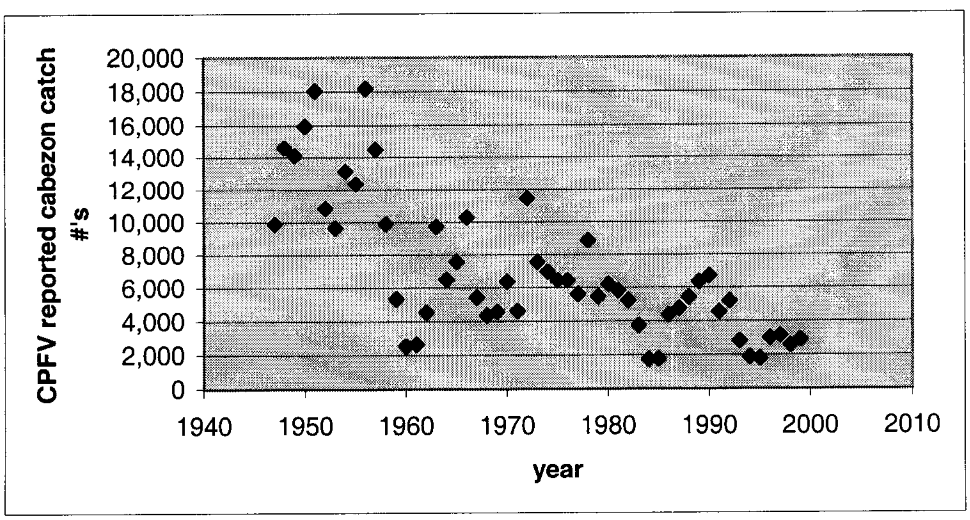
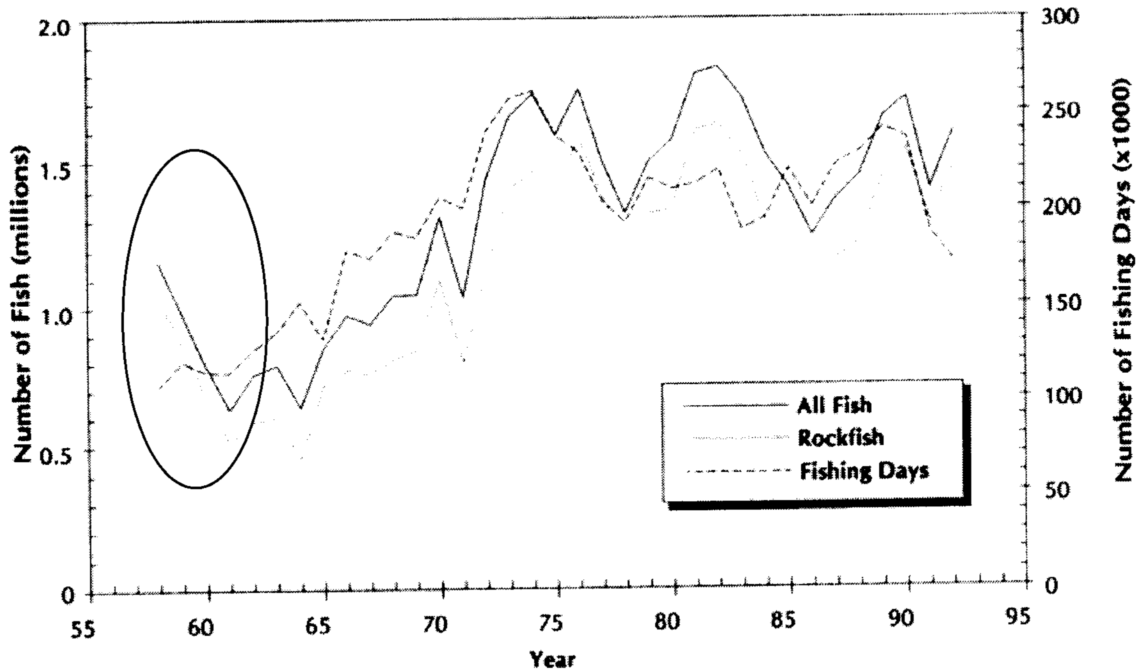


Figure 2.SSC. Numbers of reportedly caught cabezon by CPFV skippers from 1947-present.



Total fish catch, rockfish catch, and effort from northern and central California CPFV log data, 1958–92.

Figure 3.SSC. Numbers of recreationally caught rockfish and all fish by the CPFV fleets and CPFV effort from 1957-near present. Figure taken from Karpov et al. (1995).

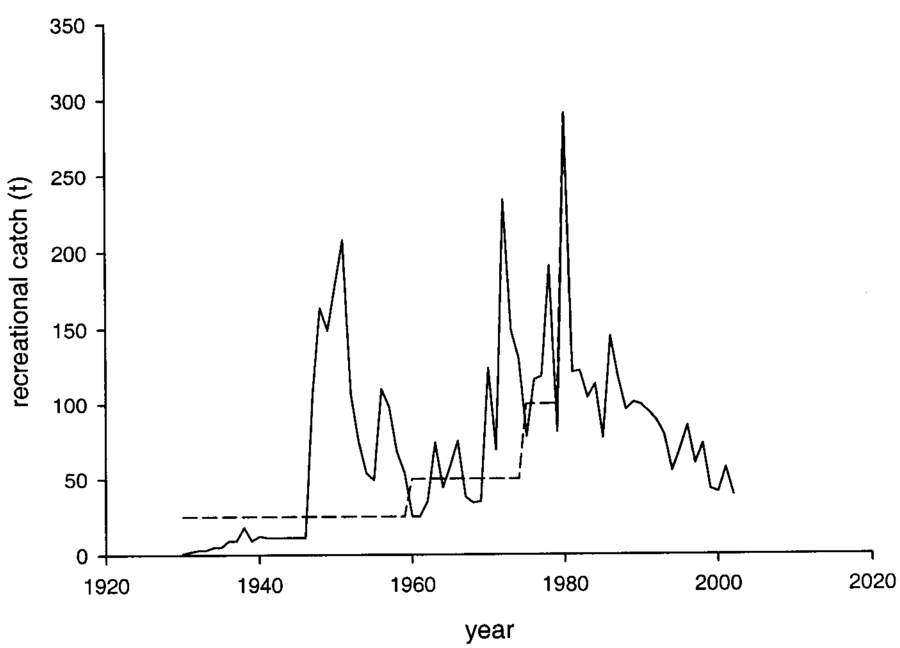
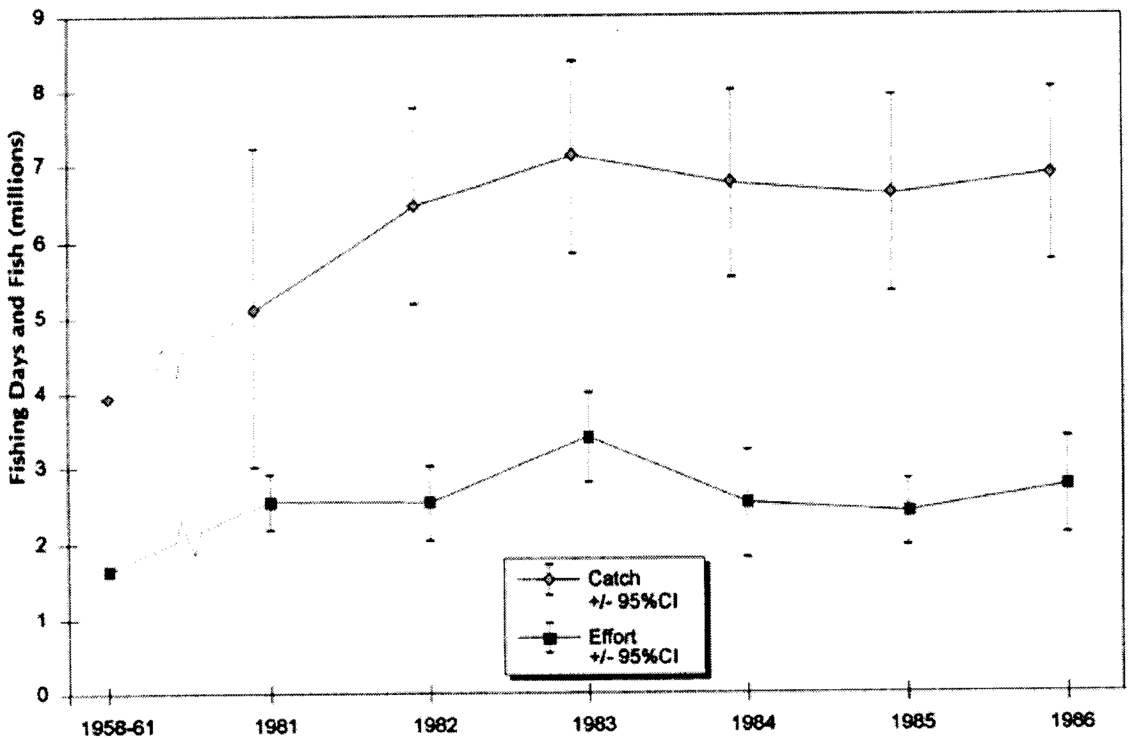


Figure 4.SSC. Estimated California recreational catch. Solid line depicts new estimates and dashed line the old estimates (Cope et al. 2003).



Average annual effort (millions of fishing days) and catch (millions of fish), with 95% confidence intervals in the marine recreational fishery in northern and central California.

Figure 5.SSC. A plot taken from Karpov et al (1995) depicting the increasing total recreational effort in California 1958-1986.

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON LINGCOD AND CABEZON STOCK ASSESSMENTS FOR 2005-2006

The Groundfish Advisory Subpanel (GAP) reviewed the lingcod and cabezon stock assessments for 2005-2006. The GAP is troubled by both of these assessments due to the paucity of data and the management results that can be implied if the assessments are accepted.

In the case of lingcod, two separate assessments were completed and combined. The result shows lingcod recovering well in the northern area, but still below a rebuilt level in the southern area. If indeed lingcod is a unit stock, as genetic data suggests, the GAP believes that stock densities should be examined to determine whether lingcod becomes more of a fringe population in the southern end of the range, rather than being uniformly distributed throughout the range. This is especially important given what appear to be overly high recreational catch levels in 2003 in California.

In the case of cabezon, the GAP believes the assessment should be held back and re-done. The GAP was informed that additional data has come to light on the cabezon population which was not included in the stock assessment process. Certainly, the data available for this assessment was exceedingly sparse, and the GAP member of the cabezon Stock Assessment Review Panel voiced this concern during panel deliberations. At the very least, the assessment should only be applied in the assessment area covered (south of 40°10' N latitude) and not coastwide.

PFMC
03/09/04

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON
LINGCOD AND CABEZON STOCK ASSESSMENTS FOR 2005-2006

Lingcod

The Scientific and Statistical Committee (SSC) reviewed results from the lingcod stock assessment at its November 2003 meeting (Exhibit D.6, Attachment 3, November 2003) and noted that values of the recruitment variability parameter (σ_r) in both the lingcod north (LCN) and lingcod south (LCS) models were too low (0.2 and 0.3, respectively) and should be increased. This parameter controls the level of year-to-year variation in recruitment. The SSC also recommended that the coastwide rebuilding analysis should be considered the sum of the outputs from the LCN and LCS models.

In reaction to the SSC's requests, the Stock Assessment Team (STAT) prepared a report (Addendum: February 1, 2004 – Response to November 2003 SSC Review, Exhibit E.2.a, Attachment 2, March 2004) that was reviewed by the SSC Groundfish Subcommittee during a public teleconference held February 25, 2004. In responding to the SSC's request the STAT Team re-evaluated the performance of the LCN and LCS lingcod models by increasing the σ_r parameter in increments of 0.1. The STAT Team found that model fit improved as the parameter increased, but that model convergence deteriorated when it exceeded 0.5. Overall, larger values of σ_r tended to better account for the observed data. Specifically, when $\sigma_r = 0.5$; (1) results indicate a much stronger 1999 year-class in both models, which is consistent with catch-at-age data obtained from both the NMFS shelf trawl survey and from commercial fisheries and (2) estimates of unfished spawning biomass (B_0) and spawning biomass in 2002 increase. As a consequence, a more favorable estimate of stock depletion ratio in 2002 results (31% for LCN and 19% for LCS). Moreover, for models with $\sigma_r = 0.5$ the estimated selectivity patterns for the various surveys and fisheries were more consistent with the comments of the STAR Panel, SSC, and Groundfish Management Team (GMT).

The SSC was concerned the model experienced convergence problems when σ_r was greater than 0.5. This problem may have been due to a combination of factors, i.e., (1) a very strong, partially-recruited cohort at the end of the modeled period, and (2) the inability of the assessment model to penalize the recruitment residual of a specific year. The latter problem is a limitation of the Coleraine modeling environment, which was used in the assessment. Given the time available, however, the SSC could not determine the exact reason for the convergence problem and concluded that some aspects of the behavior of the lingcod model are not fully understood. This issue should be explored during the next lingcod stock assessment update.

The STAT Team also re-estimated lingcod stock rebuilding, based on the new model runs using $\sigma_r = 0.5$, and computed coastwide rebuilding statistics as the sum of the outputs from the two models. For all rebuilding analyses, fishery selectivity was modeled with a dome-shaped function, which was the preferred scenario recommended by GMT, SSC, and STAR Panel. Projections from the LCN rebuilding analysis suggest that, if considered in isolation, the northern segment of the population may have rebuilt, with spawning biomass in 2004 estimated to be 28%

above the rebuilding target (40% of B_0). However, rebuilding projections from the LCS model indicate the southern stock has yet to rebuild, with current biomass estimated to be 70% of the target. However, because lingcod stock rebuilding is currently defined by the sum of outputs from the LCN and LCS models, the STAT Team evaluated rebuilding status by summing projections from the two models. Results are presented in the table below:

	LCN			LCS			Coastwide		
Year	Biomass	Target	Ratio	Biomass	Target	Ratio	Biomass	Target	Ratio
2002	6,376	8,321	0.766	3,885	8,108	0.479	10,261	16,428	0.625
2003	8,477	8,321	1.019	4,482	8,108	0.553	12,959	16,428	0.789
2004	10,661	8,321	1.281	5,656	8,108	0.698	16,317	16,428	**0.993**

These findings show that on a coastwide basis lingcod has not rebuilt because the total spawning biomass is still less than the target, albeit by less than 1%.

While it is currently the Council's policy to manage lingcod as a coastwide stock, there may be compelling biological reasons to distinguish the northern and southern areas. For example, due to more rapid growth of lingcod in the north, spawning-per-recruit is greater than in the south. Such a biological difference would imply different optimal harvest rates in the two areas. As a matter of practical importance, coastwide stock assessments are based upon larger, more comprehensive data sets, but results may suffer from blending of important spatial differences. The SSC discussed the merits of spatially explicit management of lingcod and concluded that such an approach may be desirable based solely on biological grounds. More generally, this issue is likely to be important in other groundfish stock assessments (e.g., bocaccio in central California versus southern California). When sufficient data are available to support region-specific analyses and spatial differences in productivity are evident, overall management could be improved by region-specific regulations.

The marked improvement in lingcod stock status is due to the estimation of a very strong 1999 year-class, a finding that is supported by a number of data elements in the assessment. It is important to realize, however, that this year-class is a transient phenomenon and that as the cohort ages, the projected acceptable biological catch will decline. To highlight this point, the SSC recommends that, in its final report, the STAT Team prepare a histogram of the 2004 population age-frequency distribution to accompany a graph that shows the projected spawning biomass trajectory of lingcod. Moreover, a set of management measures designed to impose effective harvest constraints will be an important issue for the Council to consider because the 2003 recreational harvest in the southern area seriously exceeded its target, and by year-end the coastwide catch was slightly more than twice the OY.

<u>Cabezon</u>

The SSC reviewed results from the cabezon stock assessment at its November 2003 meeting (Exhibit D.6, Attachment 1, November 2003) and expressed concern that the time series of California Department of Fish and Game (CDFG) Commercial Passenger Fishing Vessel (CPFV) logbook data used to model the stock was truncated to begin in 1960, although published information was available extending back to at least 1947[1/]. Moreover, cabezon harvests and catch rates were apparently highest during the excluded period from 1947-1959. Based on that concern, the SSC recommended to the cabezon STAT Team "that the CPFV logbook data be re-assembled, evaluated, and, if appropriate, included in the assessment model."

In reaction to the SSC's requests, the STAT Team prepared a response (SSC Requests from the November PFMC meeting, Exhibit E.2.a, Attachment 3, March 2004) that was reviewed by the SSC Groundfish Subcommittee during a public teleconference held February 25, 2004. Results presented in the STAT response (Table 3.SSC) indicate that inclusion of the earlier data in the model did not have a major impact on the conclusions of the assessment, especially with regard to depletion. For example, information in the original assessment (Exhibit D.6, Attachment 1, November 2003) indicated that cabezon spawning output in 2003 was 34.7% of that expected to occur in the absence of fishing, whereas when the earlier CPFV data (labeled "new catch & 1947-" in Table 3.SSC) were included, spawning output was estimated to be 33.4%. However, the model's estimate of 40-10 adjusted optimum yield (OY) changed more substantially, increasing from 60.5 mt to 74.5 mt (a 23% increase).

The STAT Team further argued in their response that "ignoring the data prior to 1960 is the most scientifically defensible approach" and recommended against inclusion of the earlier information. This view was founded on the belief that there was "no actual sampling" to verify the accuracy of self-reported CPFV logbook data from the earlier period. However, that conclusion is incorrect. Published results from a California Department of Fish and Game study[2/] that censussed the actual catch of CPFV vessels from 1947-1951 from San Francisco to San Diego showed that self-reporting by the fleet was very accurate (i.e., the total catch of 11,224 anglers was accurate to within 4%). With respect to cabezon specifically, actual catches were about 10% higher than were the self-reported CPFV logbook catches.

Other published information indicates the entire recreational catch of cabezon during the 1950s was quite high. For example, the CPFV harvest likely accounted for less than 15% of all sport catches[3/]. One investigator[4/] went so far as to say "in view of the sixfold increase in sport landings of the cabezon since the end of the war, the drain on the population may conceivably reach proportions capable of diminishing the stock in the foreseeable future." This opinion is supported by a cursory examination of the data presented in Young[1/], which shows that cabezon may well have been depleted by 1967. Morever, the STAT Team assumed that the average size of cabezon taken in the CPFV fishery was 0.8 kg-2.0 kg, depending on the year and area in question. However, Miller and Gotshall[3/] present information that shows the mean size of cabezon captured in the CPFV fishery in 1960 was 2.4 kg, which is consistent with results presented in O'Connell[4/]. Thus, underestimation of mean size is another potentially significant source of bias in establishing the historical catch of cabezon.

The reliability of the published information relating to cabezon that was collected by CDFG during the period 1947-1959 was discussed by the SSC, and it was concluded those data should be included in the assessment model. Therefore, the SSC recommends the model labeled "New Catch + CPUE index: New catch & 1947-" be adopted by the Council for management of the cabezon stock in 2005-2006. The STAT Team acknowledged that recommendation and indicated a willingness to prepare comprehensive harvest projections using that model, which would include the Council's 40:10 groundfish harvest policy and the California Nearshore Fishery Management Plan 60:20 control rule. In addition, because the SSC has lingering concerns about the status of the cabezon resource, the SSC recommends that during next year's stock assessment update all historical CDFG recreational catch and effort statistics should be more fully evaluated through modeling of the stock.

1/ Young, Parke H. 1969. California partyboat fishery, 1947-1967. Calif. Dept. Fish and Game, Fish Bulletin 145, 91 p.

2/ Baxter, J. L., and P. H. Young. 1953. An evaluation of the marine sportfishing record system in California. Calif. Fish and Game 39(3):343-353.

3/ Miller, D. J., and D. Gotshall. 1965. Ocean sportfish catch and effort from Oregon to Point Arguello, California, July 1, 1957 – June 30, 1961. Calif. Dept. Fish and Game, Fish Bulletin 130, 135 p.

4/ O'Connell, Charles P. 1953. The life history of the cabezon, *Scorpaenichthys marmoratus* (Ayres). Calif. Dept. Fish and Game, Fish Bulletin 93, 76 p.

PFMC
03/10/04

Exhibit E.2.c
Supplemental Public Comment
March 2004

South-Central Nearshore Trap Organization

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Atascadero, Calif. 93422

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Email something fishy@charter.net

RECEIVED
FEB 25 2004
PFMC

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, Oregon 9722-1384

To whom it regards concerning the cabezon assessment:

We, the South Central Nearshore Trap Organization, are concerned that the statistics used to assess the cabezon are not going to truly represent the fishery. Despite our South Central region catching **70%** of the state's cabezon, we were never consulted. We feel that by using only unreliable recreational data, hit and miss ichtyoplankton surveys and power-plant impingement in warm water where cabezon do not tend to spawn, their data was marginal at best. Despite this, if you look at the data they have in the 80's and 90's, there is limited evidence of a significant decline, and in fact, you see an increase with the power plant CPUE, and larval survey. If they used 1980 to 2000 data without extrapolating the data to 1930 (50 years of guessing) to figure the stock biomass, they would have had a spawning biomass at a much higher percentage. Also, if they would have included commercial CPUE's taken by Federal Observers in each region in 1999 and in 2003 or compared fish tickets in 2003 with those in 1995 or before during the same months, they would have had a very different picture. Here's what we sent NOAA's cabezon assessment team to consider:

1. <u>We intentionally do not catch large cabezon</u> (over 21-22"). We have asked Fish and Game to make it a law in our region that all traps must have 5"rings in the funnels this was instituted 3 years ago. We are also pushing currently for a slot size limit to decrease the catch of large by the stick fisherman.

2. The decrease in catch in 1999-2000 was when the <u>3 day/week and 2 month closures were instated</u>. The size limit was also increased to 15". The cabezon continued to be low in 2002 and 2003 secondary to a <u>low TAC set</u> by the fish and game allowing the fishery to be open only 4 months/3days/week in 2002 and 3 months 3days/week in 2003.

3. Cabezon like traps. They live in holes in the rocks and do not like going to drifting hooks. They are not a sport catch especially on large commercial passenger fishing vessels where it is too dangerous to get in close to shore. We have records of the last 3 years of CPFV catch out of Morro Bay and Avila and they catch 1-2 cabezon/trip if they catch any while we will set our traps on the same day in the same region and catch 200lbs. The MRVS data is proven inaccurate and is not appropriate to use on this fishery. <u>We think C.P.U.E.s done with traps collaboratively with fisherman locally in each region is the best tool to get an accurate picture of the cabezon status.</u>

4. We think that there are indicators that the cabezon fishery is doing well. With the long closures the last 2 years and the ring and size limits, we saw the best cabezon fishing in 10 years the few short months we were allowed to fish. Most of us didn't even get a chance to cover all the fishing grounds so many areas farther away from the harbor have gone another year untouched. We are not the only region with great catches either. We have heard the same report all up and down the coast by commercial fisherman. Look at our mandated Federal Observer information. ***<u>Look at our fish tickets. Compare them to this time 5 years ago.</u>*** We caught our quota in 29 days!!!! The quota is too low. <u>Cabezon is an untapped resource that can withstand selective harvesting and continue to do well. The tremendous catches this year proves it.</u>

5. <u>Cabezon grow comparatively fast</u> for a Nearshore fish. They have been proven to grow 3 1/2"per year depending on what they are eating. If they are eating abalone we think they grow faster. This makes them legal in 4 years. It takes lobster 7 years to be legal and they have a season and no set quota and have been a viable fishery for over a 100 years on the east coast and 75 years on the west coast.

6. <u>The cabezon are a predatory fish that eat other fish including their own young. Harvesting out some of the cabezon , we think actually increases the population of the overall Nearshore fish population.</u>

You will be lucky to have anyone left in this fishery if you use this assessment to allow further closures and smaller quotas. Currently, the cabezon allocation for commercial fisherman is 75,000lb down from 330,000lb in 1999. The trip limits set will allow less than 2600lbs/permit. This is a 80% reduction for many of us in our region. We feel this is entirely too conservative based on what we are seeing in the ocean and is wasting a valuable natural resource for harvest. We were hoping that the cabezon assessment would come up positive *if it was anywhere close to accurate* and that it would allow the commissioners to free us from these unrealistic quotas.

Please contact Tom Hafer (president) with any questions.

cc. Tom Barnes, Marine Biologist with DFG in La Jolla

Sincerely,

South-Central Nearshore Trap Org.

SOUTH CENTRAL NEARSHORE TRAP ORGANIZATION

SIGNATURE PAGE

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Exhibit E.3
Situation Summary
March 2004

STOCK ASSESSMENT PLANNING FOR 2007-2008 FISHERY MANAGEMENT

Situation: The Council approved Amendment 17 to the Pacific Coast Groundfish Fishery Management Plan as a means of providing for a biennial management cycle, more opportunity for public input, regulatory efficiencies, and various improvements in the management process. This agendum deals with planning activities for the 2007-2008 fishery management cycles. The "on year" for Council decision making for this cycle begins with the November 2005 Council meeting and includes a second Council meeting in March or April 2006 and a final Council meeting in June 2006 (Exhibit E.3.a, Attachment 1.)

Dr. Elizabeth Clarke, Division Director at the NMFS Northwest Fisheries Science Center, will report on proposed stock assessment activities from the perspective of the Fishery Resource Analysis and Monitoring Division (Exhibit E.3.b, Attachment 1). The Council is to consider the input from NMFS, the Advisory Bodies, and the public before providing guidance relevant to stock assessment priorities by species, type of assessment (full or update), and schedule of occurrence.

At the November 2003 Council meeting, there was initial discussion on "off-year" workshops and stock assessment production planning. The statements of the Scientific and Statistical Committee (SSC), Groundfish Management Team (GMT), and Groundfish Advisory Subpanel (GAP) from that meeting are included for reference (Exhibit E.3.a, Attachments 2, 3, and 4, respectively).

Council Task:

1. **Discuss stock assessment planning for the 2007-2008 management period and make recommendations to the NMFS Fishery Science Centers regarding :**
    a. **Species priorities for stock assessments.**
    b. **Type of assessment.**
    c. **Schedule of stock assessment occurrence.**
    d. **"Off-year" workshops.**

Reference Materials:

1. Exhibit E.3.a, Attachment 1: Biennial Management Process, 2005-2006 and 2007-2008.
2. Exhibit E.3.a, Attachment 2: SSC Report on Planning of "Off-year" Non-regulatory Science Activities, from the November 2003 Council meeting.
3. Exhibit E.3.a, Attachment 3: GMT Report on Planning of "Off-year" Non-regulatory Science Activities, from the November 2003 Council meeting.
4. Exhibit E.3.a, Attachment 4: GAP Report on Planning of "Off-year" Non-regulatory Science Activities, from the November 2003 Council meeting.
5. Exhibit E.3.b, Attachment 1: Proposed Groundfish Stock Assessment Activities for 2004-2005.

Agenda Order:

a. Agendum Overview — John DeVore
b. NMFS Recommendations — Elizabeth Clarke
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. Council Discussion and Guidance

PFMC
02/24/04

Exhibit E.3.a
Attachment 1
March 2004

BIENNIAL MANAGEMENT PROCESS, 2005-2006 and 2007-2008

<table>
<tr><th>Month and Year</th><th>Stock Assessments</th><th>Management Specifications and Measures</th><th>Post-Council Regulatory Process</th></tr>
<tr><td>Nov '03</td><td rowspan="5">“Off year" for stock assessments. Advanced model development and stock assessment model refinement year.</td><td>Proposed ‘05-‘06 ABC/OY; prelim mgmt measures.</td><td rowspan="3">‘04 Specs via emergency for Jan-Apr; ‘04 Specs proposed rule and implementation via final rule due 3/04.</td></tr>
<tr><td>Jan '04</td><td></td></tr>
<tr><td>Mar/Apr '04</td><td>Refined ‘05-‘06 management measures.</td></tr>
<tr><td>June '04</td><td>Final ‘05-‘06 specs and mgmt measures.</td><td></td></tr>
<tr><td>Sept '04</td><td rowspan="6">First “off year" for Council management specifications process.</td><td rowspan="2">‘05-‘06 out as proposed rule and implemented via final rule by 01/05.</td></tr>
<tr><td>Nov '04</td><td rowspan="5">“On year” for stock assessments and STAR processes.</td></tr>
<tr><td>Jan '05</td><td></td></tr>
<tr><td>Mar/Apr '05</td><td rowspan="3"></td></tr>
<tr><td>June '05</td></tr>
<tr><td>Sept '05</td></tr>
<tr><td>Nov '05</td><td rowspan="5">"Off year" for stock assessments.</td><td>Proposed ‘07-‘08 ABC/OY; prelim mgmt measures.</td><td rowspan="4">Advance regulatory streamlining process.</td></tr>
<tr><td>Jan '06</td><td></td></tr>
<tr><td>Mar/Apr '06</td><td>Refined ‘07-‘08 mgmt measures.</td></tr>
<tr><td>Jun '06</td><td>Final ‘07-‘08 specs and mgmt measures.</td></tr>
<tr><td>Sep '06</td><td rowspan="3">“Off year" for Council management specifications process.</td><td rowspan="2">‘07-‘08 out as proposed rule and implemented via final rule by 01/07.</td></tr>
<tr><td>Nov '06</td><td rowspan="2">“On year” for stock assessments and STAR processes.</td></tr>
<tr><td>Jan '07</td><td></td></tr>
</table>

Exhibit E.3.a
Attachment 2
March 2004

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON PLANNING OF "OFF-YEAR" NON-REGULATORY SCIENCE ACTIVITIES

Dr. Elizabeth Clarke presented a draft proposal (Exhibit D.9.b, Supplemental NMFS Report) for "off-year" (2004) science workshops and other non-regulatory activities to the Scientific and Statistical Committee (SSC). In order to motivate activities proposed in 2004, Dr. Clarke's presentation included a description of stock assessments and supporting activities (stock assessment review [STAR] panels, etc.) that would be conducted during 2005 (the "on-year").

Table 1 of the draft proposal lists 27 stock assessments (16 full assessments and 11 expedited). Proposed workshops for 2004 are listed in Table 3, and these are intended to alleviate the workload burden of the full assessment schedule in 2005. The first suggestion for streamlining the 2005 process, which the SSC endorses, is to divide the stock assessments among different work groups based on species type (Dover sole/thornyhead/trawl-caught sablefish complex [DTS], flatfish, rockfish, etc.). The second suggestion is to use data "stewards" for facilitating data acquisition by the stock assessment authors. The SSC highly recommends the use of data stewards in this role.

Dr. Clarke's proposal recommends a data workshop for 2004 to find new ways to improve the efficiency and implementation of different data sources to be used in the 2005 stock assessment process. The SSC considers this data workshop to be a high priority. The SSC also considers the development of standards and methodologies for incorporating new observer-based data to construct catch histories to be an important component of the proposed data workshop.

A second workshop proposed for 2004 is a stock assessment modeling workshop that could include, for example, a review of the new version of the Stock Synthesis Model ("Isabelle") as a standardized analysis tool for the 2005 assessments. The SSC also considers this workshop to be a high priority. While the Recreational Catch Per Unit Effort (CPUE) Workshop was not discussed in detail, the SSC also considers it to be a useful objective. Dr. Clarke indicated that three workshops in 2004 would likely be a maximum for administrative time and effort. Terms of Reference for the workshops will be needed, and the SSC is willing to participate in the drafting of these.

The SSC also discussed the possibility of a B_0/B_{MSY} workshop and also considers this to be worthwhile. Suggestions included coordinating a B_0 workshop with the North Pacific Council, or through the National Marine Fisheries Service (NMFS). Currently, NMFS is involved in an effort to develop environmentally explicit stock assessments, which may have a major impact on the calculation of reference points like B_0. Ecosystem-based management could be another area for coordination with the North Pacific Fishery Management Council.

The main obstacle for completing all the stock assessment objectives for 2005 appears to be scheduling and personnel for the stock assessment and review (STAR) panels that will be required for the full assessments (Table 4). The administrative maximum here is likely to be five full meetings. For logistical reasons, it appears these meetings would need to occur during the spring and fall of 2005. Even under this schedule, the SSC is concerned that all of the objectives listed in the proposal for 2005 cannot be satisfactorily completed under the current STAR process. The only alternatives appear to be conducting fewer assessments or revising the current STAR process, moving towards lighter reviews or more expedited assessments.

PFMC
11/05/03

GROUNDFISH MANAGEMENT TEAM REPORT ON PLANNING OF "OFF-YEAR" NON-REGULATORY SCIENCE ACTIVITIES

The Groundfish Management Team (GMT) received an update from Dr. Jim Hastie on the status of the Northwest Fisheries Science Center's (NWFSC) plans for science activities during the "off year" under the new biennial management process adopted by the Council under fishery management plan Amendment 17. The NWFSC tentatively plans to prepare about 21 groundfish assessments in preparation for the 2007-2008 management period. Under the terms of Amendment 17, these assessments would need to be prepared, reviewed by a Stock Assessment Review (STAR) Panel, reviewed by the Scientific and Statistical Committee (SSC), and adopted by the Council by the November 2005 Council meeting. The GMT recommends all STAR Panels for these assessments be convened in 2005. Furthermore, while the Council process may benefit by parsing SSC review and Council adoption of new assessments and rebuilding analyses between the scheduled 2005 Council meetings, the GMT recommends that all assessments and rebuilding analyses be formally reviewed and adopted by the September 2005 Council meeting. This will allow the GMT and other Council advisors the time to digest the abundance of new scientific information and recommend a range of 2007-2008 harvest levels at the November 2005 Council meeting.

PFMC
11/06/03

Exhibit E.3.a
Attachment 4
March 2004

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON PLANNING OF "OFF-YEAR" NON-REGULATORY SCIENCE ACTIVITIES

The Groundfish Advisory Subpanel (GAP) met with Dr. Elizabeth Clarke to discuss off-year science activities being coordinated by the Northwest Fisheries Science Center (NWFSC).

The GAP is pleased to see that the NWFSC considers the Magnuson-Stevens Act requirement for a two-year review of rebuilding to mean at least an assessment update. The GAP has previously testified that this is the proper way to approach this legal requirement, especially in view of our constantly changing fisheries and data inputs.

The GAP also generally concurs with the approach taken by the NWFSC, as illustrated in Supplemental NMFS Report D.9.b. However, the GAP is concerned the personnel and work requirements inherent in completing the large number of stock assessments and assessment reviews will overwhelm the capabilities of scientists and managers. The GAP, therefore, examined the list of proposed stock assessments provided in Table 1 of the report and suggested modifications based on the following criteria:

- a stock has been designated as overfished and requires a two-year review;
- a stock is commercially or recreationally important, and its status should be examined;
- concerns have been expressed about stock status, based on fishermen's knowledge; and
- the optimum yield for a stock has not been attained in recent years because of lack of harvest.

Using these criteria, the GAP proposes deleting seven stocks from the assessment list and adding one, as follows:
Petrale sole (delete)
Chilipepper rockfish (delete)
English sole (delete)
Arrowtooth (delete)
Yellowtail rockfish (delete)
Splitnose rockfish (delete)
Cabezon (delete)
Starry Flounder (add)

The GAP notes that shortbelly rockfish is also considered for an assessment in the Table 4 list. The majority of the GAP does not believe that resources need to be dedicated to shortbelly at this time. A minority of the GAP believes an assessment on shortbelly would serve as a good indicator of regime shifts.

The GAP appreciates Dr. Clarke consulting with us in regard to our views and we would be happy to provide a further justification for our recommendations.

PFMC
11/06/03

Exhibit E.3.b
Attachment 1
March 2004

Proposed Groundfish Stock Assessment Activities for 2004-2005

Elizabeth Clarke,
Division Director, FRAM Division, NWFSC
February 2004

Table 1 lists stock assessments that could be conducted in 2005. This list includes suggested agency leads. This list does not identify which assessments will be full assessments and which will be updates. Clearly, a significant number will have to be updated assessments if the full list of stocks proposed here is to be assessed. A final list of stocks and agency leads needs to be finalized before planning for workshops in 2004 can proceed. It is unclear if there are the resources and expertise on the west coast to conduct all stock assessments listed in Table 1.

Table 1. Proposed Stock Assessments for 2005

Species	Agency Lead
Arrowtooth	NWFSC
Bank Rockfish	SWFSC
Blackgill	SWFSC
Bocaccio	SWFSC
Cabezon	NWFSC
California scorpionfish	CDFG
Canary	NWFSC
Chilipepper	SWFSC
Cowcod	SWFSC
Darkblotched	NWFSC
Dover sole	NWFSC
English Sole	NWFSC
Lingcod	WDFW
Longspine Thornyhead	NWFSC
Pacific Hake	NWFSC
Petrale Sole	NWFSC
POP	NWFSC
Sablefish	NWFSC
Shortbelly	SWFSC
Shortspine Thornyhead	NWFSC
Vermillion	SWFSC
Widow	SWFSC
Yelloweye	WDFW/NWFSC
Yellowtail	NWFSC

The multi-year management process specifies that the "off" years can be used to conduct workshops to refine modeling and stock assessment approaches. The NWFSC proposes to coordinate three workshops in 2004 to facilitate the stock assessment process.

The first workshop will review the methods for calculating recreational CPUE.

The second workshop will focus on data needs for stock assessment. We propose that discussions between authors and data managers and others regarding data needs for the stock assessments occur at this first workshop. We will ask authors to discuss all potential data sources that will be used in assessments.

The third workshop will focus on new models and modeling issues that are relevant to the following year's stock assessments. During this workshop the NWFSC proposes to introduce a flexible ADMB model. Other topics that will be discussed are: methods for communicating uncertainty in assessment documents, modeling approaches that are planned by each author and refinement of the terms of reference for the 2005 stock assessment review process.

Table 2. Proposed Workshops coordinated by the NWFSC for 2004

Title	Timing	Location
Recreational CPUE Methods	April 2004	Santa Cruz
Stock assessment data workshop	July 2004	Newport
Stock assessment modeling workshop	September 2004	Seattle

Finally, the following is a proposed schedule for the review of stock assessments in 2005 (Table 3). A list of possible species for each panel is included in the table for discussion purposes only. A final list of species to be given updated assessment versus full assessments must be developed prior to finalizing the species to be included in each panel.

Table 3. Proposed Stock Assessment Review Schedule

Panel	Possible Species	Time	Location
STAR Full Assessment Panel One	Pacific Hake	February	Seattle
STAR Full Assessment Panel Two	Sablefish, Dover, Shortspine Thornyhead, Longspine Thornyhead	May	Newport
STAR Full Assessment Panel Three	Petrale, English, Arrowtooth	May	Seattle
STAR Full Assessment Panel Four	Chilipepper, Vermillion, Bank, Splitnose, Shortbelly	Late May	Santa Cruz
STAR Full Assessment Panel Five	Cowcod, California Scorpionfish, Yelloweye	June	La Jolla
STAR Update Panel One	Five species	August	TBA
STAR Update Panel Two	Five species	August	TBA

Exhibit E.3.b
Supplemental NWFSC PowerPoint
March 2004

Stock Assessment Priorities

March 2004

Elizabeth Clarke

Species	Agency Lead
Arrowtooth	NWFSC
Bank Rockfish	SWFSC
Blackgill	SWFSC
Bocaccio	SWFSC
Cabezon	NWFSC
California scorpionfish	CDFG
Canary	NWFSC
Chilipepper	SWFSC
Cowcod	SWFSC
Darkblotched	NWFSC
Dover sole	NWFSC
English Sole	NWFSC
Lingcod	WDFW
Longspine Thornyhead	NWFSC
Pacific Hake	NWFSC
Petrale Sole	NWFSC
POP	NWFSC
Sablefish	NWFSC
Shortbelly	SWFSC
Shortspine Thornyhead	NWFSC
Vermillion	SWFSC
Widow	SWFSC
Yelloweye	WDFW/NWFSC
Yellowtail	NWFSC

Panel	Possible Species	Time	Location
STAR Full Assessment Panel One	Pacific Hake	February	Seattle
STAR Full Assessment Panel Two	Sablefish, Dover, Shortspine Thornyhead, Longspine Thornyhead	May	Newport
STAR Full Assessment Panel Three	Petrale, English, Arrowtooth	May	Seattle
STAR Full Assessment Panel Four	Chilipepper, Vermillion, Bank, Shortbelly	Late May	Santa Cruz
STAR Full Assessment Panel Five	Cowcod, California Scorpionfish, Yelloweye	June	La Jolla
STAR Update Panel One	Five species	August	TBA
STAR Update Panel Two	Five species	August	TBA

Title	Timing	Location
Recreational CPUE Methods	April 2004	Santa Cruz
Stock assessment data workshop	July 2004	Newport
Stock assessment modeling workshop	September 2004	Seattle

Type	Proposed	SSC	Gap	GMT	Summary
	Arrowtooth				
	Bank Rockfish		Bank Rockfish		Bank Rockfish
full	Blackgill	Blackgill	Blackgill	Blackgill	Blackgill
update	Bocaccio	Bocaccio	Boccacio	Boccacio	Boccacio
update	Cabezon	Cabezon		Cabezon	Cabezon
full	California scorpionfish	California scorpionfish	California scorpionfish	California scorpionfish	California scorpionfish
full	Canary	Canary	Canary	Canary	Canary
full	Chilipepper				
full	Cowcod	Cowcod	Cowcod	Cowcod	Cowcod
full	Darkblotched	Darkblotched	Darkblotched	Darkblotched	Darkblotched
full	Dover sole	Dover sole	Dover sole	Dover sole	Dover sole
full	English Sole	English Sole		English Sole	English Sole
full			Gopher need info	Gopher need info	Gopher
full				Kelp Greenling	Kelp Greenling
update	Lingcod	Lingcod	Lingcod	Lingcod	Lingcod
full	Longspine Thornyhead	Longspine Thornyhead	Longspine Thornyhead	Longspine Thornyhead	Longspine Thornyhead
full	Pacific Hake	Pacific Hake	Pacific Hake	Pacific Hake	Pacific Hake
full	Petrale Sole	Petrale Sole		Petrale Sole	Petrale Sole
update	POP	POP	POP	POP	POP
update	Sablefish	Sablefish	Sablefish	Sablefish	Sablefish
full	Shortbelly	Shortbelly			Shortbelly
full	Shortspine Thornyhead	Shortspine Thornyhead	Shortspine Thornyhead	Shortspine Thornyhead	Shortspine Thornyhead
full		Splitnose			Splitnose
full		Starry Flounder	Starry Flounder need info	Starry Flounder need info	Starry Flounder
full	Vermillion	Vermillion	Vermillion	Vermillion	Vermillion
update	Widow	Widow	Widow	Widow	Widow
update	Yelloweye	Yelloweye	Yelloweye	Yelloweye	Yelloweye
update	Yellowtail	Yellowtail	Yellowtail	Yellowtail	Yellowtail
				Add skate and dogfish to data	

Panel	Possible Species	Time	Location
STAR Full Assessment Panel One	Pacific Hake	February	Seattle
STAR Full Assessment Panel Two	Sablefish, Dover, Shortspine Thornyhead, Longspine Thornyhead	May	Newport
STAR Full Assessment Panel Three	Petrale, English, Starry Flounder, Canary	May	Seattle
STAR Full Assessment Panel Four	Vermillion, Splitnose, Shortbelly, Gopher,Greenling	Late May	Santa Cruz
STAR Full Assessment Panel Five	Cowcod, California Scorpionfish, Blackgill, Darkblotched	June	La Jolla
STAR Update Panel One	four species	August	TBA
STAR Update Panel Two	three species	August	TBA

Exhibit E.3.c
Supplemental GAP Report
March 2004

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON STOCK ASSESSMENT PLANNING FOR 2007-2008 FISHERY MANAGEMENT

The Groundfish Advisory Subpanel (GAP) met with the Groundfish Management Team and Dr. Elizabeth Clarke of the Northwest Fisheries Science Center (NWFSC) to discuss stock assessment priorities for 2005.

As the starting point for its discussion, the GAP used the criteria it developed last November for determining stock assessment priorities (attached), along with Table 1 (Proposed Stock Assessments) and Table 3 (Proposed Stock Assessment Review Schedule) in Exhibit E.3.b Attachment 1.

The GAP also urges the Council review the criteria for assessment priorities that it developed and consider adopting these as formal criteria for developing future assessment schedules. On certain occasions, assessments have been moved up in the priority list because a particular scientist happens to be interested in a particular species. While we commend the science community for taking an interest in our groundfish resources, we do not believe simple personal interest represents the best rationale for allocating scarce assessment and review resources. The fact that we are considering 20 full assessments and updates, along with associated reviews in 2005, is all the more reason that a well-developed set of criteria should be adopted.

In general, the GAP agreed with the recommendations in Table 1, with the following exceptions:

- The GAP believes the assessment for cabezon should be deferred, as an assessment was just done on this species, unless the Council decides to reject the recent assessment and have it re-done with additional data added.
- The GAP believes the assessments for arrowtooth, chilipepper, English sole, shortbelly, and petrale sole should be deferred, as none of these species are exhibiting any danger of decline; and in the cases of chilipepper and shortbelly, the stocks have been under-harvested.
- The GAP suggests the NWFSC examine the possibility of conducting assessments on starry flounder and gopher rockfish, if it can be determined that enough data are available to conduct an assessment and assessment authors can be found.

A minority of the GAP disagrees with the recommendation on deferring the assessment on shortbelly rockfish.

In regard to the review schedule in Table 3, the GAP urges the NWFSC to consider including the full assessment for darkblotched rockfish and the update for Pacific ocean perch in the same review. While it is uncommon to have both a full assessment and an update assessment reviewed by the same panel, the sometimes conflicting data assumptions involving these two species mandate that they be reviewed in parallel by the same panel to avoid arriving at inconsistent stock size assumptions.

GAP ASSESSMENT PRIORITY CRITERIA

- A stock has been designated as overfished and requires a two-year review.
- A stock is commercially or recreationally important, and its status should be examined.
- Concerns have been expressed about stock status based on fishermen's knowledge.
- The optimum yield for a stock has not been attained in recent years because of lack of harvest.

PFMC
03/10/04

GROUNDFISH MANAGEMENT TEAM REPORT ON STOCK ASSESSMENT PLANNING FOR 2007-2008 FISHERY MANAGEMENT

The Groundfish Management Team (GMT) received a presentation from Dr. Liz Clarke from the National Marine Fisheries Service Northwest Fisheries Science Center on the species proposed for stock assessments in 2005. The team recognizes that concentrating all assessments in the “on” year for the subsequent two-year management cycle represents a significant challenge to both the assessment and review processes. The GMT appreciates that the species list presented by Dr. Clarke fully utilize those resources and that if species are added to the proposed list, it may be necessary to remove others to accommodate the work.

The GMT reviewed the proposed changes to the list from the Scientific and Statistical Committee and the Groundfish Advisory Subpanel and proposed the addition of an assessment for kelp greenling. The GMT also discussed with Dr. Clarke the addition of assessments for skate and spiny dogfish; however, it appears that assessments for these species probably can’t be completed during the 2005 assessment cycle. In the interim, the GMT recommends that review of the available data for these species, as well as consideration of additional biological sampling needs, take place at the data workshop planned as part of the 2005 assessment process. Additionally, the GMT believes it would be beneficial to pursue coordination with Canada regarding data sharing and assessments for both skate and spiny dogfish. Further, the GMT notes that such international coordination would be desirable in assessing any species with a transboundary distribution.

PFMC
03/10/04

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON STOCK ASSESSMENT PLANNING FOR 2007-2008 FISHERY MANAGEMENT

Dr. Elizabeth Clarke presented the proposed groundfish stock assessment schedule for 2005 (Exhibit E.3.b, Attachment 1, Table 1) to the Scientific and Statistical Committee (SSC), which included 24 species, and identified the lead agency for each assessment.

After discussing the proposal with Dr. Clarke, the SSC recommends deleting three species: arrowtooth, bank, and chilipepper and adding starry flounder and splitnose to the 2005 stock assessment list. If the SSC recommendation was adopted, 23 species would be assessed in 2005. Sixteen species would require a full assessment and seven species would be updated assessments. This will require four Stock Assessment Review (STAR) Panels for the full assessments and two panels for the update assessments (Table 1).

Although this is an extensive list, Dr. Clarke indicated that authors for most species have been identified. In order to complete all assessments, careful planning is required to utilize available personnel in an efficient manner.

The SSC Groundfish Subcommittee plans to update the Terms of Reference for the 2005 stock assessment review process. This update will be presented to the Council at the November 2004 meeting.

Table 1. SSC proposed stock assessments in 2005.

Species	Full or Update assessment
Blackgill	full
California scorpionfish	full
Canary	full
Cowcod	full
Darkblotched	full
Dover sole	full
English sole	full
Longspine thornyhead	full
Pacific hake	full
Petrale sole	full
Sablefish	full
Shortbelly	full
Shortspine thornyhead	full
Splitnose	full
Starry flounder	full
Vermillion	full
Bocaccio	update
Cabezon	update

Lingcod	update
POP	update
Widow	update
Yelloweye	update
Yellowtail	update

PFMC
03/09/04

STATUS OF GROUNDFISH FISHERIES AND INSEASON ADJUSTMENTS

Situation: The Council set optimum yield (OY) levels and various management measures for the 2004 groundfish management season, with the understanding these management measures will likely need to be adjusted periodically through the year in order to attain, but not exceed, the OYs. Under this agendum, the Council will receive updates on appropriate groundfish fisheries and consider adopting inseason adjustments.

The California Department of Fish and Game (CDFG) will present information to the Council on the status of California recreational fisheries. The report will include a review of regulatory activities that have occurred since the November, 2003 Council meeting.

The Groundfish Management Team (GMT) will present information on the status of ongoing fisheries, and any need for management measure adjustments.

Preliminary results from the West Coast Groundfish Observer Program (WCGOP) and proposed bycatch modeling methodologies are scheduled for initial review by the Scientific and Statistical Committee (SSC) at this meeting (see Ancillary E, SSC Agenda). However, it is not expected that results of the reviewed bycatch models will be available for inseason management decision making at this Council meeting.

The Council is to consider advice from advisory bodies and the public on the status of ongoing fisheries and recommended inseason adjustments and adopt changes as necessary.

Council Action:
1. **Consider information on the status of ongoing fisheries.**
2. **Consider and adopt inseason adjustments as necessary.**

Reference Materials:
Exhibit E.4.b, CDFG News Release,: Recreational Lingcod Minimum Size and Bag Limits to Change.
1. Exhibit E.4.e, Public comments received by February 20, 2004.

Agenda Order:

a.	Agendum Overview	Mike Burner
b.	CDFG Report on California Recreational Fisheries	CDFG
c.	Report of the Groundfish Management Team	
d.	Reports and Comments of Advisory Bodies	
e.	Public Comment	
f.	**Council Action:** Consider Inseason Adjustments in the 2004 Groundfish Fishery	

PFMC
02/18/04

Exhibit E.4.a
Supplemental NMFS Letter
March 2004

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

MAR 1 2004

Mr. Donald Hansen, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place
Portland, OR 97220

Dear Mr. Hansen:

In our January 8, 2004, proposed rule to implement the Council's recommendations for the 2004 groundfish specifications and management measures, NMFS announced that the 2002 lingcod harvest levels had exceeded the lingcod Acceptable Biological Catch (ABC). Under the Groundfish Fishery Management Plan (FMP,) ABCs are set at F_{MSY}. Fishing at a level that exceeds the MSY harvest rate is considered overfishing under the Magnuson-Stevens Act. Preliminary data for 2003 indicate that lingcod were also harvested at an overfishing rate in 2003.

As NMFS stated in the preamble to its proposed rule, lingcod overfishing has been largely due to excessive harvest levels in the California recreational fisheries. For 2002, recreational lingcod landings are estimated to have been 612 mt, exceeding the amount set aside for the recreational fisheries take by 286 mt. About 78 percent of the 2002 recreational fisheries lingcod landings were made into California ports, with the bulk of those landings occurring north of Point Conception, 34°27' N. lat.

In late January 2004, NMFS reviewed the available fisheries data for 2003 and began discussions with the California Department of Fish and Game (CDFG) about curtailing the 2004 California recreational fisheries harvests. By mid-February and in preparation for the NMFS 2004 groundfish specifications and management measures final rule, CDFG had proposed regulatory revisions for the California recreational lingcod fisheries intended to reduce the lingcod harvest rate. CDFG recommended increasing the lingcod size limit to 30 inches and reducing the bag limit from 2-fish to 1-fish. The state had calculated that, with an anticipated January-March 2004 lingcod catch of 31 mt, their regulatory recommendations for April-December 2004 would result in the California recreational fisheries 2004 take of lingcod being 291 mt. The Council's 2004 estimate for the California recreational fisheries lingcod take is 346.8 mt. If California's recreational fisheries catch stays at or below 291 mt, the remaining 55.8 mt should serve as a buffer against hooking mortality and other unanticipated sources of mortality.

Effective April 1, 2004, recreational vessels operating off the coast of California will be subject to a 30-inch size limit and a 1-fish bag limit for lingcod under Federal regulations. The California Fish and Game Commission (Commission) will be discussing this issue at its March 4-5, 2004 meeting. NMFS expects that the Commission will revise State regulations to conform to Federal regulations and that a State emergency regulation to conform will be implemented by April 1, 2004. If the Commission does not proceed with this emergency action, NMFS would need to respond immediately with more drastic Federal action, perhaps including pre-emption of state fishery management authority.

NMFS appreciates the Council's ongoing efforts to rebuild overfished groundfish species and to work with the states and NMFS to keep harvests at levels that will support rebuilding.

Sincerely,

William J. Robinson

for D. Robert Lohn
Regional Administrator

California Department of Fish and Game

News Release: For Immediate Release February 20, 2004

Recreational Lingcod Minimum Size and Bag Limits to Change

Contacts: Tom Barnes, Marine Region, (858) 546-7167; Marci Yaremko, Marine Region, (805) 568-1220; Carrie Wilson, Marine Region, (831) 649-7191

To comply with new federal recreational fishing regulations expected to be effective April 1, 2004, the California Department of Fish and Game (DFG) is recommending an increase in the lingcod minimum size limit to 30 inches, and a reduction in the daily bag limit to one fish. The new regulation changes will apply to recreational anglers fishing for lingcod in all waters off California. The DFG will make this recommendation to the Fish and Game Commission at the Commission's March 4-5, 2004 meeting in Redding, when the Commission will consider taking emergency action to conform to the new federal regulations.

The regulation changes are necessary to ensure that catches of lingcod in California remain at or within the coastwide acceptable harvest levels. The lingcod stock off the coast of California, Oregon and Washington has been formally classified as overfished by the Pacific Fishery Management Council (PFMC), and is currently managed under a rebuilding plan to achieve recovery of the stock. A key element of the rebuilding plan is to constrain catches to levels that allow the stock to increase to a healthy level within a specified period of time. In 2002 and 2003, coastwide lingcod catches have well exceeded allowable levels needed to achieve rebuilding of the stock.

"While the Department is reluctant to make in-season changes to recreational size and bag limits, this was the only feasible way to keep catches within allowable levels short of prohibiting all take of lingcod," said Patty Wolf, DFG Marine Regional Manager. "This management approach continues to provide some fishing opportunity for lingcod throughout the remainder of the year, and allows those anglers who catch large fish to retain them."

The DFG anticipates by increasing the minimum size limit to 30 inches and reducing the allowable daily bag limit to one lingcod per person, California's lingcod catches will be held to the allotted amount for the recreational fishery. Current regulations allow two fish per person at a minimum size of 24 inches.

Public testimony will be allowed during the March 4-5 Fish and Game Commission meeting. The need for additional measures has been determined in part from new information on fishing during the last part of 2003 which was not available to managers when the current regulations were established prior to the start of the 2004 season.

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Susan Ashcraft
Debra Aseton-Nelson

Exhibit E.4.b.
Supplemental Revised CDFG Report
March 2004

REVISED STATEMENT on 2004 Inseason Changes for California's Recreational Fishery for Presentation at March 2004 Council Meeting

State Changes to 2004 Recreational Groundfish Regulations Approved Prior to March 2004 Council Meeting

At the November 2003 Council meeting, the RecFIN catch estimates from Wave 4 (July – August) in California were considerably higher than anticipated and resulted in the cumulative coastwide landings for lingcod, canary, and the minor nearshore rockfish to exceed the annual coastwide OYs. In addition, coastwide landings for lingcod exceeded the ABC, resulting in coastwide closure of all groundfish fisheries.

Following the November Council meeting, CDFG proposed changes to the California groundfish regulations approved for 2004. The changes adopted by the Fish and Game Commission at its March 4-5, 2004 meeting are as follows.

1. Increase the number of recreational fisheries that the California Department of Fish and Game is authorized to close with 10-day notice when an annual harvest limit for lingcod, rockfish or a subgroup of rockfish, cabezon, and/or California scorpionfish has been exceeded or is projected to be exceeded prior to the end of the year. The new regulation includes all federally-managed groundfish species to enable CDFG to take conforming emergency action following federal inseason action. Also allows the Department of Fish and Game to close the fisheries for either the remainder or part of the remainder of the year.

2. Modify bag limits north of 40º10' N. lat. to match bag limits south of 40°10'.
    a. The bag limit was formerly 10 rockfish, 10 cabezon, 10 kelp greenling, and 10 rock greenling
    b. The regulation change establishes a bag for cabezon, greenlings, and all rockfish, and a sub-bag limit of 3 cabezon and 2 greenling.

3. Eliminate the 2-fish sub-bag limit for shallow nearshore rockfish within the bag limit for the rockfish-cabezon-greenlings (RCG) complex. This action was taken because the nearshore sub-bag limit adopted for 2003 did not function as anticipated and instead resulted in a substantial increase in discard rates of nearshore rockfish, notably gopher rockfish, which are attributable to the regulation.

4. Establish recreational boat limits coastwide (with individual bag limits for CPFV crew).

Attachment 1 provides a summary of these actions. California requests that the Council recommend to NMFS to change the federal rule inseason to reflect the bag limit and sub-limit changes, to have consistency between state and federal regulations.

State and Federal Actions in Response to Lingcod Overages in the CA Recreational Fishery taken from November 2003 to March 5, 2004

No changes to state lingcod regulations were proposed initially as part of the bag limit/sublimit change package already described. When the state actions listed above were taken following the November 2003 Council meeting, only Wave 4 data was available, and it was not apparent at that time what changes might be necessary to ensure that catches of lingcod in California remain at or within the coastwide allowable harvest levels set by the Council.

Because of the overfishing of lingcod in these two years, and because regulations are less restrictive in 2004 relative to 2003, NMFS and others expressed concern that the ABC would be exceeded again in 2004 if new restrictions were not imposed on California's recreational fishery. Because NMFS viewed this as a resource emergency, they indicated to the CDFG that additional restrictions for lingcod would have to be added to the final 2004 rule.

Discussions between NMFS and CDFG staff resulted in a proposal from CDFG to NMFS between to restrict take by increasing the recreational minimum size limit to 30" (fillet size 21") and reducing the bag limit to one lingcod. The commercial size limit remains at 24 inches. A copy of the letter summarizing data analysis for this action is contained in Attachment 2.

- NMFS added these restrictions to the 2004 final rule published on March 1, 2004, with an expected effective date of April 1, 2004.
- At its March 4-5 meeting, the Fish and Game Commission postponed emergency action for conformance until Council action was taken at the March 2004 Council meeting concerning lingcod and new stock assessment results.
- The CDFG and Commission decided to notify the public of potential changes to recreational lingcod regulations for 2004. A copy of the News Release is attached (Attachment 3).

Re-calculation of data analysis used to determine a 30-inch size limit:

Since the time analysis was submitted to NMFS on February 18, 2004, the CDFG has identified an error in the base catch data used in the projections. A recalculation of the projections are provided in this report, which projects that a recreational 30-inch minimum size and 1-fish limit, while still remaining within the California recreational catch target of 346.8 mt, would come closer to the target than previously known, reducing the precautionary buffer between projected catch and target.

An alternative to the lingcod regulations published in the final rule has been analyzed by the CDFG in response to biological considerations and constituent input. The alternative proposes a closed spawning season be added to the bag limit of 1 fish, beginning November 1 (to continue to April 15, 2005 if approved under 05-06 management options); and allows for a minimum size limit less than 30 inches, based on catch savings achieved from a November-December closure.

Analysis contained in Attachment 4 reflects projected catches relative to different minimum size limits in combination with the 1-fish bag and a closed spawning season. The table compares projected catch to the recreational target for California, which results in buffers between the target and catch at 26 inches and above. Increasing buffers reflect more risk-averse options relative to the risk of premature closure for lingcod and other associated fisheries if catches exceed projections.

This alternative provides biological protection to lingcod during spawning and nest-guarding in the southern stock area, which has a lower rate of recovery than the northern part of the stock, and reduces the fishing pressure on larger more fecund females compared to a 30" min size. The change in recreational size limit would increase the retention rate of lingcod during open months and may decrease time on the water relative to 30 inches.

Attachment 4 provides analysis for both options. California requests that the Council consider the two lingcod options for inseason action, and consider which size limit to apply within the second option, if selected.

Finally, complete RecFIN recreational catch data for all species of concern are now available for 2003, and are attached for your information (Attachment 5). California continues to work with RecFIN concerning the 2003 estimates contained in RecFIN but at this point no revisions to the numbers have been made.

Michele Robinson

Exhibit E.4.c
Supplemental GMT Report
March 2004

GROUNDFISH MANAGEMENT TEAM REPORT ON
THE STATUS OF GROUNDFISH FISHERIES AND INSEASON ADJUSTMENTS

The Groundfish Management Team (GMT) discussed several items for inseason consideration; with one exception, all of them pertain to California fisheries. One of the items addressed was regarding differences in federal and California state regulations for the Cowcod Conservation Area closure. Additional issues include commercial regulations to close the Cordell Banks, changes to California recreational management measures, and an update on the California selective flatfish exempted fishing permit (EFP). Lastly, the GMT updated the 2004 bycatch scorecard for all fisheries (Supplemental GMT Attachment 1); the specific changes will be highlighted as part of this report.

Cordell Banks Area Closure

The Cordell Banks area has been discussed in previous GMT meetings as an area of high catch of canary and other overfished species. NMFS received a request from California Department of Fish and Game (CDFG) during the proposed rule comment period to add a closure at Cordell Banks for both the commercial and recreational fisheries to reduce the take of overfished species. The closure for the recreational fishery was implemented through the final rule. For the recreational fishery, the closure in the federal final rule reads as follows:

> *Recreational fishing for certain groundfish species is also prohibited in waters of the Cordell Banks, located at 38°02' N. lat. and 123°25' W. long., and within a 5 nautical mile radius around this point. This portion of the Cordell Banks is closed to fishing for rockfish, lingcod, cabezon, kelp greenlings and California scorpionfish. [NOTE: California state regulations also prohibit the retention of other greenlings of the genus Hexagrammos, California sheephead and ocean whitefish.]*

However, for the commercial fishery, NMFS has requested the Council discuss whether to include the Cordell Banks in the Rockfish Conservation Area (RCA) and which species this closure should apply to. For the fixed gear fleet, the Cordell Banks is closed by default because it sits within the nontrawl RCA boundaries as they are currently scheduled for 2004. However, for the trawl fleet, the Cordell Banks is located shoreward of the trawl RCA for all of 2004. While the Cordell Banks generally consists of untrawlable habitat, the GMT thinks that for equity and enforcement reasons, and to simplify regulations, the Cordell Banks should be closed to trawling. In discussing this issue, the GMT agrees the commercial closure should apply to both the fixed gear and trawl fleets and should be closed to fishing for all species of federal groundfish, similar to the RCAs, for enforcement reasons. Regarding how to delineate the Cordell Banks closure, the GMT supports 2 options:

1. Commercial fishing for all federal groundfish species is prohibited in waters of the Cordell Banks, located at 38°02' N latitude and 123°25' W longitude, and within a 5 nautical mile radius around this point.

2. Closing the Cordell Banks by adjusting the 75 fm and 100 fm trawl RCA boundaries lines, so they incorporate the Cordell Banks into the trawl RCA. [Note: this option is cleaner, but would require diligence as the RCA boundaries change to ensure the Cordell Banks are closed to both fixed gear and trawl fishing in years to come.]

Cowcod Conservation Area (CCA) Closure

With regard to the CCA, CDFG staff noticed there is a discrepancy between federal and state recreational CCA restrictions. The following are current federal and state CCA restrictions:

- **Federal CCA Restrictions-**
  * Commercial fishing for any groundfish species will continue to be prohibited in the CCA, except that commercial fishing for rockfish and lingcod will be permitted shoreward of 20 fm in the CCA. [Commercial CCA included for informational purposes only].
  * For the recreational fishery, fishing for all groundfish, except sanddabs, will be prohibited in the CCA, except that recreational fishing for sanddabs, RCG complex, lingcod and California scorpionfish will be permitted shoreward of 20 fm in the CCA.

- **State CCA Regulations-**
  * Recreational fishing for all groundfish, except rockfish, lingcod, and associated species limited to cabezon, greenlings of the genus Hexogrammos, California scorpionfish, California sheephead, and ocean whitefish, is permitted in the CCA. Recreational fishing for all groundfish species is permitted shoreward of 20 fm in the CCA.

State recreational CCA restrictions are less restrictive than federal recreational CCA restrictions, which is illegal. Therefore, as the restrictions read above, federal CCA restrictions supercede state CCA restrictions. CDFG and NMFS brought this issue to the GMT to get clarification on the Council's original intent of the CCA. The motion on CCAs from the November 2000 Council meeting, which first recommended the CCA, stated the CCA would be closed, 'except that the CCA would be open to minor nearshore rockfish, cabezon and greenlings inside 20 fm.' CDFG commented that minor nearshore rockfish was specified to discourage any pressure for shelf rockfish, such as vermillion, near the 20 fm boundary line. Targeting on shelf rockfish might increase the interception of cowcod. At the time of the motion, minor nearshore rockfish included California scorpionfish. In addition, recreational sanddab fishing was permitted in the CCA and shoreward of 20 fm in the CCA beginning in 2003.

Therefore, the GMT believes both federal and state recreational CCA restrictions may need to be corrected. The federal recreational CCA restrictions should be corrected to limit the RCG complex to minor nearshore rockfish only. In addition, NMFS will look back through the administrative record to see if lingcod was added to the list at a later Council meeting. If not, lingcod should be removed. NMFS stated these changes could happen through a correction. The state CCA restrictions should be corrected to conform with the federal CCA restrictions. CDFG stated this could be included their 2005 regulatory process. Until that time, the more restrictive federal CCA restrictions will apply.

California Recreational Management Measures

Since the November 2003 Council meeting, the California Fish and Game Commission has adopted changes to the state's recreational management measures. These changes are:\; (1) changing the bag limit for the rockfish/cabezon/greenling (RCG) complex north of 40°10' by specifying a 10-fish aggregate limit for the RCG complex with a sublimit of 3 cabezon and a sublimit of 2 greenlings; (2) removing the 2-fish sublimit for shallow nearshore rockfish (included as part of the 10 rockfish aggregate bag limit); (3) implementing boat limits for all groundfish; and (4) revising the state authority language to include additional federal groundfish species. The GMT has not reviewed an analysis of the impacts to overfished species resulting from these regulatory changes. However, if the Council approves these changes, the GMT would recommend that the third change regarding boat limits not be included in federal regulations until further analysis. Boat limits may be an option for the 2005-2006 management cycle. This would result in differing regulations at the federal and state level.

There is an additional proposed change to the California recreational regulations that has not yet been presented to the California Fish and Game Commission. This change would increase the lingcod minimum size limit from 24-inches to 30-inches, increase the minimum filet size from 16" to 21", and reduce the bag limit from two fish to one fish. Again, the GMT has not reviewed nor discussed an analysis of the impacts to overfished species resulting from this proposed change.

California Selective Flatfish EFP

California Department of Fish and Game is proposing to increase the bycatch caps for bocaccio and cowcod rockfish in their Selective Flatfish EFP to allow the experiment to achieve the objectives of the original EFP proposal presented to the Council last fall. Specifically, bocaccio rockfish would increase from 0.5 mt to 10 mt, and cowcod rockfish would increase from 0.2 mt to 0.5 mt. As a result, it is anticipated that participating fishermen would not be constrained by either of these bycatch caps, which would allow the experiment to test whether the selective flatfish gear (which has been tested off Oregon and Washington) also excludes bocaccio rockfish (off California).

Bycatch Scorecard Update

There were several changes made to the bycatch scorecard. As a reminder, the values in the scorecard reflect the GMT's best estimate of total mortalities of the overfished species, by fishery. These changes include:

EFPs

The bycatch caps for the California Selective Flatfish EFP were updated as described above. The bycatch caps for the Washington Arrowtooth Trawl EFP were updated as follows: the canary rockfish cap was reduced from 2.5 mt to 1.5 mt as a result of decreased effort (the EFP application was modeled on having six participants, and there will be three participants in this EFP); the lingcod, Pacific ocean perch (POP), and widow caps were updated to reflect the reduced number of participants multiplied by the current trip limit for that species. The Washington Pollock EFP will also have less participants than anticipated (two, down from three), and the bycatch cap for widow rockfish has been reduced from 3.0 mt to 1.5 mt to accommodate current trip limits. The Washington Selective Flatfish Trawl EFP was removed from the list due to lack of participation.

State Recreational Catch Estimates
The Washington recreational catch estimates were updated based on 2003 catch data: the canary rockfish estimate was increased from 1.5 mt to 2.5 mt. The Washington sport fishery in 2003 harvested about 2 mt of canary; however, average weight data is not available at this time for Washington, so the average weight from the Oregon sport fishery was used as a proxy. Given the uncertainty in the weight data, the estimate was revised to 2.5 mt to be precautionary. The lingcod catch estimate was also revised from 35 mt to 73 mt; the new estimate includes discard data with a discard mortality of 5%. Again, average weights for Washington are not yet available, so Oregon weights were used as a proxy, applying the average weights of the discarded catch to the discarded catch. The catch estimate for yelloweye rockfish remains the same.

The Oregon recreational catch estimates were updated based on at-sea observations and dockside sampling data. The canary rockfish catch estimate increased from 5.9 mt to 7.0 mt; the lingcod estimate increases from 91.8 mt to 101.3 mt, which includes discard data and a discard mortality rate of 5% (applying the average weights of discarded fish to the discard portion of the catch). The GMT notes that the RecFIN Committee will be evaluating the need for consistency coastwide on the appropriate discard mortality rate for lingcod. The widow rockfish catch estimate increases from 0.9 mt to 2 mt, and the yelloweye rockfish catch estimate increases from 2.8 mt to 3.3 mt.

The California recreational catch estimates in the scorecard were not updated, and are based on 1999-2000 catch data. The GMT has requested the catch estimates be revised to reflect more recent catch data from 2002 and 2003, in place of the 1999-2000 catch data. These data were not available at this meeting; however, CDFG staff will bring an analysis of the 2002 and 2003 data as well as two additional analyses to the April Council meeting. The California catch data from the 2003 recreational fishery were available, however, and is reflected below:

(mt)	Bocaccio	Canary	Lingcod	Widow	Yelloweye
Actual Catch	10.8	18.1	1,000.1	0.1	3.7
Projection	6.3	3.3	215	1.0	0.5

Given the magnitude of these catches and the subsequent impact to other groundfish fisheries as a result of early OY attainment, the GMT recommends the Council consider alternatives that move toward regional management for some species, such as canary rockfish, yelloweye rockfish, and lingcod for 2005-2006. The GMT notes that separate regional ABCs and OYs can be set for management reasons, even if current biological data does not demonstrate stock differentiation between the regions.

Black Rockfish
Overfishing occurred on black rockfish in 2003. The total coastwide landed catch of black rockfish was 1,325 mt for all fisheries combined, compared to the 2003 coastwide ABC of 1,115 mt. The breakdown of these catches by sector is:

WA Rec	WA Comm	OR Rec	OR Comm	CA Rec	CA Comm
174 mt	0	336 mt	116 mt	656 mt	43 mt

In light of specifying separate ABCs and OYs, north (Washington) and south (Oregon and California), the GMT recommends California develop more restrictive management measures for their recreational fisheries to reduce projected black rockfish harvest for 2004. CDFG staff will bring proposals and analyses to the April Council meeting for inseason action consideration.

Other Considerations

While the GMT did not have an in-depth discussion on the new bycatch rates resulting from the NMFS Observer Program for the trawl and fixed gear fisheries, we did briefly discuss how the new rates might compare with the current values in the scorecard. The observer data for the fixed gear fishery is undergoing SSC review; however, if the proposed model were approved, the limited entry fixed gear fisheries targeting sablefish (primary sablefish and daily trip limit fisheries) would have slightly higher anticipated catches of canary and yelloweye rockfish. The updated trawl bycatch rates are also preliminary, however, lower rates for canary, bocaccio, yelloweye, and darkblotched are anticipated. These data will be presented to the Council in April and the Council may want to take this into consideration while reviewing the proposed inseason actions now in March.

GMT Recommendations

1. Publish federal corrections to the Cowcod Conservation Area closures and change California state regulations to conform to federal regulations.
2. Publish federal closure of Cordell Banks for the commercial fishery.
3. Approve higher bycatch caps for California Selective Flatfish EFP for bocaccio and cowcod rockfish.
4. Approve updated values in bycatch scorecard.
5. Consider setting separate ABCs and OYs, by region, for 2005-06 for some species, such as canary rockfish, yelloweye rockfish, and lingcod.
6. Request that California develop more restrictive management measures to reduce recreational harvest of black rockfish in 2004.

Estimated mortality (mt) of overfished West Coast groundfish species by fishery in 2004 - Updated March 10, 2004

Fishery	Bocaccio a/	Canary	Cowcod	Dkbl b/	Lingcod c/	POP	Whiting d/	Widow	Yelloweye
Limited Entry Groundfish									
Trawl- Non-whiting e/	45.0	9.8	0.6	100.7	78.4	68.1		1.5	0.4
Fixed Gear	13.4	0.5	0.1	1.5	12.7	0.2		30.0	0.1
Whiting									
At-sea whiting motherships		0.6		2.4	0.2	1.8	Whiting OY decision deferred to March 2004	200.0	0.0
At-sea whiting cat-proc		0.6		4.3	0.1	6.6			0.0
Shoreside whiting		0.3		0.7	0.4	3.4			0.0
Tribal whiting		4.2		0.0	0.4	1.1			0.0
Open Access									
Groundfish directed	10.6	0.3	0.1		62.5				0.6
CA Halibut	0.1			0.0	2.0	0.0			
CA Gillnet f/	0.5			0.0		0.0	0.0	0.0	
CA Sheephead f/				0.0		0.0	0.0	0.0	0.0
CPS- wetfish f/	0.3								
CPS- squid g/									
Dungeness crab f/	0.0		0.0	0.0		0.0			
HMS f/		0.0	0.0	0.0					
Pacific Halibut f/	0.0		0.0	0.0		0.0		0.0	0.5
Pink shrimp	0.1	0.5	0.0	0.0	0.5	0.0	1.0	0.1	0.1
Ridgeback prawn	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salmon troll	0.2	1.6	0.0	0.0	0.3	0.0		0.0	0.2
Sea Cucumber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spot Prawn (trap)									
Tribal									
Midwater Trawl		2.3		0.0	0.1	0.0		40.0	0.0
Bottom Trawl		0.5		0.0	9.0	0.0		0.0	0.0
Troll		0.5		0.0	1.0	0.0			0.0
Fixed gear		0.3		0.0	15.0	0.0		0.0	2.3
Recreational Groundfish									
WA		**2.5**			**73.0**				3.5
OR		**7.0**			**101.3**			**2.0**	**3.3**
CA (N)		0.5			195.0			1.0	0.1
CA (S)	62.8	7.6	1.8		151.8			0.4	1.3
Research: Based on 2 most recent NMFS trawl shelf and slope surveys, the IPHC halibut survey, and LOAs with expanded estimates for south of Pt. Conception.									
	2.0	1.0		1.6	3.0	3.0	200	1.5	1.1
Non-EFP Total	135.1	40.5	2.6	111.2	706.7	84.2		276.5	13.6
EFPs h/									
CA: NS FF trawl	**10.0**	0.5	**0.5**		20.0				0.5
OR: DTS i/		0.1		6.0		18.0			0.1
WA: AT trawl		**1.5**		3.0	**4.5**	**8.5**		**5.5**	0.5
WA: dogfish LL		0.1		0.5	2.0	0.5		0.5	1.0
WA: pollock j/		0.1					1,000	**1.5**	0.1
EFP Subtotal	10.0	2.3	0.5	9.5	26.5	27.0	1,000	7.5	2.2
TOTAL	145.1	45.1	3.1	120.7	733.2	111.2	3,000	284.0	15.8
2004 OY	250	47.3	4.8	240	735	444		284	22
Percent of OY	58.0%	95.4%	64.6%	50.3%	99.8%	25.1%	#DIV/0!	100.0%	71.7%
Key	(shaded) = either not applicable; trace amount (<0.01 mt); or not reported in available data sources.								

a/ South of 40°10' N. lat.

b/ Darkblotched harvest limit ("2004 OY" in this table) is the ABC of 240 mt, which is lower than the projected OY of 272 mt under the *Medium OY* alternative.

c/ Lingcod total reflects total catch, not mortality.

d/ Catch estimates of overfished non-whiting groundfish species based on average annual bycatch rates during 1998-2003. 2003 bycatch rates calculated for the at-sea sector based on observed catch rates through September 25, 2003. These data incomplete since all at-sea sectors still fishing after this date. Shoreside catches of overfished groundfish species are actual estimates through the entire 1998-2003 period. Estimated whiting mortality in non-whiting fisheries assumes a cumulative 2,000 mt impact in 2004. Tribal catch based on OY sliding scale. Non-tribal whiting fishery catch based on set allocations applied after tribal and non-whiting fishery impacts subtracted from the OY. Although the whiting OY is not decided, the bycatch impacts in the whiting fisheries are determined based on the Medium OY of 148,200 mt as a placeholder for all the stocks except widow rockfish. The widow rockfish impacts in this table represent the difference between the OY and the estimated cumulative impacts in non-whiting fisheries.

e/ Using observer data, all estimates from the Hastie trawl bycatch model.

f/ Mortality estimates are not hard numbers; based on the GMT's best professional judgement.

g/ Bycatch amounts by species unavailable, but bocaccio occurred in 0.1% of all port samples and other rockfish in another 0.1% of all port samples (and squid fisheries usually land their whole catch). In 2001, out of 84,000 mt total landings 1 mt was groundfish. This suggests that total bocaccio was caught in trace amounts.

h/ Values are proposed EFP bycatch caps, not estimates of total mortality. The EFP is terminated inseason if the cap is projected to be attained early.

I/ The darkblotched rockfish and Pacific ocean perch caps are not defined yet for this EFP but are expected to be lower than the placeholders in this scorecard.

ENFORCEMENT CONSULTANTS STATEMENT ON STATUS OF GROUNDFISHFISHERIES AND INSEASON ADJUSTMENTS

Members of the recreational fishing community have expressed concerns to the Enforcement Consultants (EC) that rules related to what is allowed when fishing in a recreational Rockfish Conservation Area (RCA) are not clear. Section (e) (2) of the Code of Federal Regulations states, in part ...., "Fishing for groundfish with recreational gear is prohibited within the recreational RCA. These restrictions do not apply to recreational vessels fishing for species other than groundfish with recreational gear. If a vessel fishes in the recreational RCA, it may not participate in any fishing on that trip that is prohibited by the restrictions that apply within the recreational RCA. For example, if a vessel participates in the recreational salmon fishery within the RCA, the vessel cannot on the same trip participate in the recreational groundfish fishery shoreward of the RCA."

The EC discussed the utility of this rule for purposes of enforcing recreational RCA's specifically, and determined that clarification of the Council's intent is needed.

The EC would suggest language changes to clarify the Councils intent; (1) to restrict combination trips when participating in fishing activity that involves the RCA or, (2) to allow combination trips when participating in fishing activity that involves the RCA. Should the Council decide to retain the prohibition of mixing recreational fishing trips inside and outside the recreational RCA, we would propose the following language change: remove the sentence, "These restrictions do not apply to recreational vessels fishing for species other than groundfish with recreational gear." The example that follows provides a sufficient illustration of the intent. As written, some readers stopped short of absorbing the entire section and missed the point.

Option 1:

(2) boundaries defined by specific latitude and longitude coordinates intended to approximate particular depth contours. The recreational RCA is closed to recreational fishing for groundfish. Fishing for groundfish with recreational gear is prohibited within the recreational RCA. It is unlawful to take and retain, possess, or land groundfish taken with recreational gear within the recreational RCA. ((~~These restrictions do not apply to recreational vessels fishing for species other than groundfish with recreational gear.~~)) If a vessel fishes in the recreational RCA, it may not participate in any fishing on that trip that is prohibited by the restrictions that apply within the recreational RCA. For example, if a vessel participates in the recreational salmon fishery within the RCA, the vessel cannot on the same trip participate in the recreational groundfish fishery shoreward of the RCA. Throughout the year, boundaries for the recreational RCAs are provided in the text in section IV.D. under each state (Washington, Oregon, and California) and may be modified by NMFS inseason. Recreational RCA boundaries that are defined by specific latitude and longitude coordinates are provided below at paragraph (f) of this section.

If the Council decides to remove the prohibition, the EC would recommend the following language: “No person may angle for fish while in possession of fish that are in violation of the harvest regulations for the area being fished.”
Option 2:

(2) boundaries defined by specific latitude and longitude coordinates intended to approximate particular depth contours. The recreational RCA is closed to recreational fishing for groundfish. Fishing for groundfish with recreational gear is prohibited within the recreational RCA. It is unlawful to take and retain, possess, or land groundfish taken with recreational gear within the recreational RCA. “ No person may angle for fish while in possession of fish that are in violation of the harvest regulations for the area being fished..” ((~~These restrictions do not apply to recreational vessels fishing for species other than groundfish with recreational gear. If a vessel fishes in the recreational RCA, it may not participate in any fishing on that trip that is prohibited by the restrictions that apply within the recreational RCA. For example, if a vessel participates in the recreational salmon fishery within the RCA, the vessel cannot on the same trip participate in the recreational groundfish fishery shoreward of the RCA~~.)) Throughout the year, boundaries for the recreational RCAs are provided in the text in section IV.D. under each state (Washington, Oregon, and California) and may be modified by NMFS inseason. Recreational RCA boundaries that are defined by specific latitude and longitude coordinates are provided below at paragraph (f) of this section.

All EC representatives support Option 2.

PFMC
03/10/04

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON STATUS OF GROUNDFISH FISHERIES AND INSEASON ADJUSTMENTS

The Groundfish Advisory Subpanel (GAP) reviewed the statement developed by the Groundfish Management Team (GMT) on this agenda item and makes the following comments in response to the GMT recommendations on page 5 of their statement.

Cowcod Conservation Area

The GAP agrees with the GMT suggestion that federal regulations be amended to achieve the necessary prohibitions, with one exception. The GAP notes that recreational fishing for sanddabs is permitted in the area as long as specific hook gear is used. Such fishing has been analyzed as having no impact on cowcod. The GAP believes that, for equity, commercial fishing for sanddabs in this area also be permitted, as long as the same hook gear - which has zero impact - is used.

Cordell Banks

The GAP recommends the suggested closure on Cordell Banks be accomplished by adjusting the 75 fm and 100 fm Rockfish Conservation Area (RCA) boundaries for the trawl fishery. This can be done fairly easily and avoids having a separate closed area adjacent to the RCA.

Bycatch Caps on California Exempted Fishing Permits (EFPs)

The GAP has no objection to changing the amount of bocaccio rockfish and cowcod assigned to the California selective flatfish EFP, since there appears to be sufficient fish available to accommodate this request.

Updated Bycatch Scorecard

The GAP will reserve comment on this issue and address widow rockfish numbers under agenda item E.5.

Setting Separate Acceptable Biological Catch (ABC)/Optimum Yield (OY) by Region

The GAP believes this is a lengthy, long-term discussion item with significant allocative and enforcement impacts which need to involve all sectors of the fishery and both federal and state management entities. This is a process that is much more complex than can be handled in the two meetings remaining to approve 2005-2006 specifications.

California Recreational Harvest of Black Rockfish

The GAP continues to express its concern with using Marine Recreational Fisheries Statistics Survey (MRFSS) data for management and believes it is urgent a new system be put in place with more accurate and up-to-date reporting. Nevertheless, the GAP recognizes we have to use the data available to address management issues, no matter how suspect that data may be. The GAP, therefore, supports the GMT recommendation that the Council request California to develop more restrictive management measures for recreational harvest of black rockfish. Specifically, the request should include asking California to examine reducing bag limits, moving scheduled closed periods to earlier in the year, institute area closures, and consider

differential regulations among recreational sectors.
In addition to the recommendations in the GMT statement, the GAP offers comments on several other issues:

Recreational Boat Limits in California Recreational Fishery
The GAP disagrees with the GMT suggestion that boat limits not be included as an inseason adjustment due to lack of analysis. The GAP believes boat limits could be helpful in converting dead discards to landed catch.

Recreational Fishery Enforcement in the RCA
The GAP discussed with the Enforcement Consultants (EC) a proposal to clarify how recreational fishing can be conducted inside and outside the RCA. The GAP supports the EC option of allowing recreational fishing for nongroundfish species within the RCA and groundfish species outside the RCA in the same trip and prohibiting possession of groundfish within the RCA while fishing gear is deployed. However, the GAP expressed its concern that the EC proposal is not fully enforceable because of the large number of vessels that can potentially violate the integrity of the RCA.

Therefore, the GAP urges the Council to do the following:

- Reconvene the Ad Hoc Open Access Conversion Subcommittee and direct it to complete its recommendations to the Council on how to deal with the open access fishery; when doing so, the Council should also review the membership of the Committee and determine whether it is appropriate.

- Request the Ad Hoc Vessel Monitoring System (VMS) Committee to continue examining extension of the VMS system to vessels which harvest groundfish and which are not currently subject to VMS requirements.

PFMC
03/10/04

Exhibit E.4.e
Public Comment
March 2004

Subject: [Fwd: Ground Fisheries]
From: "PFMC Comments" <pfmc.comments@noaa.gov>
Date: Fri, 21 Nov 2003 08:22:59 -0800
To: John DeVore <John.DeVore@noaa.gov>
CC: Mike Burner <Mike.Burner@noaa.gov>

-------- Original Message --------
Subject: Ground Fisheries
Date: Fri, 21 Nov 2003 04:10:02 EST
From: ThmWic@aol.com
To:pfmc.comments@noaa.gov

To whom it may concern;

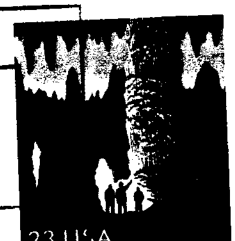
I have been scuba diving off the Oregon coast for the last 10 years and have witnessed first hand, meaning, seen the drastic reduction in ground fish populations. I would support any and all restrictions that would ensure future generations with the same fishing opportunities I was afforded. In my opinion, commercial and charter fishing operations are the toughest on fish populations. Sport fisherman come to the coast, rent a hotel, eat dinners out, by tackle at the local shop, get their boat serviced/repaired in town.....who supports the local economy more with the least impact on fish stocks??? I would support cutting the current catch level by half for sport fisherman, ensuring a future harvest.

Thomas Wick
Concerned citizen and local diver

I think no. of trawlers allowed to
fish should be cut by 50% this year +
10% every year thereafter.
I want many marine sanctuaries
set up immediately where NO BOATS
can travel - NONE - ZERO I want
this part kept sacrosanct.
I want regional fishing councils to
start having true environmentalists
on the council. I am SICK of fish
profiteers overfishing all our
waters per Pew Report/Stanford University
report. B Sachau 15 Elm St Florham
Park NJ 07932

DKT120903B
public comment
on Trawling.

RECEIVED
JAN 13 2004
PFMC



Don Hansen Chairman
Pacific Fish Mgt Comm.
7700 NE Ambassador Place
Suite 200
Portland OR 97220-1384

7220+1393

Coos Bay Trawlers' Association, Inc.
PO Box 5050
63422 Kingfisher Dr.
Coos Bay, OR 97420
Phone (541)888-8012
Fax (541)888-6165
E-mail: c.trawl@verizon.net
A Non-Profit Organization

January 21, 2004

Public Comment
Emergency Rule
and other issues

Pacific Fishery Management Council
7700 NE Ambassador Place
Suite 200
Portland, OR 97220-1384

Dear Don Hansen, Don McIsaac, Council Staff and Councilors:

We are taking this opportunity to comment on The Emergency Rule fishers are currently working under for the start of the 2004 fishing season. A few other issues need to be addressed and we offer possible alternative solutions for some impracticable policies.

Emergency Rule
It is unfortunate that all of us have been nearsighted in viewing the future of the trawl fishery. The trawl fishermen were confident that the buyback referendum would pass. Most everyone else was not sure, so looking past the vote to the future was not clear or enumerated for anyone. Most fishermen believed if the referendum passed, those left would immediately experience the said benefits of the reduced fleet with higher trip limits and immediate financial help to the nearly bankrupt fleet.

At the October 2003 GMT meeting (before the November Council meeting), I asked the GMT, Jim Hasting in particular, to prepare alternate trip limits based on a successful referendum vote. I also asked that the boats removed by the "Buy Back Program" respective discard records be removed from the data base as well. The remaining fleet need not work under outdated data. I was assured that alternatives would be developed but the 2004 management measures were already in place and would not be addressed at the November Council meeting. I made it clear that I would bring up the topic before the Council during public comment.

At the November Council meeting under "Public Comments not on the Agenda", the topic was brought up and a 200% increase was discussed. Many fishermen addressed the Council on the subject and the 200% increase was removed and The Emergency Rule was discussed and passed by the Council. The details of The Emergency Rule would be developed by NMFS and we find that we initially get 25% of what could have been allowed.

Now that The Emergency Rule has been published we find only a token increase for the first quarter of the year. We can see no reason why the increase is so tiny and we seek justification as to why the increase was set so low. What was the rationale backing the decision to provide a small token increase instead of the immediate relief the fleet was lead to believe would happen?

We demand that The Emergency Rule be overturned or rectified at the earliest possible time and give the fleet their long-over due. If the Council or the NMFS does not immediately increase the trip limits, we ask the Council to petition the government to suspend the buyback assessment until the trip limits can be adjusted to their correct amounts. The trawl fleet had an agreement with the government to reduce the fleet and the government promised to adjust the limits immediately. A token increase is not acceptable.

Vessel Monitoring System (VMS)
When the concept of a Vessel Monitoring System was introduced almost all of the fishermen were opposed to the implementation of such a program. A threat was presented that the ocean would have to be closed if such a system could not be addressed and put into place. The theory stemmed from the concept of protecting essential fish habitat (EFH) while allowing fishing to continue in places other than EFH. We were told that the only way to insure where fishermen were fishing was either a 100% observer program or VMS. We were told that the government would pay for the program and all our concerns would be addressed, including a drifting provision.

At first, we were promised by the government that the government would pay for the units. This did not happen. Then we were told that the fishermen may have to first pay for the unit but the government would reimburse the costs. Today, we are forced to have VMS on our vessels with no help, only bad advice on where to purchase the units and we have had to pay for the units ourselves. Furthermore, we being told that there is no money in the NMFS budget for VMS units in the near future. We were told differently at the beginning and now another lie to swallow, hook, line and sinker. It is strange to us that the hardest hit West Coast Fleet is the only U.S. fleet to have to pay for this enforcement system. Every other VMS in the nation has been paid for by the government. Even the richest fishery state, Alaska, with one of the most powerful senators, Stevens, has government paid VMS units. The state that has the highest unemployment rate, the state with the highest poverty level, the state with the most strict and radical regulations in the world and the state with much less powerful Senators has to pay for the system themselves. We now are forced to fish beside vessels who are using government paid for VMS units while we have to borrow money to pay for our units. Why are the West Coast fishermen constantly dealing with deception?

We were **promised** that a drifting provision would be allowed during development of the VMS but when the program was finalized, no such provision was provided. One hundred percent (100%) of the fishermen in attendance at the Council meeting, including the Council's Groundfish Advisory Panel, testified on the importance for a drifting consideration and several reasons were enumerated, many included crew and vessel safety. Managing our fisheries is a collaborative process based on consensus not convenience. But VMS was again allowed to side-step this process. What possible rationale could be used to justify the set-aside of fishermen's concerns about VMS especially about a drifting provision? What is the public process for any how?

We know that the VMS managers said that they could not tell the difference between a drifting vessel and a vessel fishing but we heard testimony from Hawaii about how their monitor watchers could determine the difference between the two activities. Fishermen even suggested that our VMS managers go to Hawaii for training before our system is activated so they could learn how to tell the difference between a drift and a tow but instead, the fishermen are forced to comply to make the designated system work even at the cost of their own safety.

Now, VMS is on our boats. We need to see the system used to help the fishermen as well. VMS, with a declaration process, could be used to open opportunities to fish rather than just to keep us out of huge areas. If we are going to have this system, it has to be used to also benefit the fishermen, not just enforcement. Again, VMS should allow us to reopen more of the ocean to fishing and not just continue to concentrate fishermen into smaller and smaller areas. This is the worst possible situation and we feel the system is being used to ensure that problems continue to exist. Now with the recent creation of the world's largest EFH protected by the RCA, stocks of concern outside of the RCA should be harvested. The so called "spillover effect" needs to be utilized not just idealized.

We ask the Council to ask the federal government to pay for the VMS units as quickly as possible, immediately provide greater fishing opportunities based on VMS technology and provide increased catch allowances of all species caught outside of the RCA.

Increase Opportunities Based on Research
EFP's have shown that the "headrope cutback net" can catch flatfish while avoiding encounters with most round fish. Three years of research have been conducted by ODF&W and fishermen and the results are so

promising that other states have joined Oregon to move the gear into regulation. Both Washington and California will be conducting EFP's with this gear during the 2004 season to facilitate the gear transition.

Scientifically proven to be an effective conservation tool, the 2004 fishery specifications penalize fishermen who choose to use the new net design, penalized for using more conservation minded gear. For example, for the first period of 2004, if a large footrope is used there is no limit on the amount of Petrale that can be landed but if a small footrope is used, even with a "cutback headrope", you can only land 10,000 pounds; use a large footrope and you can land 100,000 pounds of Sanddabs but use the small footroped cutback headrope net and you can only land 10% of what the large footrope users can land.

We believe that using gear that avoids any species of concern should be encouraged not penalized. Markets developed for flatfish are lost to foreign fish imports because with the current system, we have no hope of a consistent supply. How can a U.S. market development occur when restrictions are in place to discourage this type of success? If fishermen are using a conservation tool, the "cutback headrope net", they should not be forced to use it throughout the entire period but should be allowed to declare their strategy before they leave port and have the flexibility to switch gear during any period. Furthermore, if the "cutback headrope" is used, then the small footrope restrictive limits should not apply. To encourage the nets use, regulations should reflect a benefit those users of more conservative gear. Efficiency per hour on the ocean is sacrificed for this benefit.

Observers and Discards
Why do most government regulations continue to create more and more discards? One of the main goals of fishery management is to "reduce discards as much as possible and practicable" and to utilize the resource for the benefit of the nation. When a vessel is being observed, the vessel should be allowed to land up to the discard percentage on any given specie. It makes no sense, while a government observer is recording the catch activities, to unnecessarily discard fish. A twofold result of a solution to this problem would be reduced regulatory discards and biological specie information for the scientists.

While unmarketable fish will always be unmarketable fish, they are not the only fish discarded. Species with low trip limits or "no-take" species should not be discarded but should be landed for scientific purposes and once that information is recorded, the fish should be processed like regular landings. Fish discarded because of a price difference based on size should be retained for charity or the value of those fish could be applied to the buyback program and not count against the vessels trip limit but recorded as diverted discards for the benefit of the nation or the fleet. This way, while observers are on a boat, discard rates can still be recorded but the actual discarded fish poundage would be reduced and turn waste into a national benefit.

We want to thank you for taking the time to read about our concerns and our desire to continue to seek solutions and improve our U.S. fishery. We are being lied to and persecuted and we are all in this together. We have a healthy, safe and abundant food source that is not being harvested to its potential and it is a national calamity. A little common sense can go a long way to better manage our fisheries.

Sincerely,

Steve Bodnar, Executive Director

cc: Ron Wyden
Gordon Smith
Barbara Boxer
Dianne Feinstein
Maria Cantwell
Patty Murray
Earl Blumenauer
Peter DeFazio
Darlene Hooley
John Doolittle
David Dreier
Anna Eshoo
Sam Farr
Bob Filner
Elton Gallegly
Jane Harman
Wally Herger
Mike Honda
Loretta Sanchez
Adam Schiff
Brad Sherman
Pete Stark
Ellen Tauscher
Bill Thomas
Mike Thompson
Maxine Waters
Diane Watson

Greg Walden
David Wu
Brian Baird
Norman Dicks
Jennifer Dunn
Doc Hastings
Jan Inslee
Rick Larson
Jim McDermott
George Nethercutt
Adam Smith
Joe Baca
Xavier Becerra
Howard Berman
Mary Bono
Ken Calvert
Lois Capps
Dennis Cardoza
Christopher Cox
Randy Cunningham
Susan Davis
Cal Dooley

Duncan Hunter
Darrel Issa
Tom Lantos
Barbara Lee
Jerry Lewis
Zoe Lofgren
Buck McKeon
Hilda Solis
Robert Matsui
Juanita Millender-McDonald
Gary Miller
George Miller
Grace Napolitano
Devin Nunn
Doug Ose
Nancy Pelosi
Richard Pombo
George Radanovich
Dana Rohrabacher
Lucille Robal-Allard
Ed Royce
Linda Sanchez

Henry Waxman
Lynn Woolsey
George Bush
Bill Hogarth
Usha Varanasi
Bill Robinson
Ted Kulingoski
LA Times
Seattle Times
New York Times
The Oregonian
The Register Guard
Pacific Fishing
National Fishermen

Alex Ells
Terry Sweeney
F/V Amak
P.O. Box 41
Port Orford, Or. 97465

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, Or. 97220-1384

Attention: West Coast Ground Fish Issues

Subject: Change to ground fish regulations

Dear Sirs:

I am writing this letter to support changing the 2004 ground fish regulations and effect change in 2005 and beyond. I know that change at this late date for 2004 will come hard but is doable.

I am a second-generation trawl fisherman. My father was a pioneer in the industry, starting in the 1930s. I fished in the 6os, 70s, and 80s and now have my boat fished by a fisherman who has been with me for 27 years, Terry Sweeney. I have seen many changes over the years, not all of them good. However, as I look forward I can see a strong and viable industry on the rise. What I see is a fresh fish industry coming into its own. Here the principles of conservation and fresh fish meld perfectly. Small but steady amounts of fresh fish can come into the markets of American consumers.When I talk of fresh fish, I am referring to the many varieties that are found in the near shore waters. Unlike the Deep Water Complex, of which most is exported, with the exception of Dover Sole, which is found wanting as a fresh market fish.

Last year we participated in a Exempted Fishing Permit in conjunction with Oregon Department of Fish and Wildlife. A low rise net was used to try and escape the capture of over-fished stocks of rock cod, of which the canary rock was of crucial concern. The results of this experiment were nothing less than spectacular. Of 360,000lbs. of fish caught only 240 lbs. of canary rock was captured. This was accomplished even though the boat did not change its fishing habits from the previous year.

What is disappointing to me is the council slowness in using this exciting tool. Starting in March 2004, allow fishermen to fish out to 100 fathoms with the low-rise bottom trawl. In 2002, NMFS moved rapidly to restrict fishing area with data that showed canary discard rate was higher than expected. NMFS should work just as quickly to implement a net that greatly reduces the by catch of canaries. A high rise net should not be allowed shoreward of the RCA zone, since two fishing tests proved the low-rise net has less effect on the over-fished canaries. The low-rise net would greatly reduce, possibly eliminate, the discard rate of canaries, which caused the waters closure.

This change by the council would be very important to maintain a year around fresh fish market. The 100 fathom curve will allow fishermen to target market fish from March to October as the fish move to and from the beach. The present fathom curves provide a viable market only in July and August, when the fish are at their shallowest depths.

We see opening this 100 fathom area more important than increased quotas because without it the fresh fish market is adversely affected, and the buy back program will be paid back only by the deep water boats. A healthy inshore fisheries is necessary to provide a delightfull treat to the American consumer.

Alex Ells

Terry Sweeney

Terry Sweeney

ARGOS, INC.
Post Office Box 721
Newport, OR 97365
541-265-8881 (phone)
541-265-3571 (fax)

Robert L. Eder

Michele Longo Eder

March 2, 2004

RECEIVED
MAR 2 2004
PFMC

Via fax: 503-820-2299
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, OR 97220-1384

Re: Agenda Item E.4.c
Public Comment
Groundfish Management
Inseason Adjustments

Dear Council Members:

My husband, Bob Eder, fishes for sablefish with pots out of Newport, Oregon. We own fixed gear sablefish endorsed limited entry permits. Bob has fished for sablefish with pots for 25 years.

In regard to agenda item E.4.c, Status of Groundfish Fisheries and Inseason Adjustments, I would ask that the Council act to INCREASE the sablefish tier limits. Specifically, based on the OY for 2004, the limits are to be 62,000, 28,000 and 16,000 pounds for Tiers 1, 2, and 3 respectively.

However, in examining the report by Dr. Jim Hastie," Sablefish Discard and Bycatch of Overfished Species in the 2004 Limited Entry Fixed Gear Sablefish Fishery", Table 14 of his report illustrates that higher tier limits for the fishery could be set, after incorporating the weighted observer data from 2001-2003 in the fixed gear fishery, and depths where fishing is allowed.

Specifically, if the fishery were to be continued to be restricted outside of 150 fathoms, the primary fishery tier limits could be set as follows:

Tier 1	69,532
Tier 2	31,606
Tier 3	18,060

I have attached Dr. Hastie's Table 14 (enlarged) for your reference.

It is also important to note the minuscule bycatch ratios and projected bycatch impacts in metric tons relative to the eight overfished species.

Again, we would ask the Council to incorporate the fixed gear observer data for use in setting this year's tier limits. Utilization of the increased limits would result in positive economic gain to the fishermen, with documented insignificant impact to the overfished species.

Thank you for your consideration of this matter.

Very truly yours,

Michele Longo Eder yw

Michele Longo Eder

MLE:yw

Enclosure

Table 14.--Comparison of sablefish tier limits and projected bycatch implications for overfished species from alternative annual weightings of observer data and alternative depths in which fishing is allowed.

	Weighted 2001-2003 discard rate [3]			Unweighted 2001-2003 discard rate			Unweighted 2002-2003 discard rate		
Depths where fishing is allowed ->	>150 fm	>125 fm	>100 fm	>150 fm	>125 fm	>100 fm	>150 fm	>125 fm	>100 fm
Total catch allocated (mt)	2,755	2,755	2,755	2,755	2,755	2,755	2,755	2,755	2,755
Observed sablefish discard rate	18.5%	17.1%	15.7%	18.2%	17.0%	15.6%	20.2%	18.5%	16.8%
Assumed discard mortality rate [1]	3.7%	3.4%	3.1%	3.6%	3.4%	3.1%	4.0%	3.7%	3.4%
Assumed discard mortality (mt)	102	94	87	100	93	86	112	102	93
Landed catch target (mt)	2,653	2,661	2,669	2,655	2,662	2,669	2,644	2,653	2,662
Amount allocated to:									
DTL (mt)	398	399	400	398	399	400	397	398	399
Primary fishery (mt)	2,255	2,262	2,268	2,257	2,262	2,269	2,247	2,255	2,263
Primary fishery tier limits (lb)									
Tier 1	69,532	69,730	69,934	69,570	69,751	69,942	69,278	69,524	69,768
Tier 2	31,606	31,696	31,788	31,623	31,705	31,792	31,490	31,602	31,713
Tier 3	18,060	18,112	18,165	18,070	18,117	18,167	17,994	18,058	18,121
Bycatch ratios [2]									
Lingcod	0.114%	0.188%	0.301%	0.107%	0.181%	0.296%	0.124%	0.206%	0.307%
Widow rockfish	0.000%	0.000%	0.001%	0.000%	0.000%	0.001%	0.000%	0.000%	0.001%
Canary rockfish	0.002%	0.014%	0.026%	0.002%	0.014%	0.026%	0.002%	0.016%	0.029%
Yelloweye rockfish	0.015%	0.032%	0.053%	0.014%	0.030%	0.050%	0.017%	0.033%	0.056%
Bocaccio rockfish [4]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Cowcod rockfish [4]	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Pacific ocean perch	0.012%	0.013%	0.011%	0.012%	0.013%	0.011%	0.014%	0.015%	0.013%
Darkblotched rockfish	0.035%	0.033%	0.029%	0.033%	0.030%	0.026%	0.038%	0.035%	0.030%
Projected bycatch impacts (mt)									
Lingcod	3.1	5.2	8.3	3.0	5.0	8.1	3.4	5.7	8.5
Widow rockfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Canary rockfish	0.1	0.4	0.7	0.1	0.4	0.7	0.1	0.5	0.8
Yelloweye rockfish	0.4	0.9	1.5	0.4	0.8	1.4	0.5	0.9	1.5
Bocaccio rockfish [4]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cowcod rockfish [4]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pacific ocean perch	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.4	0.4
Darkblotched rockfish	1.0	0.9	0.8	0.9	0.8	0.7	1.0	1.0	0.8

[1] As in previous years, the rate of mortality for discarded sablefish in the fixed-gear fishery is assumed to be 20%.

[2] The bycatch ratios are calculated by dividing the total catch of each species by the total poundage of sablefish that was caught.

[3] Year specific tonnages combined using the following weights: 2003: 0.45, 2002: 0.35, 2001: 0.25.

Exhibit E.4.f
Public Comment
March 2004

Proposed Recreational Lingcod in-season Adjustments

Coastside Fishing Club

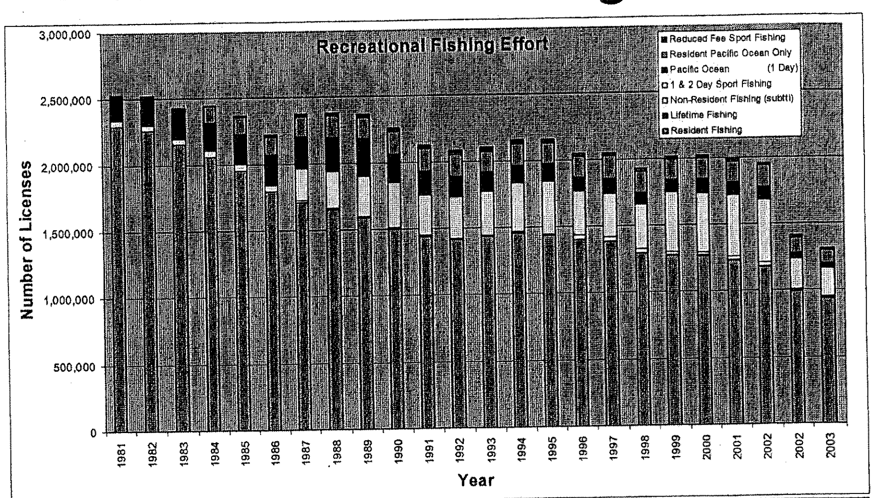
March 2004

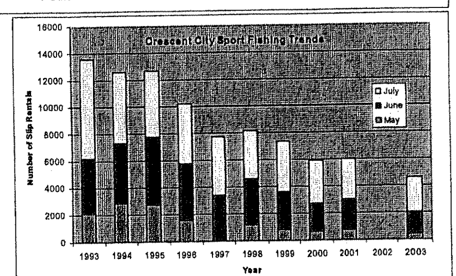
2003 Lingcod Stock Assessment

- Female spawning biomass dramatically up at >10,000 mt in 2003, from <2,000 mt in 1994 (page 5)
- Recruitment down slightly '86-'02 at ~80% of '73-'85 (page 5)
- Management constraints limit exploitation at 3-13% of available biomass (page 5)
  - Commercial age at 3-6 years in 2003 is same as 1994 (table 7)
  - 2002 California recreational CPUE double to triple what it was in late '80s, mid '90s (table 23)
- Yield projections consistently show increase for the 2004 -2008 period

Bottom Line: Lingcod stock is in good shape

General Decrease in Recreational Fishing Effort





Decreased fishing effort with high catch rates indicates large numbers of fish stock – consistent with the Stock Assessment

The Proposed 1 Fish >30 inches Adjustment is Unnecessarily Severe

- Stock Assessment indicates
  - A healthy rebuilding Lingcod stock
- Higher recreational CPUE indicates
  - A healthy Lingcod stock with overly restrictive OY
- Next year's proposed increase in OY indicates
  - Confidence in a healthy Lingcod stock
- In-season 1 fish >30 inches adjustment means
  - Recreational fishing will essentially be shut down
    - Likely that only 1 trip in 100 will result in success

The Coastside Fishing Club Recommends

- An immediate increase in this year's OY, allowing continued recreational fishing for Lingcod
  - Allow time to assess progress towards this higher OY
  - Consider slowing down the recreational catch rate by
    - Decrease the daily limit in conjunction with
      - Existing size restriction
      - Small increase in size restriction
      - Slotted size restriction to protect the largest spawners

Mr. Josh Churchman
1 Opal # 50P
Bolinas, CA 94924
415-868-0982

Dear Sir,

I would like to thank you for allowing some harvest of (S. goodei) chillie pepper rock fish in our new "central area" 40°10 to 34°27 N LAT. My boat went fishing again after over two years of sitting idle. At twenty five feet my boat is too small to access slope species and even now at nine hundred feet of water (150 FATHOMS) my hand operated operation is difficult.

My concern is the take and discard of bocaccio (S. PAUCISPINIS). Unfortunatly, the bocaccio is the predator in the "sebastes complex" and wherever schooling fish are found the bocaccio will be near. (20 fathoms to 200).

Tradition was a "total retention" approach in the hook and line fishery. Only trawlers "discarded". Current policy dictates that now hook and line must discard to comply with law. This is backward thinking. It should be illegal to discard, not the reverse.

Mr. Josh Churchman
1 Opal # 50P
Bolinas, CA 94924

415 868-0982

In the trip limits proposed for 2004 the bocaccio limits are creating a mandatory discard of all fish in March/April. and 100 lbs MAY - AUG. This is a sad situation for the bocaccio, who needs to be better understood.

Again unfortunate is the fact that bigger bocaccio are found in deeper water. Bigger fish spawn more eggs.

If the average bocaccio in 150 fathoms is ten pounds and the average chillie pepper is two pounds I need to only catch ten bocaccio for every 1000 chillie pepper in the MAY - AUG 100 LBS.

It is immoral to discard and it is not scientific in the least.

Let us bring them in for study and give the money to something worthy.

If we must discard please leave a 200 lbs - 20 fish per 1000 LBS (1000 FISH) chillie pepper to ease our pain.

JOSH.

Subject: Lingcod restrictions are absolutely ridiculous!
From: GONARVCO@aol.com
Date: Sat, 21 Feb 2004 23:35:33 EST
To: John.Coon@noaa.gov
CC: Donald.McIsaac@noaa.gov, Mike.Burner@noaa.gov, John.DeVore@noaa.gov

Gentlemen:

I am a concerned citizen and would like to express my displeasure with your conclusions that have resulted in the California DFG's new lingcod fishing restrictions. Are you a scientists? Do you employ scientific methods? Do you ever use common sense and first hand experience to develop your conclusions? Do you personally observe the fisheries that are impacted by your findings?

Your conclusion that the lingcod fishery along the Northern California coast is threatened due to overfishing is JUST PLAIN WRONG! The quotas you have set and the woeful harvest data you developed is without question, FLAWED! Recreational sportfishermen have experienced a renaissance in lingcod fishing. Many believe the fishery is as healthy as it has been in the last twenty years. Here are some recent accounts by Northern California fishermen. It is clear that you must reexamine your methods because the results are spurious.

Best regards,

Arthur Narverud
Napa, California

Fri left berkeley 7:am to farallons for some ling & rocks. pretty lumpy going out but "fishin-mishin II" handled it well. started our drifts @ 100 ft. paicked up 4 keeper lings on SE side
and a couple of nice cabs. moved over to outside (west) side and hit HOT action in 75 ft. even had a triple hook-up of lings. had limits for three by 11:30. great action great fishing ,back in berkeley @ 2:00 to beat traffic home

We were out on the 12th to the Farallon Island and did well also. There were no shortage that I could see. Most were in the 24-29 inch size. Big chrome diamond bars (12oz.) caught the bigger fish. Gees, had two legals on at one time. Both toward the 29 inch size. Dam, I thought I had Moe on until I saw color. 30 inch is going to be tough and really going to be a problem for the party boat captains and six packer's.

We landed over a dozen lings mostly under but five keepers on metal jigs and some on herring on red shrimp flys. Dual shrimp flys did nicely for olives, blues and blacks and misc with many double hookups. Released two canaries but water too bouncy for trying the Franko elevator. Gulls seemed happy. Total about 40 mixed rockfish for five. Fast drift so no stretch spectra with 1# torpedo lead best for deep water probing the bottom. Several on ling regurgitated octipus parts.

Headed for St. James Island (also known as the North Island) I say we released somewhere in the neighborhood of 10 undersized lings there and a few nice rockies. The wind started to pick up and was headed in and I stumbled accross a good rockpile between the main island and the pimple for probably another 10 shorties

The lings were suicidal today. Today my crew used TomCod swim baits, Fat baits, and scampys. Myself and one other guy also ran a stinger hook to catch a couple rockfish along with lings. We fished for about 3 hours, and over large stretches of time we had one or two lings on at all times. On two occasions we had doubles on the same rod, one ling on the stinger, and the other on the swimbait. I don't know how many we released today but fishing was obviously very good.

We tried a few spots north of Dux for nada before making the run futher up the coast. Decent action on 10 pound lings and one nice cab. had never cought a ling before and he walked off the boat with the two biggest fish (up to 15 lbs).

What a nice day and easy ride back to Emmeryville. Full load aboard and filled limits of Lings for 28 plus limits of assortments of rock fish. Lings between 5-25 lb on 12 oz. diamond bar.

We picked up four limits of lings to 30 pounds and limits of crab near N buoy. Lings were again on Fat Bait in 120 feet of water.
We fished 6 different areas north of the gate and up way past 10 mile. We put on 112 miles today. Caught and released 50 ling cod.

Went to Casper had a few bites a couple of blues 1 ling the drift was good, moved a couple of times. Went to Jug Handle three more lings, nothing big, 1 vermillion, 1 cabazon, Total of 1 limit bottom fish and two limits of lings.

Fished from South Rock to New years. One keeper at the island and one south of Davenport.(2-4 miles) Sounded like it was slow for everyone!! We did release 5-6 small lings no other rock fish.

Fished the Faralons yesterday and it was wide open lings. So much that on the fist drop of the day we both hooked into a ling within 5-10 seconds of hitting bottom. It was good fishing all morning. Then the mooching started. We took a break to eat lunch so we reeled up about 10' from the bottom, left the rods in the holders and drifted. We both hooked up within a couple of minutes. hooked a nice 29" ling and mine was 28" We probably caught 12-15 each and released most, almost all lings 2 cabs and only 2 rock fish.

PACIFIC WHITING MANAGEMENT

Situation: The Pacific whiting fishery management process is unlike other federally-managed West Coast groundfish for 2004 fisheries, for which catch specifications and management measures were adopted by the Council at the September 2003 Council meeting. The Council deferred a decision on setting harvest specifications and management measures for the 2004 Pacific whiting fisheries pending the development and review of a new stock assessment to occur during February 2004. This transboundary stock has been assessed and managed jointly with the Department of Fisheries and Oceans, Canada, and a new process is described in a treaty that has been signed by both countries and is currently awaiting ratification by the U.S. Senate and passage of implementing legislation by the U.S. Congress (Exhibit E.5.a, Attachment 1). The primary tenets of the treaty include an annual assessment and management process, a research commitment, and a harvest sharing agreement providing 73.88% for U.S. fisheries and 26.12% for Canadian fisheries. At the treaty signing ceremony, both Assistant Secretary of State, John Turner, and Canadian Fisheries Senior Minister, Pat Chamut, stressed the intent of both countries to manage 2004 fisheries in the spirit of the agreement, to the extent possible.

A new Pacific whiting assessment was prepared this winter (Exhibit E.5.a, Attachment 2) and reviewed by a Stock Assessment Review (STAR) Panel (Exhibit E.5.a, Attachment 3). The stock assessment concluded the stock size to range between 47% and 49% of the unfished level, and the STAR Panel concluded these two estimates were equally probable. The Council should consider the advice of the STAR Panel, the Scientific and Statistical Committee (SSC), and other advisors before adopting the assessment for use in management decision-making.

The assessment, once approved, will be used to set 2004 harvest specifications. The Council is tasked with setting an acceptable biological catch (ABC) and optimum yield (OY) for Pacific whiting that will be used to manage 2004 fisheries. Considerations for this decision include the stock's current and projected status with respect to the overfishing threshold, the international agreement with Canada, and widow rockfish bycatch concerns.

Another important implication of the adoption of a new stock assessment for Pacific whiting is the status of this species relative to its designation as an overfished species. In 2002, the best scientific information at the time indicated abundance in 2001 was less than the $B_{25\%}$ (biomass at 25% of the unfished level) threshold that determines the overfished status designation. Consequently, the National Marine Fisheries Service (NMFS) declared Pacific whiting overfished, and the Council began planning for development of a rebuilding plan as required by the Magnuson-Stevens Fishery Conservation and Management Act. This rebuilding plan, known as Groundfish FMP Amendment 16-4, has been scheduled for adoption in a two-meeting process for the April 2004 and June 2004 Council meetings. The rebuilding plan was to prescribe measures to rebuild the stock to the $B_{40\%}$ level, at which time it would be de-listed as overfished. In the event the Council adopts a stock assessment indicating the stock is at or greater than the $B_{40\%}$ level during 2004, transmittal of this decision to NMFS should lead to de-listing of Pacific whiting as an overfished species and removal of Amendment 16-4 from future Council workload planning. While only valuable in hindsight, the new stock assessment and STAR Panel reports note that the best scientific information available now indicates the Pacific whiting stock was not under the $B_{25\%}$ level in 2001.

Additionally, under this agendum, Mr. Bill Robinson, Assistant Northwest Regional Administrator for Sustainable Fisheries, NMFS, will inform the Council of a new management measure to be implemented in 2004 for the shoreside whiting sector under the Shoreside Whiting Exempted Fishing Permit.

Council Task:

1. **Adopt the new Pacific whiting stock assessment.**
2. **Adopt 2004 Pacific whiting ABC and OY.**

Reference Materials:

1. Exhibit E.5.a, Attachment 1: Agreement Between the Government of Canada and the Government of the United States of America on Pacific Hake/Whiting.
2. Exhibit E.5.a., Attachment 2: Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003.
2. Exhibit E.5.a, Attachment 3: STAR Panel Report on the Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003.

Agenda Order:

a. Agendum Overview — John DeVore
b. Perspectives of the Canadian Government
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. **Council Action:** Adopt Stock Assessment, Final 2004 Acceptable Biological Catch and Optimum Yield, Exempted Fishing Permit, and Management Measures

PFMC
02/24/04

AGREEMENT

BETWEEN

THE GOVERNMENT OF THE UNITED STATES OF AMERICA

AND

THE GOVERNMENT OF CANADA

ON PACIFIC HAKE/WHITING

THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE GOVERNMENT OF CANADA (hereinafter referred to as "the Parties"),

RECOGNIZING the transboundary nature of the offshore hake/whiting (*Merluccius productus)* resource off the Pacific coast of Canada and the United States,

MINDFUL of the importance of this resource to the social and economic sustainability of fishing communities, including harvesters, processors, license holders, and other stakeholders reliant on the offshore hake/whiting fishery,.

DESIRING to cooperate in the stewardship of this resource and to benefit the industries involved in this fishery, and

RECOGNIZING the desirability of maintaining existing levels of scientific research with respect to the offshore hake/whiting resource,

HAVE AGREED as follows:

ARTICLE I

Definitions

For the purposes of this Agreement:

"Catch" means all fishery removals from the offshore hake/whiting resource, including landings, discards, and bycatch in other fisheries;

"F-40 percent" means a fishing mortality rate that would reduce the biomass, calculated on a per recruit basis, to 40 percent of what it would have been in the absence of fishing mortality;

"40/10 adjustment" means an adjustment to the overall total allowable catch (TAC) that is triggered when the biomass falls below 40 percent of its unfished level. This adjustment reduces the TAC on a straight-line basis from the 40 percent level such that the TAC would equal zero when the stock is at 10 percent of its unfished level;

"Offshore hake/whiting resource" means the transboundary stock of *Merluccius productus* that is located in the offshore waters of the United States and Canada. The hake/whiting located in Puget Sound and the Strait of Georgia is not included in the offshore hake/whiting resource; and

"Potential yield" means the range of results obtained from applying the harvest rate established pursuant to paragraph 1 of Article III to a range of forecasted biomass estimates.

ARTICLE II

1. A Joint Technical Committee (JTC) is hereby established comprising up to five scientific experts, with up to two appointed by each Party and one independent member jointly appointed by the Parties from a list supplied by the Advisory Panel established pursuant to paragraph 4 of this Article. The Parties shall jointly bear the independent member's travel expenses associated with the work of the JTC. JTC members may seek advice from others as they deem appropriate. The JTC shall meet annually, and more often as necessary, to:

   (a) propose its terms of reference for approval by the Joint Management Committee (JMC) established in paragraph 3 of this Article;

   (b) develop stock assessment criteria and methods, and design survey methods;

   (c) exchange survey information, including information on stock abundance, distribution, and age composition;

   (d) exchange and review relevant annual catch and biological data, including information provided by the public;

   (e) provide, by no later than February 1 of each year unless otherwise directed by the JMC, a stock assessment that includes scientific advice on the annual potential yield of the offshore hake/whiting resource that may be caught for that fishing year, taking into account uncertainties in stock assessment and stock productivity parameters and evaluating the risk of errors in parameter estimates produced in the assessment;

   (f) take into account any adjustments pursuant to paragraph 5 of this Article as part of its stock assessment; and

   (g) perform other duties and functions that may be referred to it by the Scientific Review Group (SRG) established in paragraph 2 of this Article and by the JMC.

2. A Scientific Review Group (SRG) is hereby established to provide independent peer review of the work of the JTC. The SRG shall comprise up to six scientific experts, with up to two appointed by each Party and two independent members appointed jointly by the Parties from a list supplied by the Advisory Panel. All SRG members shall be different individuals than those who serve on the JTC. The Advisory Panel may also nominate, for appointment by the Parties, two public advisors to participate in SRG meetings. The public advisors shall have the right to provide their views on all aspects of the work of the SRG, both orally and in writing. The Parties shall jointly bear the travel expenses of the independent members and the public advisors for meetings of the SRG. In addition, SRG members may seek advice from others as they deem appropriate. SRG meetings shall be open to the public. The SRG shall meet annually, and more often as necessary, to:

(a) propose its terms of reference for approval by the JMC;

(b) review the stock assessment criteria and methods and survey methodologies used by the JTC;

(c) provide, by no later than March 1 of each year, unless otherwise directed by the JMC, a written technical review of the stock assessment and its scientific advice on annual potential yield; and

(d) perform other duties and functions that may be referred to it by the JMC.

3. A Joint Management Committee (JMC) is hereby established comprising eight members, four appointed by each Party. The members appointed by each Party shall comprise the national section of that Party. Recommendations of the JMC shall be made by agreement of the two national sections. JMC meetings shall be open to the public, unless the JMC determines that, due to extraordinary circumstances, a closed session is necessary. The JMC shall meet at least once per year and more often as necessary to:

(a) adopt its terms of reference and approve the terms of reference of the JTC and SRG;

(b) provide the SRG and JTC the direction necessary to guide their deliberations;

(c) refer any technical issues or other duties to the SRG or JTC as it deems appropriate;

(d) consider information on management measures employed by the Parties; and

(e) review the advice of the JTC, the SRG, and the Advisory Panel and, by no later than March 25 of each year, recommend for approval of the Parties the overall total allowable catch (TAC) for that year, calculate each Party's individual TAC pursuant to paragraph 2 of Article III, and identify any adjustments pursuant to paragraph 5 of this Article.

4. An Advisory Panel on Pacific Hake/Whiting (Advisory Panel) is hereby established comprising members appointed by each Party. The members appointed by each Party shall comprise the national section of that Party. Decisions of the Advisory Panel shall be made by agreement of the two national sections. Members of the Advisory Panel shall be individuals knowledgeable or experienced in the harvesting, processing, marketing, management, conservation, or research of the Pacific hake/whiting fisheries and may not be employees of either Party. Meetings of the Advisory Panel shall be open to the public. The Advisory Panel shall meet annually prior to the meeting of the JMC, or more often as necessary, to:

(a) establish its terms of reference;

(b) compile and provide to the Parties, by no later than March 25 of each year, the names of at least three scientific experts as candidates for the JTC and the names of at least five scientific experts as candidates for the SRG, for appointment in the following year;

(c) review the advice of the SRG and JTC;

(d) review the management of the fisheries of the two Parties during the previous year; and

(e) make recommendations to the JMC regarding the overall TAC.

5. Adjustments:

(a) If, in any year, a Party's catch exceeds its individual TAC, an amount equal to the excess catch shall be deducted from its individual TAC in the following year.

(b) If, in any year, a Party's catch is less than its individual TAC, an amount equal to the shortfall shall be added to its individual TAC in the following year, unless otherwise recommended by the JMC. Adjustments under this sub-paragraph shall in no case exceed 15 percent of a Party's unadjusted individual TAC for the year in which the shortfall occurred.

6. In any year in which the JMC has made recommendations pursuant to sub-paragraph 3(e) of this Article, paragraph 5 of this Article or paragraph 1 of Article III, the Parties shall manage their respective fisheries for the offshore hake/whiting resource consistent with such recommendations of the JMC as the Parties have approved.

ARTICLE III

1. For the purposes of this Agreement, the default harvest rate shall be F-40 percent with a 40/10 adjustment. Having considered any advice provided by the JTC, the SRG or the Advisory Panel, the JMC may recommend to the Parties a different harvest rate if the scientific evidence demonstrates that a different rate is necessary to sustain the offshore hake/whiting resource. If the Parties approve such a recommendation, they shall so inform the JMC.

2. The United States' share of the overall TAC shall be 73.88 percent. The Canadian share of the overall TAC shall be 26.12 percent. This division shall apply for an initial nine-year period, and thereafter unless the Parties agree in writing to adjust it. Any such adjustment shall take effect in the following year, unless the Parties agree otherwise.

ARTICLE IV

The Parties agree to conduct scientific research to support the effective implementation of this Agreement, including trawl, acoustic, and recruit surveys to provide adequate data on the offshore hake/whiting resource. The Parties should, where appropriate, conduct such research using private vessels.

ARTICLE V

1. This Agreement shall enter into force upon an exchange of written notifications by the Parties, through diplomatic channels, that they have completed their respective internal procedures.

2. This Agreement may be amended at any time by written agreement of the Parties.

3. Either Party may terminate this Agreement by notice in writing to the other Party through diplomatic channels. Unless such notice has been withdrawn, this Agreement shall terminate on December 31 of the calendar year following that in which such notice was received by the other Party.

IN WITNESS WHEREOF, the undersigned, duly authorized by their respective Governments, have signed this Agreement.

DONE at Seattle, this 21st day of November 2003 in duplicate in the English and French languages, both texts being equally authentic.

FOR THE GOVERNMENT OF THE UNITED STATES OF AMERICA:

John F. Turner

FOR THE GOVERNMENT OF CANADA:

[illegible signature]

ACCORD

RELATIF AU MERLU DU PACIFIQUE

ENTRE

LE GOUVERNEMENT DES ÉTATS-UNIS D'AMÉRIQUE

ET

LE GOUVERNEMENT DU CANADA

LE GOUVERNEMENT DES ÉTATS-UNIS D'AMÉRIQUE ET LE GOUVERNEMENT DU CANADA (ci-après dénommés « les Parties »),

RECONNAISSANT le caractère transfrontalier du stock de merlu du Pacifique (*Merluccius productus*) au large des côtes du Pacifique du Canada et des États-Unis,

CONSCIENTS de l'importance de ce stock pour la viabilité sociale et économique des communautés de pêcheurs, notamment les pêcheurs eux-mêmes, les entreprises de transformation, les titulaires de permis et les autres parties dépendantes de la pêche du merlu du Pacifique au large des côtes,

DÉSIREUX de coopérer pour la gestion de ce stock et de faire profiter les industries concernées, et

RECONNAISSANT le bien-fondé d'un maintien des niveaux actuels de recherche scientifique relativement au stock de merlu du Pacifique,

SONT CONVENUS de ce qui suit :

ARTICLE PREMIER

Définitions

Aux fins du présent accord :

« Prise » s'entend de toute ponction du stock de merlu du Pacifique au large des côtes, y compris le débarquement, le rejet à la mer et les prises accessoires lors de la pêche d'autres espèces;

« Pourcentage F-40 » s'entend d'un taux de mortalité halicutique qui réduirait la biomasse, calculé sur la base des recrues, à 40 pour cent de ce qu'elle aurait été s'il n'y avait aucune mortalité halieutique;

« Ajustement 40/10 » s'entend de tout ajustement du total autorisé des captures (TAC) global effectué lorsque le niveau non exploité de la biomasse tombe sous 40 pour cent. Cet ajustement réduit le TAC de façon linéaire à compter du niveau de 40 pour cent de telle façon que le TAC serait égal à zéro si le niveau non exploité du stock correspondait à 10 pour cent;

« Stock de merlu du Pacifique au large des côtes » s'entend du stock transfrontalier de *Merluccius productus* qui vit dans les eaux hauturières des États-Unis et du Canada. Le merlu du Pacifique qui vit dans le Puget Sound et dans le détroit de Georgie n'est pas considéré comme faisant partie du stock de merlu du Pacifique au large des côtes; et

« Rendement potentiel » s'entend de la série des résultats obtenus après avoir appliqué le taux d'exploitation établi conformément au paragraphe 1 de l'Article III à une série de prévisions de la biomasse.

ARTICLE II

1. Un Comité technique mixte (CTM) est constitué par la présente et compte jusqu'à cinq experts scientifiques, soit jusqu'à deux experts nommés par chaque Partie et un membre indépendant qu'elles nomment conjointement à partir d'une liste fournie par le Groupe consultatif institué conformément au paragraphe 4 du présent article. Les Parties supportent conjointement les frais de déplacements engagés par le membre indépendant dans l'exercice de ses fonctions au sein du CTM. Les membres peuvent consulter d'autres personnes lorsqu'ils le jugent nécessaire. Le CTM se réunit une fois par année, et plus souvent au besoin, pour :

   a) proposer l'approbation de son mandat au Comité de gestion mixte (CGM) institué en vertu du paragraphe 3 du présent article;

   b) élaborer des critères et des modes d'évaluation de la ressource halieutique, et concevoir les méthodes à suivre pour les campagnes d'évaluation;

   c) échanger les informations que rapportent les campagnes d'évaluation, notamment sur l'abondance de la ressource halieutique, sa distribution et sa composition par âge;

   d) échanger et examiner les données annuelles pertinentes sur les prises et les données biologiques, y compris les renseignements fournis par le public;

   f) fournir, au plus tard le 1er février de chaque année sauf indication contraire du CGM, une évaluation de la ressource halieutique, dont des données scientifiques sur le rendement potentiel annuel du stock de merlu du Pacifique au large des côtes pour l'année de pêche en cours, qui tienne compte des incertitudes entourant les évaluations de ressources halieutiques et les paramètres de productivité de la ressource et mesure les possibilités d'erreurs dans les paramètres de l'évaluation;

   g) tenir compte de tout ajustement décrété conformément au paragraphe 5 du présent article dans le cadre de son évaluation de la ressource halieutique; et

   h) exercer toute autre fonction et assumer toute autre responsabilité que lui a déléguées le Groupe d'examen scientifique (GES) institué en vertu du paragraphe 2 du présent article et le CGM.

2. Un Groupe d'examen scientifique (GES) est constitué par la présente pour procéder à un contrôle indépendant par les pairs des travaux du CTM. Le GES comprend jusqu'à six experts scientifiques, deux experts au plus nommés par chaque Partie et deux membres indépendants qu'elles nomment conjointement à partir d'une liste fournie par le Groupe consultatif. Les membres du GES ne peuvent siéger au CTM. Le Groupe consultatif peut également proposer aux Parties la nomination de deux conseillers représentant le public devant participer aux réunions du GES. Ces conseillers peuvent faire connaître leurs vues, oralement et par écrit, sur tous les aspects des travaux du GES. Les Parties supportent conjointement les frais de déplacements engagés par les membres indépendants et des conseillers représentant le public pour assister aux réunions du GES. De plus, les membres du GES peuvent consulter d'autres personnes lorsqu'ils le jugent nécessaire. Les séances du GES sont publiques; il se réunit une fois par année, et plus souvent au besoin, pour :

a) proposer l'approbation de son mandat au CGM;

b) examiner les critères et les modes d'évaluation de la ressource halieutique ainsi que les modes des campagnes d'évaluation du CTM et les méthodes utilisées;

c) fournir, au plus tard le 1er mars de chaque année, sauf indication contraire du CGM, un compte rendu technique écrit de l'évaluation de la ressource halieutique et son avis scientifique sur le rendement potentiel annuel; et

d) exercer toute autre fonction et assumer toute autre responsabilité que lui a déléguées le CGM.

3. Un Comité de gestion mixte (CGM) est constitué par la présente et comprend huit membres, quatre membres étant nommés par chaque Partie. Les membres nommés par chaque Partie forment la section nationale de cette Partie. Les deux sections nationales conviennent des recommandations faites par le CGM. Les séances du CGM sont publiques, sauf s'il juge le huis clos nécessaire en raison de circonstances extraordinaires. Le CGM se réunit au moins une fois par année, et plus souvent au besoin, pour :

a) adopter son mandat et approuver celui du CTM et du GES;

b) donner au GES et au CTM l'orientation nécessaire à la tenue de leurs délibérations;

c) déléguer les questions techniques ou d'autres responsabilités au GES ou au CTM lorsqu'il le juge nécessaire;

d) examiner des renseignements sur les mesures de gestion adoptées par les Parties; et

e) revoir les recommandations du CTM, du GES et du Groupe consultatif et, au plus tard le 25 mars de chaque année, recommander aux Parties l'approbation du TAC global pour l'année, calculer le TAC propre à chaque Partie conformément au paragraphe 2 de l'Article III et préciser tout ajustement à apporter en vertu du paragraphe 5 du présent article.

4. Un Groupe consultatif sur le merlu du Pacifique (Groupe consultatif) formé de membres nommés par chaque Partie est constitué par la présente. Les membres nommés par une Partie forment la section nationale de cette Partie. Les deux sections nationales conviennent des décisions prises par le Groupe consultatif. Les membres du Groupe consultatif doivent avoir des connaissances ou de l'expérience en matière de prise, de transformation, de commercialisation, de gestion, de conservation ou de recherche relativement à la pêche du merlu du Pacifique et ne peuvent être des employés ni de l'une des Parties ni de l'autre. Les séances du Groupe consultatif sont publiques. Le Groupe consultatif se réunit une fois par année avant la réunion du CGM, ou plus souvent au besoin, pour :

a) établir son mandat;

b) obtenir et fournir aux Parties, au plus tard le 25 mars de chaque année, le nom d'au moins trois experts scientifiques comme candidats au CTM et d'au moins cinq autres comme candidats au GES, en vue des nominations de l'année suivante;

c) revoir les recommandations du GES et du CTM;

d) passer en revue la gestion qu'ont faite de la pêche les deux Parties au cours de l'année précédente; et

e) faire des recommandations au CGM relativement au TAC global.

5. Ajustements :

a) Si, pour une année donnée, les prises d'une Partie dépassent son TAC individuel, une quantité égale à la quantité excédentaire doit être soustraite de son TAC individuel de l'année suivante.

b) Si, pour une année donnée, les prises d'une Partie sont inférieures à son TAC individuel, une quantité égale au nombre de prises toujours permises est ajoutée à son TAC individuel de l'année suivante, à moins d'une recommandation contraire du CGM. Les ajustements effectués en vertu du présent alinéa ne doivent en aucun cas dépasser 15 pour cent du TAC individuel non ajusté d'une Partie pour l'année au cours de laquelle des prises lui sont toujours permises.

6. Pour toute année durant laquelle le CGM fait des recommandations en vertu de l'alinéa 3*e)* du présent article, du paragraphe 5 du présent article ou du paragraphe 1 de l'Article III, les Parties gèrent leur pêche respective du stock de merlu du Pacifique au large des côtes conformément aux recommandations du CGM qu'elles ont approuvées.

ARTICLE III

1. Aux fins de cet accord, le taux d'exploitation par défaut correspond à F-40 pour cent avec un ajustement de 40/10. Après avoir pris en considération les recommandations du CTM, du GES ou du Groupe consultatif, le CGM peut recommander aux Parties un taux d'exploitation différent si des preuves scientifiques démontrent qu'un tel taux est nécessaire à la viabilité du stock de merlu du Pacifique au large des côtes. Si les Parties approuvent la recommandation, ils en informent le CGM.

2. La portion du TAC global applicable aux États-Unis est de 73,88 pour cent, tandis que celle applicable au Canada est de 26,12 pour cent. Cette répartition s'applique pour une période initiale de neuf ans, et par la suite, à moins que les Parties ne conviennent par écrit d'un ajustement. Un tel ajustement prend effet au cours de l'année suivante, à moins que les Parties n'en conviennent autrement.

ARTICLE IV

Les Parties conviennent de procéder à des recherches scientifiques pour assurer une mise en œuvre efficace du présent accord, notamment à des campagnes d'évaluation de la pêche au chalut et acoustique ainsi que des recrues, afin d'obtenir des données pertinentes sur le stock de merlu du Pacifique au large des côtes. Les Parties devraient, s'il y a lieu, utiliser des bateaux privés pour procéder à de telles recherches.

ARTICLE V

1. Le présent accord entrera en vigueur à la suite de l'échange par les Parties de notifications écrites, par la voie diplomatique, attestant qu'elles ont respectivement rempli les formalités internes applicables à cet effet.

2. Le présent accord peut être amendé à tout moment par accord écrit entre les Parties.

3. L'une des Parties peut mettre fin au présent accord par avis écrit donné à l'autre par la voie diplomatique. À moins de rétractation de l'avis, le présent accord prend fin le 31 décembre de l'année civile qui suit celle où l'avis a été reçu par la Partie contractante.

EN FOI DE QUOI, les soussignés, dûment autorisés par leur gouvernement respectif, ont signé le présent accord.

FAIT à Seattle, le 21 novembre 2003, en double exemplaire, en anglais et en français, les deux textes faisant également foi.

POUR LE GOUVERNEMENT DES ÉTATS-UNIS D'AMÉRIQUE :	**POUR LE GOUVERNEMENT DU CANADA :**
John F. Turner	B. Charest

Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003

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Summary of Stock Status

The coastal population of Pacific hake (*Merluccius productus*, also called Pacific hake) was assessed using an age-structured assessment model. The U.S. and Canadian fisheries were treated as distinct fisheries. The primary indicator of stock abundance is the acoustic survey, and a midwater trawl juvenile survey provides an indicator of recruitment. New data in this assessment included updated catch at age through 2003, recruitment indices from the juvenile survey in 2003, and results from the U.S./Canadian acoustic survey conducted in summer of 2003. Based on the new acoustic survey and updated data, the strength of the 1999 year class, and consequently mature female spawning biomass was greater than previously estimated in the 2002 assessment.

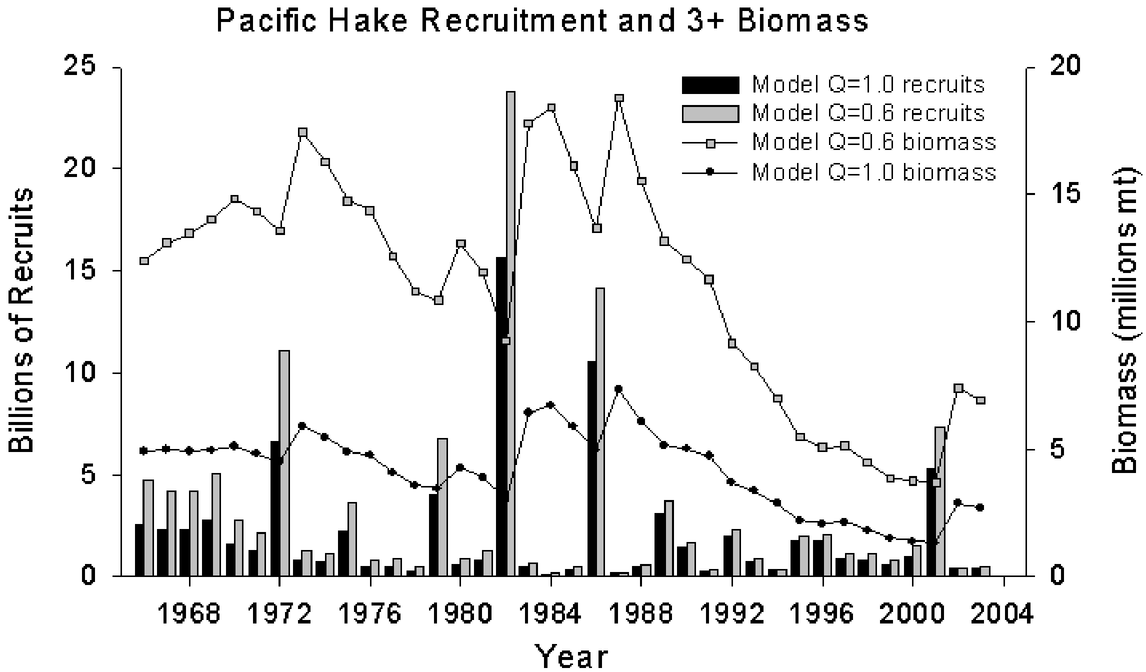
Status of Stock: The hake stock in 2003 was estimated to range from 2.6 to 4.0 million mt (age 3+ biomass) for the Q=1.0 and Q=0.6 model scenarios, respectively. Stock biomass increased to a historical high in 1987 due to exceptionally large 1980 and 1984 year classes, then declined as these year classes passed through the population and were replaced by more moderate year classes. Stock size stabilized briefly between 1995-1997, but then declined continuously to its lowest point in 2001. Since 2001, stock biomass has increased substantially as the strong 1999 year class has entered the population. The mature female biomass in 2003 was estimated to range from 47% to 49% (Q=1.0 and Q=0.6) of an unfished stock. Thus the stock can be considered to be rebuilt to the target level of abundance only 3 years after reaching a low level that resulted in the depleted (overfished) determination. The hindcast estimation of biomass in 2001 remains near, but slightly above, the depleted level (25% of the unfished level).

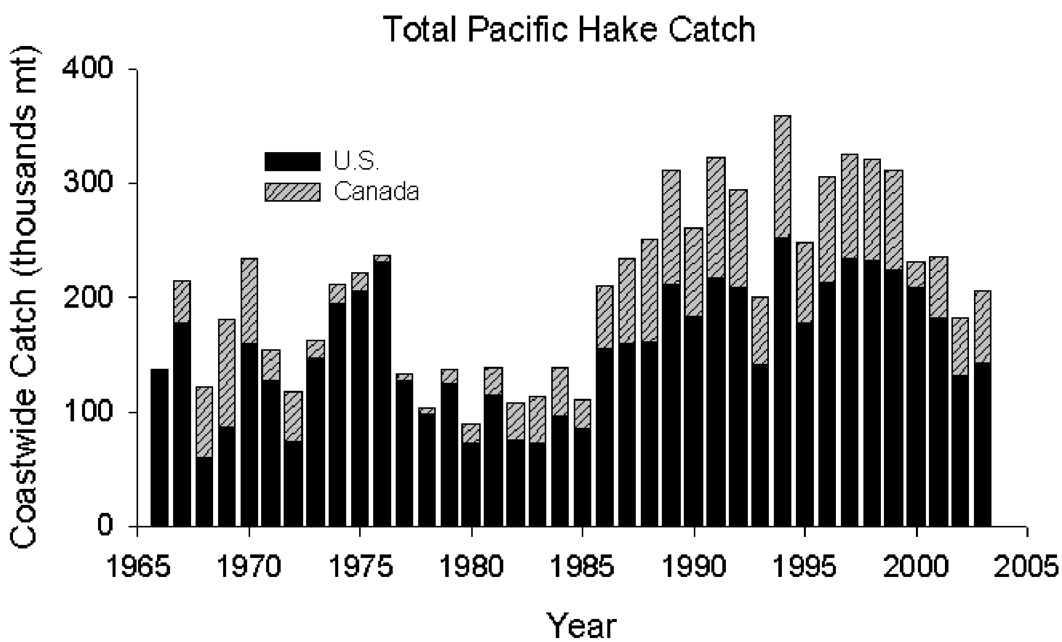
The coastwide ABC and OY for 2004 are estimated to be 501,000 mt and 740,000 mt (Q=1.0 and Q=0.6) based upon a F40% harvest rate and 416,000 mt and 630,000 mt mt (Q=1.0 and Q=0.6) based upon the F45% harvest rate. With biomass above 40% unfished biomass level, the 40:10 OY adjustment would not be applied. Projections beyond 2004 are for a decline in stock biomass and ABC-OY as the 1999 year class passes through its age of peak abundance. At this time there is no evidence of sufficiently large recruitments after 1999 to maintain the stock at a high abundance level. By 2006, the spawning stock biomass is projected to again decline to near the depleted threshold (25% unfished). Such a rapid increase and subsequent decrease in stock abundance and potential yield is to be expected for a stock with such extreme fluctuations in recruitment. A new examination of the harvest policy that takes into account this variability is recommended for this highly fluctuating stock.

Pacific hake (hake) catch and stock status table (catches in thousands of metric tons and biomass in millions of metric tons):

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
U.S. landings	141	253	178	213	233	233	225	208	182	132	144
Canadian landings	59	106	70	93	92	89	87	22	54	51	62
Total	200	359	248	306	325	321	312	230	236	183	206
ABC	178	325	223	265	290	290	290	290	238	208	235
Model 1b (Q=1.0)											
Age 3+ stock biomass	3.4	2.9	2.2	2.1	2.1	1.8	1.5	1.4	1.3	2.9	2.7
Female mature biomass	1.7	1.5	1.2	1.1	1.0	0.9	0.8	0.7	0.7	1.2	1.3
Exploitation rate	6%	12.5%	11.2%	14.7%	15.3%	17.5%	20.7%	16.6%	17.9%	6.4%	7.6%
Model 1c (Q=0.6)											
Age 3+ stock biomass	4.9	4.2	3.3	3.0	3.1	2.7	2.3	2.3	2.2	4.4	4.2
Female mature biomass	2.6	2.2	1.8	1.6	1.5	1.4	1.2	1.2	1.2	1.9	2.0
Exploitation rate	4.0%	8.6%	7.5%	10.1%	10.6%	11.9%	13.5%	10.2%	10.7%	4.1%	5.9%

Data and Assessment: An age-structured assessment model was developed by Dorn et al. (1998) using AD model builder , a modeling environment for developing and fitting multi-parameter non-linear models. The most recent assessment presented here for 2003 used revised 1977-1992 acoustic survey biomass estimates based on new deep-water and northern expansion factors and a slightly different model configuration than used in 2002 assessment. However, the results of the assessment were robust among numerous model configurations explored.





Major Uncertainties: The hake assessment is highly dependent on acoustic survey estimates of abundance. Since 1993, the assessment has relied primarily on an absolute biomass estimate from the joint US-Canadian acoustic survey. The acoustic target strength of Pacific hake, used to scale acoustic data to biomass, is based on a small number of *in situ* observations. While the fit to the acoustic survey time series has improved with revision of the survey biomass estimates (1977-1992) these are still uncertain with poor fits in some years. Large fluctuations in the most recent estimates of recruitment and biomass (2001) are not entirely unexpected given the high uncertainty in terminal year estimates. This is because the information content regarding the 1999 year class, in particular, was only present as age 2 fish in the 2001 fishery and acoustic survey age compositions, and coupled with the relatively low acoustic survey biomass in 2001 produced lower estimates. The addition of new information regarding fishery and survey age compositions, along with the 2003 survey biomass estimate, decreases the level of uncertainty about this year class.

Uncertainty in the assessment result is characterized in terms of variability in model parameters and in terms of the assumption regarding the acoustic survey catchability coefficient, Q. All past assessment results and recommendations have been based upon fixing the acoustic survey Q=1.0; thus asserting that the acoustic survey estimate of biomass is an absolute measure of biomass and not just a relative measure. The past several assessments have explored relaxation of this assumption, but final results have been based upon the Q=1.0 scenario. The ability to relax the Q=1.0 assumption in this year's assessment is based upon: 1) continued lengthening of the acoustic survey time series, thus allowing the survey to be treated as an index of relative abundance in the model; 2) relatively better model fits to the data when Q is less than 1.0; and 3) high quality of expertise in the STAR Panel to allow critical examination of the Q=1.0 assertion. Uncertainty in the final model result is therefore represented by a range of biomass. The lower biomass end of the range is based upon the conventional assumption that the acoustic survey catchability coefficient, Q=1.0, while the higher end of the range represents the Q=0.6 assumption. Even lower Q values are indicated by some model runs, but these are considered by the STAT team and STAR panel to be implausibly low. Future assessments may be able to explore alternative model configurations that could provide more insight on which aspect of the data lead to the low Q estimates.

The relative probability of the range of plausible Q levels was discussed extensively. The two endpoints are considered as less likely than intermediate points and an equal blending of results from the two endpoints is not unreasonable.

Target Fishing Mortality Rates: Target fishing mortality rates used in projections were based on F40% and F45% the fishing mortality rate corresponding to the corresponding F %B0 of unfished spawning stock biomass-per-recruit, with the 40-10 policy implemented when biomass falls below 40% unfished. Bayesian credibility intervals generated from 1,000,000 Markov Chain Monte Carlo samples were used to evaluate uncertainty in biomass, spawning biomass, depletion rates and coastwide yield. An estimate of stock productivity (e.g. ABC) that equally blends the two model endpoints is reasonable as a risk-neutral best estimate. An OY that is closer to the Q=1.0 result would be risk-averse, would not constrain the expected short-term fishery demands and would reduce the magnitude of the projected short-term stock decline.

Projection table of coastwide yield (thousands of tons), spawning biomass (millions of tons), and depletion rates under different harvest rate policies and model alternatives. Percentiles shown (10%, 50% and 90%) are based on 2,500,000 Markov chain Monte Carlo simulations:

Final Model 1b (Q=1.0)

		3+ Bioimass (million mt)			SpawningBioimass (million mt)			Depletion Rate			Coastwide yield (t)		
Harvest Policy	Year	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
	2004	2.007	2.307	2.673	1.011	1.160	1.337	0.385	0.434	0.495	428372	501073	580313
	2005	1.573	1.839	2.190	0.801	0.927	1.084	0.304	0.346	0.401	288914	355372	438254
F40% (40-10)	2006	1.061	1.251	1.523	0.573	0.675	0.831	0.215	0.253	0.310	181377	241722	331852
Harvest Policy	2007	0.954	1.284	2.395	0.509	0.655	1.052	0.192	0.245	0.396	137269	220477	436093
	2008	0.956	1.494	3.072	0.507	0.737	1.361	0.189	0.276	0.510	137269	220477	436093
	2004	1.999	2.298	2.691	1.011	1.157	1.339	0.381	0.432	0.494	351816	412814	482618
	2005	1.661	1.933	2.288	0.840	0.974	1.138	0.317	0.362	0.421	255813	316302	383068
F45% (40-10)	2006	1.158	1.355	1.655	0.624	0.732	0.894	0.233	0.272	0.331	176448	227319	304560
Harvest Policy	2007	1.042	1.387	2.437	0.559	0.716	1.085	0.209	0.266	0.412	137933	210085	379724
	2008	1.040	1.600	3.178	0.550	0.790	1.425	0.204	0.294	0.530	137933	210085	379724

Final Model 1c (Q=0.6)

		3+ Bioimass			SpawningBioimass			Depletion Rate			Coastwide yield (t)		
Harvest Policy	Year	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
	2004	2.753	3.530	4.513	1.417	1.806	2.302	0.369	0.452	0.549	560224	740368	955991
	2005	2.159	2.727	3.485	1.110	1.398	1.776	0.289	0.350	0.426	363334	503666	682808
F40% (40-10)	2006	1.486	1.832	2.325	0.809	1.011	1.293	0.210	0.250	0.313	225035	325649	482064
Harvest Policy	2007	1.361	1.903	3.534	0.735	0.976	1.561	0.188	0.244	0.391	175928	299935	630135
	2008	1.406	2.190	4.477	0.740	1.089	1.988	0.186	0.271	0.497	175928	299935	630135
	2004	2.773	3.581	4.588	1.431	1.834	2.336	0.373	0.454	0.552	471371	629709	812876
	2005	2.265	2.895	3.719	1.170	1.484	1.889	0.304	0.367	0.448	331550	457371	613371
F45% (40-10)	2006	1.612	2.001	2.582	0.879	1.095	1.418	0.227	0.270	0.335	221059	308924	453286
Harvest Policy	2007	1.482	2.020	3.361	0.800	1.057	1.551	0.205	0.261	0.383	174915	283252	519288
	2008	1.475	2.315	4.629	0.793	1.160	2.095	0.198	0.287	0.520	174915	283252	519288

INTRODUCTION

This assessment has been developed in the spirit of a recent agreement between the U.S. and Canada for the sharing of this trans-boundary resource. Under this agreement, not yet ratified by Congress, the stock assessment is to be reviewed by a Scientific Review Group (SRG), appointed by both parties. Prior to 1997, separate Canadian and U.S. assessments were submitted to each nation's assessment review process. In the past, this has resulted in differing yield options being forwarded to managers. Multiple interpretations of stock status made it difficult to coordinate overall management policy for this trans-boundary stock. To address this problem, the working group agreed in 1997 to present scientific advice in a single assessment, while that agreement was officially formalized in 2003. To further coordinate scientific advice, this report was submitted to a joint Canada-U.S. SRG for technical review in fulfillment of the agreement and to satisfy management responsibilities of both the U.S. Pacific Fisheries Management Council (PFMC) and the Canadian Pacific Stock Assessment Review Committee (PSARC). The Review Group meeting was held in Seattle, WA at the Northwest Fisheries Science Center, during Feb 2-4, 2003. While this report forms the basis for scientific advice to managers, final advice on appropriate yield is deferred to Canadian DFO managers by the PSARC Groundfish Sub-committee and the PSARC Steering Committee, and to the U.S. Pacific Fisheries Management Council by the Groundfish Management Team.

Stock Structure and Life History

Pacific hake (*Merluccius productus*), also called Pacific whiting, is a codlike species distributed off the west coast of North America from 25° N. to 51° N. lat. It is among 11 other species of hakes from the genus, *Merluccidae*, which are distributed in both hemispheres of the Atlantic and Pacific Oceans and constitute nearly two millions t of catches annually (Alheit and Pitcher 1995). The coastal stock of Pacific hake is currently the most abundant groundfish population in the California Current system. Smaller populations of hake occur in the major inlets of the north Pacific Ocean, including the Strait of Georgia, Puget Sound, and the Gulf of California. Electrophoretic studies indicate that Strait of Georgia and the Puget Sound populations are genetically distinct from the coastal population (Utter 1971). Genetic differences have also been found between the coastal population and hake off the west coast of Baja California (Vrooman and Paloma, 1977). The coastal stock is distinguished from the inshore populations by larger body size, seasonal migratory behavior, and a pattern of low median recruitment punctuated by extremely large year classes.

The coastal stock typically ranges from southern California to Queen Charlotte Sound. Spawning occurs off south-central California during January-March. Due to the difficulty of locating major spawning concentrations, spawning behavior of hake remains poorly understood (Saunders and McFarlane, 1997). In spring, adult Pacific hake migrate onshore and to the north to feed along the continental shelf and slope from northern California to Vancouver Island. In summer, hake form extensive midwater aggregations near the continental shelf break, with highest densities located over bottom depths of 200-300 m (Dorn et al. 1994). The prey of hake include euphausiids, pandalid shrimp, and pelagic schooling fish (such as eulachon and herring) (Livingston and Bailey, 1985). Larger hake become increasingly piscivorous, and herring are large component of hake diet off Vancouver Island.

Although hake are cannibalistic, the geographic separation of juveniles and adults usually prevents cannibalism from being an important factor in their population dynamics (Buckley and Livingston, 1997).

Older (age 5+), larger, and predominantly female hake migrate into the Canadian zone. During El Niños, a larger proportion of the stock migrates into Canadian waters, apparently due to intensified northward transport during the period of active migration (Dorn 1995). Range extensions to the north also occur during El Niños, as evidenced by reports of hake from S.E. Alaska during warm water years. During the warm period experienced in 1990s, there have been changes in typical patterns of distribution. Spawning activity has been recorded north of California, and frequent reports of unusual numbers of juveniles from Oregon to British Columbia suggest that juvenile settlement patterns have also shifted northwards in the late 1990s. Because of this, juveniles may be subjected to increased predation from cannibalism and to increased vulnerability to fishing mortality. Subsequently, La Niña conditions apparently caused a southward shift in the center of the stock’s distribution and a smaller portion was found in Canadian water in the 2001 survey.

Fisheries

The fishery for the coastal population of Pacific hake occurs primarily during April-November along the coasts of northern California, Oregon, Washington, and British Columbia. The fishery is conducted almost exclusively with midwater trawls. Most fishing activity occurs over bottom depths of 100-500 m, but offshore extensions of fishing activity have occurred. The history of the coastal hake fishery is characterized by rapid changes brought about by the development of foreign fisheries in 1966, joint-venture fisheries in the early 1980's, and domestic fisheries in 1990's (Fig. 1).

Large-scale harvesting of Pacific hake in the U.S. zone began in 1966 when factory trawlers from the former Soviet Union began targeting on Pacific hake. During the mid 1970's, the factory trawlers from Poland, Federal Republic of Germany, the former German Democratic Republic and Bulgaria also participated in the fishery. During 1966-1979, the catch in U.S. waters averaged 137,000 t per year (Table 1). A joint-venture fishery was initiated in 1978 between two U.S. trawlers and Soviet factory trawlers acting as motherships. By 1982, the joint-venture catch surpassed the foreign catch. In the late 1980's, joint-ventures involved fishing companies from Poland, Japan, former Soviet Union, Republic of Korea and the People’s Republic of China. In 1989, the U.S. fleet capacity had grown to a level sufficient to harvest entire quota, and no foreign fishing was allowed.

Historically, the foreign and joint-venture fisheries produced fillets and headed and gutted products. In 1989, Japanese motherships began producing surimi from Pacific hake, using a newly developed process to inhibit myxozoan-induced proteolysis. In 1990, domestic catcher-processors and motherships entered the Pacific hake fishery in the U.S. zone. Previously, these vessels had engaged primarily in Alaskan pollock fisheries. The development of surimi production techniques made Pacific hake a viable alternative. In 1991, joint-venture fishery for Pacific hake ended because of the high level of participation by domestic catcher-processors and motherships, and the growth of shore-based processing capacity. Shore-based processors of Pacific hake had been constrained historically by a limited domestic market for Pacific hake fillets and headed and gutted products. The construction of surimi plants in Newport and Astoria led to a rapid expansion of shore-based landings in the early 1990's.

The Pacific hake fishery in Canada exhibits a similar pattern, although phasing out of the foreign and joint-venture fisheries has lagged a few years relative to the U.S. experience. Since 1968, more Pacific hake have been landed than any other species in the groundfish fishery on Canada's west coast (Table 1). Prior to 1977, the former Soviet Union caught the majority of hake in the Canadian zone, with Poland and Japan harvesting much smaller amounts. Since declaration of the 200-mile extended fishing zone in 1977, the Canadian fishery has been divided into shore-based, joint-venture, and foreign fisheries. In 1990, the foreign fishery was phased out. Since the demand of Canadian shore-based processors remains below the available yield, the joint-venture fishery will continue through 2002. Poland is the only country that participated in the 1998 joint-venture fishery. The majority of the shore-based landings of the coastal hake stock are processed into surimi, fillets, or mince by processing plants at Ucluelet, Port Alberni, and Delta. Small deliveries were made in 1998 to plants in Washington and Oregon. Although significant aggregations of hake are found as far north as Queen Charlotte Sound, in most years the fishery has been concentrated below 49° N lat. off the south coast of Vancouver Island, where there are sufficient quantities of fish in proximity to processing plants.

Management of Pacific hake

Since implementation of the Fisheries Conservation and Management Act in the U.S. and the declaration of a 200 mile fishery conservation zone in Canada in the late 1970's, annual quotas have been the primary management tool used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. The scientists from both countries have collaborated through the TSC, and there has been informal agreement on the adoption of an annual fishing policy. However, overall management performance has been hampered by a long-standing disagreement between the U.S. and Canada on the division of the acceptable biological catch (ABC) between U.S. and Canadian fisheries. In 1991-1992, U.S. and Canadian managers set quotas that summed to 128% of the ABC, while in 1993-2001, the combined quotas were 107% of the ABC on average. The 2002 and 2003 fishing year were somewhat different from years past in that the ABC of Pacific hake was utilized at an average of 87%. In a recent preliminary agreement between the United States and Canada (2003) 74% and 26%, respectively, of the coastwide allowable biological catch is to be allocated to the two countries. Furthermore, the agreement, yet to be ratified, states that a Joint Technical Committee will exchange data and conduct stock assessments which will be reviewed by a Scientific Review Group.

United States

Prior to 1989, catches in the U.S. zone were substantially below the harvest guideline, but since 1989 the entire harvest guideline has been caught with the exception of 2000, 2001 and 2003 which were 90%, 96% and 96% of the quota, respectively. The total U.S. catch has not significantly exceeded the harvest guideline for the U.S. zone (Table 2), indicating that in-season management procedures have been very effective.

In the U.S. zone, participants in the directed fishery are required to use pelagic trawls with a codend mesh that is at least 7.5 cm (3 inches). Regulations also restrict the area and season of fishing to reduce the bycatch of chinook salmon. At-sea processing and night fishing (midnight to one hour after official sunrise) are prohibited south of 42° N lat. Fishing is prohibited in the Klamath and Columbia River Conservation zones, and a trip limit of 10,000 pounds is established for hake caught inside the 100-fathom contour in the Eureka INPFC area. During 1992-95, the U.S. fishery opened on April 15, however in 1996 the opening date was moved to May 15. Shore-based fishing is allowed after April 1 south of 42° N. lat. But is limited to 5% of the shore-based allocation being taken prior to the opening of the main shore-based fishery. The main shore-based fishery opens on June 15. Prior to 1997, at-sea processing was prohibited by regulation when 60 percent of the harvest guideline was reached. A new allocation agreement, effective in 1997, divided the U.S. non-tribal harvest guideline between factory trawlers (34%) , vessels delivering to at-sea processors (24%), and vessels delivering to shore-based processing plants (42%).

Shortly after this allocation agreement was approved by the PFMC, fishing companies with factory trawler permits established the Pacific Whiting Conservation Cooperative (PWCC). The primary role of the PWCC is to allocate the factor trawler quota between its members. Anticipated benefits of the PWCC include more efficient allocation of resources by fishing companies, improvements in processing efficiency and product quality, and a reduction in waste and bycatch rates relative to the former "derby" fishery in which all vessels competed for a fleet-wide quota. The PWCC also conducts research to support hake stock assessment. As part of this effort, PWCC sponsored a juvenile recruit survey in summer of 1998 and 2001, which continued in 2002 and 2003 in collaboration with NMFS scientists.

Canada

The Canadian Department of Fisheries and Oceans (DFO) is responsible for managing the Canadian hake fishery. Prior to 1987, the quota was not reached due to low demand for hake. In subsequent years the quota has been fully subscribed, and total catch has been successfully restricted to ±5% of the quota (Table 2).

Domestic requirements are given priority in allocating yield between domestic and joint-venture fisheries. During the season, progress towards the domestic allocation is monitored and any anticipated surplus is re-allocated to the joint-venture fishery. The Hake Consortium of British Columbia coordinates the day-to-day fleet operations within the joint-venture fishery. Through 1996, the Consortium split the available yield equally among participants or pools of participants. In 1997, Individual Vessel Quotas (IVQ) were implemented for the British Columbia trawl fleet. IVQs of Pacific hake were allotted to licence holders based on a combination of vessel size and landing history. Vessels are allocated proportions of the domestic or joint-venture hake quota. There is no direct allocation to individual shoreside processors. Licence holders declare the proportion of their hake quota that will be landed in the domestic market, and shoreside processors must secure catch from vessel licence holders.

Overview of Recent Fishery and Management

United States

In 1998, the GMT recommended a status quo ABC of 290,000 mt for 1998 (i.e. the same as 1997). The ABC recommendation was based on a decision table with alternative recruitment scenarios for the 1994 year class, which was again considered a major source of uncertainty in current stock status. Recommendations were based on the moderate risk harvest strategy. The PFMC adopted the recommended ABC and allocated 80 percent of the ABC (232,000 mt) to U.S. fisheries.

The GMT recommended a status quo ABC of 290,000 mt for 1999 and 2000. This coastwide ABC was roughly the average coastwide yield of 301,000 mt and 275,000 mt projected for 1999 and 2000, respectively based on F40% (40-10 option) harvest policy.

In 2000, a Pacific hake assessment update was performed by Helser et al. (2001). While additional catch and age composition data were available at the time of the assessment, the 2001 coastwide acoustic survey which serves as the primary index of hake abundance was not. Using the same configuration with the updated fishery composition data and recruitment indices the assessment model showed consistent projections with the 1998 assessment. Based on this, the GMT recommended that the ABC in 2001 be set to the projected yield of 238,000 mt based on the F40% (40-10 option) harvest policy. Allowable biological catches in 2002 and 2003 were based the 2001 Pacific hake stock assessment (Helser et al. 2001) with updated fishery data and a new acoustic survey biomass estimated for 2001. Due to declining biomass and an estimated depletion level of 20% unfished biomass in the 2001 assessment the ABC in 2002 was 208,000 mt and based the F45% (40-10) harvest policy. However, the ABC in 2003 was adjusted upward to 235,000 mt under the same harvest policy to reflect projected increases in biomass from the relatively strong 1999 year class.

Landings of the at-sea fishery constituted roughly 54% of the total U.S. fishery catches since 1999. Significant distributional shifts in the Pacific hake population, presumably due to oceanographic conditions, has caused major fluctuations in the center of the at-sea harvesting sector. Most notable in recent years was the northward shift in 1999 at-sea fleet activity in which most catches were distributed North of the Columbia River (roughly 91% of the at-sea catches) and coincided with a strong El Nino the preceding year. At sea catches returned to more normal spatial distribution patterns in the 2000 fishing season with roughly 60% occurring north and 40% occurring south of the Columbia River. In 2001, the pattern of the at-sea catches were opposite of those seen in 1999 with only roughly 22% north of the Columbia River (Fig. 2). This coincided with a relatively strong La Nina. The at sea catch distributions for 2002 and 2003 were representative of more normal patterns with roughly 60% and 40% of the catches south and north of Newport, OR., respectively. In 2003, the at-sea catch of hake was 67,473 mt, with Motherships harvesting 39% (26,021m t) while the catcher/processor sector harvesting 61% (55,389 mt) of the hake allocation.

The total shore-based U.S. landings in 2002 and 2003 were 46,000 mt and 45,000 mt, respectively. The primary ports harvesting Pacific hake in 2002 were Newport, Oregon (18,553m t), Astoria, Oregon (12,171 mt), Coos Bay, Oregon (1,580 mt), Washington coastal ports (primarily Westport) (10,610 mt) , and Eureka, California (2,773 mt). In 2003, landings from Eureka were down roughly 50% from 2002, but up by over 2,000 mt in the Washington coastal port of Ilwaco. In aggregate, these ports accounted for more than 99% of all shore-based hake landings. The shore-based fishery began in mid June and ended on July 14 when the harvest guideline was attained.

Since 1996, the Makah Indian Tribe has conducted a separate fishing in its" Usual and Accustomed Fishing Area." The tribal fishery was allocated 15,000 mt of hake in 1996 with an increase to 25,000 mt in 1997- 1999, 32,500 mt in 1999-2000, and 20,000 mt in 2001-2003. The tribal harvest essentially all of its allocated catch between 1996-1999, however, in 2000 and 2001 the Makah Tribe only harvested 6,500 mt and 6,774 mt, respectively. In 2003, the Makah fishery began in June 13 and harvested roughly 90% of its allocated 25,000 mt.

Canada

DFO managers allow a 15% discrepancy between the quota and total catch. The quota may be exceeded by up to 15%, which is then taken off the quota for the subsequent year. If less than the quota is taken, up to 15% can be carried over into the next year. For instance, the overage in 1998 (Table 2) is due to carry-over from 1997 when 9% of the quota was not taken. Between 1999-2001 the PSARC groundfish subcommittee recommended to DFO managers yields based on F40% (40-10) option and Canadian managers adopted allowable catches prescribed at 30% of the coastwide ABC (Table 14; Dorn et al. 1999).

The all-nation catch in the Canadian zone was 53,585 mt in 2001, up from only 22,401 mt in 2000 (Table 1). In 2000, the shore-based landings in the Canadian zone hit a record low since 1990 due to a decrease in availability. Catches in 2001 increased substantially over those of 2000 for both the Joint Venture and shore-based sectors over catches in 2000, but were still below recommended TAC. Total Canadian catches in 2002 and 2003 were 50,769 mt and 62,090 mt, respectively, and constituted nearly 87% of the total allocation of that country.

ASSESSMENT

Modeling Approaches

Age-structured assessment models have been used to assess Pacific hake since the early 1980's. Modeling approaches have evolved as new analytical techniques have been developed. Initially, a cohort analysis tuned to fishery CPUE was used (Francis et al. 1982). Later, the cohort analysis was tuned to NMFS triennial survey estimates of absolute abundance at age (Hollowed et al. 1988a). Since 1989, a stock synthesis model that utilizes fishery catch-at-age data and survey estimates of population biomass and age composition has been the primary assessment method (Dorn and Methot, 1991). Dorn et al. (1999) converted the age-structured stock synthesis Pacific hake model to an age-structured model using AD model builder (Fournier 1996). The conversion from stock synthesis to AD model builder consisted of programming the population dynamics and likelihood equations in the model implementation language (a superset of C++). In that assessment, Dorn et al. (1999) provided model validation using a side-by-side comparison of model results between stock synthesis and ADMB, and then extended the approach to take advantage of AD model builder's post-convergence routines to calculate standard errors (or likelihood profiles) for any quantity of interest, allowing for a unified approach to the treatment of uncertainty in estimation and forward projection. Helser et al. (2001), using the same AD model builder modeling framework, conducted the Pacific hake stock assessment for 2001. That assessment included updated fishery and new survey biomass estimates, with exploration of numerous alternative model structures and assumptions. While the same modeling framework is employed in this assessment, several important modifications have been made, most notable of which are: 1) revision of acoustic survey biomass estimates from 1977-1992 to reflect new deep-water and northern expansion factors; 2) initialization of the population age composition in 1966 (vs. 1972) including estimates of recruitment at age 2 from 1966-2003; and 3) discrete temporal changes in the acoustic survey selectivity.

Data Sources

The data used in the stock assessment model included:

- Total catch from the U.S. and Canadian fisheries (1966-2003).

- Catch at age and average weights at age from the U.S. (1973-2003) and Canadian fisheries (1977-2003).

- Biomass and age composition from the Joint US-Canadian acoustic/midwater trawl surveys (1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, 2001, and 2003).

- Indices of young-of-the-year abundance from the Santa Cruz Laboratory larval rockfish surveys (1986-2003). In this assessment and in the previous assessment (Helser et al. 2001), Santa Cruz Laboratory indices of young -of-the-year were used as an age-2 tuning index for s stock reconstruction and for future projections (two years out from the terminal year in the assessment).

The model also uses biological parameters to characterize the life history of hake. These parameters are used in the model to estimate spawning and population biomass, and obtain predictions of fishery and survey biomass from the parameters estimated by the model:

- Proportion mature at age.

- Weight at age and year by fishery and by survey

- Natural mortality (*M*)

Total catch

Table 1 gives the catch of Pacific hake for 1966-2003 by nation and fishery. Catches in U.S. waters for 1966-1980 are from Bailey et al. (1982). Prior to 1977, the at-sea catch was reported by foreign nationals without independent verification by observers. Bailey et al. (1982) suggest that the catch from 1968 to 1976 may have been under-reported because the apparent catch per vessel-day for the foreign feet increased after observers were placed on foreign vessels in the late 1970's. For 1981-2003, the shore-based landings are from Pacific Fishery Information Network (PacFIN). Foreign and joint-venture catches for 1981-1990, and domestic at-sea catches for 1991-2003 are estimated by the North Pacific Groundfish Observer Program (NPGOP).

At-sea discards are included in the foreign, joint-venture, at-sea domestic catches in the U.S. zone. Discards have not been estimated for the shore-based fishery. The majority of vessels in the U.S. shore-based fishery operate under experimental fishing permits that require them to retain all catch and bycatch for sampling by plant observers. Canadian joint-venture catches are monitored by at-sea observers, which are placed on all processing vessels. Observers use volume/density methods to estimate total catch. Domestic Canadian landings are recorded by dockside monitors using total catch weights provided by processing plants.

Fishery age composition

Catch at age for the foreign fishery in the U.S. zone during 1973-1975 is given in Francis and Hollowed (1985), and was reported by Polish and Soviet scientists at bilateral meetings. Estimates of catch at age for the U.S. zone foreign and joint-venture fisheries in 1976-1990, and the at-sea domestic fishery in 1991-2003, were derived from length-frequency samples and length-stratified otolith samples collected by observers. Sample size information is provided in Table 3. In general, strata were defined by the combination of three seasonal time periods and three geographic areas. Methods and sample sizes by strata are given in Dorn (1991, 1992). During 1992-2003, at-sea catch was generally restricted to between May and August in the early part of the year (April-June) north of 42° N. lat., so only two spatial strata were used (roughly north and south of Cape Falcon, 45° 46′ N. lat.), and no seasonal strata were defined. The Makah fishery (1996-2003) was defined as a separate strata because of its restricted geographic limits and different seasons.

Biological samples from the shore-based fishery were collected by port samplers at Newport, Astoria, Crescent City, and Westport from 1997-2003. A stratified random sampling design is used to estimate the age composition of the landed catch (sample size information provided in Table 3). Shore-based strata are defined on the basis of port of landing. In 1997- 2003, four strata defined 1) northern California (Eureka and Crescent City), 2) southern Oregon (Newport and Coos Bay), and 3) northern Oregon (Astoria and Warrenton), and 4) Washington coastal ports (Illwaco and Westport). No seasonal strata have been used for the shore-based fishery due to the general brevity of the fishery; however, port samplers are instructed to distribute their otolith samples evenly throughout the fishing season.

Biological samples from the Canadian joint-venture fishery were collected by fisheries observers, placed on all foreign processing vessels in 1997-2003. Shore-based Canadian landings are sampled by port samplers. The Canadian catch at age is estimated from random otoliths samples.

Figure 3 shows the estimated age composition for the shore-based fishery by port in the

U.S. zone from 2001-2003. The shore-based age compositions show both temporal and spatial variation. In general, the age compositions are composed of older fish in the more northerly fishing ports, particularly Washington coastal ports. The 1999 year class is prominent in all ports as age 3 fish in 2002 and age 4 fish in 2003.

Figure 4 shows the estimated age composition for the at sea fishery by stratum (including Makah tribal fishing area) in the U.S. zone from 2001-2003. As in the shore-based fishery age compositions comprise older fish in the northern stratum and the Makah area. The 1999 year class is also a dominate age in the at sea fishery catches seen as age 3 fish in 2002 and age 4 fish in 2003.

Table 4 (Figs. 5-6) give the estimated U.S. fishery (1973-2003) and Canadian fishery catch at age (1977-2003). The U.S. fishery catch at age was compiled from the NORPAC database maintained by the North Pacific Groundfish Observer Program, and from an additional database of shore-based biological sampling maintained by the Resource Assessment and Resource Ecology Program at AFSC. The Canadian catch at age for 1997-2003 was compiled from a database at the Pacific Biological Station. The 1980 and 1984 year classes appear as the dominant year classes in both the U.S. fishery and Canadian fishery age compositions (Figs. 5-6). The 1970 and 1977 year classes, and more recently the 1999 year class, are also evident.

Since aging Pacific hake was transferred to the Northwest Fisheries Science Center in 2001 an effort was made to cross-calibrate age reader agreement. Cross-calibration was performed on a total of 197 otoliths from the 2003 acoustic survey between the Northwest Fisheries Science Center (NWFSC) and Department of Fisheries and Oceans (DFO). Overall agreement between NWFSC/DFO was 50%, and for ages assigned that were aged within one and two years, the agreement was 86% and 96%, respectively. As would be expected, agreement between the three labs was better for younger fish than for older fish. These cross-calibration results were somewhat better than 2001 comparisons between NWFSC/DFO, but poorer than 1998 comparisons between AFSC (Alaska Fishery Science Center) and DFO. It should be noted, however, that agreement between two age readers at NWFSC was closer to 87%, with 98% agreement within one year of age. Agreement for ages 3-4 and ages 5-7 was 82% and 40%, respectively, for NWFSC between reader comparisons, with similar results for NWFSC/DFO comparisons. Also, when ages did not agree between the three labs agers at the NWFSC tended to assign older ages than DFO. Additional comparisons are needed to further calibrate ageing criteria between agencies.

Triennial Acoustic Survey (Biomass and Age Composition)

The integrated acoustic and trawl surveys, used to assess the distribution, abundance and biology of coastal Pacific hake, *Merluccius productus*, along the west coasts of the United States and Canada have been historically conducted triennially by Alaska Fisheries Science Center (AFSC) since 1977 and annually along the Canadian west coast since 1990 by Pacific Biological Station (PBS) scientists. The triennial surveys in 1995, 1998, and 2001 were carried out jointly by AFSC and DFO. Following 2001, the responsibility of the US portion of the survey was transferred to Fishery Resource Analysis and Monitoring (FRAM) Division scientists at the Northwest Fisheries Science Center (NWFSC). The joint

2003 survey was conducted by FRAM and PBS scientists, marking not only the change in the US participants but also shortens the frequency between surveys.

The 2003 survey was conducted by joint US and Canadian science teams aboard the vessel CCGS *W.E. Ricker* from 29 June to 1 September 2003, covering the length of the west coast from south of Monterey California (36.1° N) to the Dixon Entrance area (51.4° N). A total of 119 line transects, generally oriented east-west and spaced at 10 nm intervals, were completed (Fig. 7). During the 2003 acoustic survey, aggregations of hake were found along the continental shelf break from just north of San Francisco Bay (38° N) to Queen Charlotte Sound (52° N). Peak concentrations of hake were observed north of Cape Mendocino, California (ca. 43° N), in the area spanning the US-Canadian border off Cape Flattery and La Perouse Bank (ca. 48.5° N), and in Queen Charlotte Sound (ca. 51° N). Along transect 44 (42.9° N), hake were found in a continuous aggregation that extended to over 2500 meters of water and 20 nm further offshore than seen previously in this area. By contrast, no hake were found north of transect 98 in Queen Charlotte Sound (52° N). As revealed by the associated midwater and bottom trawl samples, the majority of the coastal stock is currently dominated by the 1999 year-class (age 4), with most fish at an average size of 43-44 cm in tows south of 48° N, are larger hake found further north.

Hake distribution during the 2003 acoustic survey appeared to be more representative of normal years. Aggregations of Pacific hake showed a marked contrast in 1998 and 2001 relative to the 2003 acoustic survey (Fig. 7 continued). In 1998, major aggregations were observed off Oregon between Cape Blanco and Coos Bay; near the US-Canada border, between northern Vancouver Island and southern Queen Charlotte Sound, and to lesser extent along the west side of the Queen Charlotte Islands, northern Hecate Strait, and Dixon Entrance. Hake were found as far north as 58° N. lat. in the Gulf of Alaska. There was also a large northward shift in the distribution of biomass compared to previous surveys. In contrast, most of the biomass of hake in the 2001 acoustic survey was distributed south of Newport, Oregon (Fig 7). Aggregations of hake in the 2001 acoustic survey were observed off northern California between Cape Mendocino and San Francisco Bay and off southern Oregon near Cape Blanco. The most notable differences between the 1998 and 2001 survey was the presence of hake aggregations south of Cape Blanco and the absence of hake off the Washington coast in the 2001 survey.

The 2001 and 2003 acoustic survey were similar in that 80% and 86%, respectively, of the total hake biomass occurred south of 47°30'N (i.e., Monterey, Eureka, and Columbia INPFC areas). In contrast, only 35% of the total biomass in 1998 was observed south of 47°30'N. The biomass in Canadian waters in 1998 was nearly triple the level reported in 1995. In 2001 and 2003, age 3+ hake biomass was split 80/20 between the U.S. and Canadian zone.

The 1998 survey results indicate a moderate decline of about 15% in hake biomass relative to the previous coastwide survey in 1995, however the 2001 acoustic survey dropped 62% relative to the 1998 survey. In contrast, the 2003 biomass estimate (1843 million mt) increased 120% over the 737,000 mt of the 2001 survey. The strong 1999 year class shown entering the population as age 4 fish in 2003 is principally responsible for the increase.

Revision of the Acoustic Survey Biomass and Age Composition

In 1996, research on hake acoustic target strength (Traynor 1996) resulted in a new target strength model of TS = 20 log L - 68. Target strength (TS) is a measure of the acoustic reflectivity of the fish and is necessary to scale relative acoustic estimates of fish abundance to absolute estimates of abundance. Biomass estimates for the 1977-89 acoustic surveys were re-estimated using the new target strength.

Relative to the more recent surveys (1992-2003) in which hake aggregations were found further offshore and in more northerly latitudes, the 1977-1989 surveys were corrected for the limited geographic coverage by calculating deep water and northern expansion factors used to adjust the total acoustic backscatter (Dorn 1996). Dorn's (1996) revised acoustic time series, which averaged 31% higher than the original time series for 1977-89, had been used in subsequent stock assessments until 2001.

In this assessment, we revisited the deep water and northern expansion factor calculations with additional acoustic survey data, 1992-2001 inclusive. Appendix 1 shows the steps in the calculation of the new biomass estimates for 1977-1989. Tables A-F show the calculations used for deep-water expansion factors while Tables G-H show northern expansions. Table A gives the biomass (at -35dB/kg) by stratum and the offshore and northern limits of each survey from 1977-1989. Deep-water expansion factors were estimated by latitudinal strata (INPFC area) as the total biomass in an area divided by the biomass within the depth limits of the earlier surveys. These expansion factors are shown by stratum in Table B and are based on the 1992-2001 surveys, with 1992-2001 average in Table C. The biomass at -35dB/kg by stratum was converted back into total acoustic backscatter for the stratum based on the equation, $\sigma_{bs} = 4\pi 10^{(TS/10)}$, and the deep-water expansion factors multiplied to each year on a per stratum basis (Appendix A, Table D). The mean acoustic backscattering cross section per fish in a stratum was obtained as a weighted average from the raw length frequency distribution with that stratum and the length-specific acoustic backscattering cross section, σ, for a length-TS relationship of TS=20 log L-68. The mean acoustic backscattering cross section per fish by strata are shown in Table E. Dividing total area acoustic backscatter by the mean acoustic backscatter cross section per fish give an estimate of the total number of fish by stratum based on the new target strength relationship (Table F).

The next step was to adjust the total numbers of fish due to the limited northern latitudinal coverage of the 1977-1992 surveys. We include 1992 in these calculations since that survey ended at 51.7 ^{o} N latitude and subsequent surveys (1998) showed hake aggregations further north. Thus, only the survey years 1995-2001 were used to generate northern expansion factors. Northern expansion factors were estimated on the basis of age since older hake are known to migrate further north (Dorn et al. 1993). Northern expansion factors were estimated as the total biomass divided by the biomass within the northern latitudinal limits of the earlier surveys. Table G shows the northern expansion factors by survey year 1995-2001, along with the average for all three years. Due to the variability in expansion factors from one age to the next we used the predicted value from a smoothing function for application. Before the northern expansions could be applied, the total adjusted numbers (after applying deep-water expansions) by stratum (Table F) had to be converted to biomass at age. To do this, the adjusted numbers at age were partitioned into proportions at age for each stratum, after which the total numbers summed by age across stratum were multiplied by the mean weight at age to derive biomass at age. Table H shows an example of this calculation using the smoothed average northern expansion factors at age are applied to biomass at age generated from adjusted numbers in 1983(based on smoothed average deep-water expansion factors).

Finally, two sets of calculations of the expansions were performed. The first was based on the average deep-water (1992-2001) and average (1995-2001) northern expansion factors. The second set of calculations was based on applying more recent survey years to the earlier survey years which were more representative of the oceanographic conditions observed. For instance, expansion factors calculated from the 1998 survey year with the strong El Nino event was applied to the 1992 and 1983 survey years, while the 2001 survey year during which a La Nina was observed was applied to the 1989 survey year. Calculations based on the 1995 survey years, which are more typical of transition years between El Nino and La Nina, were applied similarly to the 1977, 1980, and 1986 survey years. The revised 1977-1989 acoustic survey biomass estimates based on the new expansion factors are shown in Figure 8. Only nominal differences between Dorn's (1996) and the revised acoustic biomass estimates were observed for all years except 1992 for calculations based on average expansion factors. The 29% increase in revised biomass estimates for 1992 is mostly due to the increase in the age-based northern expansion factor which was applied to substantial biomass of the 1980 and 1984 year class still present as age 8 and age 12 fish in the 1992 age compositions. Revised biomass estimates based on year-specific expansion factor calculations, shown in the bottom panel, also show an increase in 1992 biomass estimates (35%) in addition to increases in biomass for 1977-1986 (16%-20%). Again, these increases are principally due to the application of age-based expansion factors.

In general, we feel the year-specific expansion factor calculations are superior to those based on averages since these take advantage on our knowledge of the migratory response of the hake population to varying oceanographic conditions and the northern distributional extent of the different age classes in the population. In either case, uncertainty regarding the actual acoustic survey biomass between 1977-1989 remains and because of their dependence on the deep water and northern expansion factors, the 1977-89 biomass estimates were assumed to be more uncertain than the 1992-2001 biomass estimates. For this reason, we applied a CV = 0.2 for the 1977-1989 acoustic survey biomass estimates, whereas a CV=0.1 was applied to the 1992-2003 biomass. We feel that a lower CV (0.2) than compared to previous assessments (CV=0.5) for 1997-1989 biomass estimates is warranted because additional survey data (1992-2001) and age-based northern expansion factors were used in the revised calculations. As a measure of consistency, we also revised the numbers at age and therefore the age compositions for 1977-1992 used in the ADMB model based on the new expansion factors. The previous and revised age compositions and biomass for the AFSC acoustic survey are given in Table 5 and Figure 9 shows the acoustic survey age compositions. To reflect this we halved the effected multinomial sample sizes for the 1977-1989 age compositions (N=40) relative to the effective samples sizes from 1992-2003 (N=80). Finally, as a sensitivity analysis model runs were preformed using revised biomass estimates based on both the year-specific and time averaged expansion factors.

Triennial Shelf Trawl Survey (Hake distribution)

The Alaska Fisheries Science Center has conducted a triennial bottom trawl survey along the west coast of North America between 1977-2001 (Wilkins et al. 1998). In 2003, the Northwest Fisheries Science Center took responsibility for the triennial bottom trawl survey. Despite similar seasonal timing of the two surveys, the 2003 survey differed in size/horsepower of the chartered fishing vessels and bottom trawl gear used. For this reason, the continuity of the shelf survey remains to be evaluated. In addition, the presence of significant densities of hake both offshore and to the north of the area covered by the trawl survey limits the usefulness of this survey to assess the hake population. More over, bottom trawl used in the survey is limited in its effectiveness at catching mid-water schooling hake. In the context of this assessment we examine the spatial distribution of hake in this survey relative to that found in the acoustic survey.

The most recent survey conducted by the NWFSC was carried out from June 30 to September, 2003, from south of Point Conception (33° N. lat.) to the U.S./Canadian border (approx. 48°30′ N. lat.) aboard four chartered commercial trawlers (See Turk et al. 2001 for details). The vessels were equipped with the FRAM Division's standardized Aberdeen bottom trawls and net mensuration equipment. Pacific hake were caught at 436 of the 511 successfully sampled stations. Catch rates of age 2+ hake were highest in the Columbia and Vancouver INPFC areas followed by Eureka (Figure 10). Catch rates over the entire survey area increased with depth. By in large, the spatial distribution of hake in the acoustic survey is consistent with the distribution of hake seen in the triennial bottom trawl survey in 2003.

Santa Cruz Laboratory Midwater Trawl Recruit Survey

The Santa Cruz Laboratory of the Southwest Fisheries Science Center has conducted annual surveys since 1983 to estimate the relative abundance of pelagic juvenile rockfish off central California. Although not specifically designed to sample juvenile hake, young-of-the-year juvenile hake occur frequently in the midwater trawl catches. In this assessment as in the previous 2001 assessment the index is used to project the relative strength of recruitment (Table 8, fig 11). This index was obtained using from a generalized linear model (GLM) fit to the log-transformed CPUEs (Ralston et al. 1998; Sakuma and Ralston 1996). Specifically, the year effect from the GLM was back-transformed to obtain an index of abundance. Only the Monterey outside stratum was used because of its higher correlation with hake recruitment. Also, Dorn et al. (1999) showed that the juvenile index was significantly correlated to the predicted recruitment two years later in the stock assessment model. The index in 1999 suggested that recruitment in 2001 may be above average, which has largely been confirmed by other data sources such as numbers at age in the fishery catches and acoustic survey. Except for the 2001 larval index (representing age 2 recruitment in 2003) which appears to be average, the most recent 2002 and 2003 indexes are among the lowest observed since 1986. As will be discussed below, the PWCC recruit survey shows a marked contrast to the 2003 survey index. The series average CV, estimated from the GLM, was calculated to be approximately 0.50 and was therefore used in the assessment model.

PWCC-NMFS midwater trawl survey

The Pacific Whiting Conservation Cooperative (PWCC) and the National Marine Fisheries Service, Northwest Science Center (NWFSC) and Santa Cruz Laboratory (SCL), Southwest Fisheries Science Center has been conducting a cooperative survey of juvenile hake and rockfish relative abundance and distribution off Oregon and California since 1999. This survey is an expansion of the Santa Cruz Laboratory's juvenile survey conducted in between Monterrey Bay and Pt. Reyes, California. Prior to 2001 results between the PWCC survey and the SCL survey were not comparable because of trawl gear differences. Since 2001, the gear has been comparable and side-by-side comparisons were made between the PWCC vessel *Excalibur* and the SCL vessel *David Starr Jordan.*

The PWCC Pacific whiting prerecruit survey is conducted in May at stations across the continental shelf between Newport Oregon (44º30'N) and Point Arguello California (34º 30' N). Several stations were sampled on transects located at 30 nm intervals. Transect stations were located over waters between 50 m. and approximately 1200 m. depth. A total of 113 trawl samples were taken during the survey.

A modified anchovy midwater trawl with an 86' headrope and ½" codend with a 1/4" liner was used to obtain samples of juvenile hake and rockfish. Trawling was done at night with the head rope at 30 m at a speed of 2.7 kt. Some trawls were made prior to dusk to compare day/night differences in catch. Trawls sets of 15 minutes duration at target depth were conducted along transects located at 30 nm intervals along the coast (Figure 1). Stations were located along each transect from 50m bottom depth seaward to 700 m. with hauls taken over bottom depths of 50, 100, 200, 300, and 500 meters at each transect.

The hake YOY were primarily distributed between 40 and 41 N. Lesser amounts of YOY hake were encountered in the Monterey Bay area relative to earlier years, and fewer hake YOY were captured at the southern extreme of the survey area. The total number of YOY hake captured in the 2003 PWCC/NMFS survey was much greater than in prior years. In 2001 5,610 hake YOY were captured, and in 2002 a total of 6,359 were captured, while in 2003 the number increased to 42,541. The absolute variance was higher in 2003 with a high proportion of YOY hake in a few hauls; however the coefficient of variation was nearly similar between years, indicating that 2003 results were not anomalous.

The Santa Cruz survey results indicate that 2001 hake year class is near the long-term mean of the index, but that 2002 is a relatively weak year class, and 2003 estimated abundance is the lowest observed. The PWCC index, on the other hand, indicates that the 2001 and 2002 are both near average year-classes and 2003 a strong year class. The conclusion of two near average year classes is based on a comparison of 2001 and 2002 results. In 2001, the Santa Cruz index was average and the PWCC coast wide distribution of hake YOY showed Monterrey Canyon as the center of abundance. However, in 2002, the center of abundance in the PWCC survey was further north, and proportionally less hake YOY occurred in the Monterrey Bay area.

In 2003 the difference in number of hake YOY between the PWCC and Santa Cruz surveys was more pronounced. The PWCC survey had a nearly seven fold increase in estimated abundance over the previous two years, while the Santa Cruz survey found the lowest number in the time series.
The PWCC hake prerecruit survey results are interesting that they show an entirely different time series than the Santa Cruz survey over the same time period. The PWCC survey indicates 2001 and 2002 abundance to be about the same magnitude and 2003 to be significantly higher. The Santa Cruz Survey, on the other hand indicates a totally opposite trend, with 2003 indicated to be the least abundant year class of the series. However, until a longer time series is established, or a calibration can be achieved with the Santa Cruz juvenile rockfish survey it is difficult to determine what the results mean in terms of future abundance levels of the measured year class. As the year classes in question accrue to the catch the question of relative year class size will be established. The expansion of the hake recruitment index beyond the traditional NMFS Santa Cruz Lab survey area raises questions of consistency in hake larval distribution. The results of the 2002 and 2003 PWCC survey suggest that transport of larval may spatially varying with larvae reaching the outer shelf north of the Monterey index area in some years. However, it is possible that the larvae follow a set transport pattern but varying temporally. If there is a temporal component there may be some evidence in larval daily growth or an environmental signal. With additional data, it may be possible to model and predict the distribution of YOY and better deploy survey effort.

Weight at age

Year-specific weights at age are used in all years for each fishery and survey and for the population because significant variation in Pacific hake weight at age has been observed (Table 9) (Dorn 1995). In particular, weight at age declined substantially during the 1980's, then remained fairly constant to 1998. Interestingly, average weights at age increased substantially in 2000 and 2001 in both the fishery and surveys, suggesting more favorable growth in recent years. Weights at age, however, have declined in both the fishery and survey in 2003. Weight at age is inversely correlated with sea-surface temperature and (to a lesser extent) adult biomass (Dorn 1992). Weight at age estimates for 1977-87 are given in Hollowed et al. (1988b). Weight-at-age vectors since 1987 were derived from the length-weight relationship for that year and unbiased length at age calculated using age length keys (Dorn 1992). In some cases, a linear interpolation of the weight at age of the strong year classes was used for the weaker year classes whose weight at age was poorly estimated or not available due to small sample sizes. This was necessary only for the older or less abundant age groups. Population weight at age, used to calculate spawning biomass, was assumed to be equal to the nearest AFSC acoustic survey weight-at-age.

Age at Maturity

Dorn and Saunders (1997) estimate female maturity at age with a logistic regression using ovary collections and visual maturity determinations by observers as

Age														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.000	0.176	0.661	0.890	0.969	0.986	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Natural mortality

The natural mortality currently used for Pacific hake stock assessment and population modeling is 0.23. This estimate was obtained by tracking the decline in abundance of a year class from one triennial acoustic survey to the next (Dorn et. al 1994). Pacific hake longevity data, natural mortality rates for Merluciids worldwide, and previously published estimates of Pacific hake natural mortality indicate that natural morality rates in the range 0.20-0.30 could be considered plausible for Pacific hake (Dorn 1996).

Model Development

Population dynamics

The age-structured model for hake describes the relationships between population numbers by age and year. The modeled population includes individuals from age 2 to age 15, with age 15 defined as a "plus" group, i.e., all individuals age 15 and older. The model extends from 1966 to 2003. The Baranov (1918) catch equations are assumed, so that

$$c_{ijk} = N_{ij} \frac{F_{ijk}}{Z_{ij}} [1 - \exp(-Z_{ij})]$$

$$N_{i+1\,j+1} = N_{ij} \exp(-Z_{ij})$$

$$Z_{ij} = \sum_k F_{ijk} + M$$

except for the plus group, where

$$N_{i+1,15} = N_{i,14} \exp(-Z_{i,14}) + N_{i,15} \exp(-Z_{i,15})$$

where N_{ij} = population abundance at the start of year *I* for age *j* fish, F_{ijk} = fishing mortality rate in year *I* for age *j* fish in fishery *k*, and c_{ijk} = catch in year *I* for age *j* fish in fishery *k*. A constant natural mortality rate, *M*, irrespective of year and age, is assumed.

The U.S. and Canadian fisheries are modeled as distinct fisheries. Fishing mortality is modeled as a product of year-specific and age-specific factors (Doubleday 1976)

$$F_{ijk} = s_{jk} f_{ik}$$

where s_{jk} = age-specific selectivity in fishery k, and f_{ik} = the annual fishing mortality rate for fishery k. To ensure that the selectivities are well determined, we require that $\max(s_{jk}) = 1$ for each fishery. Following previous assessments, a scaled double-logistic function (Dorn and Methot 1990) was used to model age-specific selectivity

$$s_j' = \left(\frac{1}{1 + \exp[-\beta_1(j - \alpha_1)]} \right) \left(1 - \frac{1}{1 + \exp[-\beta_2(j - \alpha_2)]} \right)$$

$$s_j = s_j' \,/\, \max_j \, (s_j')$$

where α_1 = inflection age, β_1 = slope at the inflection age for the ascending logistic part of the equation, and α_2 , β_2 = the inflection age and slope for the descending logistic part. The subscript k , used to index a fishery or survey, has been suppressed in the above and subsequent equations in the interest of clarity.

Measurement error

Model parameters were estimated by maximum likelihood (Fournier and Archibald 1982, Kimura 1989, 1990, 1991). Fishery observations consist of the total annual catch in tons, C_i, and the proportions at age in the catch, p_{ij}. Predicted values from the model are obtained from

$$\hat{C}_i = \sum_j w_{ij} \, c_{ij}$$

$$\hat{p}_{ij} = c_{ij} \,/\, \sum_j c_{ij}$$

where w_{ij} is the weight at age j in year I . Year- and fishery-specific weights at age are used because of the changes in weight at age during the modeled time period.

Log-normal measurement error in total catch and multinomial sampling error in the proportions at age give a log-likelihood of

$$\log L_k = -\sum_i [\log(C_i) - \log(\hat{C}_i)]^2 / 2\sigma_i^2 + \sum_i m_i \sum_j p_{ij} \log(\hat{p}_{ij} / p_{ij})$$

where σ_i is standard deviation of the logarithm of total catch (~ CV of total catch) and m_i is the size of the age sample. In the multinomial part of the likelihood, the expected proportions at age have been divided by the observed proportion at age, so that a perfect fit to the data for a year gives a log likelihood value of zero (Fournier and Archibald 1982). This formulation of the likelihood allows considerable flexibility to give different weights (i.e. emphasis) to each estimate of annual catch and age composition. Expressing these weights explicitly as CVs (for the total catch estimates), and sample sizes (for the proportions at age) assists in making reasonable assumptions about appropriate weights for estimates whose variances are not routinely calculated.

Survey observations from age-structured survey (acoustic survey) consist of a total biomass estimate, B_i, and survey proportions at age π_{ij}. Predicted values from the model are obtained from

$$\hat{B}_i = q \sum_j w_{ij} \; s_j \; N_{ij} \; \exp[-\phi_i \; Z_{ij}]$$

where q = survey catchability, s_j = selectivity at age for the survey, and ϕ_i = fraction of the year to the mid-point of the survey. Survey selectivity was modeled using a double-logistic function of the same form used for fishery selectivity. The expected proportions at age in the survey in the ith year are given by

$$\hat{\pi}_{ij} = s_j \; N_{ij} \; \exp[-\phi_i \; Z_{ij}] \; / \sum_j s_j \; N_{ij} \; \exp[-\phi_i \; Z_{ij}]$$

Log-normal errors in total biomass and multinomial sampling error in the proportions at age give a log-likelihood for survey k of

$$\log L_k = -\sum_i [\log(B_i) - \log(\hat{B}_i)]^2 / 2\sigma_i^2 + \sum_i m_i \sum_j \pi_{ij} \log(\hat{\pi}_{ij} / \pi_{ij})$$

where σ_i is the standard deviation of the logarithm of total biomass (~ CV of the total biomass) and m_i is the size of the age sample from the survey.

For surveys that produce only an index of recruitment at age 2, R_i , predicted values from the model are

$$\hat{R}_i = q\ N_{i2}$$

Log-normal measurement error in the survey index gives a log-likelihood of

$$\log\ L_k = -\sum_i [\log(R_i) - \log(\hat{R}_i)]^2\ /\ 2\sigma_i^2$$

where σ_i is the standard deviation of the logarithm of recruitment index. Since the recruitment surveys occur several years before recruitment at age 2, the indices need to be shifted forward the appropriate number of years.

Process error and Bayes priors

Process error refers to random changes in parameter values from one year to the next. Annual variation in recruitment and fishing mortality can be considered types of process error (Schnute and Richards 1995). In the hake model, these are estimated as free parameters, with no additional error constraints. We use a process error to describe changes in fisheries selectivity over time using a random walk (Gudmundsson 1996).

To model temporal variation in a parameter γ , the year-specific value of the parameter is given by

$$\gamma_i = \bar{\gamma} + \delta_i$$

where $\bar{\gamma}$ is the mean value (on either a log scale or linear scale), and δ_i is an annual deviation subject to the constraint $\Sigma\ \delta_i = 0$. For a random walk process error where annual *changes* are normally distributed, the log-likelihood becomes

$$\log\ L_{Proc.\ Err.} = -\Sigma \frac{(\delta_i - \delta_{i+1})^2}{2\sigma_i^2}$$

where σ_i is the standard deviation of the annual change in the parameter. We use a process error model for all four parameters of the U.S. fishery double-logistic curve. For the Canadian fishery double-logistic curve, a process error model was used only for the two parameters of the ascending part of the curves. Since the descending portion is almost asymptotic, little improvement in fit can be obtained by including process error for those parameters.

Bayesian methods offer a number of conceptual and methodological advantages in stock assessment (Punt and Hilborn 1997). We adopt an incremental approach of adding Bayes priors to what is essentially a maximum likelihood model. In non-linear optimization, the usual practice is to place upper and lower bounds on estimated parameters (a feature of both stock synthesis and AD model builder). From a Bayesian perspective, placing bounds on the possible values of a parameter corresponds to using a uniform prior for that parameter. Additional constraints are imposed on a parameter γ by adding the log likelihood for a log-normal prior,

$$\log L_{Prior} = \frac{-[\log(\gamma) - \log(\tilde{\gamma})]^2}{2\sigma^2}$$

where $\tilde{\gamma}$ is the prior mean, and σ is the standard deviation of the logarithm of the prior. In this assessment, we continue to use a prior for the slope of the ascending part of the acoustic survey double-logistic function.

The total log likelihood is the sum of the likelihood components for each fishery and survey, plus terms for process error and priors,

$$Log\ L = \sum_k Log\ L_k + \sum_p Log\ L_{Proc.\ Err.} + Log\ L_{Prior}\ .$$

Likelihood components and variance assumptions for the base-run assessment model are given in the following table:

Likelihood component	Error model	Variance assumption
U.S. fishery total catch	Log-normal	CV = 0.05
U.S. age composition	Multinomial	Sample size = 80
Canadian fishery total catch	Log-normal	CV = 0.05
Canadian fishery age composition	Multinomial	Sample size = 80
Acoustic survey biomass	Log-normal	CV = 0.10, CV = 0.50 for 1977-89
Acoustic survey age composition	Multinomial	Sample size = 80 (92-03)
Santa Cruz Laboratory larval rockfish survey	Log-normal	CV = 0.5
Fishery selectivity random walk process error	Slope: Log-normal Inflection age: Normal	CV = 0.25 SE = 1.0
Prior on acoustic survey slope	Log-normal	Prior mean = 0.9, Prior CV = 0.2

Ageing error

The model was configured to accumulate the marginal age groups at different ages to prevent obvious instances of aging error from affecting the model fit. This approach was used most frequently when a portion of an incoming strong year classes was misaged into an adjacent year class. We also used this approach to obtain reliable estimates of initial age composition. Marginal age groups were combined in the following situations:

- Accumulate the older fish at age 13 in 1973 at age 14 in 1974. Rationale: an age 12+ group is estimated for the initial age composition in 1972 (or 1966 with the 2003 basemodel).

- Accumulate the older fish in the fishery and survey data at age 7 in 1978, age 8 in 1979, age 9 in 1980, etc.. The Canadian age data was only accumulated in 1978 and 1979, but not in subsequent years. Rationale: large numbers of the strong 1970 year class were misaged into the 1971 year class starting in 1978.

- Accumulate the younger fish at age-3 fish in 1979. Rationale: The strong 1977 year class appeared as 3-year-old fish in 1979 due to a small sample size in the age-length key for that year.

- Accumulate the younger fish to age 4 in 1984 and age 5 in 1985 in the Canadian fishery age composition. Rationale: The strong 1980 year class was misaged into the 1981 year class.

- Accumulate the younger fish to age 3 in the 1986 U.S. fishery age composition. Rationale: The strong 1984 year class (2-year-old fish) was misaged into the 1983 year class (3-year-old fish).

- Accumulate the younger fish to age 5 in 1995 and age 6 in 1996 in the Canadian fishery age composition. Rationale: In the 1995 Canadian age composition, the number of 4-year-old fish was greater than the number of 5-year-old fish. In 1996, the age 5-fish were 75% as abundant as the age-6 fish in the Canadian fishery age composition, but only 35% as abundant in the U.S. fishery age composition. The 1991 year class (4-year-old fish in 1995) has been much less common in U.S. fishery samples than the 1990 year class (5-year-old fish in 1995) in each year during 1992-95. It is likely that the 4-year-old fish in the Canadian age composition data are misaged fish from the 1990 year class.

Optimization algorithm and convergence criteria

The optimizer in AD model builder is a quasi-Newton routine that uses auto-differentiation to obtain the gradient (Press et al. 1972). The model is determined to have converged when the maximum gradient component is less than a small constant (set to 1 x 10^{-4} for the hake model). Optimization occurs over a number of phases, in which progressively more parameters are estimated. Typically the initial phase consists of a catch curve analysis (Ricker 1973) to obtain rough estimates of mean recruitment and fishing mortality. The intermediary stages correspond to separable age-structured models (Deriso et al 1987), while the final stages also include the parameters for time varying selectivity. Thus the model mimics the entire historical development of quantitative stock assessment during a single estimation run. Identical parameter estimates (to 5 decimal places) were obtained when the initial values for mean recruitment and mean fishing mortality were halved and doubled (R = 0.5, 1.0, 2.0 billion, F = 0.1, 0.2, 0.4), suggesting that final parameter estimates were independent of initial values. After the model converges, the Hessian is estimated using finite differences. Standard errors are obtained using the inverse Hessian method. We also assess uncertainty using AD model builder routines for obtaining likelihood profiles and Markov chain Monte Carlo samples from the likelihood function.

Model parameters as in the previous assessment model as well as the 2003 update, can be classified as follows:

Population process modeled	Number of parameters estimated	Estimation details
Initial age structure	Ages 3-12 (age 12 is the plus group in 1972) = 10	Estimated as log deviances from the log mean
Recruitment	Years 1972-2003 = 32	Estimated as log deviances from the log mean
Average selectivity to fisheries and age-structured surveys	4 * (No. of fisheries + No. of surveys) = 4 * (2 + 3) = 20	Slope parameters estimated on a log scale, a prior is used for the acoustic survey ascending slope parameter.
Annual changes in fishery selectivity	4 * (No. of fisheries) * (No. of yrs -1) = 4 * 1.5 * 32 = 192	Estimated as deviations from mean selectivity and constrained by random walk process error
Year and age-specific selectivity for the 1994 & 1997 year class	U.S fishery: 1996 & 1997 = 2 Canadian fishery: 1999- 2002 = 4	Bounded by (0,1)
Survey catchability	No. of surveys = 1	Acoustic survey catchability not estimated, SWFSC catchabilities estimated on a log scale
Natural mortality	Age- and year-invariant = 1	Not estimated
Fishing mortality	No. of fisheries * (No. of yrs) = 2 * 32 = 64	Estimated as log deviances from the log mean
Total	130 conventional parameters + 192 process error parameters + 4 fixed parameters = 326	

Model selection and evaluation

This assessment used the AD model builder software with initially the same model structure and assumptions as in the 2001 assessment. Since Dorn et al. (1999) confirmed consistency with the previous assessment using the stock synthesis program and confirmed model estimates of recruitment and biomass with simulated data, there was little need for further testing and confirmation. The steps toward model selection and evaluation taken in this assessment were to first compare model results between the 2001 assessment and the present assessment using updated catch at age information and survey biomass data without changes to the model structure or assumptions. This model was hence forth referred to as the 2003 updated model and does not yet include the revised expansion factors. The basic model structure included 1) acoustic survey biomass CVs = 0.1 during 1992-2003 and CVs = 0.5 during 1977-1989 to better reflect uncertainty in the earlier years, 2) an index of recruitment to age 2 based on the SWFSC larval rockfish survey, 1986-2003 with a CV=0.5, 3) use of time varying fishery selectivity functions modeled as a random walk process error, and 4) use of a prior on the ascending limb slope parameter of the acoustic survey selectivity. For the most part, the addition of the random walk process error was to account for changes in fishery selectivity which was strongly influenced by El Niño (1983, 1992, 1997-98) driven distribution changes in the hake population. In addition, it was clear that the 1997 year class was unusually abundant as age-2 and age-3 fish in the 1999 and 2000 Canadian catch at age data, respectively (fig. 6). This pattern in the age composition data was unlike any other year and apparently due to the extreme northward extension of juvenile hake in 1997. Since age-specific selectivity is estimated as smooth functions over time the model was unable to accommodate this rapid shift in catch at age. Thus, we estimated year- and age-specific selectivity patterns for the 1997 year class in the 1999 - 2002 Canadian fishery. Dorn et al. (1999)

provided similar model accommodation by estimating year- and age-specific selectivity parameters for the 1994 year class in the 1996 and 1997 U.S. fishery.

Comparison of preliminary model results of the 2003 updated model with the 2001 assessment using only updated data show similar trends in biomass and recruitment over time. In particular, the increase in biomass during 1980-1987, due to the large 1980 and 1984 year classes, and subsequent decline in biomass between 1987-1995 were nearly identical between the two model runs (Fig. 12). Biomass between 1995 and 2001, however, was higher in the 2003 updated model than previously predicted by the 2001 stock assessment. Recruitment shows a similar pattern between assessments, except that in recent years (1995-2001) recruitment was estimated to be more optimistic than previously estimated in the 2001 assessment. As such, higher recruitment would be expected to generate higher recent biomass. Of particular note is the contrast in the relative strength of the 1999 year class (age 2 fish in 2001), which is estimated to be 64% higher in the present assessment. Large fluctuations in the most recent estimates of recruitment and biomass are not entirely unexpected given the high uncertainty in terminal year estimates. This is because the information content regarding the 1999 year class, in particular, was only present as age 2 fish in the 2001 fishery and acoustic survey age compositions, and coupled with the relatively low acoustic survey biomass in 2001 produced lower estimates. The addition of new information regarding fishery and survey age compositions, along with the 2003 survey biomass estimate, reduces the level of uncertainty about this year class.

Model fits to the observed acoustic and trawl survey biomass estimates also show similar patterns between 2003 updated model and the 2001 assessment (Fig. 13). While both assessment results show relatively poor fits to the acoustic survey (between 1983-1992), the 2003 update predicts slightly less biomass between 1983-1989, and more biomass in 2001. Finally, estimated selectivity, averaged for the most recent three years, were compared between the two assessments (Fig. 14). Both the U.S. and Canadian fishery selectivity showed changes between assessments. U.S. fishery selectivity at age 2 and 3 in 2003 updated model declined relative to the previous assessment, but in both cases fish were fully selected by age 4. Hake of younger ages were slightly less selected in the Canadian fishery than compared to the U.S., and selectivity again declined relative to the previous assessment. Differences in the acoustic survey selectivity were less pronounced between this and the previous assessments, but this assessment did show a slight decline in fish less than five years of age.

The next step was then to examine the 2003 updated model (updated data through 2003 with same model structure as used in the 2001 assessment) results relative to changes in revision of the acoustic survey biomass estimates, initializing the population age structure in 1966 to take advantage of the information content of the age compositions in the early years of the fishery (1973-1979), and explore alternative possible model structures. Specifically our intent was to incorporated the new revised acoustic survey biomass estimates 1977-1992 into the assessment model with updated data through 2003 and then build upon this foundation incrementally by initializing the population age structure back to 1966 (estimating recruitment from 1966-2003) and allowing for a time discrete acoustic survey selectivity. To facilitate results and discussion these model variants are defined as follows:

Option 1: 2003 updated model with an acoustic survey biomass CV of 0.5 in 1977-89 and a CV = 0.1 in 1992-2003. Santa Cruz Laboratory juvenile index survey CV=0.5.

Option 2: 2003 updated model as in Option 1 but incorporate revised acoustic survey biomass based on time averaged deep-water and northern expansion factors. Acoustic survey biomass CV=0.2 in 1977-1989 and CV=0.1 in 1992-2003. Santa Cruz Laboratory juvenile index survey CV=0.5.

Option 3: 2003 updated model as in Option 1 but incorporate revised acoustic survey biomass based on year-specific deep-water and northern expansion factors. Acoustic survey biomass CV=0.2 in 1977-1989 and CV=0.1 in 1992-2003. Santa Cruz Laboratory juvenile index survey CV=0.5.

Option 4: Model as in Option 3 with year-specific expansion factors, but initialize the population age structure back to 1966 and estimate recruitment from 1966-2003.

Option 5: same as Option 4 but allow acoustic survey selectivity to be estimated separately for discrete time periods. Initial examination of time varying acoustic survey selectivity showed a marked shift to older ages in 1983 and again in 1992. Thus, we estimated a separate acoustic survey selectivity for 1983 and 1992 and another for the other years.

Comparison of the model results based on the above revised survey data and model variants are shown in Figs. 15-17 and in the table below. In particular, results of Options 2-3 are compared specifically to Option 1 to systematically track changes based on revised acoustic biomass series. Model results of Options 4-5 and specifically compared to those of Option 3 as alternative model configurations. Only very nominal differences were observed in model output between the 2003 updated model (Option 1) and results based on revised acoustic survey biomass (both Option 2 and Option 3). Acoustic survey selectivity changed slightly for both Options 2 and 3 compared to Option 1; selectivity declined on younger aged fish but increased on older fish. However, there was little if any difference between survey selectivity for Options 2 and 3. The actual fit of the acoustic survey to the revised data series for Options 2 and 3 also appeared to show very nominal differences except that the expected survey biomass was closer to that observed in 1983 and 1992 for Option 3 (year-specific expansion factors) (Fig. 15).

Model configuration	AVE. R	B0	Depletion 2001	Depletion 2002	Depletion 2003
2001 basemodel	1.71	2.10	0.20	-	-
2001 basemodel - data revision	1.72	2.12	0.20		
Option 1	1.73	2.13	0.29	0.44	0.49
Option 2	1.75	2.16	0.31	0.50	0.56
Option 3	1.76	2.17	0.30	0.47	0.52
Option 4	1.75	2.09	0.31	0.46	0.50
Option 5	1.74	2.18	0.28	0.43	0.46

* See text for description of model options.

These results translate into very little differences in the estimated time series of spawning biomass and recruitment to age 2 among Options 1 - 3 (Fig. 16). In fact, the table above which gives the average recruitment, unfished biomass and estimated depletion rates in 2001-2003, illustrates that among Options 1 - 3 the depletion rate in 2001 varied only between 29% and 31%. The difference was slightly greater by 2003 in which the depletion rate varied from a low of 49% for Option 1 vs. 56% for Option 2. Because of these very slight differences and our endorsement of using the new acoustic survey biomass based on year-specific expansion factors (Option 3), we compared subsequent model configurations (Options 4-5) relative to Option 3. For Option 4 there was very little difference in the acoustic survey selectivity or the relative fit of the expected biomass to the revised year-specific biomass time series (Fig. 15). Estimates of spawning biomass were, however, higher prior to1983 from Option 4 vs. Option 3, largely due to higher estimated recruitments (Fig. 17). An intermediate run consisting of the 2003 updated model (Option 1) and initializing the population age composition back in 1966 revealed that re-configuring the model to reach an equilibrium biomass and age composition in 1996 had a greater impact on early biomass estimates than incorporating revised acoustic survey biomass estimates alone (see "initialize 1966" on Fig. 17). This effect, however, had little impact on the declining trend in biomass during 1987-2001 or on the current estimated depletion level (Fig. 17 and table above).

For Option 5, employing a discrete time-varying acoustic survey selectivity appeared to produce better fits between the expected and revised acoustic survey biomass compared to all other options, particularly in the 1983 and 1992 survey year (Fig. 15). Acoustic survey selectivity for Option 5 shows a much lower selectivity at younger ages (2-8) in 1983 and 1992, while for all other years the selectivity pattern remains largely unchanged from the2003 updated model (Option 1). Again these differences translate into relatively high spawning biomass and recruitment prior to the time series peak in 1987 (Fig. 17). Despite the differences in biomass and recruitment during the earlier years among the different options, the decline in spawning biomass during the last decade has been very consistent. Again, the above table shows relatively small differences in the estimated depletion rates in 2001 ranging from 27% to 31%, and ranging from 45% to 50% in 2003.

The STAT team, upon consultation with the STAR convened on February 2-4 in Seattle, WA, examined a wide range of different model configurations and model assumptions, other than the 5 options described above. In general, this evaluation focused on values other than Q=1.0 for the acoustic survey catchability as well as model error structure assumptions. Resultant analyses revealed that the assumed model error structures (i.e. log-normal for survey biomass and multinomial for age compositions) were reasonably supported by examination of Q-Q plots of standardized residuals for each of the data components in the assessment model (Figures 18-20), but that modifications in acoustic and recruitment

Standard deviation of the Pearson residuals for the five data sets used in the hake assessment model by model run designation.

Run	Acoustic Survey Biomass Indices	Tiburon recruitment Indices	US fishery age proportions	Canada fishery age proportions	AFSC acoustic survey age proportions
Option 4	2.46	2.30	0.70	0.81	0.94
1.A	0.98	1.09	1.20	1.02	0.91
1.B	2.42	1.10	1.21	1.04	1.06
1.C	1.04	1.13	1.20	1.01	0.87
2.A	1.11	1.16	1.20	1.00	0.82
2.B	1.07	1.15	1.21	0.99	1.10

survey CVs and age composition effective sample sizes were warranted. The table above illustrates these results showing the standard deviation of the Pearson residuals for the five data sources used by the various assessment model configurations. Values substantially higher and lower than unity indicates that the data are over- or under-dispersed, respectively, relative to the error assumed for the individual data component in the model. In general, the results suggested that the assumed CVs for the acoustic and the Santa Cruz Laboratory (Tiburon) recruitment surveys (based on the original model options as shown in Option 4 above) were too low relative to the actual deviations predicted by the model. Through a process of tuning, the CVs specified for subsequent modeling were increased to CV=0.5 (1977-1989) and CV=0.3 (1992-2003) for the acoustic survey and CV=1.1 for the Santa Cruz Laboratory recruitment survey. Standard deviations of Pearson residuals shown above for model runs 1a, 1c, 2a, and 2b reflect the increased CVs. Model run 1b was specified at original lower CVs as a means for comparison of results. Similarly, the results in the above table show that a decrease in effective samples sizes for acoustic survey age compositions and increases in effective sample sizes for fishery age compositions are warranted as shown by comparison of Option 4 and other model runs (1a, 1c, 2a, and 2b). The above models representing changes in assumed CVs and weights on age compositions produced internally consistent mean squared errors.

In addition, various model configurations that included different data component weights were explored in which acoustic survey Q was freely estimated. In nearly all cases, the models tended to fit the data better when survey Q was less than 1.0; in some case Q was estimated as low as 0.26.

Based on these considerations, and after extensive review of alternative models and discussion, the STAT and STAR settled on two alternative models that encompassed the range in model uncertainty and represented equally plausible alternatives (model 1b and model 1c). The final two models are given below with two others that assisted in an orthogonal evaluation of the chosen alternatives. Each of these are in essence progeny from Option 4 above. These model configuration s were:

Final Model 1a: Model as in Option 4 (above) with year-specific expansion factors; initialization of the population age structure back to 1966 and estimate recruitment from 1966-2003; time invariant acoustic survey selectivity; acoustic survey fixed at Q=1.0; acoustic survey CV=0.5 (1977-1989) and CV=0.3 (1992-2003); Santa Cruz recruitment survey CV=1.1; 1986 acoustic survey biomass and age composition data removed (removed due to transducer calibration issues).

Final Model 2a: Model as in Final Model (1a) above but freely estimate acoustic survey Q.

Final Model 1b: Model as in Final Model (1a) above, but acoustic survey CV=0.2 (1977-1989) and CV=0.1 (1992-2003).

Final Model 1c: Model as in Final Model (1a) above, except acoustic survey fixed at Q=0.6.

Final Model 2b: Model as in Final Model (2a) but acoustic survey age compositions removed. Model results were evaluated at the STAR but not report here.

Results of the above model runs are given in Table 10 and Figures 21-22. Model 1a, 1c, and 2a are directly comparable in terms of the change in likelihoods because each assumes identical data component weights. Based on the relative difference in total negative log likelihoods model 2a (-502.36) fits better than model 1a (-515.82) or model 1c (506.67). Model 2a freely estimates acoustic survey catchability (Q=0.26) compared to model 1a in which it is fixed at Q=1.0, and a decrease in 13 likelihood units for one additional parameter to estimate Q provides some justification of the former model. Model 1a fits better compared to the model 1b (Q=1.0) because it assumes a lower fixed value of Q=0.6. Improvement in model fits appears to occur in the acoustic survey biomass and age composition data with Qs less than one (Table 10). These results are shown graphically in Figure 21 which shows the expected acoustic survey biomass closer to the observed biomass for model 2a. As in previous model runs, the alternative models fit poorly to the early acoustic biomass due to the large CVs on the earlier surveys (1977-1989) and also because the age composition data predict greater biomass during the mid 1980s (due to the strong 1980 and 1984 year class) than would be predicted by the trend in survey biomass. Model 2a attempts to better reconcile the difference in expected biomass between the age composition data and the trend in acoustic biomass better because a Q less than 1.0 would allow for biomass to be scaled higher than the observed trend. Thus, the acoustic survey biomass would be considered a relative index.

Acoustic survey selectivity is highly "domed" as in the early model Options. Each model show roughly the same pattern in acoustic survey selectivity on the descending limb, but models in which either survey Q is freely estimated or less than 1.0 have slighly higher selectivity for the younger ages of fish (Figure 21).

As might be expected, trends in spawning stock biomass are higher for models 2a and 1c in which acoustic survey Q is either estimated or assumed less than 1.0 (Figure 22). Correspondingly, spawning biomass is lowest for models 1b and 1a in which survey Q is assumed to be 1.0. Results among the models are similar in estimates of recruitment to age 2; higher recruitment for model with Q less than 1.0 to essentially account for the higher biomass (Figure 22). These results illustrate the nature of treating the primary abundance index (i.e., the acoustic survey) as an absolute measure compared to a relative measure of biomass by either estimating Q ($<<1.0$ in the present case) or assuming it to be less than 1.0. As such, the implications can be profound in terms of determining the allowable harvest levels based on estimated exploitable biomass and thus determining the most plausible Q is by no means trival.

All past assessment results and recommendations have been based upon fixing the acoustic survey Q=1.0; thus asserting that the acoustic survey estimate of biomass is an absolute measure of biomass and not just a relative measure. This was in large part based upon the best expert opinions and inability to quantitatively estimate it. This assessment, as well as the past several, have explored relaxation of this assumption. The ability to relax the Q=1.0 assumption in this year's assessment is based upon: 1) continued lengthening of the acoustic survey time series, thus allowing the survey to be treated as an index of relative abundance in the model; 2) relatively better model fits to the data when Q is less than 1.0; and 3) high quality of expertise in the STAR Panel to allow critical examination of the Q=1.0 assertion.

Because of the importance of Q in scaling biomass, a Bayesian prior would be the best means to quantitatively blend expert belief and simultaneously allow the model to best fit the data. Presently, the best model fit to the data and expert opinion are incongruous. Accordingly, two models (Q=0.6 and Q=1.0 as specified in Final Models 1c and 1b, respectively) are asserted as representing plausible extremes in the state of nature and therefore uncertainty in the final model result is represented by a range of biomass. The lower biomass end of the range is based upon the conventional assumption that the acoustic survey catchability coefficient, Q=1.0 (Model 1b), while the higher end of the range represents the Q=0.6 assumption (Model 1c). Even lower Q values are indicated by some model runs, but these are considered by the STAT team and STAR panel to be implausibly low (as in Model 2a). Future assessments may be able to explore alternative model configurations that could provide more insight on which aspect of the data lead to the low Q estimates. It was agreed by both the STAT team and STAR panel that model 2a unlikely because a $Q < 0.3$ would be implausible for an acoustic echo integration survey with the level of coverage provided by the joint US-Canadian survey. Model 1b was chosen over Model 1a (intermediate to Model 1b and Model 1c) to represent the lower bound on expected biomass over the assessment time series.

Model Evaluation

Residual plots were prepared to examine the goodness of fit of the base-run model to the age composition data. The Pearson residuals for a multinomial distribution are

$$r_i = \frac{p_i - \hat{p}_i}{\sqrt{(\hat{p}_i(1-\hat{p}_i)/m)}},$$

where p_i is the observed proportion at age, and m is the nominal sample size (McCullagh and Nelder 1983). Figures 23-25 show Pearson residuals of the fit to the U.S. fishery, Canadian fishery, and acoustic survey age compositions. Although there are large residuals for some ages and years, no severe pattern of residuals is evident in the fishery age composition. There is a moderate residual pattern of positive residuals for the strong year classes and negative residuals for the weak year classes, particularly for the older fish. This pattern is strongest in the Canadian fishery age composition, but is also present to some degree in the U.S. fishery age composition. A tendency for age readers to prefer the strong year classes as fish become older and more difficult to age could account for this pattern (Kimura et al. 1992).

In general, the revised acoustic survey biomass based on the new deep-water and northern expansion factors reconciles the model to the data better than previous assessments, except with regard to the 1989 acoustic survey biomass which now lies well below the expected survey biomass (Fig. 26). The model fits the most recent surveys estimates, 1992-2001, reasonably well, but seems to essentially split the difference between the 2001-2003 survey biomass. As in previous assessments, the age composition data favors an increased biomass to 1986 followed by a decline to at least 1995. The acoustic biomass time series is highest in 1986, but otherwise is relatively flat. The 1986 acoustic survey, the second largest disparity between the expected and observed survey biomass, may have underestimated the biomass present in those years. In 1986, there was a 1.7 dB drop in the acoustic source level between pre- and post-survey calibrations. Due to uncertainty in the 1986 acoustic survey calibration the biomass from that year was omitted from the data series as specified in all final models.

Comparison of the expected survey age composition from both final models 1b and 1c to the observed revised acoustic survey age composition also shows reasonable model fits to the data (Fig. 27). Some major differences are represented in the relative strength of year classes predicted between the two alternative models (i.e., the 1980 yearclass).

Final Model Results

Parameter estimates and model output for models 1b and 1c are presented in a series of tables and figures. Results of both models 1b and 1c are presented to bracket the uncertainty in model configurations, specifically related to different assumptions of acoustic survey Q. Estimated selectivity for the U.S. and Canadian fisheries is shown in Figure 27. U.S. fishery selectivity was strongly dome-shaped in the early years (<1980) with ages 6-12 being fully selected by the fishery. Over time the age-specific selectivity in the U.S. fishery increased on both younger and older fish. Average selectivity in recent years (1998-2003) is 20% on age-2, 70% on age-3 and 90% on age-4 fish. Changes in Canadian fishery selectivity is equally pronounced over time and generally shows the same pattern with increasing selectivity toward younger fish. The descending limb of the Canadian fishery selectivity was time-invariant and thus selectivity on the oldest age groups remained constant through time. Both models 1b and 1c show qualitatively the same fishery selectivity and hence only those patterns associated with model 1b are shown.

Selectivity of acoustic survey is given in Table 11 and previously shown in Figure 26. Selectivity in the acoustic survey was high on age-2 through age-4 fish relative to the fishery selectivity, but both reached maximum selectivity on ages 5-9. Acoustic survey selectivity from model 1c was higher on younger ages relative to model 1b and due to the lower value of survey Q assumed for model 1c.

Table 12 provides estimated time series of population biomass, age-2 recruitment, and percent utilization of the total age 3+ biomass by the U.S. and Canadian fisheries for 1966-2003 for models 1b and 1c (see also Fig. 28). Both models show largely the same biomass and recruitment trajectories through time with the exception that model 1c (Q=0.6) has absolute estimates elevated above those of model 1b. In the early 1970s to early 1980s biomass was relatively stable with low levels of recruitment punctuated infrequently by more moderate year classes (Fig. 28) Biomass increased substantially during the middle 1980s as the 1980 (1982 recruitment) and 1984 (1986 recruitment) year classes recruited to the population. The time series peak 1987 biomass ranges between 7 and 11 million mt for model 1b and 1c, respectively. Population biomass then declined after 1987 as the 1980 and 1984 year class were replaced by more moderate year classes and the 1980 and 1984 year classes were exploited. In more recent years (1997 - 2001), biomass declined to its lowest level in the time series of 1.3 and 2.7 million mt in 2001 for models 1b and 1c, respectively. However, as the 1999 year class, estimated to be the fourth largest, recruited into the population biomass increase substantially in 2002 and 2003. As a consequence, spawning biomass in 2003 was estimated to be between 2.7 million mt (Model 1b) and 4.2 million mt (Model 1c), and at roughly 48% of unfished biomass. The harvest rate of age-3+ Pacific hake was generally below 10% during 1972-93, then increased to above 20% in 1999-2001.

Uncertainty and Sensitivity Analyses

Uncertainty in current stock size and other state variables were explored using a Markov Chain Monte Carlo simulation in AD model builder. Although MCMC has been used mostly in Bayesian applications, it can also be used to obtain likelihood-based confidence regions. It has the advantage of producing the true marginal likelihood (ore marginal distributions) of the parameter, rather than the conditional mode, as with the likelihood profile. We ran the MCMC routine in ADMB drawing 2,500,000 samples in which the first 25% of the samples were discarded (as the burn-in) and every 1000th sample saved to reduce autocorrelation in the chain sequence. Initial MCMC runs revealed significant autocorrelation among sequential draws of the chain even after a lag of 100. Results of the MCMC simulation were evaluated for nonconvergence to the target posterior distribution. The final samples from the MCMC were used to develop the probability distributions of the target marginal posterior. MCMC diagnostic results are only shown for model 1b since results were qualitatively similar for both final models 1b and 1c.

Convergence diagnostics of selected parameters from the MCMC simulation suggests that no severe problems of non-convergence is present for the 2003 basemodel (Fig. 29 and 30). Trace plots (panels A) of two selected model state variables, Bzero or unfished biomass and 2003 spawning biomass, illustrate that these variables are quite stable over the thinned chain sequence and that the percentiles (panels C) shown suggest reasonable stationarity. In addition, autocorrelations between 1000th draws of the chain sequence drop below +/- 0.10 after the first lag indicating that thinning the chain at a rate of every 1000th draw should substantially reduce between draw correlation. Kernel density plots for these variables are also shown in Figure 29 (panel D). Figure 30 provides a more thorough summary of 46 parameters (and state variables) from the MCMC simulation. Except for a few parameters with autocorrelation above 0.15, most of the 46 parameters examined achieve autocorrelations of less than 0.10 after chain sequence thinning rate of every 1000th draw. Furthermore, most of the 46 parameters examined have a Geweke statistic of less than +/- 1.96 indicating stationarity of the mean of the parameter. Finally, all 46 parameters passed the Heidelberger-Welch statistic test. If passed the retained sample is deemed to estimate the posterior mean with acceptable precision, while if failed, it implies that a longer MCMC run is needed to increase the accuracy of the posterior estimates for the given variable. Based on the above diagnostic tests the retained MCMC sample appears acceptable for use in characterizing the uncertainty (distribution) of state variables.

Sensitivity to survey catchability assumptions

A decision analysis was conducted to evaluate the consequences of assuming a harvest rate policy associated with lower or higher acoustic survey Q (assumed state on nature) when in fact the converse was true (true state on nature). This analysis defines a 2x2 matrix with two assumed states of nature (Q=1.0 and Q=0.6) and two true states of nature (Q=1.0 and Q=0.6) under both the F40%(40-10) and F45%(40-10) harvest rate policies. It should be noted that Q=1.0 and Q=0.6 correspond to Final Models 1b and 1c, respectively, which have slightly different specifications. Projected spawning biomass, depletion level (% unfished biomass), and exploitation rates in 2004-2005 were examined (Table 13). Results of this analysis suggest that more dire consequences occur when assuming harvest rate policies consistent with the Q=0.6 model assumption when in fact the Q=1.0 model assumption turns out to be the true state of nature (lower left diagonal of Table13), than when the converse is the case. As such, the female spawning biomass drops to 490 million mt in 2006 with a depletion level of only 18% compared to spawning biomass of 655 million mt and a depletion level of 24% when the harvest policy is assume correctly for the Q=1.0 model assumption. Under the more conservative scenario when harvest rates are consistent with the Q=1.0 model assumption and the Q=0.6 model assumption turns out to be the true state of nature (upper right diagonal of Table 15) the depletion level reaches 29% compared to 24% when the harvest policy assumed is consistent with the true state of nature. In general, these results suggest rather significant differences between which model is assumed for setting harvest rates and the resulting risks involved because survey acoustic Q determines directly the assumed absolute level of harvest from the exploitable stock biomass.

To further evaluate uncertainty both final models 1b and 1c were run in which acoustic survey Q was freely estimated. As specified, the final model acoustic survey catchabilities were fixed and Q=1.0 (Final Model 1b) and Q=0.6 (Final Model 1c) in the model runs, which represent fixed point estimates. To explore the uncertainty in these values based upon the model configurations for models 1b and 1c, acoustic survey Q was freely estimated and then uncertainty was characterized using the samples drawn from a Markov Chain Monte Carlo simulation of the posterior distribution. Marginal posteriors of acoustic survey catchability from Final Models 1b and 1c were also compared to acoustic survey Q freely estimated from model option 4. Acoustic survey q was estimated to be approximately 0.58 (posterior model of MCMC sample) with 95% credibility intervals ranging from 0.38 to 0.76 (Fig. 31) for model option 4. Acoustic survey Q was estimated to be much lower for Final Models 1b and 1c; Q=0.38 and Q=0.26, respectively. In the case of Final Model 1c, a lower emphasis on the acoustic survey biomass for all years caused survey Q to be lower in order to scale biomass up to a level of magnitude consistent with that predicted by the age compositions. Correspondingly when higher emphasis was placed on survey biomass (i.e. Final Model 1b) survey Q was estimated to be higher because greater weight was given to the model to fit the survey biomass relative to the age compositions. It should be noted that estimated biomass and recruitment translate into substantially higher biomass for models when q is assumed to be less than 1.0. Both the STAT and STAR conceded that acoustic survey catchability substantially less than 0.6 seems unplausible.

Uncertainty in 2003 stock size and female spawning biomass

The results of the MCMC based on 2,500,000 simulations was then plotted to evaluate the uncertainty of the state variables of interest. Results show that 2003 female spawning biomass was estimated to be 1.25 million mt and 2.0 million mt for final models 1b and 1c, respectively (Fig. 32). Based on the marginal posterior distributions 2003 female spawning biomass has greater than a 70% probability of exceeding the 40% unfished biomass level for both model alternatives (Fig. 32). Uncertainty in the 2003 depletion level was also examined. The posterior mode of the depletion level (B_{2003}/B_{zero}) was estimated to be approximately 48% of unfished biomass for both models 1b and 1c, with less than a 5% chance of being below 40%B0 (Fig. 32).

TARGET FISHING MORTALITY RATES

To evaluate harvesting strategies and target fishing mortality rates for projections, we employed the 40-10 option that provides a more gradual response to declining stock sizes by reducing *catches* linearly, rather than fishing mortality. The 40-10 option can be expressed approximately in fishing mortality as

$$F_{ABC} = F_{40\%} \frac{B_{40\%}}{B} \left[\frac{B - B_{10\%}}{B_{40\%} - B_{10\%}} \right],$$

Dorn et al. (1999) evaluated the 40-10 option relative to the hybrid F strategy (Shuter and Koonce, 1985) that was formerly used to manage the hake stocks and found approximately the same overall reduction in harvest rates. In general, they concluded that as a control law the general form of 40-10 policy was an improvement over the hybrid F strategy. Moreover, using a Bayesian meta-analysis of Merluciid stock recruit relationships, Dorn et al. (1999) showed that F40-F45% may be appropriate proxies for F_{MSY} depending of the level of risk aversion.

The following estimates of F40%, F45%, and F50% under the 40-10 option were obtained using the life history vectors in Table 14. The Canadian F multiplier is used to scale the Canadian fishing mortality so that the mean yield per recruit for the U.S. and Canadian fisheries corresponds to the historical distribution of catches (~25%). Previous work has demonstrated that overall yield per recruit is relatively insensitive to the allocation of yield within the range in dispute. Unfished spawning biomass was based on mean 1966-2003 recruitment (2.1 and 3.1 billion for models 1b and 1c, respectively) and SPR at F=0 (1.233 kg/recruit).

Final Model 1b

SPR rate	U.S. Fishing mortality	Canadian F multiplier	Equilibrium harvest rate
F40%	0.243	0.546	20.1%
F45%	0.187	0.627	16.8%
F50%	0.153	0.659	14.0%
Unfished female spawning biomass	2.73 million t		
B40%	1.092 million t		

Final Model 1c			
SPR rate	U.S. Fishing mortality	Canadian F multiplier	Equilibrium harvest rate
F40%	0.227	0.630	20.2%
F45%	0.168	0.595	16.8%
F50%	0.153	0.568	13.9%
Unfished female spawning biomass	4.10 million t		
B40%	1.64 million t		

HARVEST PROJECTIONS

For harvest projections, model estimates of population numbers at age in 2001 and their variance were projected forward for the years 2004-2008. Estimates of future recruitment, N_{i2}, are also needed for the projections. Survey indices of age-0 abundance in 2002 and 2003 available from the Santa Cruz Laboratory larval rockfish survey are used to represent projected recruitment in 2004 and 2005. Recruitment estimates projected in future years were modeled to account for two sources of variability: random variation in recruitment (process error), and sampling variability of the index (measurement error). For example, if recruitment itself is not highly variable, an index that shows an extremely low or high value should be shrunk towards the mean, particularly if it is known that sampling variability for that index is large. The appropriate tradeoff between these different sources of uncertainty is obtained by adding a log likelihood term for future recruitments in the final estimation phase. Assuming that both recruitment variability and sampling variability are log normal,

$$\log L_{Fut.\ Recr.} = -\frac{1}{2\sigma_r^2}\sum_i[\log(N_{i2}) - \overline{\log(N_2)}\,]^2 - \sum_k \frac{1}{2\sigma_k^2}\sum_i[\log(q_k N_{i2}) - \log(R_i)]^2$$

where $\overline{\log(N_2)}$ is the mean log recruitment as estimated by the base-run model, σ_r is the standard deviation of log recruitment, and σ_k is the standard deviation of the log index from survey k, which can be estimated using the prediction error of the index in the assessment model. These parameters were fixed at the values estimated by the two final model alternatives. The standard deviations for log recruitment ($Model1b{:}\sigma_r = 1.17 Model1c{:}\sigma_r = 1.27$) and the log index ($Model1b{:}\sigma_k = 1.28 Model1c{:}\sigma_k = 1.36$) of the Santa Cruz Laboratory recruitment survey were similar implying that estimates of future recruitment should be roughly an average of the log mean recruitment from the assessment model run and the Santa Cruz Laboratory survey prediction. In years when no indices are available, as in 2006-2008, the estimated log recruitment will be drawn toward the mean log recruitment from the assessment model and thus uncertainty will be equal to the process error in recruitment. As with other state variables, the uncertainty in short-term projections were evaluated using MCMC simulation. Use of MCMC for projections would be particularly appropriate since the MCMC draws from a log-normal distribution and, as such, produces biomass levels more like that generated from the arithmetic mean recruitment.

Results of short-term projections are given in Table 15 and state variables are summarized in terms of 10%, 50% and 90% of 2,500,000 MCMC samples for each of the harvest rates policies (Also see Fig. 33-34). Under both final model alternatives 1b and 1c and under all harvest rates policies, female spawning biomass is projected to decline to near 25% unfished biomass between 2004 and 2006, due to lower than average recruitment expected from the Santa Cruz Laboratory recruit index. Both final model alternatives 1b and 1c show essentially the same levels of projected depletion, although their actual biomass levels differ. However, the decline in spawning biomass is somewhat dependent upon the harvest policy chosen; under the F45% (40-10) option the 2006 depletion rate falls to 27%B0 as compared to 25%B0 under the F40% option (Table 15). Despite the short- term decline, spawning biomass is projected to increase only slightly to between 27% and 30%B0 by 2008 depending upon the model and harvest rate policy, as the assumed low 2002 and 2003 year classes are replaced by long-term average recruitment. Information on recruitment from the NMFS-PWCC survey is not yet of sufficient duration to include in this assessment, but it suggests that the 2003 year class may not be as low as indicated by the Tiburon index.

Projected 2004 Coastwide yield varies substantially between the two final model alternatives 1b and 1c. Under final model 1b with assumed survey Q=1.0, 2004 coastwide yield ranges from a low of 412,800 mt to 501,000 mt under the F45% (40-10) and F40% (40-10) harvest rate policy, respectively (Table 15, Fig. 34). Contrastingly, higher 2004 coastwide yields are estimated from final model 1c ranging from 629,700 mt to 740,400 mt under the F45% (40-10) and F40% (40-10) harvest rate policy, respectively (Table 15, Fig. 34). As with spawning biomass, coastwide yield is projected to decline, but without a subsequent increase after 2006.

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Table 1. Annual catches of Pacific whiting (1,000 t) in U.S. and Canadian management zones by foreign, joint venture (JV), domestic at-sea, domestic shore-based, and tribal fisheries, 1966-2003.

	U.S.						Canada				U.S. and Canada
			Domestic								
Year	Foreign	JV	At-sea	Shore	Tribal	Total	Foreign	JV	Shore	Total [1]	total
1966	137.000	0.000	0.000	0.000	0.000	137.000	0.700	0.000	0.000	0.700	137.700
1967	168.699	0.000	0.000	8.963	0.000	177.662	36.713	0.000	0.000	36.713	214.375
1968	60.660	0.000	0.000	0.159	0.000	60.819	61.361	0.000	0.000	61.361	122.180
1969	86.187	0.000	0.000	0.093	0.000	86.280	93.851	0.000	0.000	93.851	180.131
1970	159.509	0.000	0.000	0.066	0.000	159.575	75.009	0.000	0.000	75.009	234.584
1971	126.485	0.000	0.000	1.428	0.000	127.913	26.699	0.000	0.000	26.699	154.612
1972	74.093	0.000	0.000	0.040	0.000	74.133	43.413	0.000	0.000	43.413	117.546
1973	147.441	0.000	0.000	0.072	0.000	147.513	15.125	0.000	0.001	15.126	162.639
1974	194.108	0.000	0.000	0.001	0.000	194.109	17.146	0.000	0.004	17.150	211.259
1975	205.654	0.000	0.000	0.002	0.000	205.656	15.704	0.000	0.000	15.704	221.360
1976	231.331	0.000	0.000	0.218	0.000	231.549	5.972	0.000	0.000	5.972	237.521
1977	127.013	0.000	0.000	0.489	0.000	127.502	5.191	0.000	0.000	5.191	132.693
1978	96.827	0.856	0.000	0.689	0.000	98.372	3.453	1.814	0.000	5.267	103.639
1979	114.909	8.834	0.000	0.937	0.000	124.680	7.900	4.233	0.302	12.435	137.115
1980	44.023	27.537	0.000	0.792	0.000	72.352	5.273	12.214	0.097	17.584	89.936
1981	70.365	43.556	0.000	0.839	0.000	114.760	3.919	17.159	3.283	24.361	139.121
1982	7.089	67.464	0.000	1.024	0.000	75.577	12.479	19.676	0.002	32.157	107.734
1983	0.000	72.100	0.000	1.050	0.000	73.150	13.117	27.657	0.000	40.774	113.924
1984	14.722	78.889	0.000	2.721	0.000	96.332	13.203	28.906	0.000	42.109	138.441
1985	49.853	31.692	0.000	3.894	0.000	85.439	10.533	13.237	1.192	24.962	110.401
1986	69.861	81.640	0.000	3.463	0.000	154.964	23.743	30.136	1.774	55.653	210.617
1987	49.656	105.997	0.000	4.795	0.000	160.448	21.453	48.076	4.170	73.699	234.147
1988	18.041	135.781	0.000	6.876	0.000	160.698	38.084	49.243	0.830	90.490	251.188
1989	0.000	203.578	0.000	7.418	0.000	210.996	29.753	62.618	2.563	99.532	310.528
1990	0.000	170.972	4.713	8.115	0.000	183.800	3.814	68.313	4.022	76.680	260.480
1991	0.000	0.000	196.905	20.600	0.000	217.505	5.605	68.133	16.178	104.522	322.027
1992	0.000	0.000	152.449	56.127	0.000	208.576	0.000	68.779	20.048	86.370	294.946
1993	0.000	0.000	99.103	42.119	0.000	141.222	0.000	476.422	12.355	58.783	200.005
1994	0.000	0.000	179.073	73.656	0.000	252.729	0.000	85.162	23.782	106.172	358.901
1995	0.000	0.000	102.624	74.965	0.000	177.589	0.000	26.191	46.193	70.418	248.007
1996	0.000	0.000	112.776	85.127	14.999	212.902	0.000	66.779	26.395	93.174	306.076
1997	0.000	0.000	121.173	87.410	24.840	233.423	0.000	42.565	49.227	91.792	325.215
1998	0.000	0.000	120.452	87.856	24.509	232.817	0.000	39.728	48.074	87.802	320.619
1999	0.000	0.000	115.259	83.419	25.844	224.522	0.000	17.201	70.132	87.333	311.855
2000	0.000	0.000	116.090	85.828	6.500	208.418	0.960	15.059	6.382	22.401	230.819
2001	0.000	0.000	102.129	73.474	6.774	182.377	0.000	21.650	31.935	53.585	235.962
2002	0.000	0.000	63.258	45.708	23.148	132.114	0.000	0.000	50.769	50.769	182.883
2003	0.000	0.000	67.473	55.335	20.684	143.492	0.000	0.000	62.090	62.090	205.582
Average 1966-2003						156.482				51.506	207.988

[1] Canadian fishery total catch revised 1996-2001.

Table 2. Harvest strategies, coastwide ABCs, quotas or havest guidelines for U.S. and Canadian zones, and Pacific whiting catches (t) in the U.S. and Canadian zone (1978-98).

Year	Harvest strategy	Acceptable Biological Catch (t) (coastwide)	U.S. harvest guideline or quota (t)	U.S. catch (t)	% of U.S. harvest guideline utilized	Canadian scientific recommendations, low to high risk (t), (CAN) = Canadian zone only	Canadian quota (t)	Canadian catch (t)	% of Canadian quota utilized	Total Catch (t)	% of ABC harvested
1978	N/A	---	130,000	98,372	75.7	NA	NA	5,267	NA	103,639	---
1979	N/A	---	198,900	124,681	62.7	35,000 (CAN)	35,000	12,435	35.5	137,116	---
1980	N/A	---	175,000	72,353	41.3	35,000 (CAN)	35,000	17,584	50.2	89,937	---
1981	N/A	---	175,000	114,762	65.6	35,000 (CAN)	35,000	24,361	69.6	139,123	---
1982	N/A	---	175,500	75,578	43.1	35,000 (CAN)	35,000	32,157	91.9	107,735	---
1983	N/A	---	175,500	73,151	41.7	35-40,000 (CAN)	45,000	40,774	90.6	113,925	---
1984	N/A	270,000	175,500	96,381	54.9	35-40,000 (CAN)	45,000	42,109	93.6	138,490	51.3
1985	N/A	212,000	175,000	85,440	48.8	45-67,000 (CAN)	50,000	24,962	49.9	110,402	52.1
1986	N/A	405,000	295,800	154,963	52.4	75-150,000 (CAN)	75,000	55,653	74.2	210,616	52.0
1987	N/A	264,000	195,000	160,449	82.3	75-150,000 (CAN)	75,000	73,699	98.3	234,148	88.7
1988	Variable effort	327,000	232,000	160,690	69.3	98-176,000 (CAN)	98,000	90,490	92.3	251,180	76.8
1989	Variable effort	323,000	225,000	210,992	93.8	87-98,000 (CAN)	98,000	99,532	101.6	310,524	96.1
1990	Variable effort - high risk	245,000	196,000	183,800	93.8	32-70,000 (CAN)	73,500	76,680	104.3	260,480	106.3
1991	Hybrid -mod. risk	253,000	228,000	217,505	95.4	175-311,000	98,000	104,522	106.7	322,027	127.3
1992	Hybrid -mod. risk	232,000	208,800	208,576	99.9	160-288,000	90,000	86,370	96.0	294,946	127.1
1993	Hybrid -mod. risk	178,000	142,000	141,222	99.5	122-220,000	61,000	58,783	96.4	200,005	112.4
1994	Hybrid-low risk	325,000	260,000	252,729	97.2	325-555,000	110,000	106,172	96.5	358,901	110.4
1995	Hybrid-low risk	223,000	178,400	176,107	98.7	223-382,000	76,500	70,418	92.0	246,525	110.5
1996	Hybrid-low risk	265,000	212,000	212,900	100.4	161-321,000	91,000	88,240	97.0	301,140	113.6
1997	Hybrid-moderate risk	290,000	232,000	233,423	100.6	161-321,000	99,400	90,630	91.2	324,053	111.7
1998	Hybrid-moderate risk	290,000	232,000	232,509	100.2	116-233,000	80,000	86,738	108.4	319,247	110.1
1999	40-10 option-moderate risk	290,000	232,000	242,522	104.5	90,300	90,300	86,637	95.9	329,159	113.5
2000	40-10 option-moderate risk	290,000	232,000	208,418	89.8	90,300	90,300	22,257	24.6	230,675	79.5
2001	40-10 option-moderate risk	238,000	190,400	182,377	95.8	81,600	81,600	53,257	65.3	235,634	99.0
2002		208,000	129,600	129,993	100.3			50,796		180,789	86.9
2003		235,000	148,200	141,506	95.5			62,090		203,596	86.6

Table 3. Length and age sample sizes for estimates of Pacific whiting age composition for U.S. surveys and fisheries. A. AFSC acoustic survey, B. U.S. shore-based fishery, C. U.S. at-sea fishery.

A. AFSC acoustic survey

Year	No. hauls	No. lengths	No. aged
1977	116	11,695	4,262
1980	72	8,296	2,952
1983	38	8,614	1,327
1986	48	12,702	2,074
1989	25	5,606	1,730
1992	62	15,852	2,184
1995	95	22,896	2,118
1998	108	33,347	2,417
2001	90	16,442	2,536
2003	182	3,007	3,007

B. U.S. shore-based fishery

Year	No. samples	No. aged
1990	15	660
1991	26	934
1992	47	1,062
1993	36	845
1994	50	1,457
1995	51	1,441
1996	34	1,123
1997	58	1,759
1998	66	2,021
1999	61	1,452
2000	75	1,314
2001	39	1,983
2002	71	1,582
2003	79	1,561

Estimation methods:
A. Acoustic survey. Age-length keys by geographic strata (Wilson and Guttormsen 1997)
B. U.S. shore-based fishery. Stratified random design with strata based on port groups.
C. U.S. at-sea fishery. Age-length keys by geographic strata (Dorn 1991). Number of hauls are those where length samples were taken.

C. U.S. at-sea fishery

Year	No. hauls	No. lengths	No. aged
1973		NA	
1974		NA	
1975		NA	
1976	279	53,429	4,077
1977	1,103	142,971	7,698
1978	832	124,771	5,839
1979	1,156	173,356	3,124
1980	682	102,248	5,336
1981	905	135,740	4,268
1982	1,145	171,816	4,258
1983	1,112	166,858	3,232
1984	1,625	243,684	3,310
1986	3,161	474,107	3,070
1987	2,876	431,454	3,175
1988	2,801	420,144	3,043
1989	2,666	368,807	3,041
1990	2,101	268,083	3,112
1991	1,022	112,477	1,335
1992	848	78,626	2,175
1993	423	33,100	1,196
1994	645	47,917	1,775
1995	434	30,285	690
1996	530	33,209	1,333
1997	632	49,592	1,147
1998	744	47,789	998
1999	284	49,246	1,047
2000	237	48,143	1,257
2001	287	48,426	1,104
2002	258	23,433	1,970
2003	264	24,420	1,770

Table 4. Catch at age (millions of fish) for the Pacific whiting fisheries, 1973-2003. Separate tables are given for U.S. and Canadian fisheries. The aggregate catch from all foreign, joint venture, domestic fisheries is included in these estimates.

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
U.S. fisheries																
1973	0.00	0.00	55.92	9.67	21.72	40.22	25.16	23.01	21.51	10.33	4.51	1.94	1.08	0.00	0.00	215.07
1974	29.31	1.30	0.98	150.14	20.52	35.50	44.29	25.73	11.40	3.58	1.63	0.98	0.33	0.00	0.00	325.69
1975	0.00	88.43	2.69	3.70	128.11	21.86	23.54	38.00	17.15	7.40	3.70	1.35	0.34	0.00	0.00	336.27
1976	0.00	0.33	36.85	29.29	29.62	185.27	27.65	13.82	4.93	0.99	0.33	0.00	0.00	0.00	0.00	329.09
1977	0.00	1.81	3.80	54.35	11.23	19.93	68.11	11.05	5.80	2.72	1.45	0.73	0.18	0.00	0.00	181.16
1978	0.01	0.02	4.56	8.58	51.87	9.48	20.32	38.57	5.74	2.48	1.28	0.52	0.20	0.05	0.01	143.69
1979	0.00	4.34	8.74	17.41	10.15	48.01	15.47	29.48	20.82	4.25	1.70	0.50	0.22	0.05	0.03	161.17
1980	0.00	0.13	24.67	2.16	6.90	7.16	20.11	9.57	11.99	9.92	1.74	1.35	1.01	0.59	0.14	97.44
1981	13.38	1.25	2.30	97.62	6.89	9.64	6.77	23.33	6.26	7.24	7.05	0.95	0.48	0.12	0.13	183.41
1982	0.00	27.51	1.93	1.57	57.88	5.02	5.78	5.02	11.96	2.43	2.53	4.64	0.34	0.13	0.03	126.77
1983	0.00	0.00	86.60	7.22	3.63	36.79	4.68	3.72	3.32	5.24	1.62	1.00	1.00	0.16	0.14	155.12
1984	0.00	0.00	2.59	164.97	7.18	5.18	17.54	2.17	1.24	0.82	1.34	0.21	0.20	0.31	0.03	203.78
1985	2.27	0.55	1.32	12.36	113.50	9.74	4.30	6.75	0.61	0.34	0.24	0.36	0.00	0.00	0.00	152.34
1986	0.00	62.92	12.88	1.85	9.34	171.79	21.55	10.76	12.45	1.53	1.05	0.38	0.79	0.15	0.05	307.49
1987	0.00	0.00	124.20	6.58	1.68	2.72	151.56	7.89	3.09	14.87	0.57	0.15	0.15	1.25	0.00	314.71
1988	0.00	1.22	1.31	172.76	8.02	1.40	2.60	96.93	5.16	0.72	8.32	0.15	0.24	0.00	0.65	299.48
1989	0.00	8.65	9.57	3.88	257.20	7.80	2.46	2.74	106.63	6.62	0.87	5.37	0.03	0.12	0.57	412.51
1990	0.00	5.69	85.34	10.97	1.92	152.02	2.56	1.14	0.71	95.97	0.47	0.00	6.07	0.00	0.41	363.27
1991	0.00	0.95	43.96	98.32	19.35	6.00	151.49	6.63	1.31	0.93	60.10	2.11	0.00	9.74	0.65	401.54
1992	0.97	18.53	9.94	51.95	109.58	10.27	5.09	131.94	4.84	2.38	0.79	42.06	0.63	0.20	1.88	391.05
1993	0.00	1.90	70.49	9.07	42.90	59.65	3.75	3.06	81.86	1.81	0.43	0.20	20.95	0.12	2.47	298.66
1994	0.00	0.23	16.48	121.89	4.82	76.93	104.64	3.29	2.04	115.38	0.46	2.06	0.22	29.13	3.65	476.31
1995	0.20	1.02	0.41	19.96	114.38	3.32	27.40	66.22	3.09	0.53	58.19	1.09	0.91	0.10	18.55	315.36
1996	0.00	102.26	71.90	6.75	34.60	97.87	1.81	17.17	46.84	0.90	0.17	50.38	0.00	0.49	14.81	445.94
1997	0.00	2.00	173.73	163.98	3.01	27.17	48.41	3.05	10.71	18.59	0.39	0.77	17.33	0.47	8.38	477.97
1998	0.00	26.97	117.63	103.21	133.25	16.56	20.27	41.66	4.83	2.35	17.29	1.52	0.48	11.85	3.32	501.20
1999	0.00	47.58	112.329	100.72	91.74	54.50	16.20	19.69	19.86	3.94	6.16	9.99	1.34	1.68	9.92	495.66
2000	2.13	15.24	34.58	50.95	46.19	62.31	40.85	21.48	13.48	7.83	6.52	6.74	2.83	2.72	7.44	321.30
2001	0.00	52.82	59.10	40.31	59.74	29.69	25.99	15.21	3.99	4.54	3.64	2.31	1.80	1.55	2.86	303.57
2002	0.00	0.00	156.354	36.31	15.63	12.58	8.08	6.75	5.32	1.26	1.16	1.36	0.50	0.32	1.04	246.68
2003	0.03	1.40	9.57	198.18	30.70	6.74	8.30	7.00	4.18	2.86	1.42	0.59	0.88	0.31	0.62	272.78

Table 4. Continued. Canadian catch at age.

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
								Canadian fisheries								
1977	0.00	0.01	0.01	0.25	0.09	0.30	1.83	0.53	0.50	0.42	0.40	0.35	0.16	0.00	0.00	4.85
1978	0.00	0.00	0.00	0.20	0.35	0.28	1.06	1.31	1.12	0.62	0.48	0.21	0.18	0.09	0.00	5.90
1979	0.00	0.00	0.00	0.21	0.62	1.30	1.14	2.10	3.02	1.10	0.79	0.37	0.25	0.17	0.12	11.19
1980	0.00	0.00	0.00	0.00	0.47	0.62	2.46	0.92	1.18	6.74	1.27	0.62	0.62	0.20	0.00	15.10
1981	0.00	0.00	0.00	1.01	0.27	1.41	1.38	4.28	0.85	2.36	6.18	1.49	0.60	0.85	0.00	20.68
1982	0.00	0.00	0.00	0.69	13.35	1.10	1.44	1.41	4.41	1.00	0.78	6.04	0.59	0.47	0.00	31.28
1983	0.00	0.06	14.02	1.03	1.80	32.15	1.29	1.87	1.67	5.59	0.77	0.26	3.41	0.26	0.13	64.31
1984	0.00	0.00	1.11	13.27	1.73	9.26	20.86	2.04	2.35	1.54	4.81	0.93	0.80	2.65	0.37	61.72
1985	0.00	0.06	0.06	2.45	8.03	1.65	3.25	9.62	0.49	0.55	0.55	1.65	0.37	0.00	1.59	30.32
1986	0.00	0.14	0.14	0.28	3.97	38.41	2.41	2.41	11.48	1.28	0.57	0.99	1.42	0.43	1.42	65.35
1987	0.00	0.00	0.90	0.60	0.15	2.56	70.71	2.86	2.86	10.38	0.60	0.45	1.20	0.90	1.20	95.37
1988	0.00	0.00	0.31	15.28	0.62	1.13	2.36	66.66	2.26	1.44	7.90	0.51	0.21	0.21	0.62	99.51
1989	0.00	0.00	0.20	0.59	35.55	0.20	0.39	0.59	69.34	1.76	1.37	8.59	0.39	0.20	1.17	120.34
1990	0.00	0.00	2.80	2.08	0.21	48.67	0.73	0.21	0.00	27.50	0.42	0.00	1.25	1.04	2.08	86.99
1991	0.00	0.00	0.11	6.11	2.46	0.43	70.60	0.54	0.00	0.21	47.47	0.21	0.11	2.25	0.11	130.61
1992	0.00	0.00	0.67	7.63	17.81	3.55	0.40	56.83	0.27	0.00	0.13	30.79	0.07	0.13	1.21	119.49
1993	0.00	0.07	0.77	2.52	12.91	17.54	1.89	0.21	40.62	0.21	0.14	0.14	12.49	0.21	0.21	89.93
1994	0.00	0.00	0.70	2.87	3.07	15.20	26.86	4.20	0.80	67.45	0.87	0.27	0.13	22.73	1.33	146.48
1995	4.88	0.04	0.53	6.31	5.03	3.21	10.72	15.96	3.25	0.67	33.81	0.68	0.04	0.15	9.41	94.70
1996	0.00	12.46	2.89	1.44	12.03	16.06	4.31	14.28	17.05	2.84	1.10	34.27	0.06	0.00	10.01	128.80
1997	0.00	0.81	22.17	19.19	2.52	17.21	16.22	2.25	11.08	14.42	3.24	0.54	18.65	1.35	4.06	133.73
1998	0.14	0.14	9.15	39.39	38.25	3.56	13.74	14.27	1.64	7.74	7.17	0.99	0.67	5.50	1.91	144.26
1999	1.45	26.28	9.65	18.35	40.74	25.71	1.94	8.39	8.47	2.65	3.66	4.26	0.56	0.19	4.05	156.36
2000	0.00	0.11	9.45	1.96	2.38	7.03	4.16	0.53	1.94	1.07	0.34	0.79	0.49	0.25	0.79	31.28
2001	0.00	0.04	0.86	12.32	3.24	5.06	14.31	7.54	1.70	2.37	2.72	0.95	1.69	1.41	1.61	55.81
2002	0.00	0.00	0.55	4.24	14.59	4.85	5.37	10.57	5.81	0.85	1.15	1.53	0.20	0.59	1.68	51.98
2003	0.00	0.00	0.54	28.66	16.21	6.24	10.16	5.88	6.52	4.63	1.60	0.65	0.96	0.24	0.53	82.81

Table 5. AFSC acoustic survey estimates of Pacific whiting biomass and age composition. Surveys in 1995 and 1998 were cooperative surveys between AFSC and DFO. Biomass and age composition for 1977-89 were adjusted as described in Dorn (1996) to account for changes in target strength, depth and geographic coverage. Biomass estimates at 20 log l - 68 in 1992 and 1995 are from Wilson and Guttormson (1997). The biomass in 1995 includes 27,251 t of Pacific whiting found by the DFO survey vessel W.E. Ricker in Queen Charlotte Sound. (This estimate was obtained from 43,200 t, the biomass at -35 dB/kg multiplied by 0.631, a conversion factor from -35 dB/kg to 20 log l - 68 for the U.S. survey north of 50^{o}30' N lat.). In 1992, 1995, and 1998, 20,702 t, 30,032 t, and 8,034 t of age-1 fish respectively is not included in the total survey biomass. In 2001 no age one fish were captured in survey trawls.

	Total biomass at 20 log l - 68 (1,000 t)	Number at age (million)														
Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1977	1596.422	0.22	135.48	121.24	718.01	63.29	87.41	745.78	106.23	78.20	40.90	39.47	21.80	8.49	2.18	2.25
1980	1701.482	0.00	14.45	1641.32	151.15	91.20	70.79	326.83	110.38	248.08	97.65	60.94	9.71	16.66	3.71	2.89
1983	1364.656	0.00	1.23	2918.17	50.86	20.64	304.29	31.84	34.78	26.00	51.01	12.46	13.39	14.84	2.69	0.00
1986	2397.386	0.00	3610.65	91.38	17.56	112.09	1701.85	179.58	131.65	181.21	21.62	21.03	1.47	10.37	2.35	0.00
1989	1805.603	0.00	571.25	200.82	39.29	1864.35	38.91	15.27	24.54	626.89	30.64	2.77	53.71	0.00	0.00	2.00
1992	1417.327	190.54	227.03	45.97	235.77	502.09	57.21	19.85	994.22	28.52	16.85	6.93	323.37	17.19	0.00	14.81
1995	1385.205	316.41	880.52	117.80	32.62	575.90	26.58	88.78	403.38	5.90	0.00	429.34	0.96	17.42	0.00	130.39
1998	1185.932	98.31	414.33	460.41	386.81	481.76	34.52	135.59	215.61	26.41	39.14	120.27	7.68	4.92	104.47	29.19
2001	737.743	0.00	1471.36	185.56	109.35	117.25	54.26	54.03	29.41	17.11	12.03	5.07	4.48	8.73	0.83	3.10
2003	1842.627	5.19	99.78	84.88	2146.50	366.87	92.55	201.22	133.09	73.54	74.67	24.06	14.18	14.63	10.33	14.12

Estimates of numbers at age based on year-specific deep-water and northern expansion factors applied to 1977-1992.

	Total biomass at 20 log l - 68 (1,000 t)	Number at age (million)														
Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1977	1915.01	0.24	151.94	144.57	902.04	82.60	115.79	1001.86	138.13	102.08	58.53	54.82	28.54	10.61	2.79	3.46
1980	2115.09	0.00	16.18	1971.21	190.90	115.65	94.42	417.83	154.83	333.21	133.62	78.76	13.26	22.81	4.75	3.49
1983	1646.68	0.00	1.10	3254.35	107.83	32.62	428.59	68.59	47.27	33.71	92.68	21.86	25.80	26.90	4.32	0.00
1986	2857.06	0.00	4555.66	119.65	21.04	148.80	2004.57	215.71	171.63	225.45	27.33	28.72	2.08	10.85	3.49	0.00
1989	1237.69	0.00	411.82	141.76	31.19	1276.32	28.43	10.08	18.30	435.18	22.95	1.75	43.08	0.00	0.00	1.76
1992	2169.20	230.71	318.37	42.50	246.38	630.74	77.96	31.61	1541.82	46.68	28.08	14.14	533.23	27.13	0.00	28.42
1995	1385.00	316.41	880.52	117.80	32.62	575.90	26.58	88.78	403.38	5.90	0.00	429.34	0.96	17.42	0.00	130.39
1998	1185.00	98.31	414.33	460.41	386.81	481.76	34.52	135.59	215.61	26.41	39.14	120.27	7.68	4.92	104.47	29.19
2001	737.00	0.00	1471.36	185.56	109.35	117.25	54.26	54.03	29.41	17.11	12.03	5.07	4.48	8.73	0.83	3.10
2003	1840.00	5.19	99.78	84.88	2146.50	366.87	92.55	201.22	133.09	73.54	74.67	24.06	14.18	14.63	10.33	14.12

Table 6. AFSC trawl survey estimates of Pacific whiting biomass (1,000 t) and age composition (million). The biomass estimates for 1977 and 1986, when the trawl survey did not extend into the Canadian zone, were adjusted as described in Dorn et al. (1991). In 1995, 53,730 t of age-1 fish is not included in the biomass estimate. In 1998, 20,658 t of age-1 fish is not included in the biomass estimate. Age composition data for 2001 should be considered preliminary. AFSC acoustic survey age-length key was applied to trawl survey length compositions to derive numbers and biomass at age.

Year	Area-swept biomass estimate (1,000 t)	Number at age (million)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1977	76.307	0.57	7.96	4.05	16.87	3.28	7.46	33.45	7.70	6.11	3.96	2.21	1.14	0.41	0.02	0.08
1980	188.299	0.30	1.80	234.42	6.91	12.53	11.37	22.31	14.32	16.93	11.96	4.63	2.28	1.20	0.99	1.43
1983	128.808	0.11	0.27	201.77	7.40	1.43	34.06	8.53	6.63	8.57	10.71	4.36	3.16	2.20	0.24	0.43
1986	254.566	0.00	203.50	8.95	2.81	1.33	202.20	10.37	5.21	59.96	2.23	2.20	0.55	8.88	0.20	0.69
1989	379.810	114.10	44.57	14.09	11.93	172.32	10.24	15.84	4.97	270.64	9.69	1.43	36.48	0.14	0.33	2.65
1992	352.538	56.14	47.95	5.72	28.12	78.63	9.10	3.32	202.78	3.60	3.25	2.61	74.35	3.43	0.00	4.85
1995	529.527	592.70	171.38	22.12	20.88	97.14	6.48	49.25	233.89	0.00	0.00	181.53	0.00	4.61	0.00	142.41
1998	476.459	212.14	442.40	285.14	132.36	151.01	12.48	34.31	72.23	12.36	7.24	46.03	0.68	4.55	33.74	14.03
2001	379.276	36.74	398.62	93.26	50.07	78.97	45.24	55.03	27.47	11.10	12.92	6.52	4.31	4.46	1.30	0.86
2003	Not Available															

Table 7. DFO acoustic survey estimates of Pacific whiting biomass (1,000 t) and age composition (proportion in numbers) in the Canadian zone. The biomass and age composition in 1995 are from the U.S.-Canadian joint survey of the Canadian zone, and is reported in Wilson and Guttormsen (1997).

Year	Total biomass at -35 dB/kg (1,000 t)	Number at age (million)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	317.338	0.00	0.00	37.40	10.33	0.98	287.37	2.95	0.00	0.00	145.16	1.97	0.00	3.94	0.00	0.98
1991	563.308	0.00	0.00	2.96	54.46	10.69	1.48	448.06	1.48	0.00	1.48	346.79	3.49	1.48	23.97	0.00
1992	1101.328	0.00	0.00	8.58	88.95	214.54	54.69	1.04	840.57	3.24	0.00	0.00	351.39	0.52	4.29	7.77
1993	638.906	0.00	0.35	12.34	14.79	97.23	154.49	24.32	9.55	421.22	4.03	1.86	2.49	173.32	1.44	7.66
1994	224.907	0.00	1.44	5.96	7.87	8.34	36.86	53.37	10.35	2.33	138.50	1.08	0.00	0.00	37.16	0.74
1995	374.400	112.05	0.00	0.00	1.49	71.19	7.40	29.33	144.78	2.84	0.00	181.00	0.00	10.15	0.00	38.41
1996	447.410	1.18	77.89	21.83	7.08	79.07	61.96	29.51	57.83	92.06	18.88	8.26	175.26	17.11	3.54	41.31
1997	649.793	0.00	1.30	179.48	143.06	15.61	120.95	115.75	13.01	72.83	94.94	10.40	5.20	146.97	1.30	24.71

Table 8. Tiburon Midwater trawl laval rockfish survey estimates of log whiting abundance (Sakuma and Ralston 1997).

		All Strata		Monterey outside stratum only	
Year class	Year of recruitment	log(numbers)	SE	log(numbers)	SE
1986	1988	1.679	0.192	3.131	0.494
1987	1989	3.129	0.172	6.258	0.475
1988	1990	3.058	0.161	4.921	0.461
1989	1991	0.979	0.170	2.008	0.475
1990	1992	1.323	0.173	3.553	0.475
1991	1993	2.134	0.167	3.769	0.475
1992	1994	0.583	0.166	2.507	0.494
1993	1995	3.095	0.173	7.048	0.475
1994	1996	2.152	0.177	3.470	0.475
1995	1997	0.768	0.173	1.940	0.475
1996	1998	1.968	0.174	4.594	0.494
1997	1999	1.487	0.197	3.034	0.525
1998	2000	0.602	0.177	1.557	0.494
1999	2001	-	-	4.589	0.475
2000	2002	-	-	2.584	0.494
2001	2003	-	-	3.415	0.475
2002	2004	-	-	2.089	0.513
2003	2005	-	-	0.508	0.475

Table 9. Weight at age (kg) used in the stock assessment model.

	U.S. fishery weight at age [1]														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1966-78	0.119	0.264	0.407	0.514	0.610	0.656	0.696	0.743	0.812	0.880	0.956	0.993	1.065	1.093	1.125
1979	0.143	0.264	0.456	0.570	0.667	0.734	0.793	0.831	0.905	0.944	1.016	1.088	1.156	1.071	1.208
1980	0.141	0.298	0.470	0.559	0.646	0.722	0.790	0.825	0.867	0.899	0.995	1.046	1.050	1.040	1.159
1981	0.137	0.286	0.429	0.547	0.632	0.697	0.760	0.809	0.858	0.888	0.934	1.000	1.055	1.075	1.176
1982	0.143	0.253	0.396	0.509	0.605	0.669	0.730	0.788	0.856	0.877	0.901	0.976	1.053	1.061	1.016
1983	0.150	0.253	0.328	0.447	0.525	0.589	0.637	0.680	0.721	0.791	0.806	0.850	0.878	1.005	0.999
1984	0.187	0.293	0.387	0.434	0.550	0.607	0.658	0.712	0.753	0.798	0.863	0.906	0.934	0.952	1.113
1985	0.213	0.321	0.412	0.491	0.545	0.619	0.679	0.796	0.777	0.831	0.920	0.961	1.023	1.004	1.111
1986	0.192	0.294	0.386	0.464	0.518	0.538	0.617	0.663	0.735	0.755	0.816	0.877	0.919	0.928	1.094
1987	0.187	0.297	0.394	0.460	0.517	0.546	0.563	0.627	0.681	0.720	0.748	0.834	0.856	0.893	0.975
1988	0.197	0.303	0.395	0.466	0.520	0.570	0.572	0.596	0.641	0.702	0.733	0.803	0.874	0.886	0.955
1989	0.192	0.232	0.320	0.402	0.454	0.502	0.538	0.565	0.577	0.584	0.668	0.752	0.826	0.900	0.854
1990	0.195	0.248	0.364	0.418	0.515	0.522	0.553	0.559	0.542	0.589	0.616	0.759	0.707	0.779	0.851
1991	0.195	0.291	0.374	0.461	0.505	0.527	0.576	0.629	0.604	0.566	0.641	0.601	0.802	0.866	0.887
1992	0.216	0.275	0.367	0.472	0.513	0.554	0.579	0.581	0.600	0.581	0.600	0.617	0.763	0.521	0.797
1993	0.196	0.283	0.348	0.402	0.468	0.511	0.509	0.524	0.557	0.556	0.569	0.603	0.587	0.636	0.615
1994	0.196	0.236	0.357	0.428	0.458	0.518	0.562	0.613	0.563	0.612	0.566	0.638	0.765	0.656	0.645
1995	0.120	0.277	0.468	0.488	0.493	0.514	0.591	0.590	0.601	0.619	0.636	0.617	0.651	0.655	0.669
1996	0.120	0.278	0.378	0.451	0.519	0.547	0.568	0.574	0.599	0.583	0.760	0.629	0.625	0.647	0.630
1997	0.097	0.340	0.421	0.471	0.536	0.532	0.572	0.584	0.603	0.625	0.746	0.657	0.684	0.623	0.716
1998	0.204	0.238	0.364	0.452	0.490	0.506	0.535	0.549	0.560	0.780	0.620	0.719	0.630	0.689	0.687
1999	-	0.244	0.338	0.414	0.505	0.527	0.548	0.572	0.638	0.582	0.722	0.698	0.846	0.750	0.780
2000	0.184	0.401	0.478	0.556	0.630	0.687	0.707	0.730	0.810	0.782	0.825	0.770	0.883	0.818	0.906
2001	-	0.319	0.485	0.591	0.632	0.681	0.740	0.749	0.767	0.826	0.780	0.823	0.838	0.801	0.825
2002	-	0.435	0.443	0.547	0.679	0.684	0.743	0.847	0.810	0.756	0.876	0.813	0.821	0.929	0.925
2003	0.429	0.420	0.472	0.500	0.539	0.585	0.609	0.620	0.641	0.664	0.669	0.697	0.674	0.685	0.760

[1] U.S. Fishery mean weights age age revised 1998-2001.

	Canadian fishery weight at age [2]														
1972-76	0.135	0.370	0.606	0.742	0.827	0.861	0.905	0.987	1.221	1.111	1.163	1.206	1.222	1.213	1.247
1977	0.143	0.355	0.570	0.744	0.824	0.871	0.875	0.957	1.020	1.104	1.164	1.222	1.240	1.207	1.273
1978	0.133	0.313	0.502	0.658	0.783	0.818	0.825	0.858	0.922	0.992	1.072	1.153	1.171	1.132	1.205
1979	0.141	0.332	0.532	0.701	0.830	0.916	0.935	0.969	0.989	1.046	1.137	1.175	1.266	1.237	1.299
1980	0.140	0.319	0.496	0.655	0.780	0.869	0.979	0.955	0.970	1.037	1.073	1.180	1.229	1.225	1.301
1981	0.136	0.309	0.479	0.660	0.741	0.829	0.891	0.985	0.961	0.977	1.137	1.096	1.172	1.204	1.272
1982	0.126	0.288	0.449	0.584	0.674	0.779	0.842	0.902	0.904	0.959	0.987	1.028	1.097	1.127	1.269
1983	0.120	0.264	0.399	0.515	0.607	0.630	0.730	0.785	0.824	0.789	0.890	0.926	0.883	0.960	1.091
1984	0.137	0.296	0.439	0.557	0.643	0.710	0.723	0.816	0.856	0.896	0.911	0.975	0.987	0.957	1.076
1985	0.142	0.311	0.465	0.584	0.712	0.740	0.792	0.871	0.889	0.931	0.978	1.048	1.037	1.012	1.067
1986	0.125	0.281	0.431	0.548	0.633	0.659	0.742	0.795	0.888	0.880	0.932	0.986	1.143	0.988	1.048
1987	0.149	0.314	0.457	0.566	0.643	0.692	0.706	0.768	0.801	0.827	0.877	0.919	0.943	0.940	0.978
1988	0.120	0.315	0.655	0.608	0.754	0.652	0.767	0.801	0.909	1.066	1.054	0.766	1.159	1.111	1.305
1989	0.192	0.315	0.521	0.666	0.657	0.690	0.924	0.807	0.806	1.071	0.950	1.049	0.779	0.852	1.515
1990	0.195	0.315	0.567	0.603	0.598	0.659	0.709	0.660	0.753	0.745	0.738	0.805	0.938	0.852	1.225
1991	0.195	0.315	0.521	0.629	0.751	0.777	0.712	0.891	0.753	0.782	0.758	0.794	0.779	0.957	0.923
1992	0.216	0.315	0.550	0.561	0.633	0.684	0.689	0.713	0.710	0.782	0.722	0.754	0.779	0.890	0.958
1993	0.196	0.315	0.440	0.515	0.530	0.558	0.588	0.567	0.600	0.589	0.834	0.805	0.619	0.852	0.923
1994	0.196	0.315	0.557	0.594	0.648	0.692	0.714	0.745	0.719	0.772	0.720	0.788	0.779	0.792	0.921
1995	0.120	0.315	0.668	0.652	0.663	0.728	0.741	0.766	0.800	0.909	0.805	0.757	0.779	0.852	0.847
1996	0.120	0.329	0.481	0.568	0.628	0.632	0.671	0.676	0.693	0.762	0.676	0.739	0.779	0.852	0.786
1997	0.120	0.496	0.536	0.574	0.658	0.700	0.687	0.717	0.739	0.746	0.754	0.811	0.782	0.836	0.819
1998	-	0.351	0.448	0.570	0.580	0.607	0.676	0.667	0.669	0.699	0.717	0.756	0.809	0.794	0.775
1999	-	0.284	0.413	0.494	0.620	0.616	0.645	0.715	0.713	0.729	0.778	0.810	0.779	0.850	0.802
2000	-	0.528	0.524	0.604	0.695	0.782	0.764	0.831	0.851	0.837	0.811	0.931	0.882	0.892	0.951
2001	-	0.315	0.766	0.812	0.842	0.909	1.020	1.016	1.047	1.099	1.102	1.120	1.053	1.045	1.150
2002	-	0.315	0.697	0.897	0.980	0.953	1.058	1.113	1.091	1.119	1.124	1.104	1.367	1.149	1.192
2003	-	0.400	0.606	0.656	0.709	0.848	0.785	0.813	0.898	0.84	0.9	0.982	0.845	0.899	1.134

[2] Canadian fishery mean weights at age (1988-2002) revised. See Appendix 1.

Table 9. Weight at age (kg) used in the stock assessment model (cont).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AFSC acoustic survey weight at age [1]															
1977	0.123	0.256	0.388	0.492	0.589	0.662	0.724	0.796	0.860	0.892	0.949	1.008	1.057	1.093	1.119
1980	0.107	0.261	0.455	0.561	0.672	0.759	0.861	0.894	0.948	1.003	1.081	1.122	1.170	1.176	1.205
1983	0.122	0.228	0.308	0.457	0.570	0.667	0.723	0.776	0.826	0.891	0.917	0.935	0.985	1.034	1.032
1986	0.165	0.262	0.367	0.465	0.532	0.558	0.658	0.715	0.815	0.823	0.865	0.908	1.006	0.995	1.069
1989	0.143	0.321	0.387	0.461	0.521	0.561	0.599	0.621	0.634	0.638	0.682	0.729	0.870	0.984	1.069
1992	0.119	0.205	0.357	0.508	0.554	0.578	0.654	0.642	0.688	0.655	0.758	0.705	0.697	0.734	0.800
1995	0.097	0.220	0.344	0.438	0.548	0.605	0.639	0.624	0.630	0.682	0.717	0.701	0.727	0.752	0.728
1998	0.081	0.189	0.343	0.527	0.534	0.587	0.658	0.631	0.645	0.766	0.709	0.830	0.735	0.744	0.790
2001	-	0.250	0.419	0.505	0.617	0.708	0.795	0.845	0.894	1.211	1.038	1.101	0.941	0.875	1.056
2003	0.139	0.264	0.411	0.515	0.544	0.716	0.687	0.728	0.788	0.754	0.769	0.820	0.780	0.815	0.841
[1] Mean weights at age from 2001 acoustic survey revised.															
AFSC bottom trawl survey weight at age															
1977	0.123	0.256	0.388	0.492	0.589	0.662	0.724	0.796	0.860	0.892	0.949	1.008	1.057	1.093	1.119
1980	0.107	0.261	0.455	0.561	0.672	0.759	0.861	0.894	0.948	1.003	1.081	1.122	1.170	1.176	1.205
1983	0.122	0.228	0.308	0.457	0.570	0.667	0.723	0.776	0.826	0.891	0.917	0.935	0.985	1.034	1.032
1986	0.165	0.262	0.367	0.465	0.532	0.558	0.658	0.715	0.815	0.823	0.865	0.908	1.006	0.995	1.069
1989	0.143	0.321	0.387	0.461	0.521	0.561	0.599	0.621	0.634	0.638	0.682	0.729	0.870	0.984	1.069
1992	0.119	0.205	0.357	0.508	0.554	0.578	0.654	0.642	0.688	0.655	0.758	0.705	0.697	0.734	0.800
1995	0.091	0.204	0.279	0.408	0.476	0.530	0.609	0.659	0.682	0.704	0.727	0.730	0.733	0.706	0.679
1998	0.097	0.189	0.339	0.480	0.502	0.532	0.534	0.575	0.583	0.655	0.669	0.639	0.762	0.670	0.710
2001	-	0.189	0.339	0.480	0.502	0.532	0.534	0.575	0.583	0.655	0.669	0.639	0.762	0.670	0.710
DFO acoustic survey weight at age															
1990	0.119	0.205	0.533	0.575	0.592	0.647	0.623	0.646	0.646	0.669	0.656	0.957	0.957	0.957	0.957
1991	0.119	0.205	0.533	0.560	0.592	0.641	0.615	0.633	0.633	0.650	0.656	0.657	0.657	0.657	0.657
1992	0.119	0.205	0.629	0.600	0.653	0.685	0.686	0.705	0.657	0.698	0.698	0.739	0.744	0.744	0.810
1993	0.196	0.283	0.541	0.595	0.624	0.641	0.688	0.718	0.704	0.827	0.847	0.624	0.741	0.685	0.995
1994	0.196	0.567	0.585	0.614	0.654	0.694	0.720	0.782	0.775	0.761	1.083	0.935	0.935	0.787	0.810
1995	0.098	0.235	0.371	0.508	0.642	0.778	0.739	0.740	0.691	0.739	0.787	0.769	0.752	0.771	0.790
1996	0.330	0.403	0.482	0.582	0.655	0.650	0.665	0.693	0.686	0.688	0.684	0.705	0.779	0.798	0.671
1997	0.330	0.488	0.572	0.598	0.673	0.710	0.722	0.731	0.746	0.785	0.749	0.713	0.761	0.689	0.742
Population weight at age															
1972-78	0.123	0.256	0.388	0.492	0.589	0.662	0.724	0.796	0.860	0.892	0.949	1.008	1.057	1.093	1.119
1979-81	0.107	0.261	0.455	0.561	0.672	0.759	0.861	0.894	0.948	1.003	1.081	1.122	1.170	1.176	1.205
1982-84	0.122	0.228	0.308	0.457	0.570	0.667	0.723	0.776	0.826	0.891	0.917	0.935	0.985	1.034	1.032
1985-87	0.165	0.262	0.367	0.465	0.532	0.558	0.658	0.715	0.815	0.823	0.865	0.908	1.006	0.995	1.069
1988-90	0.143	0.321	0.387	0.461	0.521	0.561	0.599	0.621	0.634	0.638	0.682	0.729	0.870	0.984	1.069
1991-93	0.119	0.205	0.357	0.508	0.554	0.578	0.654	0.642	0.688	0.655	0.758	0.705	0.697	0.734	0.800
1994-96	0.097	0.220	0.344	0.438	0.548	0.605	0.639	0.624	0.630	0.682	0.717	0.701	0.727	0.752	0.728
1997-99	0.081	0.189	0.343	0.527	0.534	0.587	0.658	0.631	0.645	0.766	0.709	0.830	0.735	0.744	0.790
1999-01	-	0.250	0.419	0.505	0.617	0.708	0.795	0.845	0.894	1.211	1.038	1.101	0.941	0.875	1.056
2002-03	0.139	0.264	0.411	0.515	0.544	0.716	0.687	0.728	0.788	0.754	0.769	0.820	0.780	0.815	0.841
Female multiplier for spawning biomass															
All yrs.	0.511	0.510	0.511	0.510	0.512	0.522	0.525	0.535	0.543	0.547	0.569	0.568	0.572	0.581	0.589

Table 10. Configuration, error assumptions and output (likelihoods and derived parameters) from various final model alternatives explored in the 2004 Pacific hake assessment. See text for description of model configurations.

	Model Configuration					
Parameters	4.0	1.A	1.B	1.C	2.A	2.B
q	0.563	1.000	1.000	0.600	0.276	0.208
Sigmas						
Acoustic: 77-89	0.50	0.50	0.20	0.50	0.50	0.50
Acoustic: 92-03	0.10	0.30	0.10	0.30	0.30	0.30
Tiburon	0.50	1.10	1.10	1.10	1.10	1.10
US Fishery effective sample	80	300	300	300	300	300
Canada Fishery effective sample	80	130	130	130	130	130
Acoustic survey effective sample	80	60	60	60	60	60
Rdevs	1.15	1.26	1.17	1.27	1.26	1.25
Likelihoods						
US Fishery: catch	-0.03	-0.02	-0.10	-0.01	0.00	0.00
US Fishery:age	-79.19	-245.40	-248.67	-244.39	-243.53	-244.54
Canadian Fishery: catch	0.00	-0.01	-0.02	0.00	0.00	0.00
Canadian Fishery: age	-96.20	-160.26	-167.85	-157.98	-157.00	-155.04
Acoustic survey biomass	-21.32	-10.84	-33.52	-6.68	-5.86	-5.42
Acoustic survey age	-43.90	-31.57	-37.97	-29.59	-28.08	0.00
Tiburon survey index	-40.17	-8.98	-9.01	-9.56	-10.08	-9.84
Acoustic survey slope	-0.12	-0.12	-0.48	-0.02	0.00	0.00
Recruits	-19.85	-21.83	-20.20	-21.93	-21.80	-21.51
Random walk	-16.61	-32.65	-32.00	-32.38	-31.88	-31.93
Forecast	-4.13	-4.13	-4.13	-4.13	-4.13	-4.13
Total likelihood	-321.53	-515.82	-553.96	-506.67	-502.36	-472.41
Derived Parameters						
B0	3.64	3.33	2.72	4.03	6.34	6.24
B2003	1.80	1.31	1.28	2.03	4.28	3.87
Ratio	49.6%	39.4%	47.1%	50.5%	67.5%	62.0%
US Fishery 2004 catch (X1000 t)	510.7	350.1	381.9	585.8	1238.2	1143.1
US Fishery 2004 F	0.25	0.23	0.24	0.25	0.26	0.26
Canada Fishery 2004 catch (X 1000 t)	180.6	123.8	135.0	207.1	437.8	404.1
Canada Fishery 2004 F	0.08	0.10	0.11	0.09	0.08	0.08
Total Catch (X 1000 t)	691.2	473.9	517.0	792.9	1675.9	1547.2

Table 11. Selectivity at age for Pacific whiting fisheries and surveys for final models 1b and 1c (See text for description). The fisheries and surveys were modeled using double logistic selectivity functions, with random walk process error for the U.S. and Canadian fisheries. The fishery selectivity coefficients reported below are the average of the annual selectivity coefficients for all years (1966-2003), and for the last ten years (1994-2003).

Age	U.S. fishery, all years		U.S. fishery, 1994-03		Canadian fishery, all years		Canadian fishery, 1994-03		Acoustic survey (all years)	
Model	1b	1c	1b	1c	1b	1c	1b	1c	1b	1c
2	0.104	0.108	0.131	0.136	0.016	0.017	0.040	0.040	0.323	0.536
3	0.411	0.458	0.495	0.539	0.062	0.070	0.155	0.173	0.518	0.752
4	0.768	0.827	0.854	0.886	0.138	0.172	0.238	0.289	0.725	0.901
5	0.945	0.977	0.987	1.000	0.354	0.435	0.504	0.610	0.889	0.977
6	0.997	1.000	1.000	1.000	0.625	0.712	0.694	0.812	0.980	1.000
7	1.000	0.980	0.998	0.981	0.854	0.906	0.894	0.959	1.000	0.988
8	0.972	0.926	0.991	0.949	0.957	0.979	0.973	0.995	0.962	0.946
9	0.907	0.830	0.977	0.897	0.991	1.000	0.995	1.000	0.877	0.872
10	0.795	0.690	0.950	0.815	1.000	1.000	1.000	0.994	0.754	0.763
11	0.626	0.510	0.893	0.693	0.996	0.976	0.995	0.969	0.609	0.624
12	0.434	0.322	0.782	0.527	0.963	0.887	0.961	0.881	0.460	0.471
13	0.268	0.178	0.585	0.342	0.815	0.655	0.813	0.650	0.327	0.329
14	0.143	0.092	0.339	0.193	0.449	0.324	0.448	0.322	0.221	0.214
15	0.067	0.047	0.161	0.102	0.133	0.109	0.133	0.108	0.144	0.132

Table 12. Time series of estimated biomass, recruitment, and utilization for 1966-2003 for final models 1b and 1c (See text for description). U.S. and Canadian exploitation rate is the catch in biomass divided by the total biomass of age 3+ fish at the start of the year. Population biomass is in millions of tons of age-3 and older fish at the start of the year. Recruitment is given in billions of age-2 fish.

Year	Population biomass (million t)		Female spawning biomass		Recruits (billion)		U.S. exploitation rate		Canada exploitation rate		Total exploitation rate	
Model	1b	1c	1b	1c	1b	1c	1b	1c	1b	1c	1b	1c
1966	4.912	7.425	2.538	3.857	2.536	4.704	2.8%	1.8%	0.0%	0.0%	2.8%	1.9%
1967	4.974	7.856	2.532	3.971	2.303	4.211	3.6%	2.3%	0.7%	0.5%	4.3%	2.7%
1968	4.913	8.086	2.498	4.080	2.290	4.174	1.2%	0.8%	1.2%	0.8%	2.5%	1.5%
1969	4.961	8.397	2.532	4.258	2.764	5.041	1.7%	1.0%	1.9%	1.1%	3.6%	2.1%
1970	5.099	8.886	2.548	4.411	1.581	2.800	3.1%	1.8%	1.5%	0.8%	4.6%	2.6%
1971	4.818	8.597	2.449	4.353	1.248	2.116	2.7%	1.5%	0.6%	0.3%	3.2%	1.8%
1972	4.503	8.132	2.447	4.398	6.638	11.097	1.6%	0.9%	1.0%	0.5%	2.6%	1.4%
1973	5.892	10.456	2.746	4.908	0.787	1.326	2.5%	1.4%	0.3%	0.1%	2.8%	1.6%
1974	5.455	9.751	2.739	4.915	0.717	1.163	3.6%	2.0%	0.3%	0.2%	3.9%	2.2%
1975	4.891	8.846	2.571	4.658	2.251	3.653	4.2%	2.3%	0.3%	0.2%	4.5%	2.5%
1976	4.744	8.614	2.405	4.396	0.492	0.816	4.9%	2.7%	0.1%	0.1%	5.0%	2.8%
1977	4.080	7.551	2.135	3.968	0.521	0.872	3.1%	1.7%	0.1%	0.1%	3.3%	1.8%
1978	3.588	6.706	1.904	3.573	0.304	0.514	2.7%	1.5%	0.1%	0.1%	2.9%	1.5%
1979	3.449	6.506	1.941	3.655	4.059	6.786	3.6%	1.9%	0.4%	0.2%	4.0%	2.1%
1980	4.273	7.851	2.041	3.806	0.559	0.914	1.7%	0.9%	0.4%	0.2%	2.1%	1.1%
1981	3.904	7.169	2.005	3.713	0.830	1.314	2.9%	1.6%	0.6%	0.3%	3.6%	1.9%
1982	3.006	5.539	1.875	3.381	15.620	23.809	2.5%	1.4%	1.1%	0.6%	3.6%	1.9%
1983	6.419	10.656	2.684	4.572	0.464	0.686	1.1%	0.7%	0.6%	0.4%	1.8%	1.1%
1984	6.719	11.030	3.230	5.361	0.146	0.210	1.4%	0.9%	0.6%	0.4%	2.1%	1.3%
1985	5.876	9.661	3.006	4.976	0.331	0.462	1.5%	0.9%	0.4%	0.3%	1.9%	1.1%
1986	4.962	8.195	2.840	4.640	10.559	14.178	3.1%	1.9%	1.1%	0.7%	4.2%	2.6%
1987	7.337	11.256	3.309	5.205	0.173	0.224	2.2%	1.4%	1.0%	0.7%	3.2%	2.1%
1988	6.096	9.305	3.046	4.707	0.466	0.582	2.6%	1.7%	1.5%	1.0%	4.1%	2.7%
1989	5.153	7.897	2.749	4.225	3.067	3.725	4.1%	2.7%	1.9%	1.3%	6.0%	3.9%
1990	4.984	7.475	2.503	3.818	1.425	1.666	3.7%	2.5%	1.5%	1.0%	5.2%	3.5%
1991	4.731	6.989	2.403	3.614	0.283	0.324	4.6%	3.1%	2.2%	1.5%	6.8%	4.6%
1992	3.688	5.493	1.966	2.955	2.025	2.322	5.7%	3.8%	2.3%	1.6%	8.0%	5.4%
1993	3.376	4.941	1.714	2.563	0.773	0.908	4.2%	2.9%	1.7%	1.2%	5.9%	4.0%
1994	2.870	4.193	1.480	2.204	0.325	0.380	8.8%	6.0%	3.7%	2.5%	12.5%	8.6%
1995	2.198	3.293	1.193	1.810	1.722	2.022	8.1%	5.4%	3.2%	2.1%	11.3%	7.5%
1996	2.080	3.044	1.061	1.591	1.735	2.055	10.2%	7.0%	4.5%	3.1%	14.7%	10.1%
1997	2.131	3.076	1.040	1.549	0.903	1.129	11.0%	7.6%	4.3%	3.0%	15.3%	10.6%
1998	1.833	2.688	0.915	1.376	0.838	1.103	12.7%	8.7%	4.8%	3.3%	17.5%	11.9%
1999	1.509	2.309	0.755	1.183	0.572	0.794	14.9%	9.7%	5.8%	3.8%	20.7%	13.5%
2000	1.391	2.254	0.716	1.180	1.013	1.511	15.0%	9.2%	1.6%	1.0%	16.6%	10.2%
2001	1.317	2.214	0.746	1.242	5.308	7.317	13.8%	8.2%	4.1%	2.4%	17.9%	10.7%
2002	2.855	4.441	1.164	1.878	0.398	0.433	4.6%	3.0%	1.8%	1.1%	6.4%	4.1%
2003	2.696	4.161	1.283	2.016	0.457	0.493	5.3%	3.4%	2.3%	1.5%	7.6%	4.9%
Avg. 1966-03	4.150	6.867	2.098	3.499	2.065	3.101	4.9%	3.1%	1.6%	1.0%	6.6%	4.2%

Table 13. Decision table evaluating the consequences of assuming a harvest rate policy associated with lower or higher acoustic survey Q (assumed state on nature) when in fact the converse was true (true state on nature). This analysis defines a 2x2 matrix with two assumed states of nature (Q=1.0 and Q=0.6 as specified in final models 1b and 1c, respectively) and two true states of nature (Q=1.0 and Q=0.6) under both the F40%(40-10) and F45%(40-10) harvest rate policies. Projected spawning biomass (millions mt), depletion level (% unfished biomass), and exploitation rates in 2004-2005 are given. Bottom of table also includes consequences of a constant harvest in which US fisheries take 250,000 mt annually while Canada takes allocated percentage (26.12% OY) of optimum yield.

			True State of Nature					
Assumed State of Nature			***Q = 1.0***			***Q = 0.6***		
	Year	**OY Assumed**	**Spawning Biomass**	**Percent Unfished**	**Exploitation Rate**	**Spawning Biomass**	**Percent Unfished**	**Exploitation Rate**
Q = 1.0								
	2004	514,441	1.193	0.437	0.215	1.866	0.455	0.136
F40% (40-10)	**2005**	362,573	0.940	0.344	0.195	1.574	0.384	0.116
	2006	228,593	0.655	0.240	0.185	1.183	0.288	0.110
	2004	442,698	1.193	0.437	0.178	1.866	0.455	0.112
F45% (40-10)	**2005**	322,020	0.988	0.361	0.165	1.621	0.395	0.100
	2006	219,329	0.714	0.261	0.163	1.241	0.302	0.098
Q = 0.6								
	2004	780758	1.193	0.437	0.310	1.866	0.455	0.212
F40% (40-10)	**2005**	528,428	0.820	0.300	0.309	1.424	0.347	0.190
	2006	313,132	0.490	0.179	0.356	0.976	0.238	0.173
	2004	649,304	1.193	0.437	0.264	1.866	0.455	0.177
F45% (40-10)	**2005**	472,590	0.879	0.321	0.262	1.494	0.364	0.162
	2006	302,340	0.559	0.205	0.294	1.061	0.258	0.154
Constant Catch	**2004**	384,372	1.193	0.437	0.162	-	-	-
250,000 mt US +	**2005**	344,704	1.007	0.369	0.174	-	-	-
.2612*F40%OY Can.	**2006**	309,708	0.717	0.262	0.230	-	-	-
Constant Catch	**2004**	453,934	-	-	-	1.866	0.455	0.125
250,000 mt US +	**2005**	388,025	-	-	-	1.597	0.389	0.126
.2612*F40%OY Can.	**2006**	331,790	-	-	-	1.183	0.288	0.152

Table 14. Life history and fishery vectors used to estimate spawning biomass per recruit (SPR) fishing mortalities.

Age	Natural mortality	U.S. fishery selectivity (Avg. 1994-2003)		Canadian fishery selectivity (Avg 1994-2003)		U.S. fishery weight at age (kg) (Avg. 1978-2003)	Canadian fishery weight at age (kg) (Avg. 1976-2003)	Population weight at age (kg) (Avg. 1977-2003)	Proportion of mature females	Multiplier for female weight at age
		1b	1c	1b	1c					
2	0.23	0.1311	0.1361	0.040	0.040	0.294	0.332	0.246	0.176	0.510
3	0.23	0.4950	0.5389	0.155	0.173	0.401	0.528	0.378	0.661	0.511
4	0.23	0.8541	0.8858	0.238	0.289	0.481	0.626	0.493	0.890	0.510
5	0.23	0.9873	0.9998	0.504	0.610	0.549	0.702	0.568	0.969	0.512
6	0.23	1.0000	1.0000	0.694	0.812	0.590	0.745	0.640	0.986	0.522
7	0.23	0.9977	0.9810	0.894	0.959	0.632	0.789	0.700	0.996	0.525
8	0.23	0.9910	0.9486	0.973	0.995	0.668	0.827	0.727	1.000	0.535
9	0.23	0.9774	0.8965	0.995	1.000	0.695	0.857	0.773	1.000	0.543
10	0.23	0.9496	0.8151	1.000	0.994	0.723	0.896	0.832	1.000	0.547
11	0.23	0.8931	0.6933	0.995	0.969	0.769	0.920	0.849	1.000	0.569
12	0.23	0.7818	0.5269	0.961	0.881	0.797	0.953	0.886	1.000	0.568
13	0.23	0.5848	0.3424	0.813	0.650	0.845	0.975	0.897	1.000	0.572
14	0.23	0.3393	0.1933	0.448	0.322	0.845	0.989	0.920	1.000	0.581
15+	0.23	0.1615	0.1020	0.133	0.108	0.903	1.084	0.971	1.000	0.589

Table 15. Projections of Pacific hake biomass, yield and depletion rates for 2004-2008 under different harvest rate policies from final models 1b and 1c. Shown are Bayesian credibility intervals (10%, 50%, and 90%) generated from 2,500,000 MCMC samples.

Final Model 1b

		3+ Bioimass (million mt)			SpawningBioimass (million mt)			Age-2 Recruits (billion)			Depletion Rate			Coastwide yield (t)		
Harvest Policy	Year	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
	2004	2.007	2.307	2.673	1.011	1.160	1.337	0.177	0.459	1.255	0.385	0.434	0.495	428372	501073	580313
	2005	1.573	1.839	2.190	0.801	0.927	1.084	0.080	0.228	0.583	0.304	0.346	0.401	288914	355372	438254
F40% (40-10)	2006	1.061	1.251	1.523	0.573	0.675	0.831	0.259	1.079	4.384	0.215	0.253	0.310	181377	241722	331852
Harvest Policy	2007	0.954	1.284	2.395	0.509	0.655	1.052	0.257	1.034	4.193	0.192	0.245	0.396	137269	220477	436093
	2008	0.956	1.494	3.072	0.507	0.737	1.361	0.273	1.104	4.472	0.189	0.276	0.510	137269	220477	436093
	2004	1.999	2.298	2.691	1.011	1.157	1.339	0.171	0.480	1.274	0.381	0.432	0.494	351816	412814	482618
	2005	1.661	1.933	2.288	0.840	0.974	1.138	0.078	0.212	0.587	0.317	0.362	0.421	255813	316302	383068
F45% (40-10)	2006	1.158	1.355	1.655	0.624	0.732	0.894	0.267	1.076	4.242	0.233	0.272	0.331	176448	227319	304560
Harvest Policy	2007	1.042	1.387	2.437	0.559	0.716	1.085	0.269	1.060	4.246	0.209	0.266	0.412	137933	210085	379724
	2008	1.040	1.600	3.178	0.550	0.790	1.425	0.257	1.106	4.457	0.204	0.294	0.530	137933	210085	379724

Final Model 1c

		3+ Bioimass			SpawningBioimass			Age-2 Recruits (billion)			Depletion Rate			Coastwide yield (t)		
Harvest Policy	Year	10%	50%	90%	10%	50%	90%	0.100	0.500	0.900	10%	50%	90%	10%	50%	90%
	2004	2.753	3.530	4.513	1.417	1.806	2.302	0.198	0.551	1.497	0.369	0.452	0.549	560224	740368	955991
	2005	2.159	2.727	3.485	1.110	1.398	1.776	0.092	0.262	0.722	0.289	0.350	0.426	363334	503666	682808
F40% (40-10)	2006	1.486	1.832	2.325	0.809	1.011	1.293	0.366	1.560	6.617	0.210	0.250	0.313	225035	325649	482064
Harvest Policy	2007	1.361	1.903	3.534	0.735	0.976	1.561	0.348	1.517	6.065	0.188	0.244	0.391	175928	299935	630135
	2008	1.406	2.190	4.477	0.740	1.089	1.988	0.381	1.514	6.470	0.186	0.271	0.497	175928	299935	630135
	2004	2.773	3.581	4.588	1.431	1.834	2.336	0.204	0.575	1.542	0.373	0.454	0.552	471371	629709	812876
	2005	2.265	2.895	3.719	1.170	1.484	1.889	0.091	0.252	0.677	0.304	0.367	0.448	331550	457371	613371
F45% (40-10)	2006	1.612	2.001	2.582	0.879	1.095	1.418	0.331	1.472	5.488	0.227	0.270	0.335	221059	308924	453286
Harvest Policy	2007	1.482	2.020	3.361	0.800	1.057	1.551	0.343	1.507	6.476	0.205	0.261	0.383	174915	283252	519288
	2008	1.475	2.315	4.629	0.793	1.160	2.095	0.375	1.610	6.674	0.198	0.287	0.520	174915	283252	519288

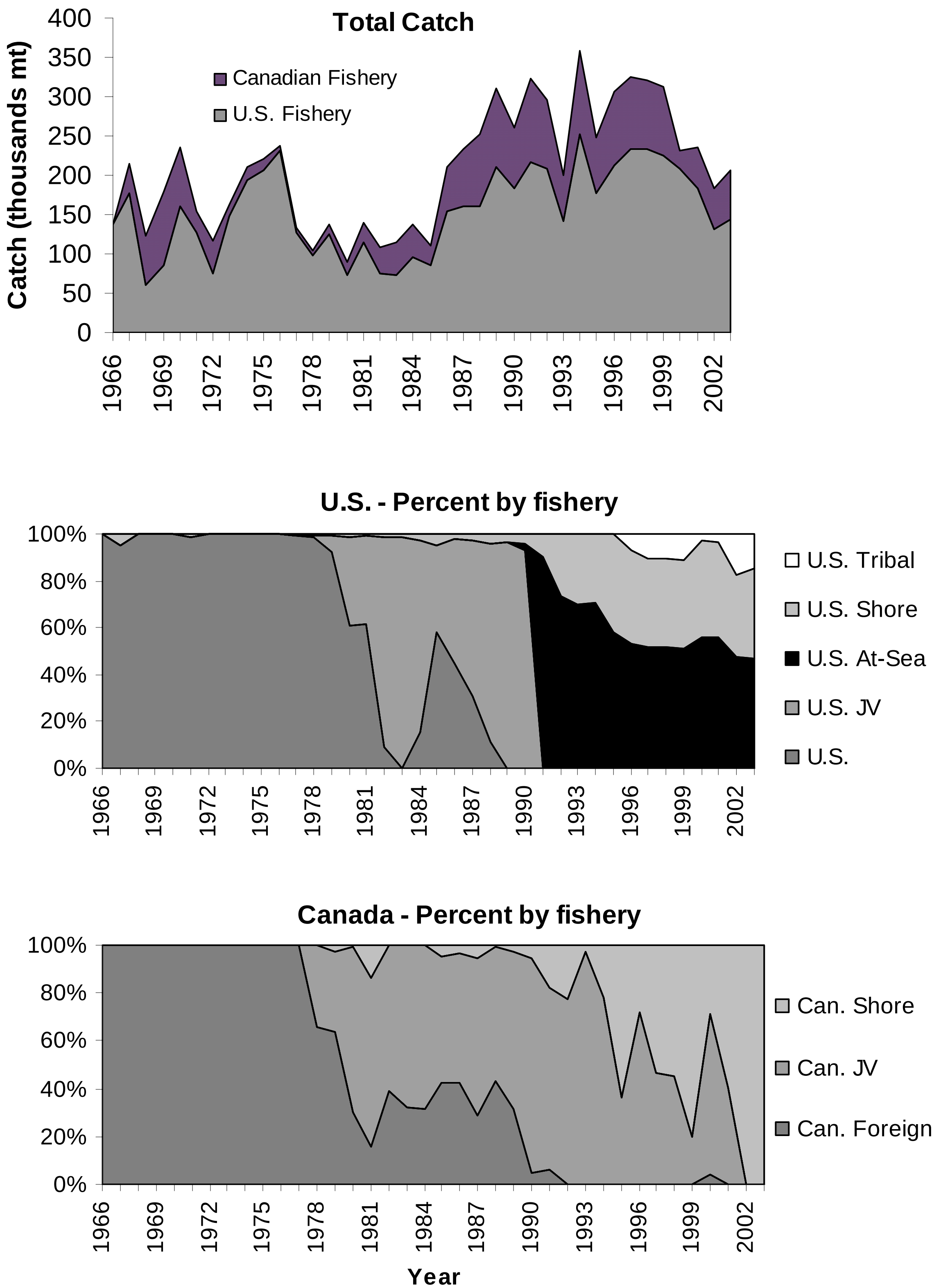


Figure 1. Total catch of Pacific hake in the U.S. and Canadian zones (1966-2003) (upper panel). Percent catch by fishery within each zone (lower panels).

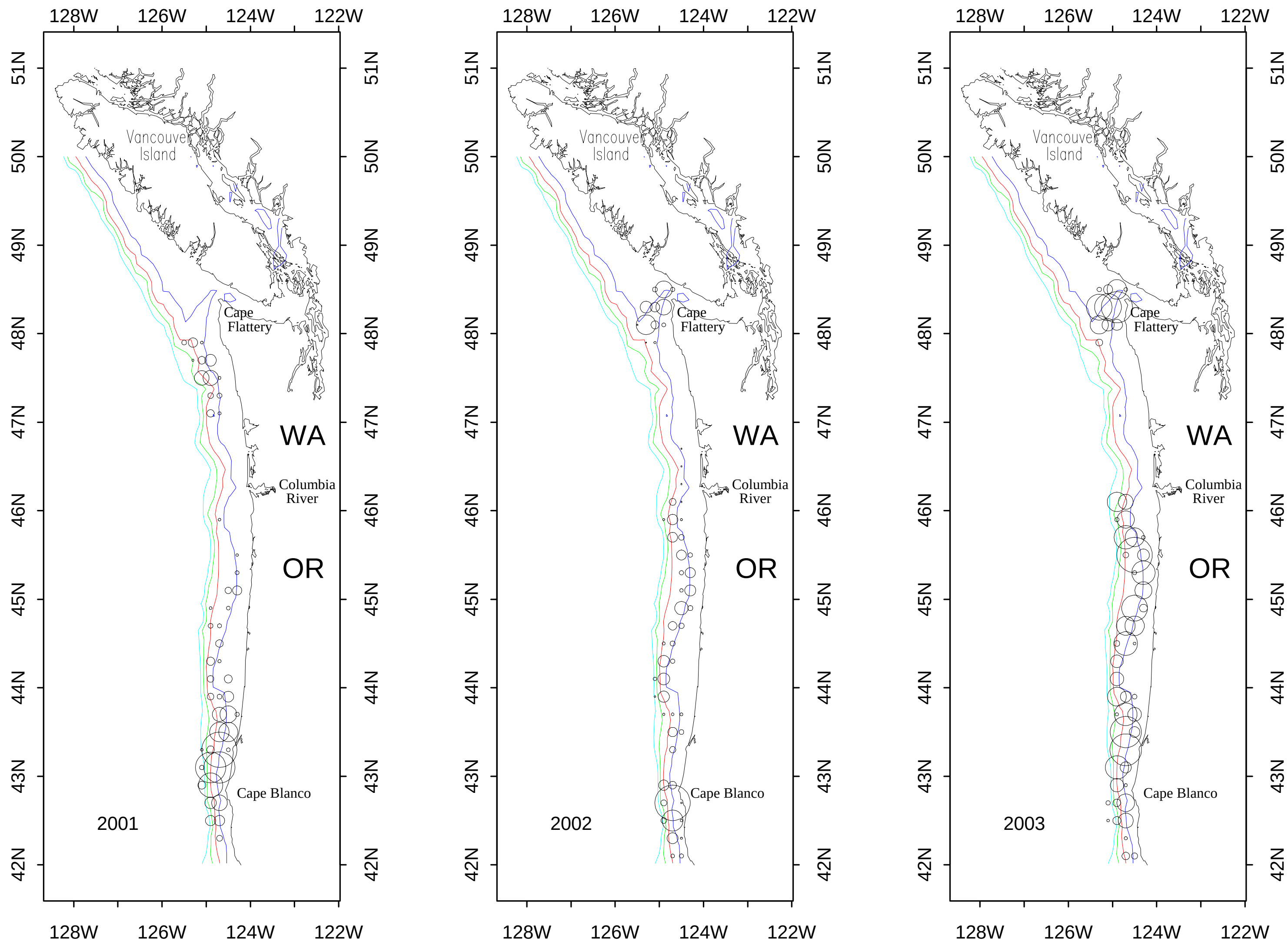


Figure 2. Catch by 20 km^2 block for factory and catcher boats in the 2001-2003 at-sea fishery for Pacific hake. Area of circle is proportional to the total catch within the block.

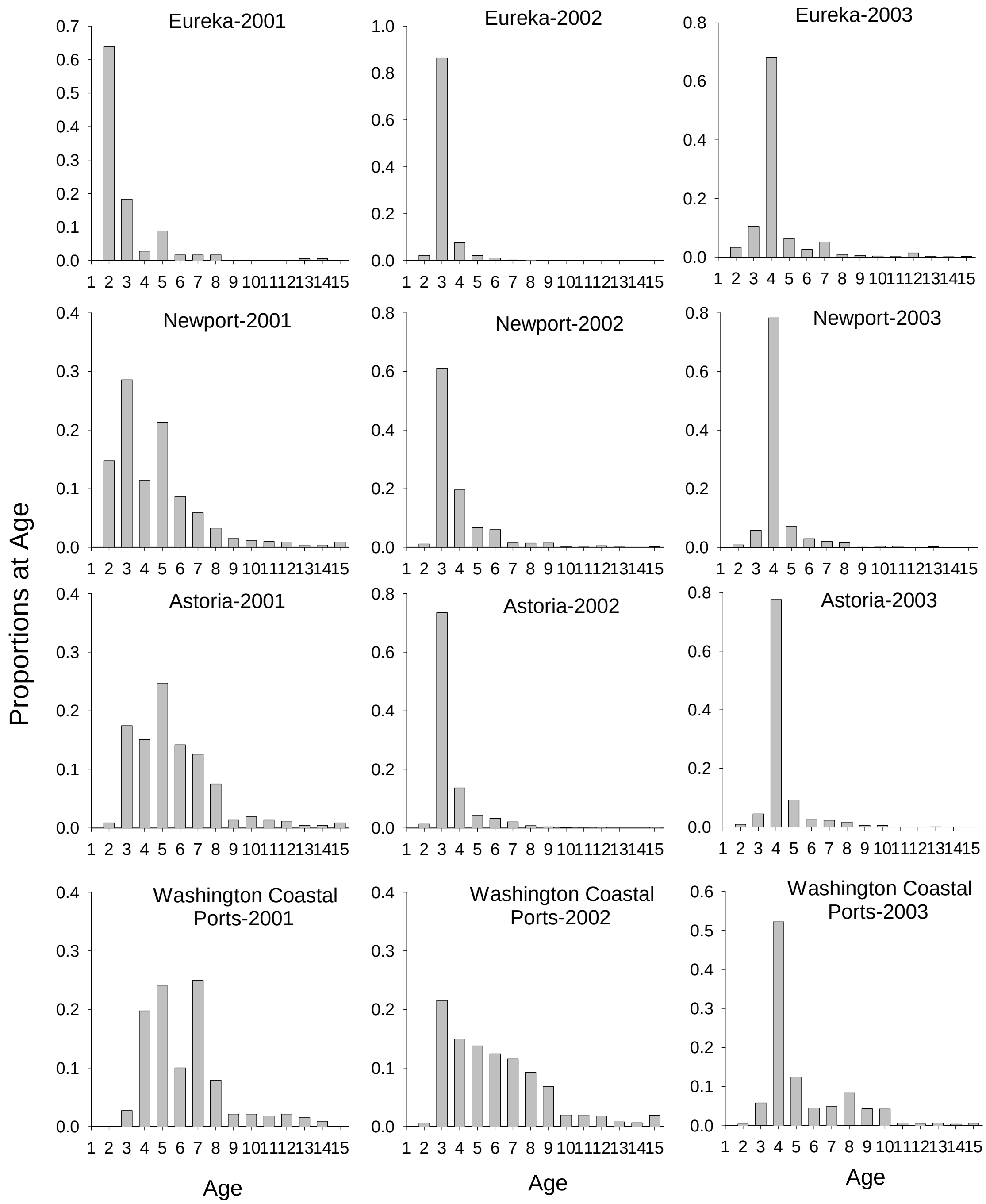


Figure 3. Pacific hake proportion by age from shore-based landings in the U.S. zone, 2001-2003.

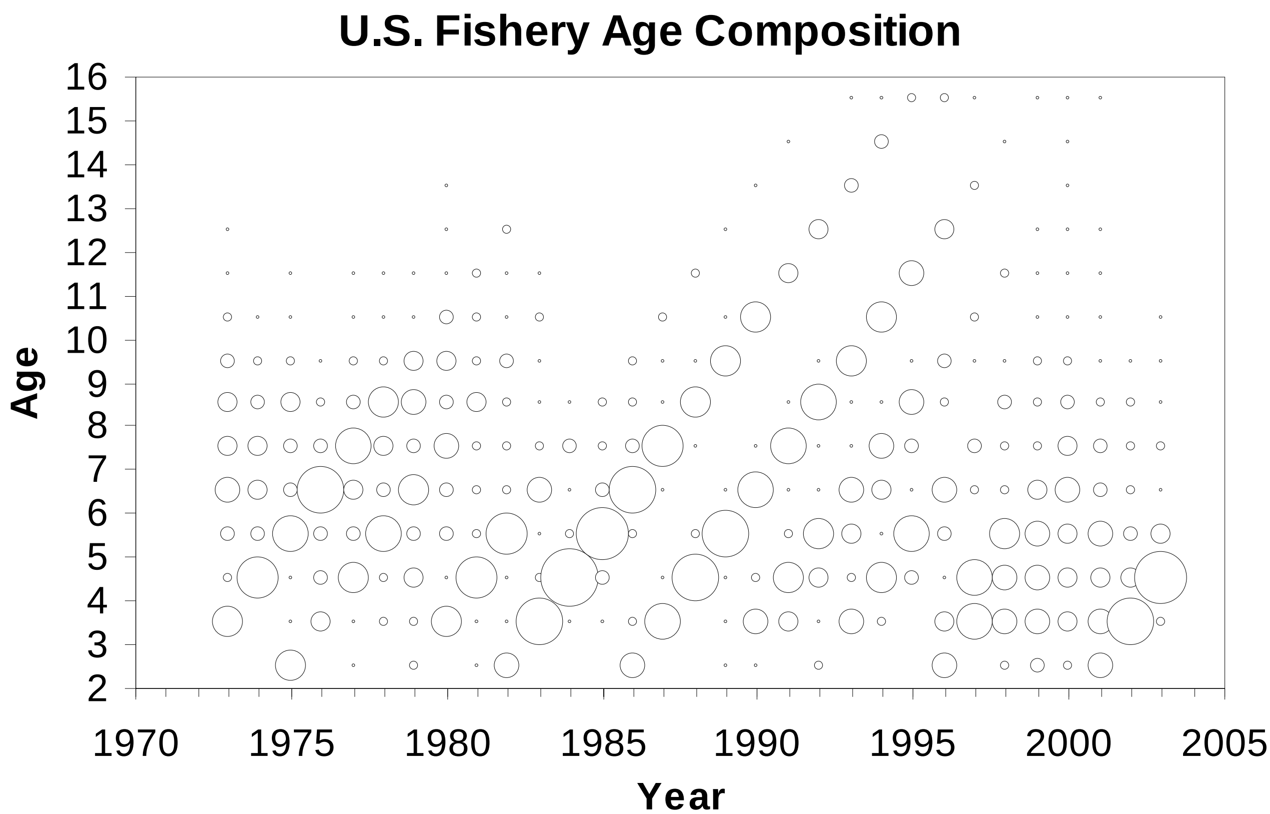


Figure.5. Catch at age of Pacific hake in the U.S. fisheries during 1973-2003. The diameter of the circle is proportional to the catch at age

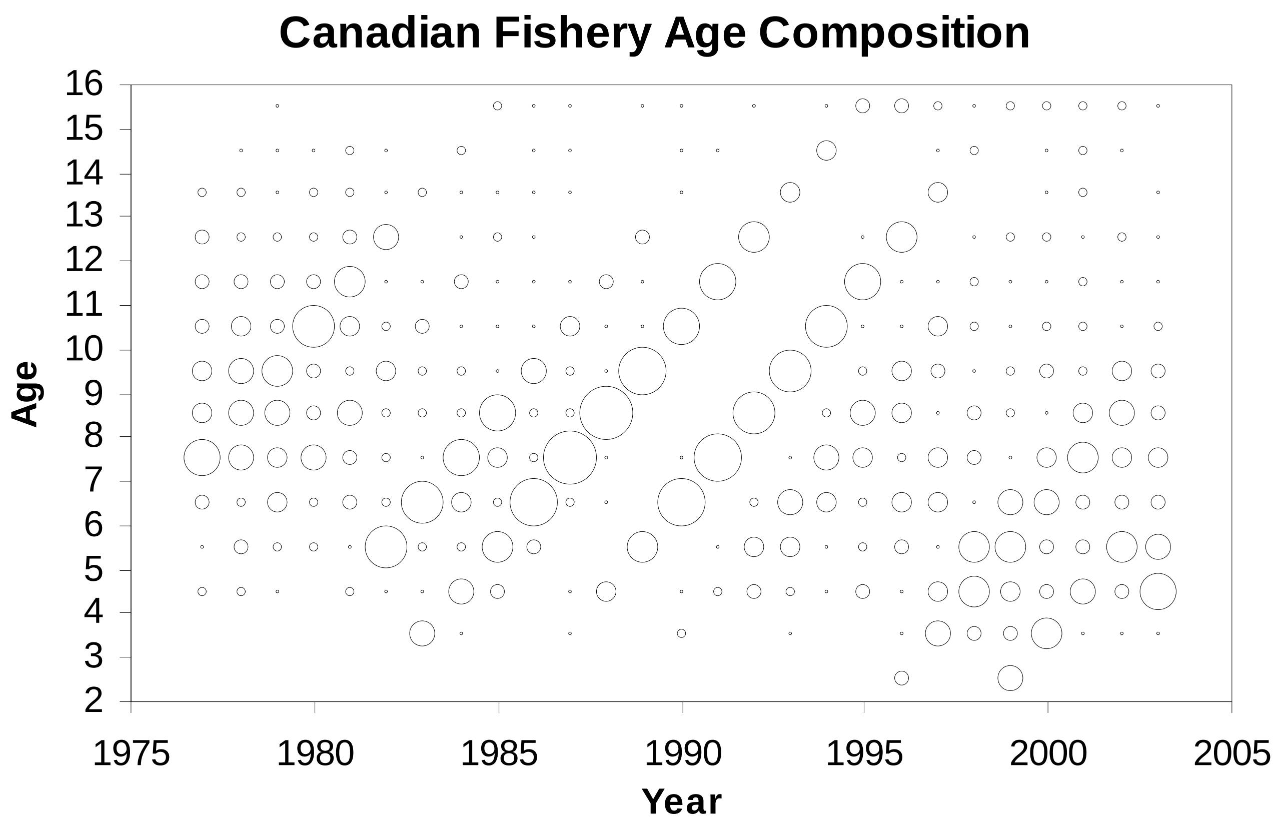


Figure 6. Catch at age of Pacific hake in the Canadian fisheries during 1977-2003. The diameter of the circle is proportional to the catch at age

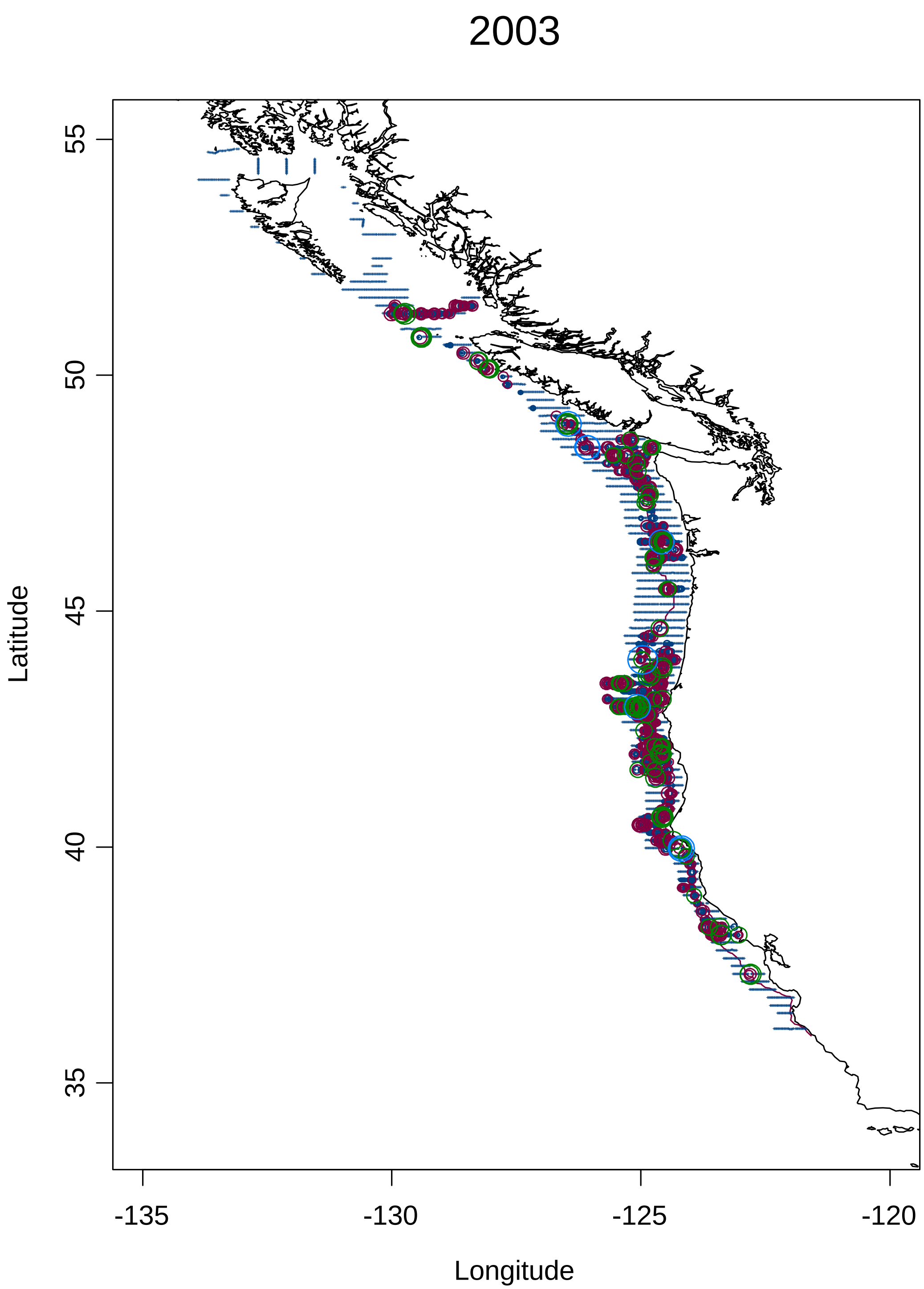


Figure 7. Acoustic backscattering (SA) attributed to Pacific hake along transects off the U.S. and Canada west coast shelf and slope between Monterey, CA, and Newport, OR, during the 2003 acoustic echo integration-trawl survey.

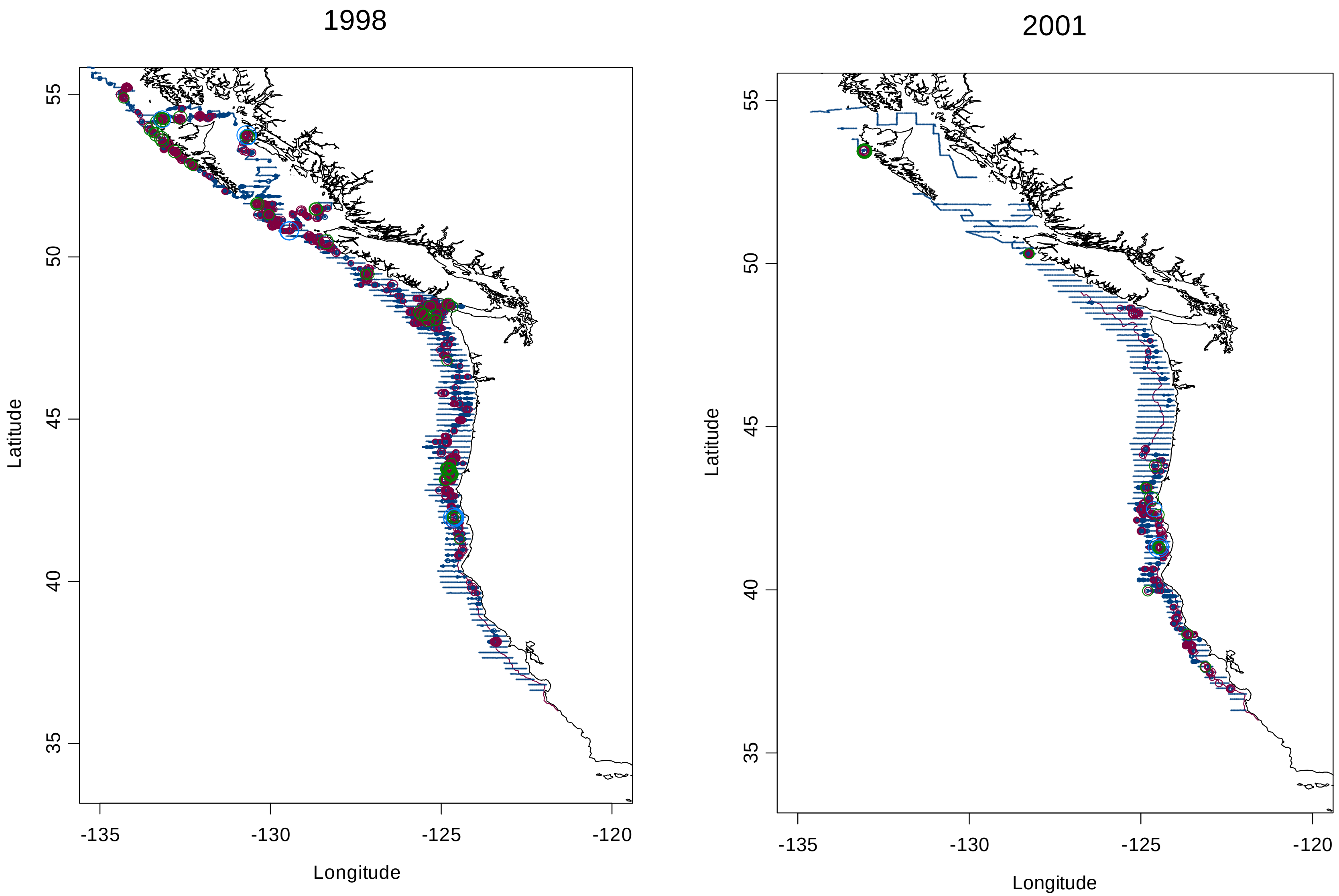


Figure 7 continued. Acoustic backscattering (SA) attributed to Pacific hake along transects off the U.S. and Canada west coast shelf and slope between Monterey, CA, and Newport, OR, during the 1998 and 2001 acoustic echo integration-trawl survey.

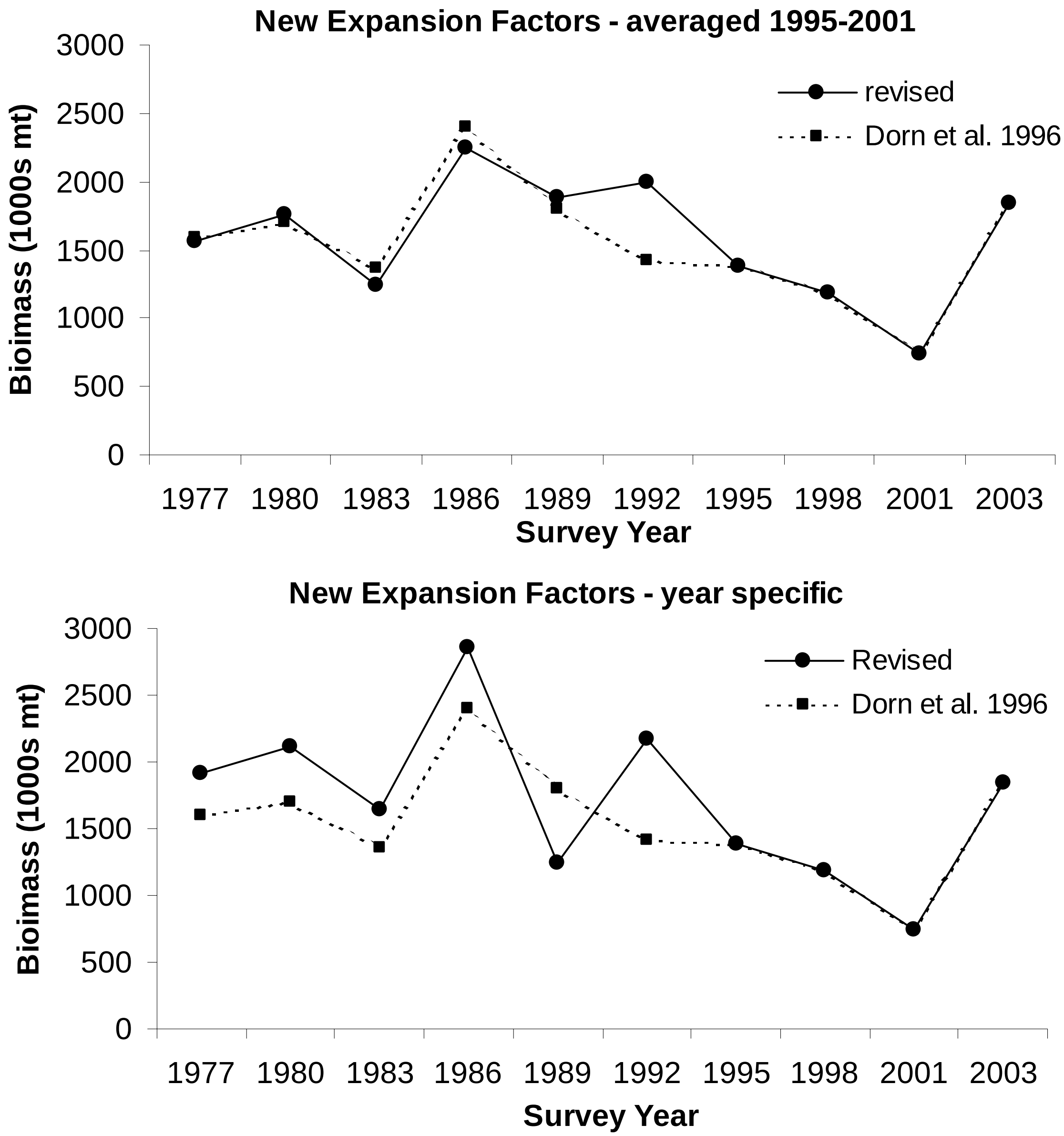
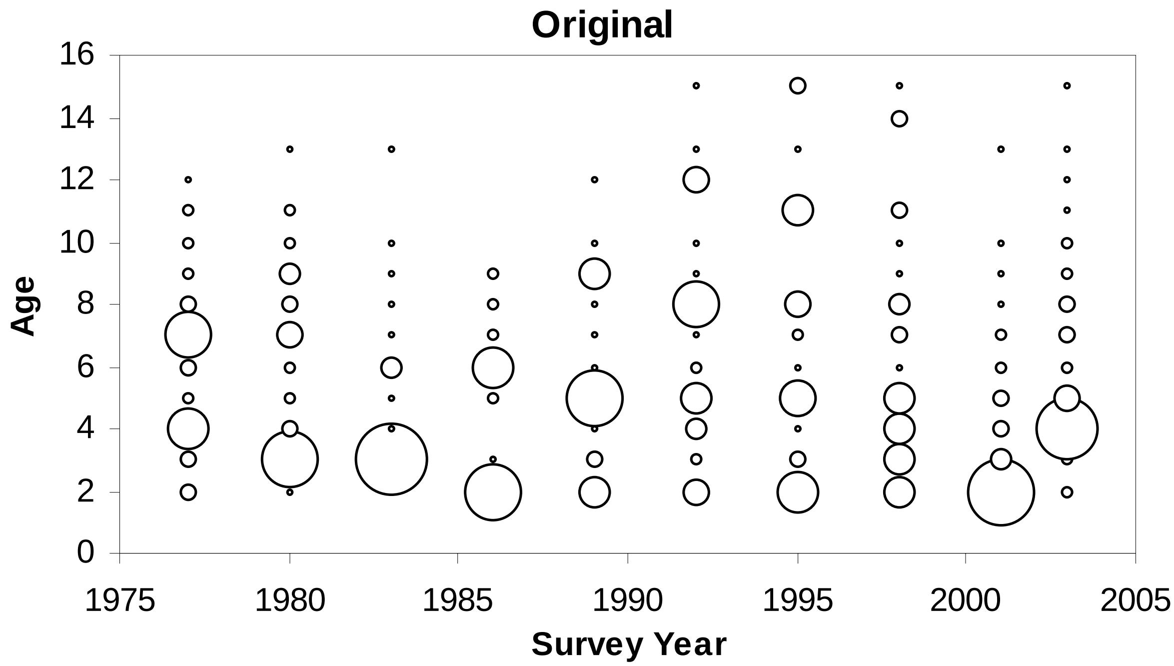


Figure 8. Trends in Pacific hake biomass in the acoustic survey based of revised deep water and northern expansion factors. Estimates in top panel were based on average deep water expansion factors from the 1992-2001 acoustic survey and average northern expansion factors from the 1995-2001 acoustic survey. Estimates in bottom panel were based on year-specific deep water and northern expansions factors corresponding to similar oceanographic conditions, i.e. 1998 survey was used to calculate expansion factors which were applied to the 1983 survey (See text for details).



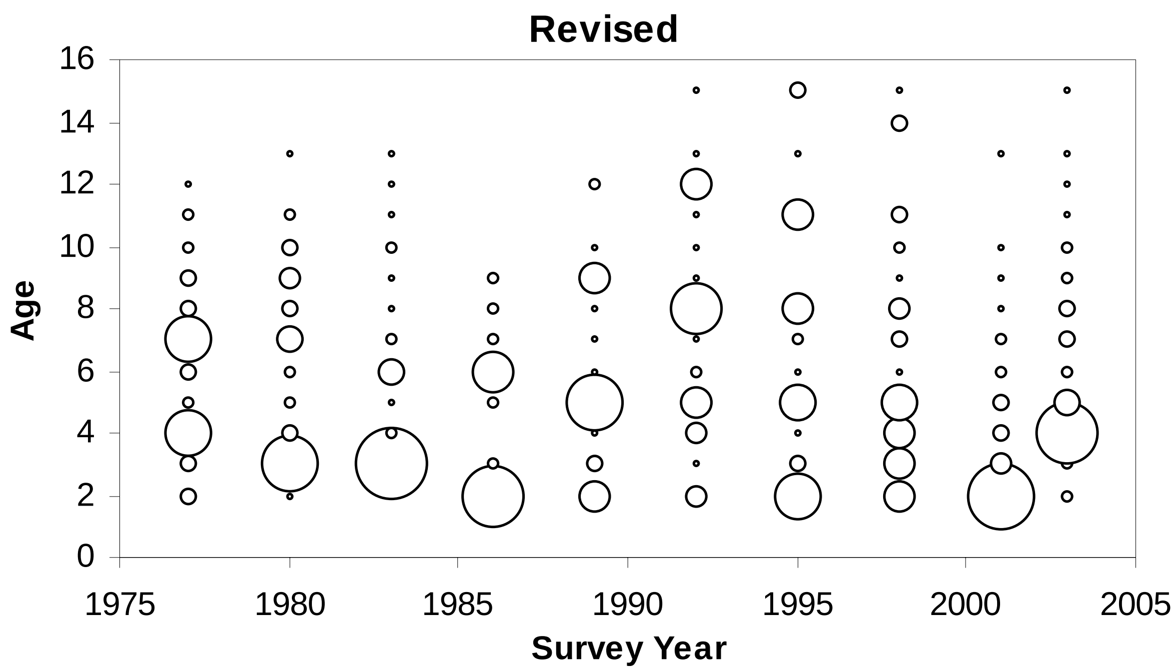


Figure 9. Catch at age of Pacific hake from the acoustic survey, 1977-2003. Top panel shows original catch at age while bottom panel give revised catch at age based on the new year-specific deep-water and northern expansion factors. The diameter of the circle is proportional to the catch at age

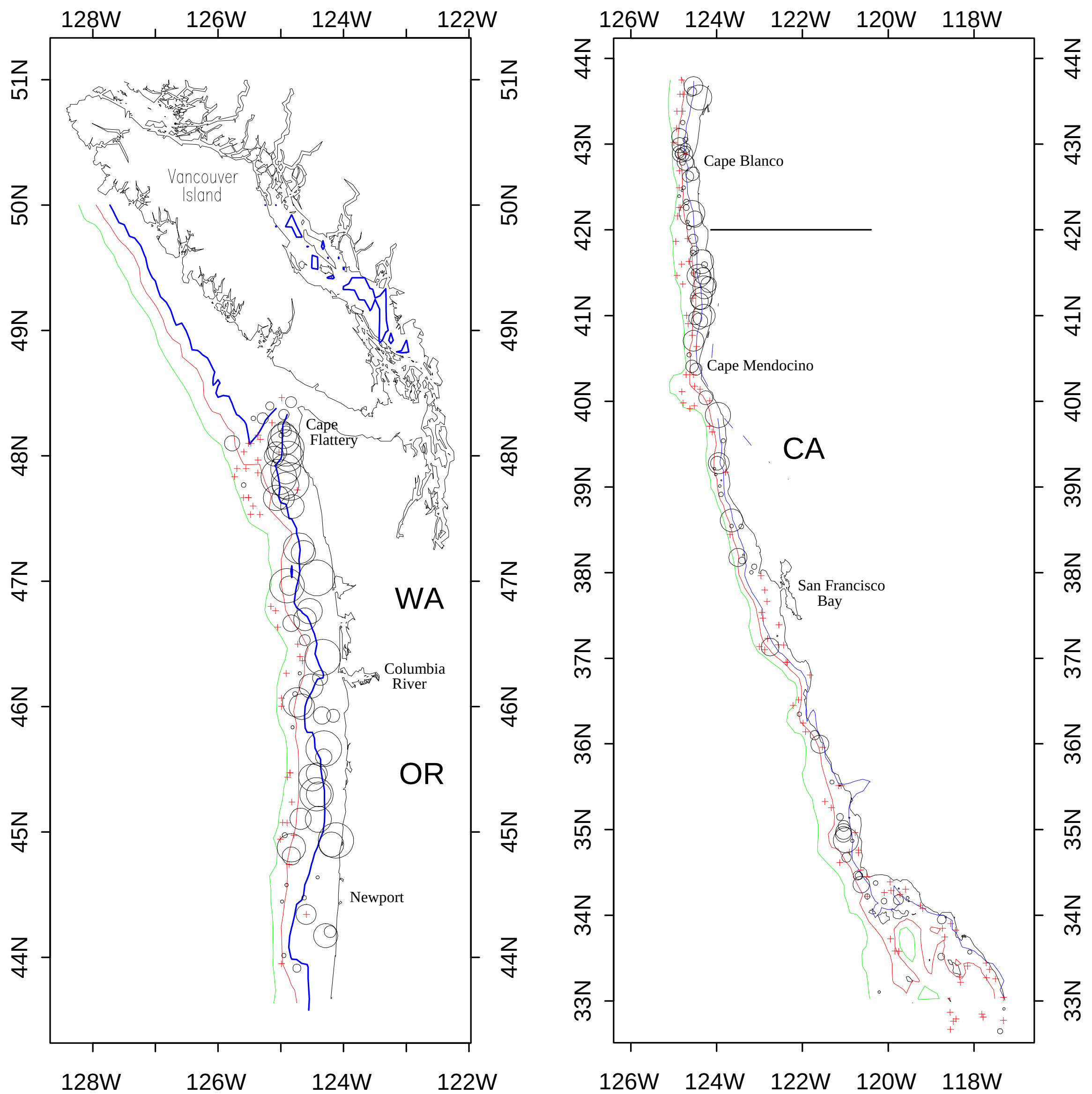


Figure 10. Spatial distribution of age 2+ (> 30 cm) Pacific hake in the NWFSC 2003 bottom trawl (Triennial) survey.

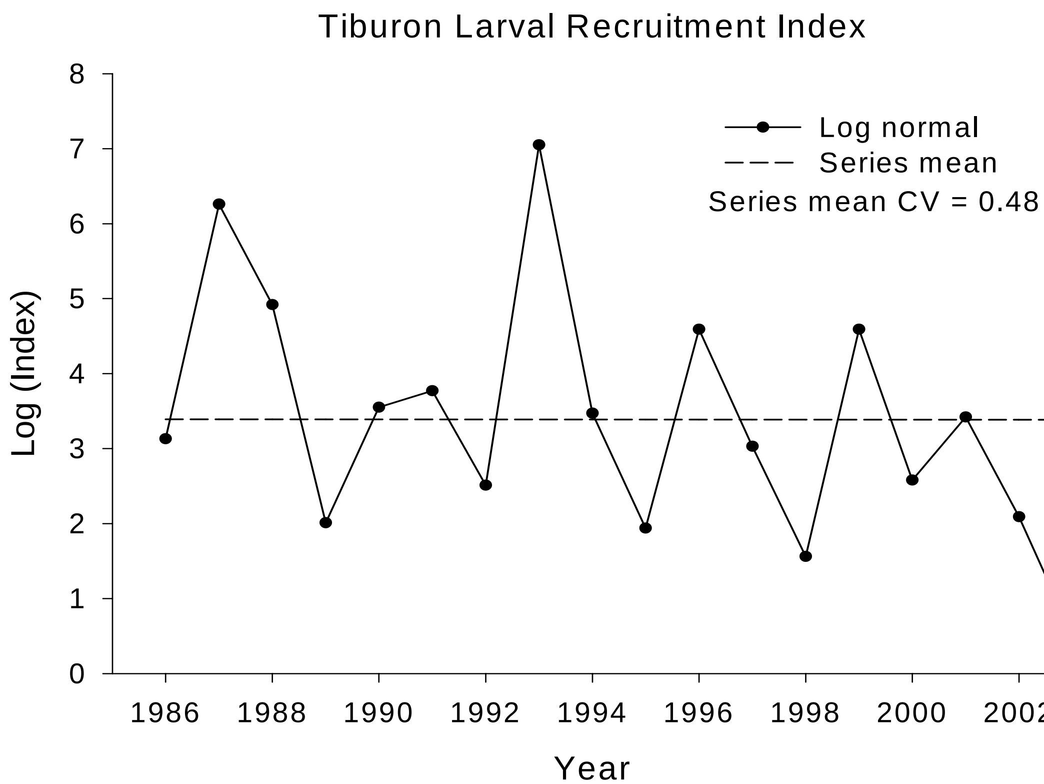


Figure 11. Santa Cruz Laboratory juvenile recruitment index (Monterey inside stratum only), 1986-2003. Index is obtained from a generalized linear model fit to the log-transformed CPUEs (Ralston et al. 1998). The juvenile index is projected two years in advance and is used as an index of age 2 hake recruitment, i.e., 1986 juvenile index represents age 2 hake recruitment in 1988.

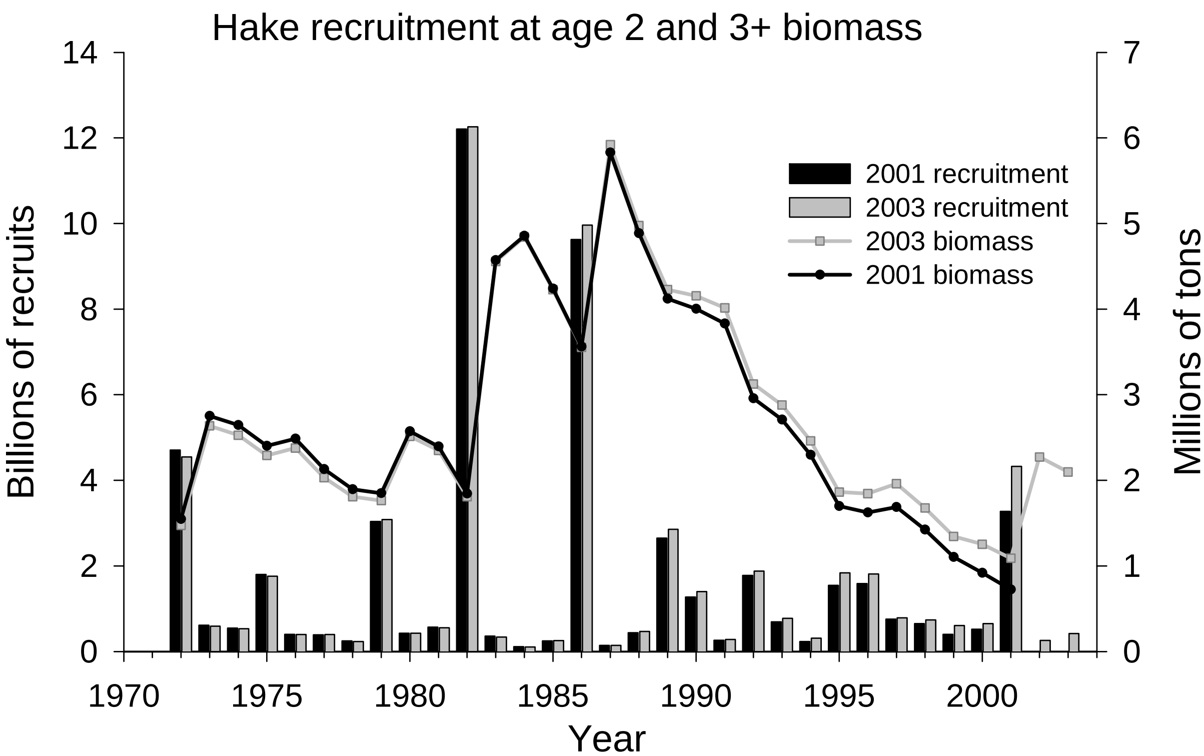


Figure 12. Comparison of trends in age 2+ biomass and recruitment between the most recent assessment 2003 model update presented in this document and the 2001 Pacific hake assessment (Helser et al. 2001). Both models employed the same model structure and assumptions, but the 2003 updated reflects only updated fishery catch and the new 2003 acoustic survey biomass estimate.

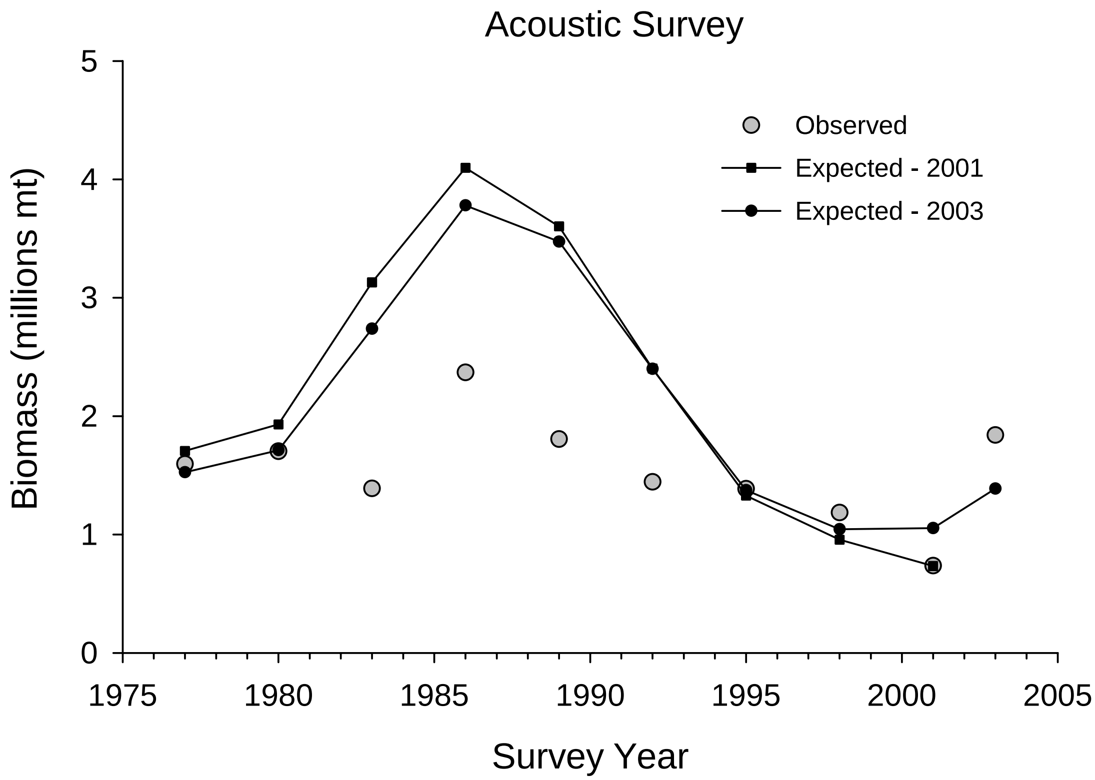
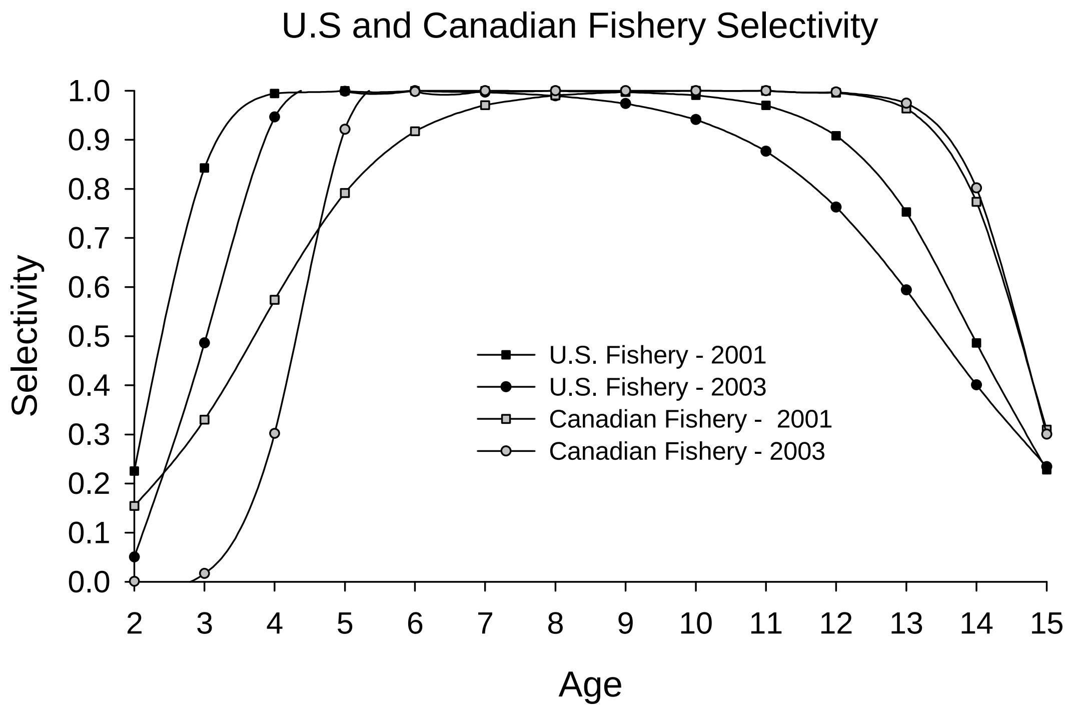


Figure 13. Comparison of observed and predicted acoustic survey biomass indices estimated from the 2003 model update presented in this document and the 2001 Pacific hake assessment (Helser et al. 2001). Both models employed the same model structure and assumptions.



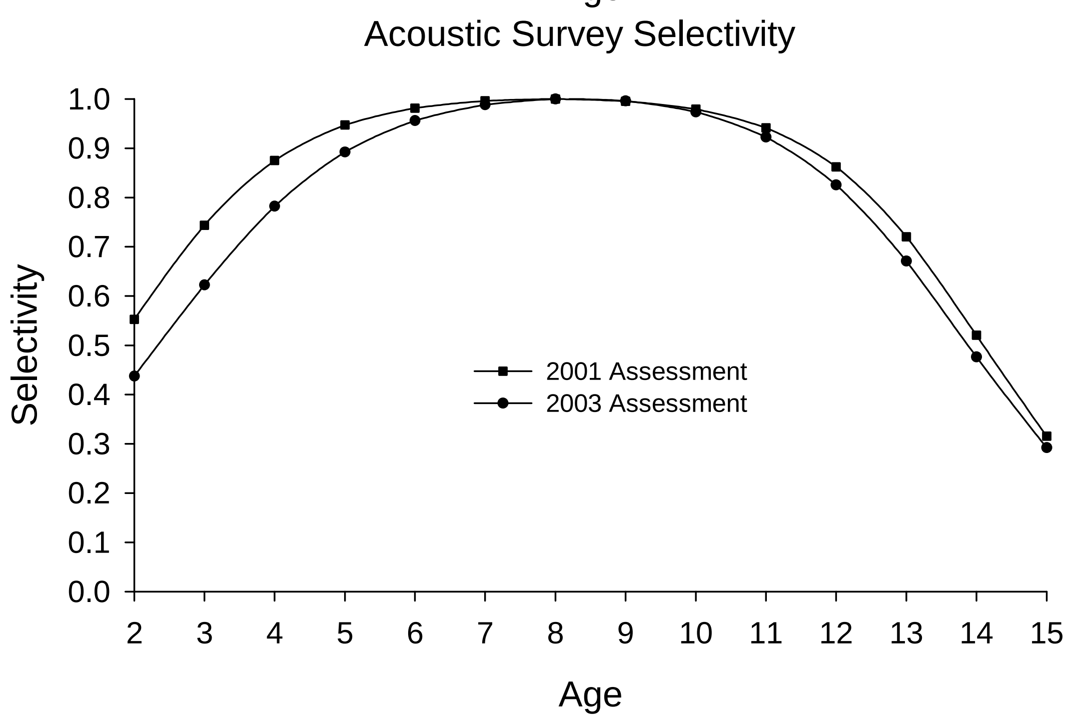


Figure 14. Comparison of average fishery and acoustic survey selectivity (most recent three years) estimated from the 2003 model update presented in this document (2003) and the 2001 Pacific hake assessment (Helser et al. 2001). Both models employed the same model structure and assumptions.

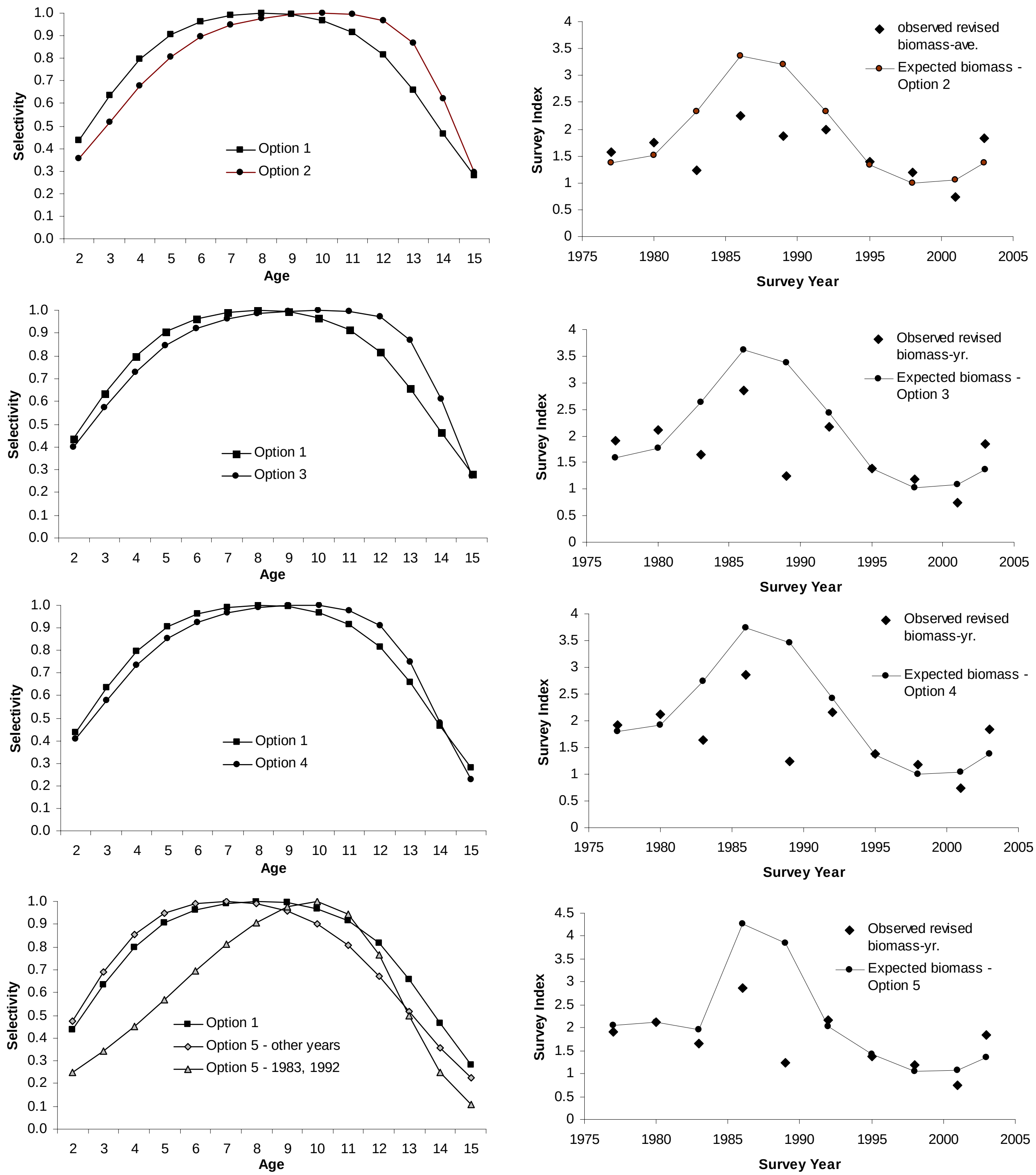


Figure 15. Comparison of acoustic survey selectivity and the fit of expected to observed acoustic survey biomass estimates, 1977-2003, among five different model options. See text for explanation of model options.

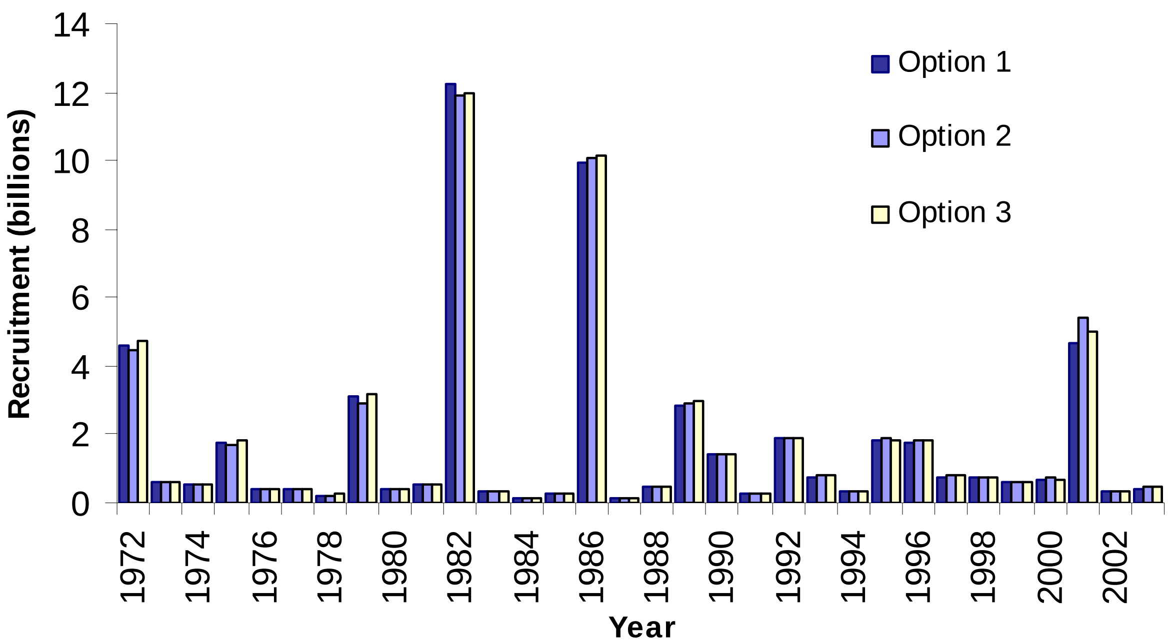
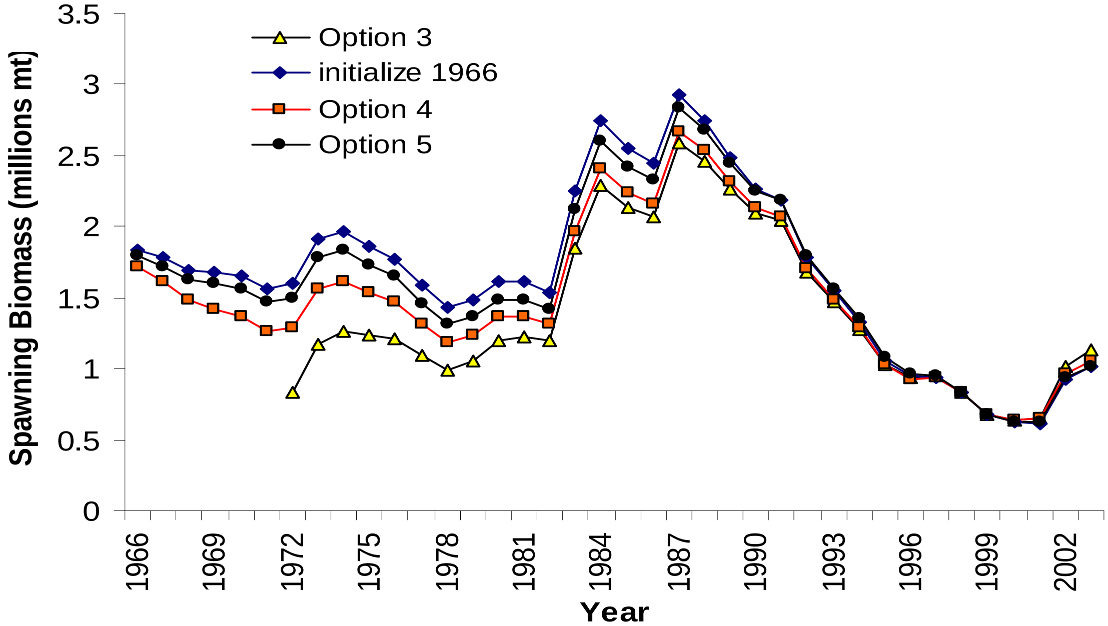


Figure 16. Estimates of Pacific hake spawning biomass and recruitment to age 2 among three different model options. See text for explanation of different model options.



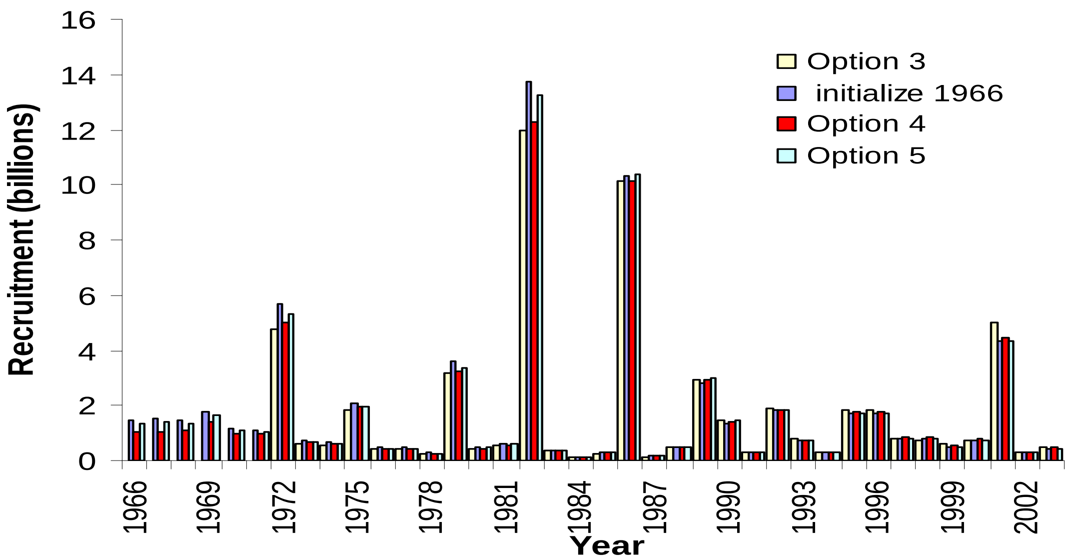


Figure 17. Estimates of Pacific hake spawning biomass and recruitment to age 2 among different model options. See text for explanation of different model options.

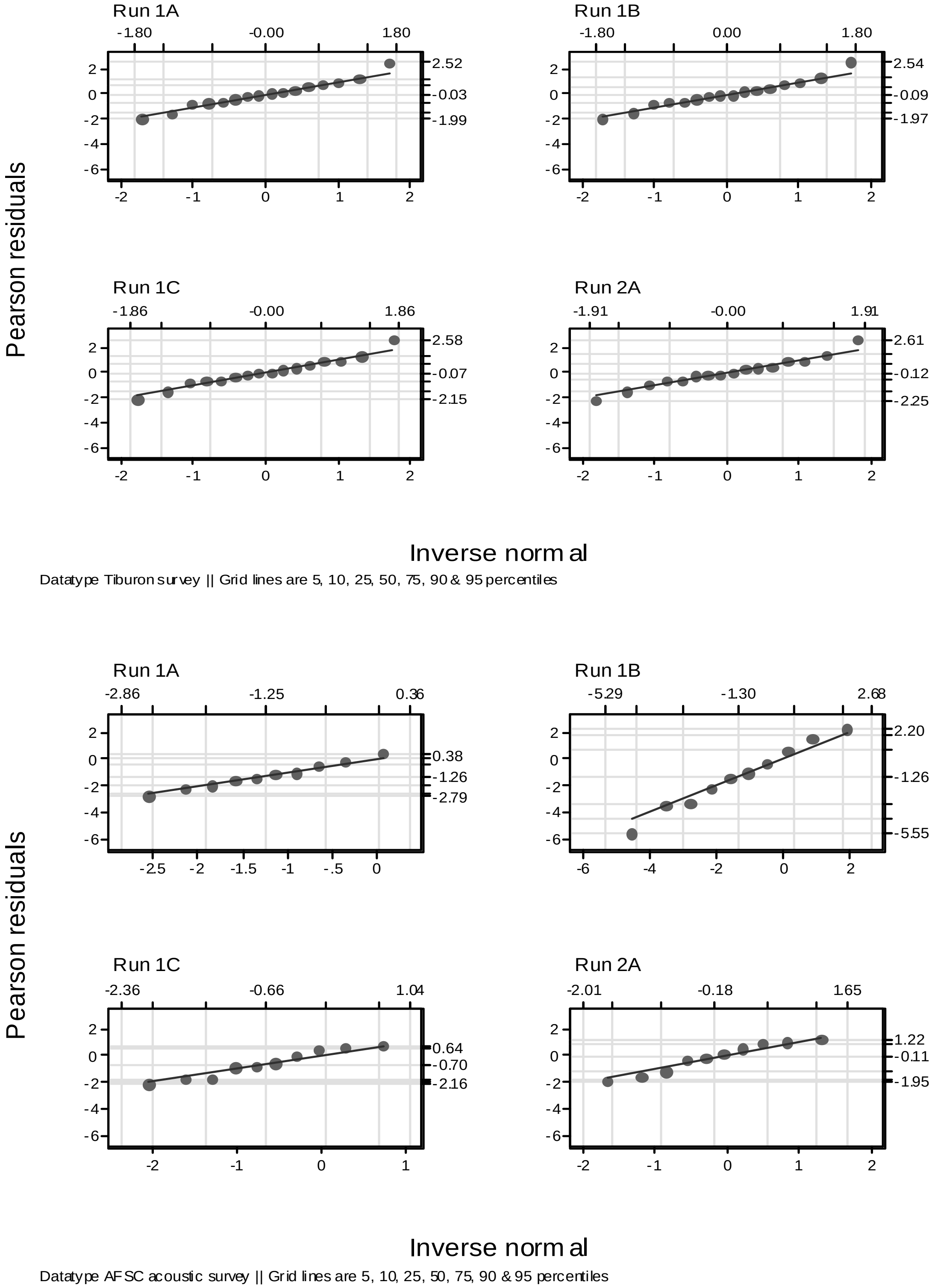


Figure 18. Q-Q plots of the Pearson residuals for the fit to the acoustic survey biomass (top) and Tiburon recruitment survey (bottom) data for Runs 1A, 1B, 1C and 2A.

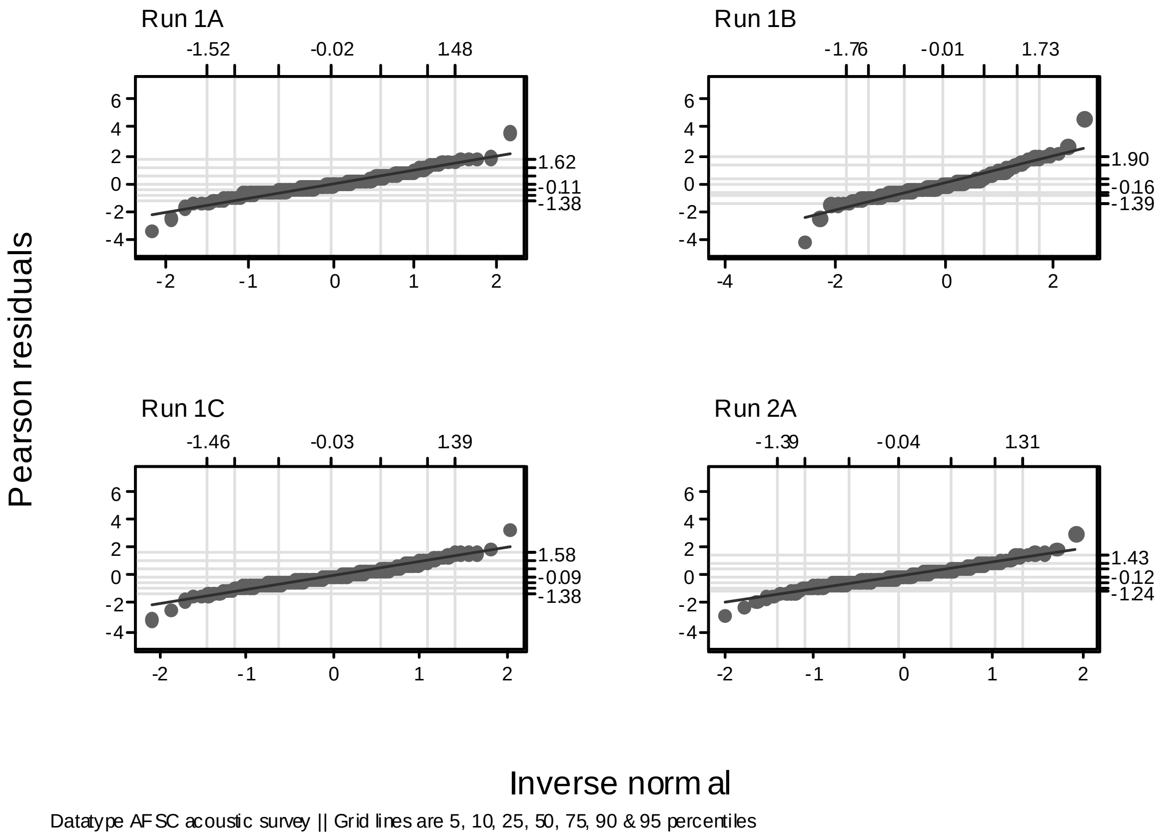


Figure 19. Q-Q plots of the Pearson residuals for the fit to the acoustic survey age composition data for Runs 1A, 1B, 1C and 2A.

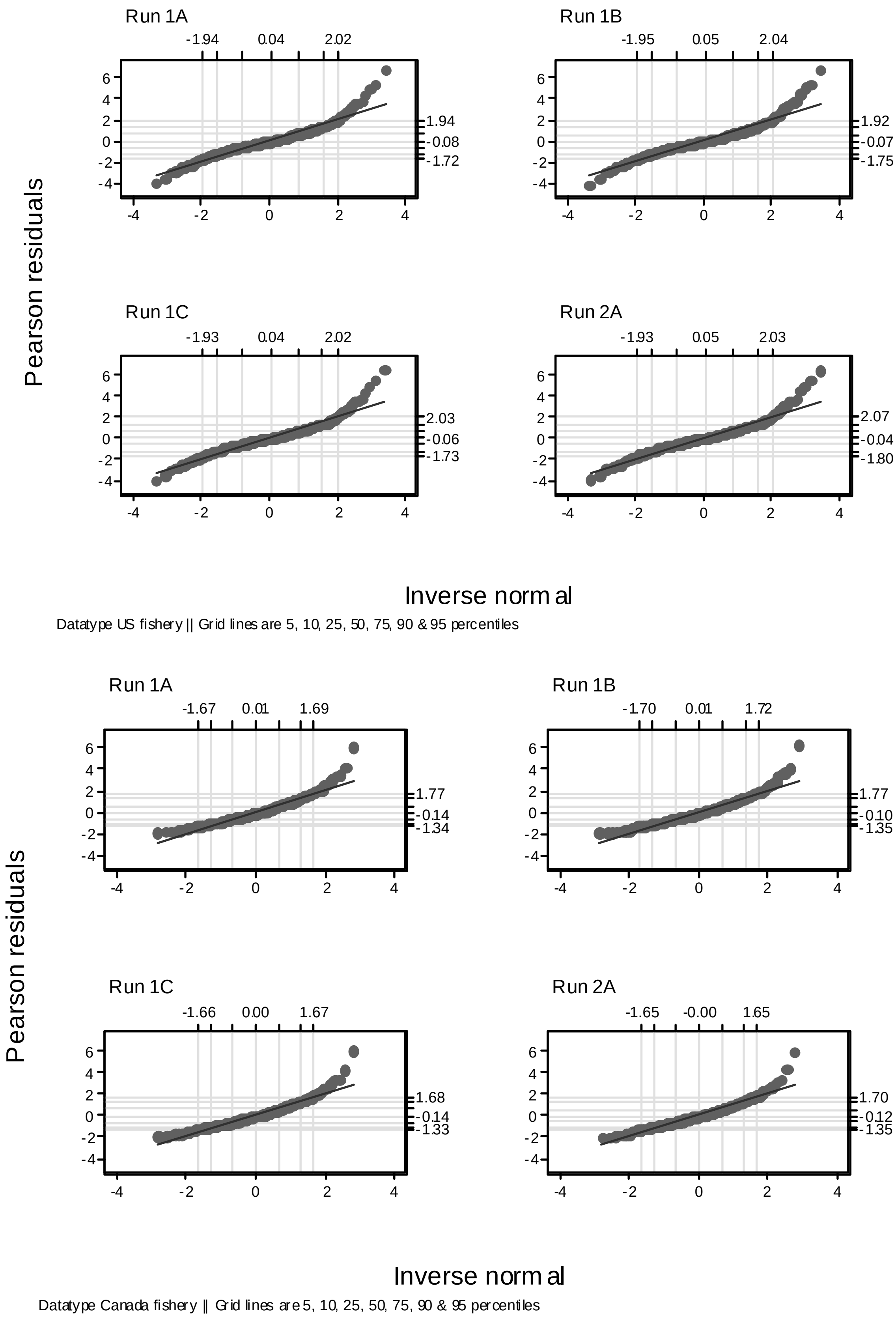
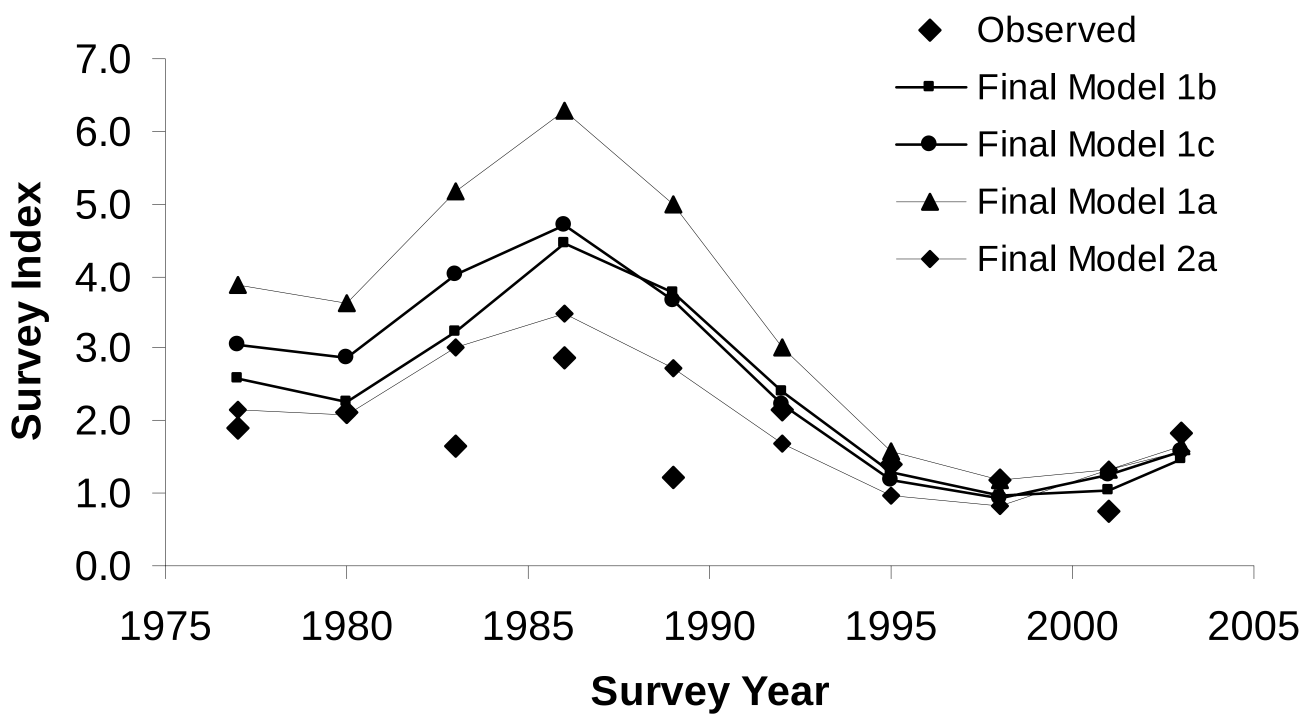


Figure 20. Q-Q plots of the Pearson residuals for the fit to the U.S (top) and Canadian (bottom) fishery age composition data for Runs 1A, 1B, 1C and 2A.



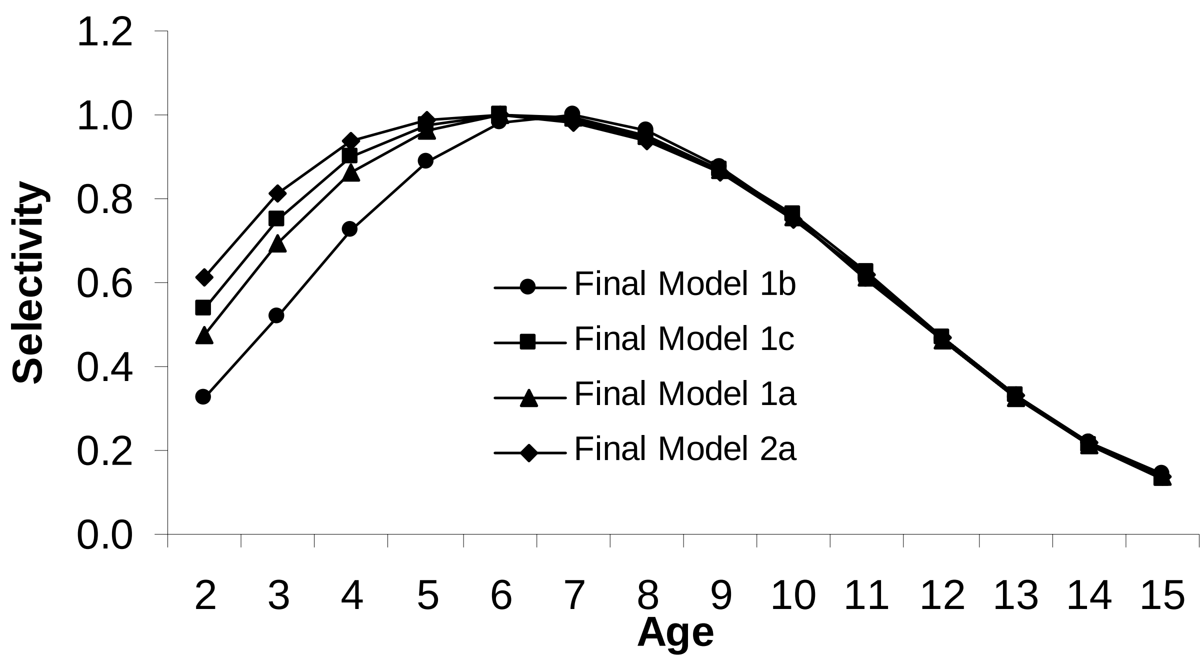
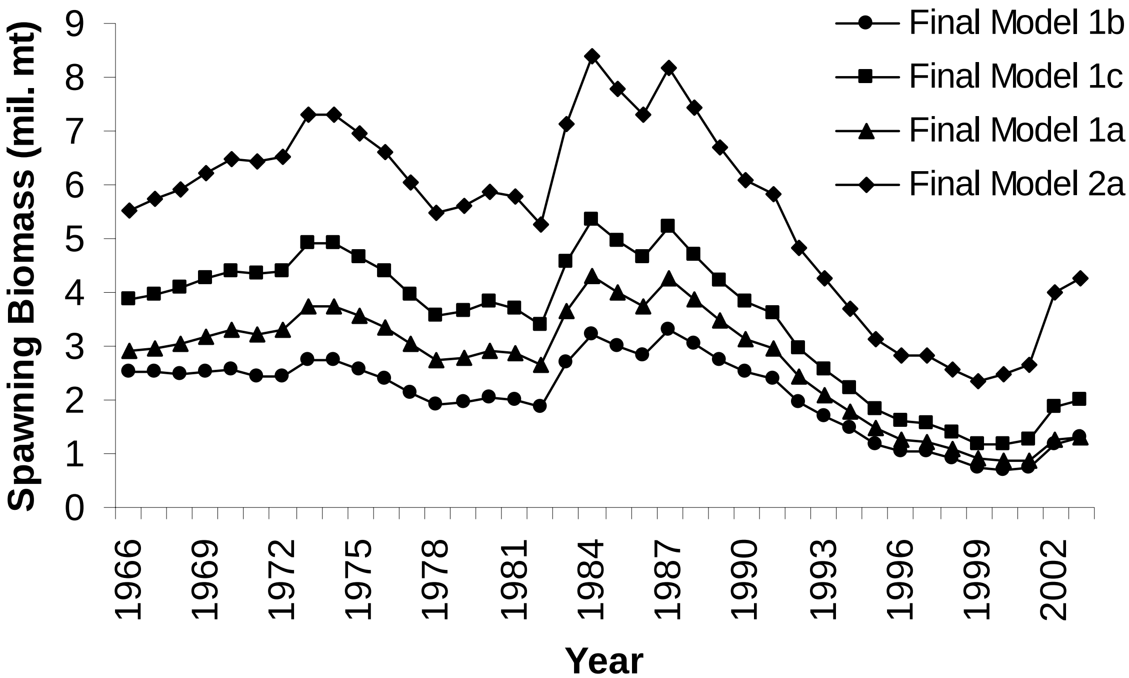


Figure 21. Comparison of acoustic survey selectivity and the fit of expected to observed acoustic survey biomass estimates, 1977-2003, among 4 final model options. See text for explanation of model options.



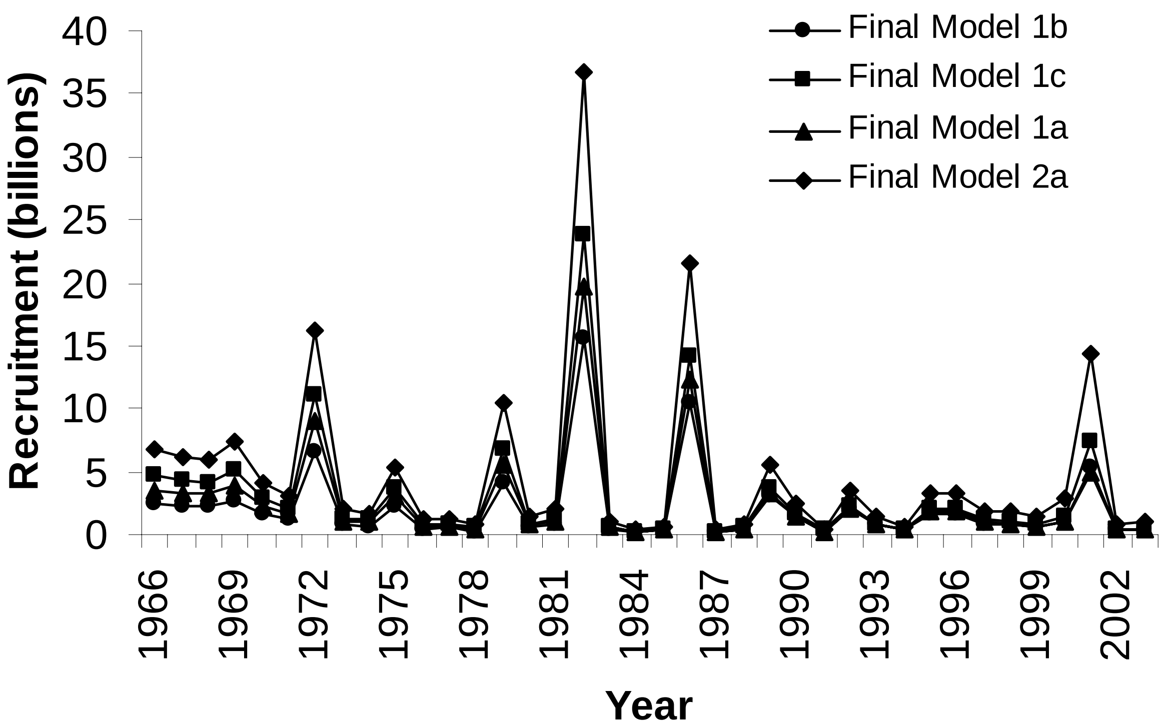


Figure 22. Estimates of Pacific hake spawning biomass and recruitment to age 2 among four different final model options. See text for explanation of different model options.

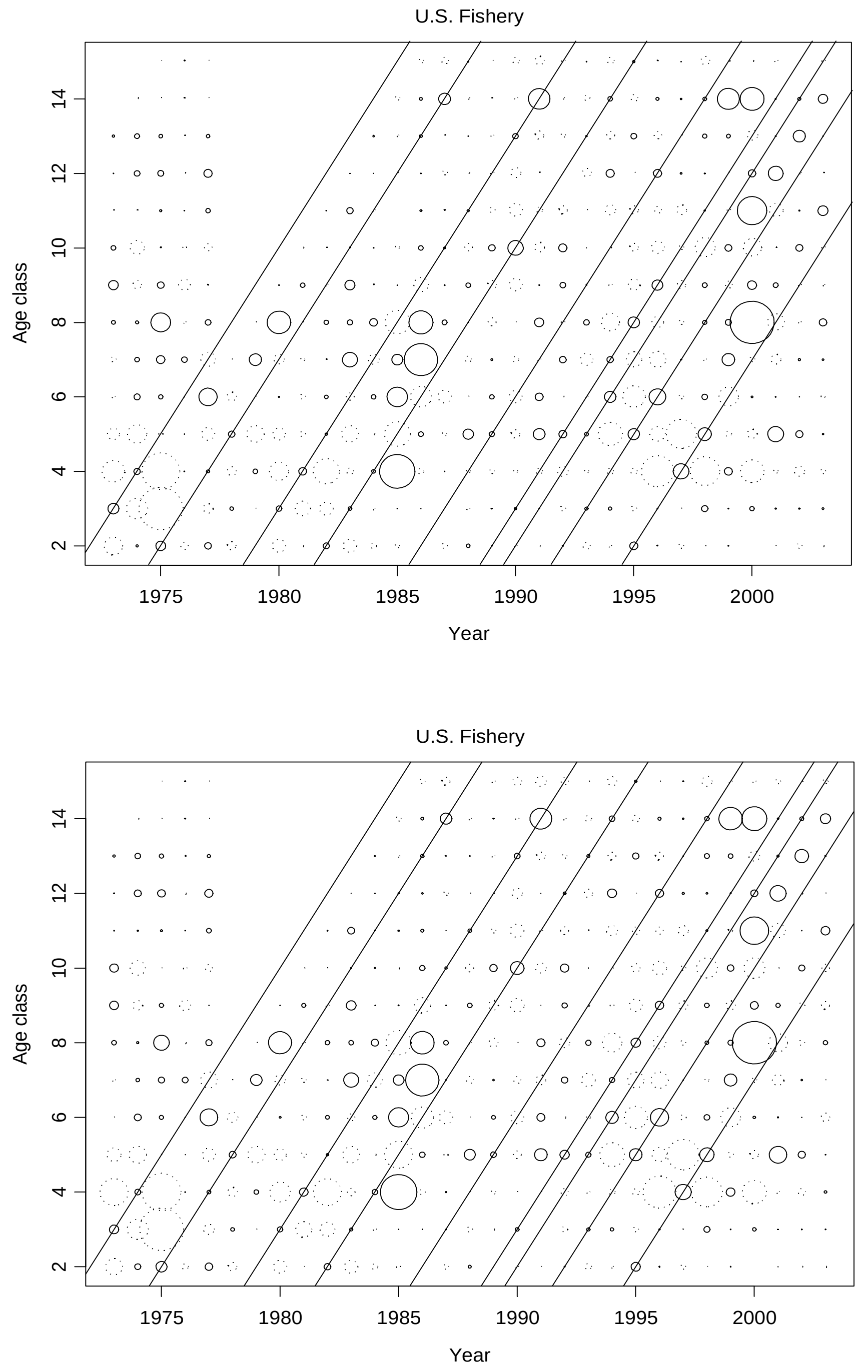
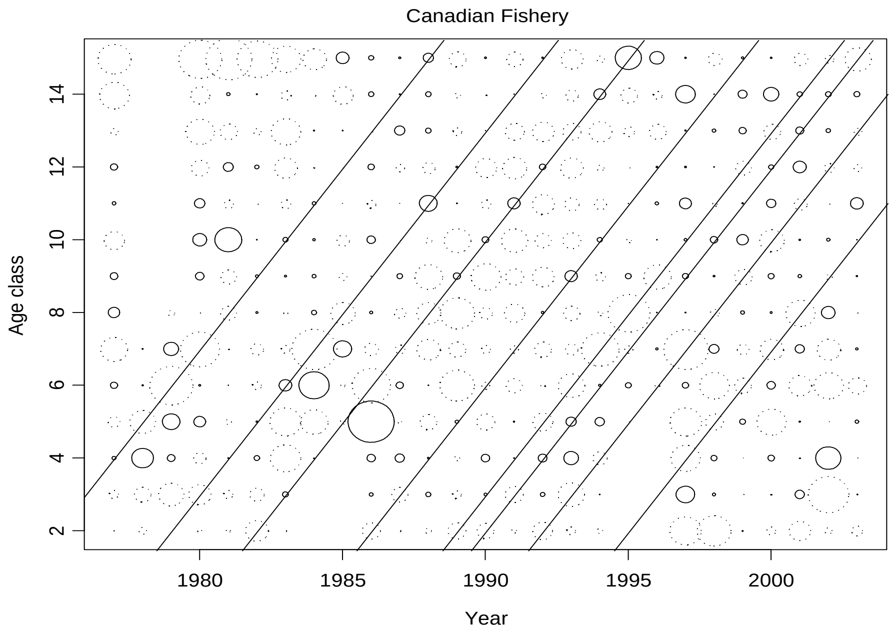


Figure 23. Pearson residuals from Final Models 1b (top panel) and 1c (bottom panel) for the U.S. fishery age composition. Circle areas are proportional to the magnitude of the residual. Circles drawn with dotted lines indicate negative residuals. The largest residual in absolute value is 3.7 for the age-2 fish in 1975. Diagonal lines show strong year classes (1970, 1973, 1977, 1980, 1984, 1988, 1990, and 1993).



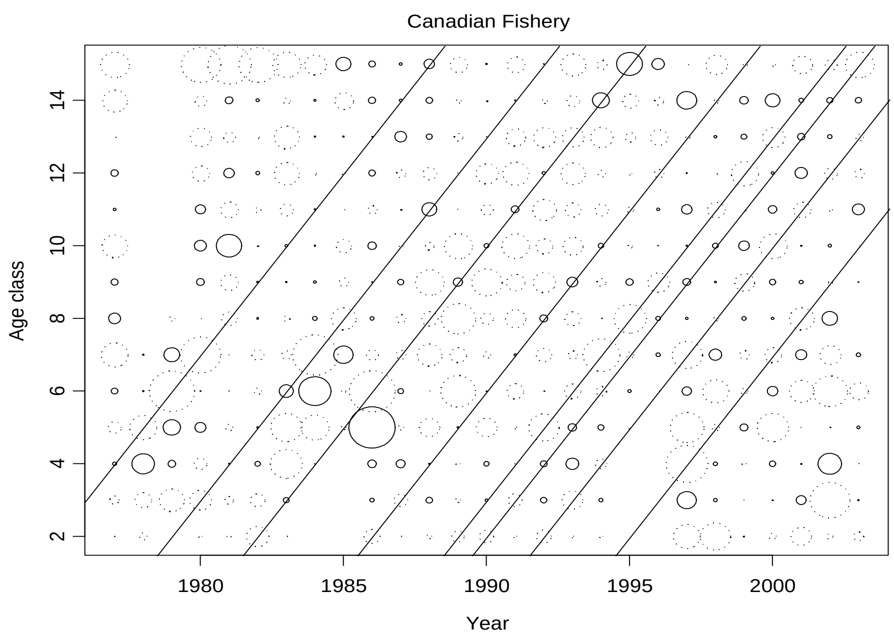
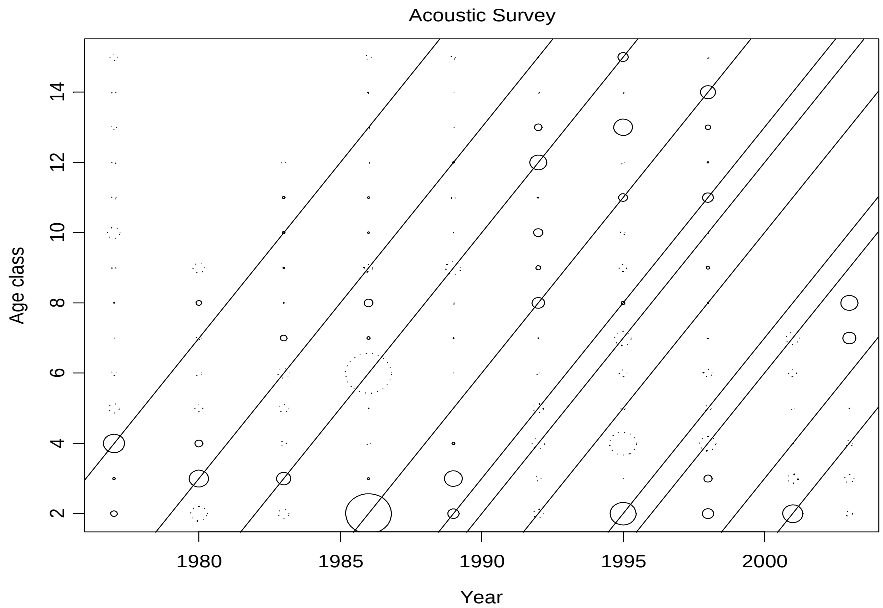


Figure 24. Pearson residuals from Final Models 1b (top panel) and 1c (bottom panel) for the Canadian fishery age composition. Circle areas are proportional to the magnitude of the residual. Circles drawn with dotted lines indicate negative residuals. The largest residual in absolute value is 5.1 for the age-5 fish in 1986. Diagonal lines show strong year classes (1973, 1977, 1980, 1984, 1987, 1988, 1990, and 1993).



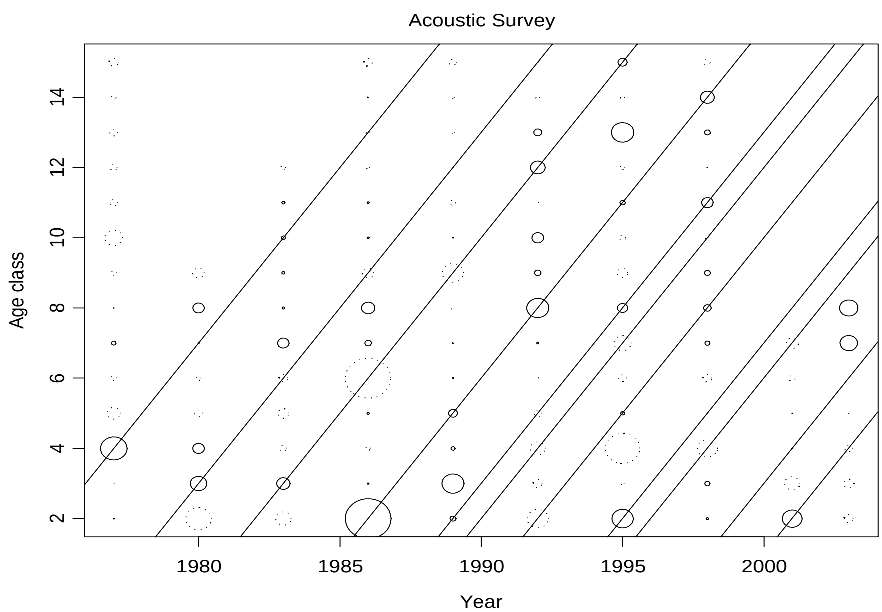
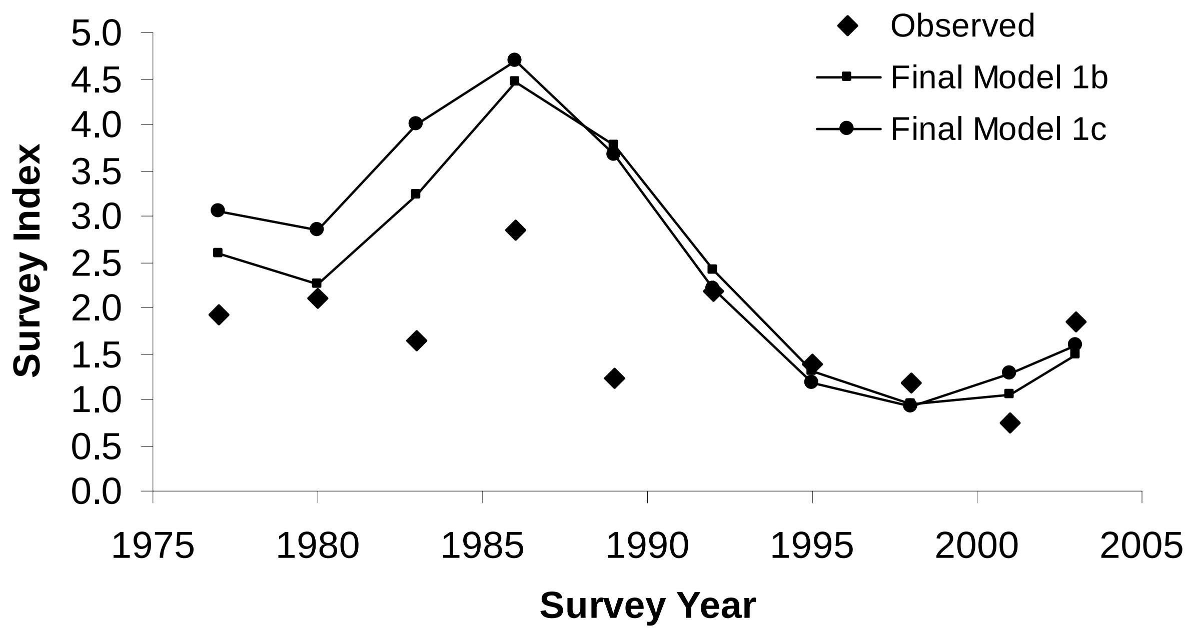


Figure 25. Pearson residuals from Final Models 1b (top panel) and 1c (bottom panel) for the acoustic survey age composition. Circle areas are proportional to the magnitude of the residual. Circles drawn with dotted lines indicate negative residuals. The largest residual in absolute value is -2.9 for the age-6 fish in 1986. Diagonal lines show strong year classes (1973, 1977, 1980, 1984, 1988, 1990, and 1993).



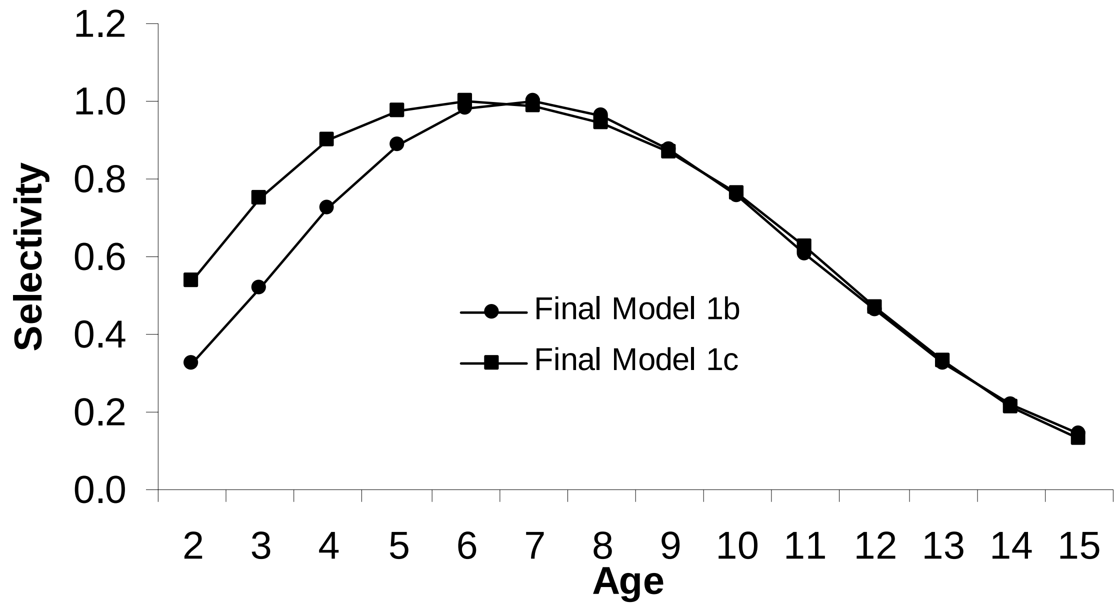


Figure 26. Fit of the expected to observed (revised 1977-1992 year-specific expansion factors) acoustic survey biomass and acoustic survey selectivity from final models 1b and 1c. See text for description of model configurations.

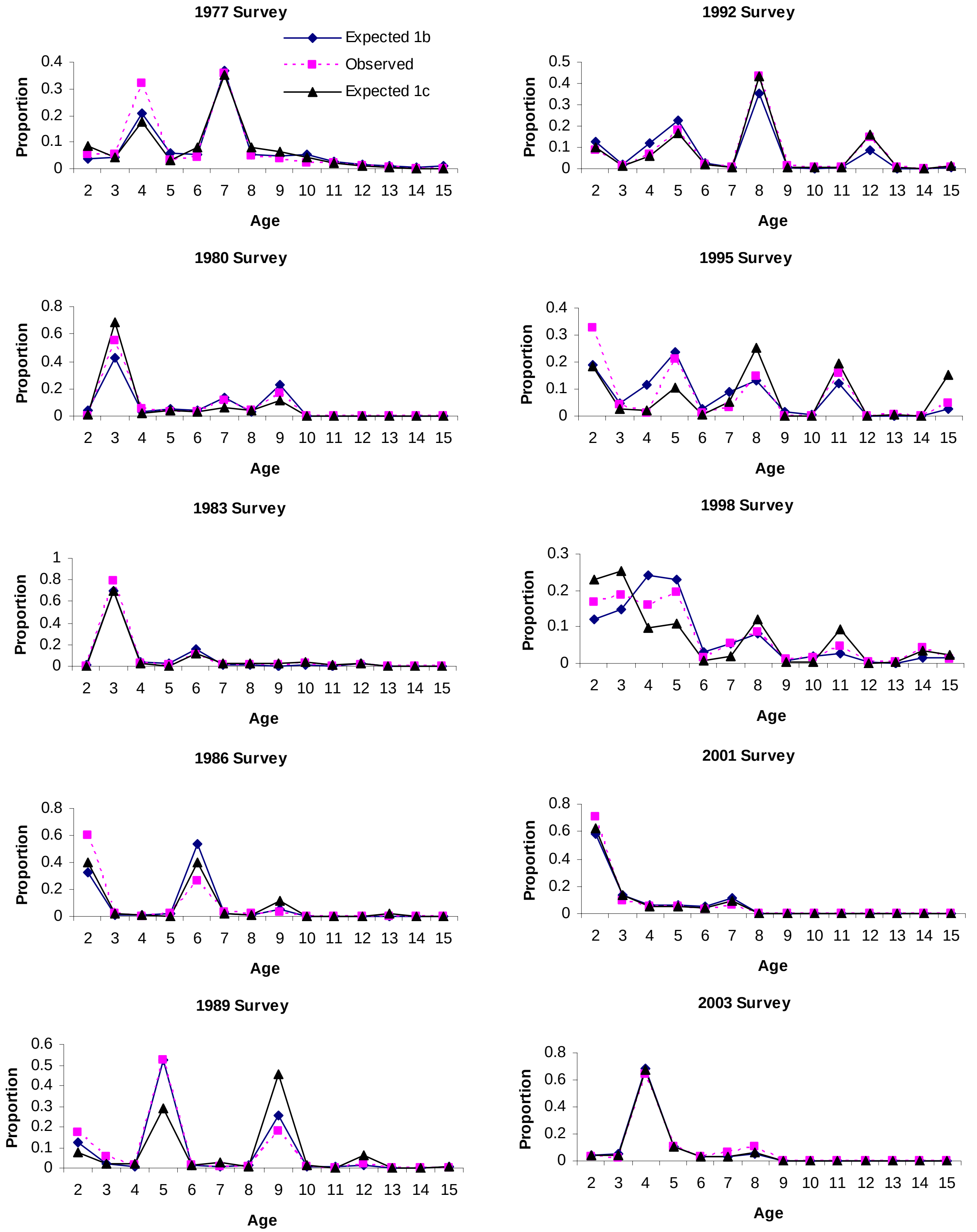


Figure 22. Fit of the expected to the observed acoustic survey age compositions, 1977-2003, for Final Models 1b and 1c (See text for description of model configuration).

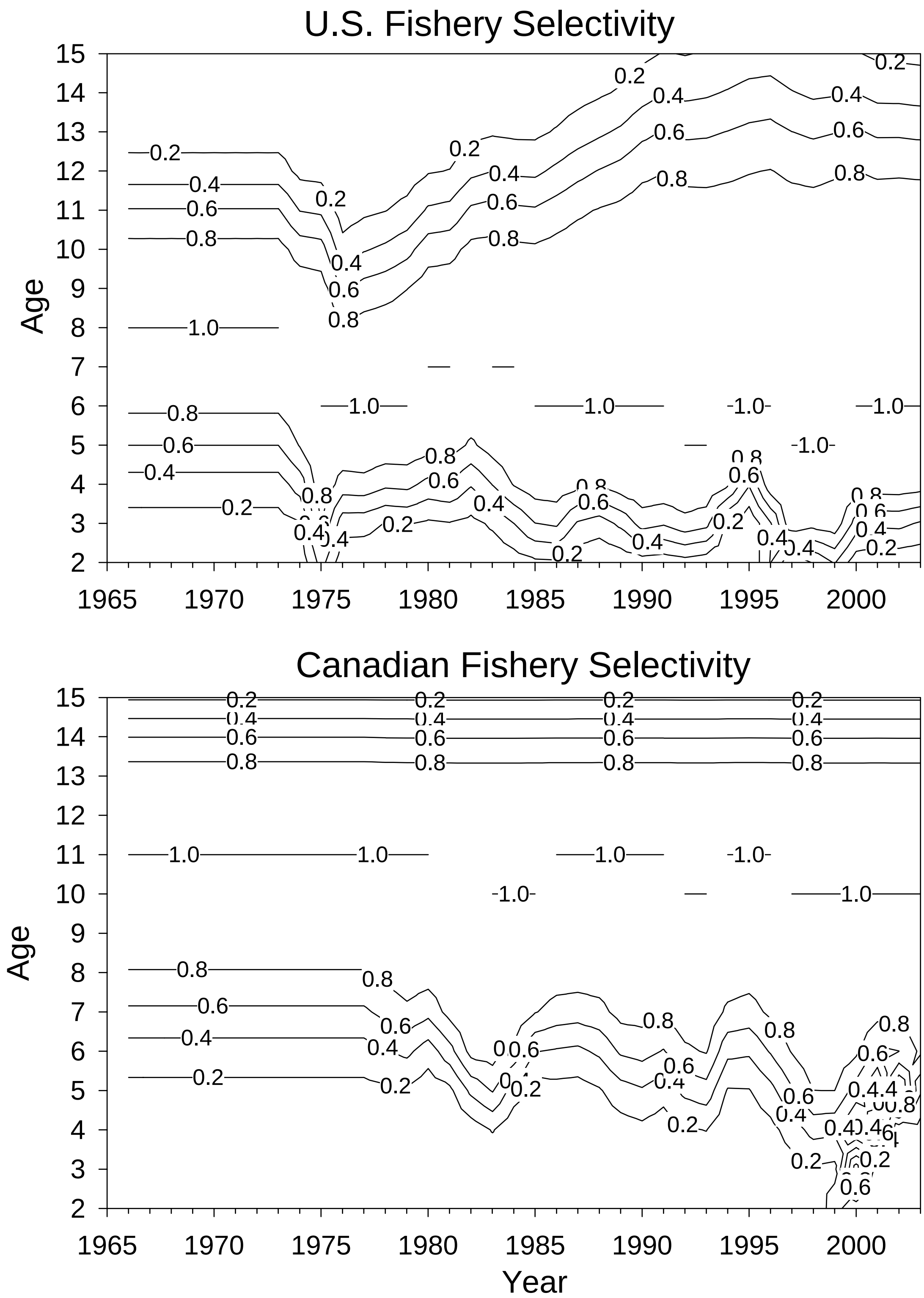


Figure 27. Contour plot showing annual changes in the U.S. and Canadian fishery selectivity at age estimated by Final Model 1b (Fishery selectivity from Final model 1c is qualitatively similar and not shown). Time varying selectivity was estimated using a random walk process error for parameters associated with both the ascending and descending limb of the selectivity function in the U.S. fishery. In the Canadian fishery annual variation was assumed for only the ascending portion of the double logistic function.

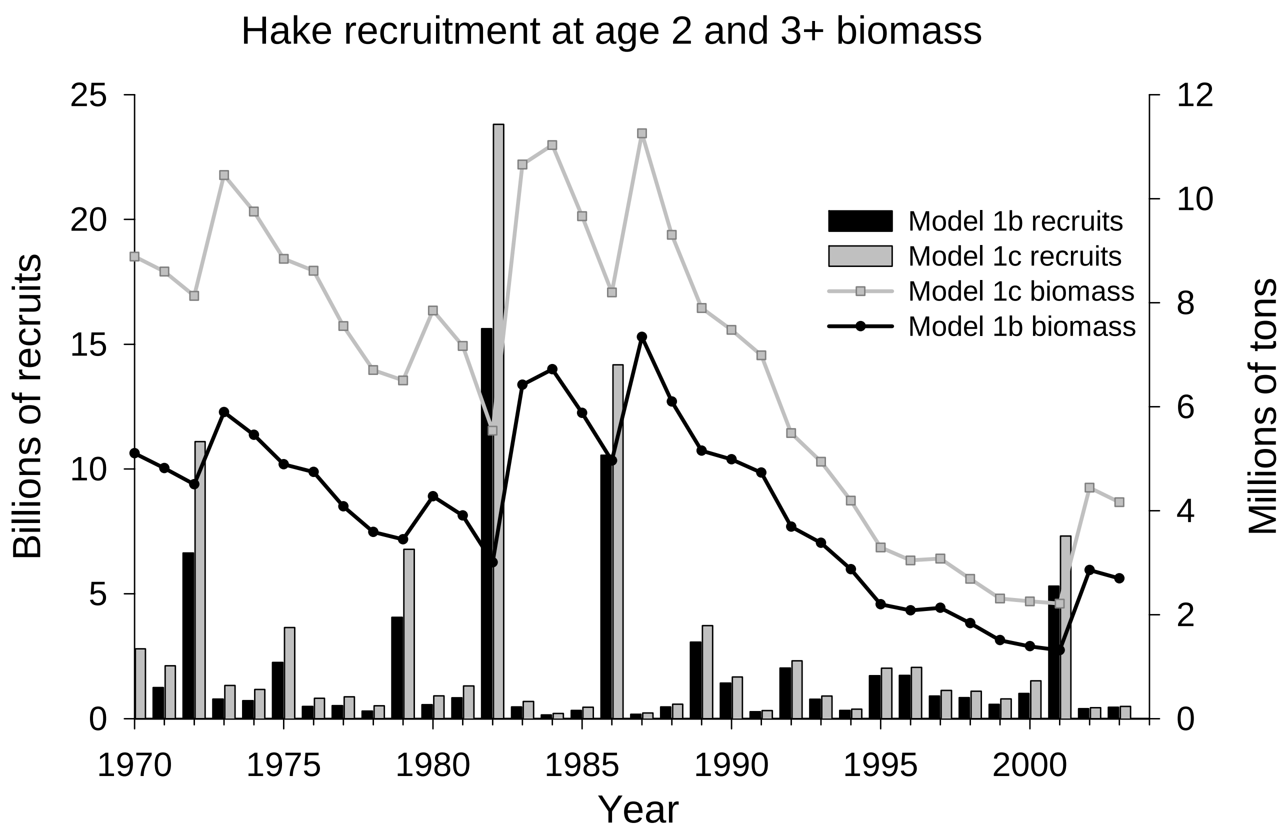


Figure 28. Estimated time series of Pacific hake age 3+ biomass (million mt) and age-2 recruitment (billions of fish) during 1966-2003 from Final Models 1b and 1c (See text for description of model configurations).

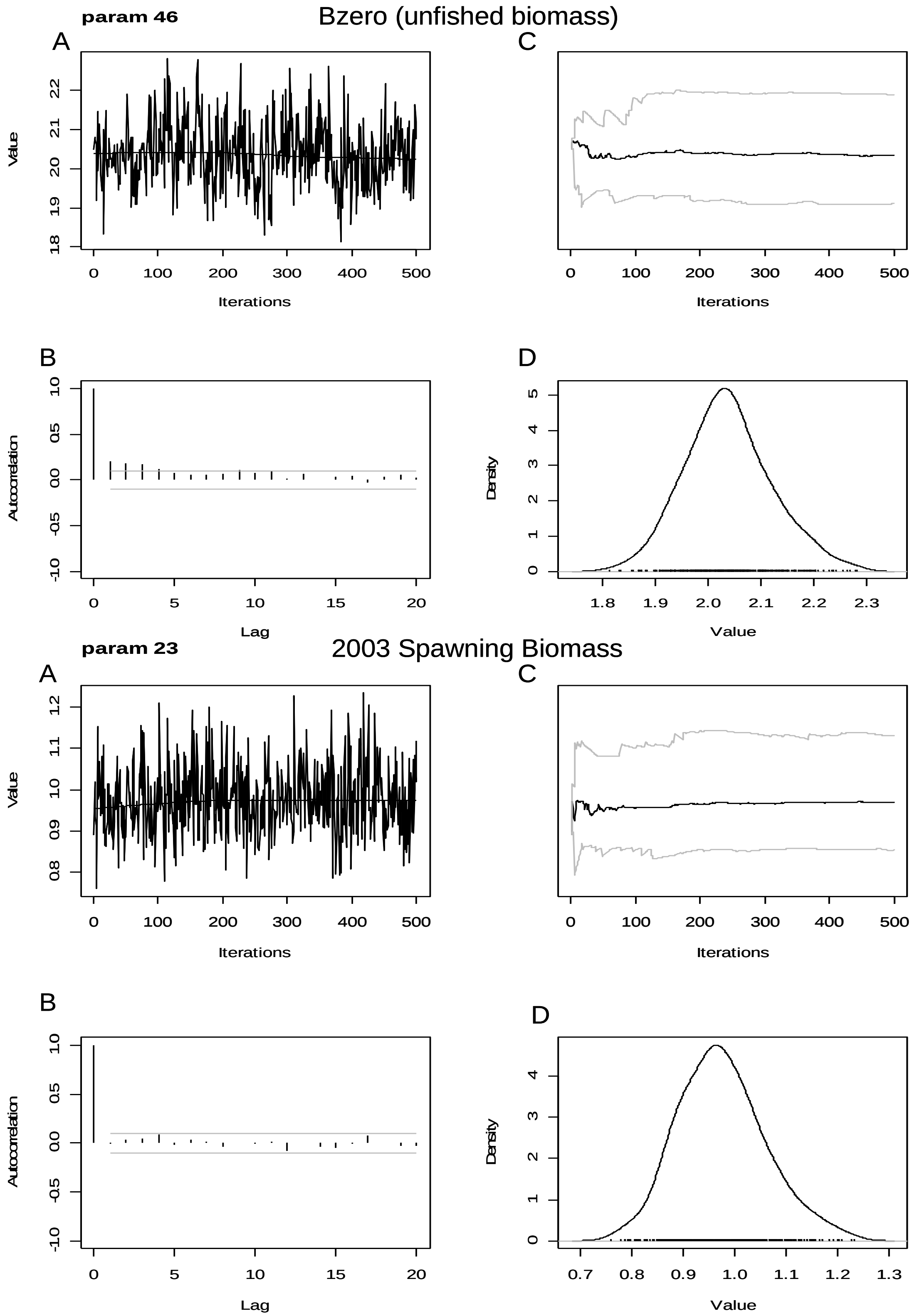


Figure 29. Results of Markov Chain Monte Carlo simulation diagnostics for selected parameters, Bzero (top) and spawning biomass (bottom), from Final Model 1b showing: A) trace plots (with running average), B) chain sequence autocorrelation, C) 5%, 50% and 95% of the chain sequence, and D) kernel density. MCMC diagnostics were qualitatively similar for Final Model 1c and are not shown.

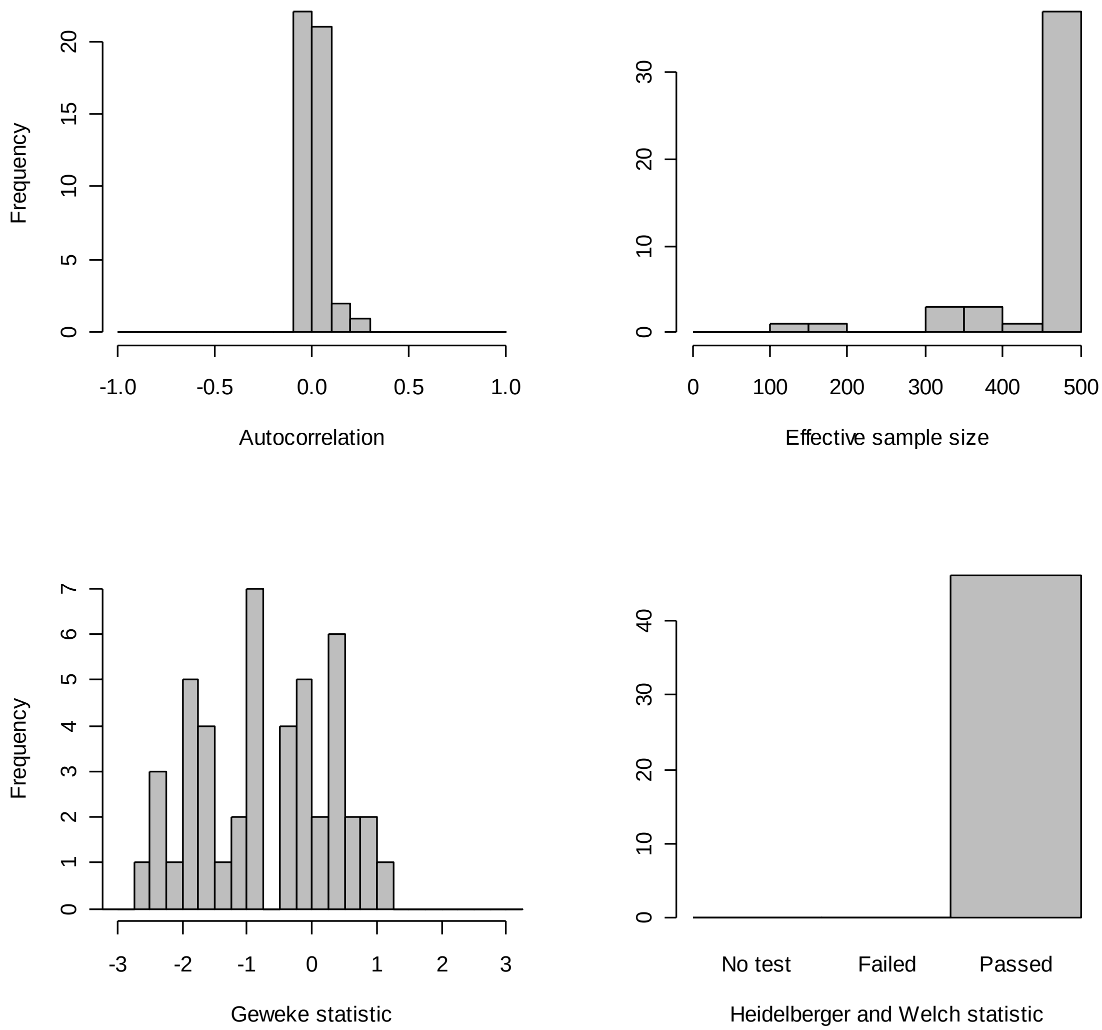


Figure 30. Summary diagnostics for 46 parameters from Final Model 1b based on 1,000 draws (after discarding first 20% of samples and thinned at every 1000th sample) from the Markov Chain Monte Carlo simulation of the posterior distribution. Plots shown are autocorrelation, effective sample size (x10), Geweke statistics of convergence of the mean (should be < |2|), and Heidelberger and Welch statistic. MCMC diagnostics were qualitatively similar for Final Model 1c and are not shown.

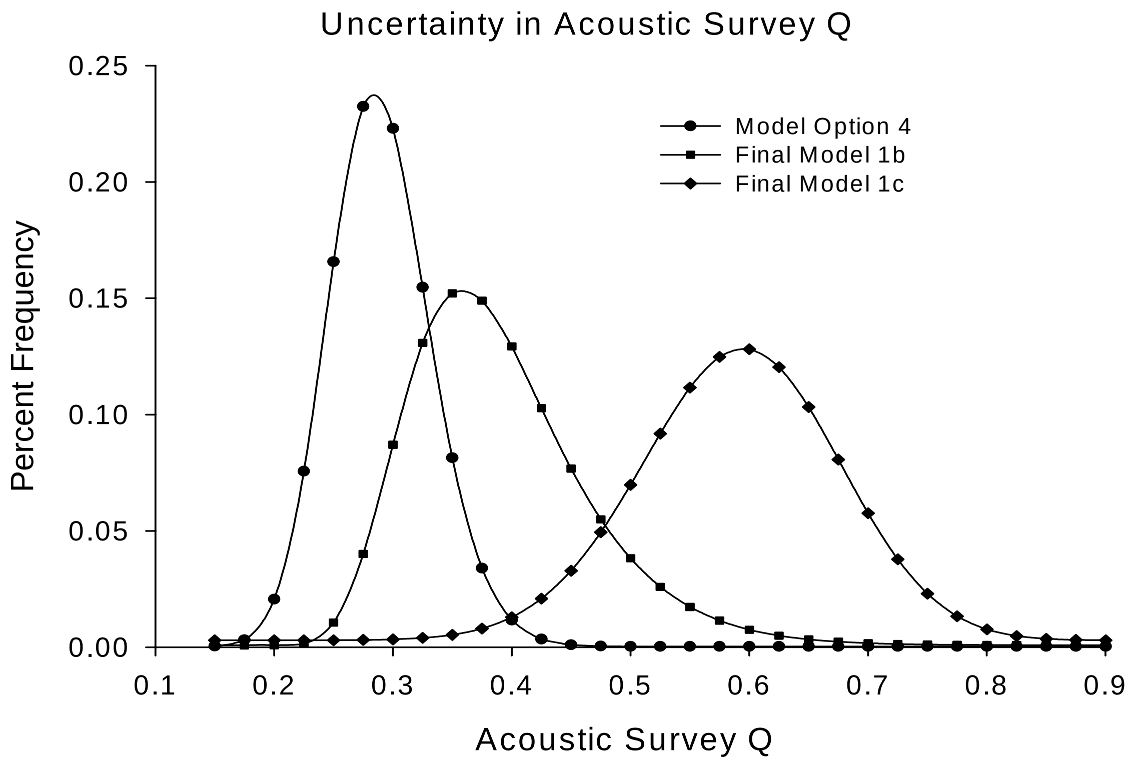


Figure 31. Uncertainty in acoustic survey catchability (q) for Model Option 4 and Final Models 1b and 1c from 2,500,000 MCMC samples.

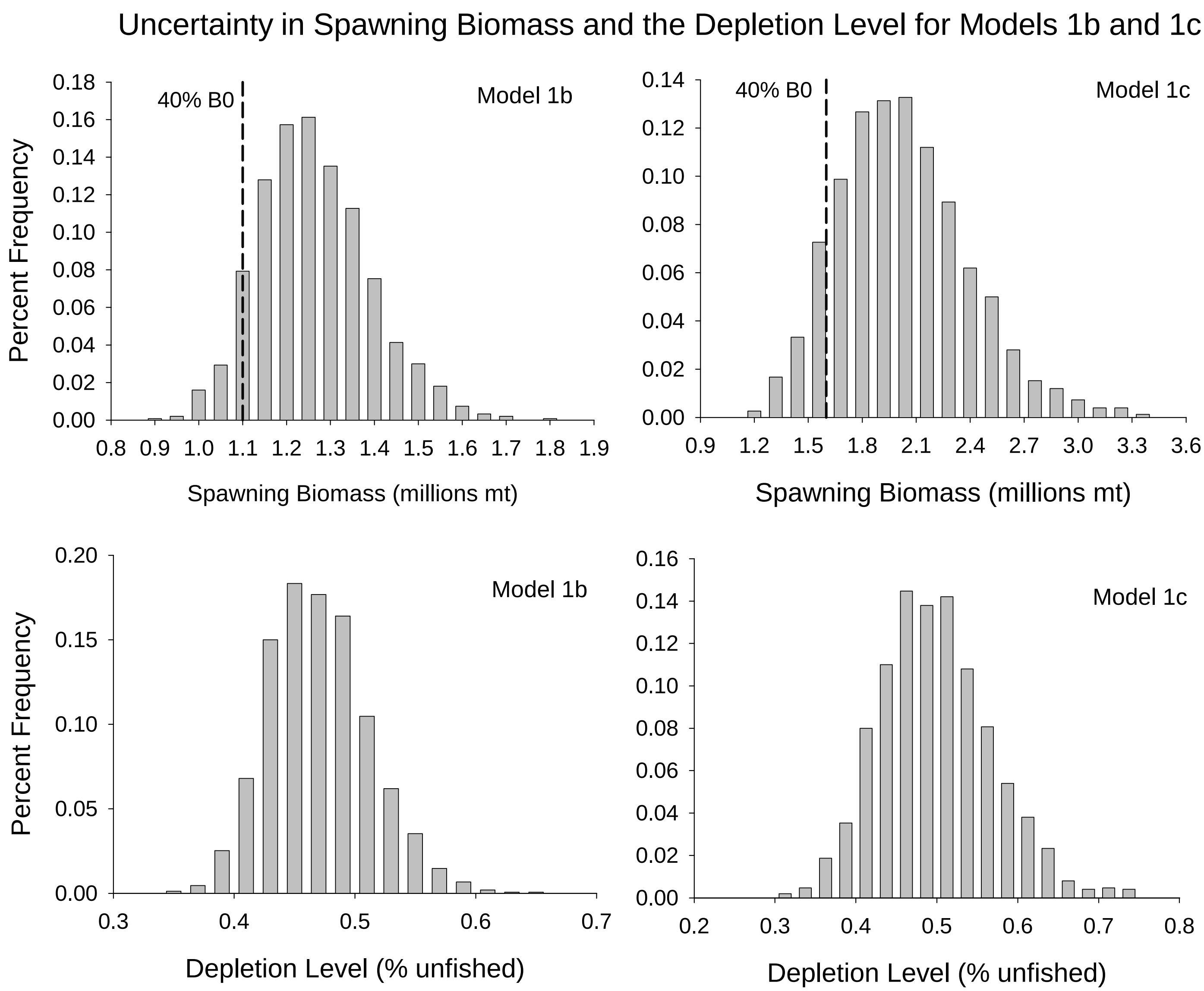


Figure 32. Uncertainty in the 2003 female spawning biomass and the corresponding depletion rate (% unfished biomass) for the Final Models 1b and 1c as shown by marginal posterior distributions based on 2,500,000 Markov Chain Monte Carlo samples.

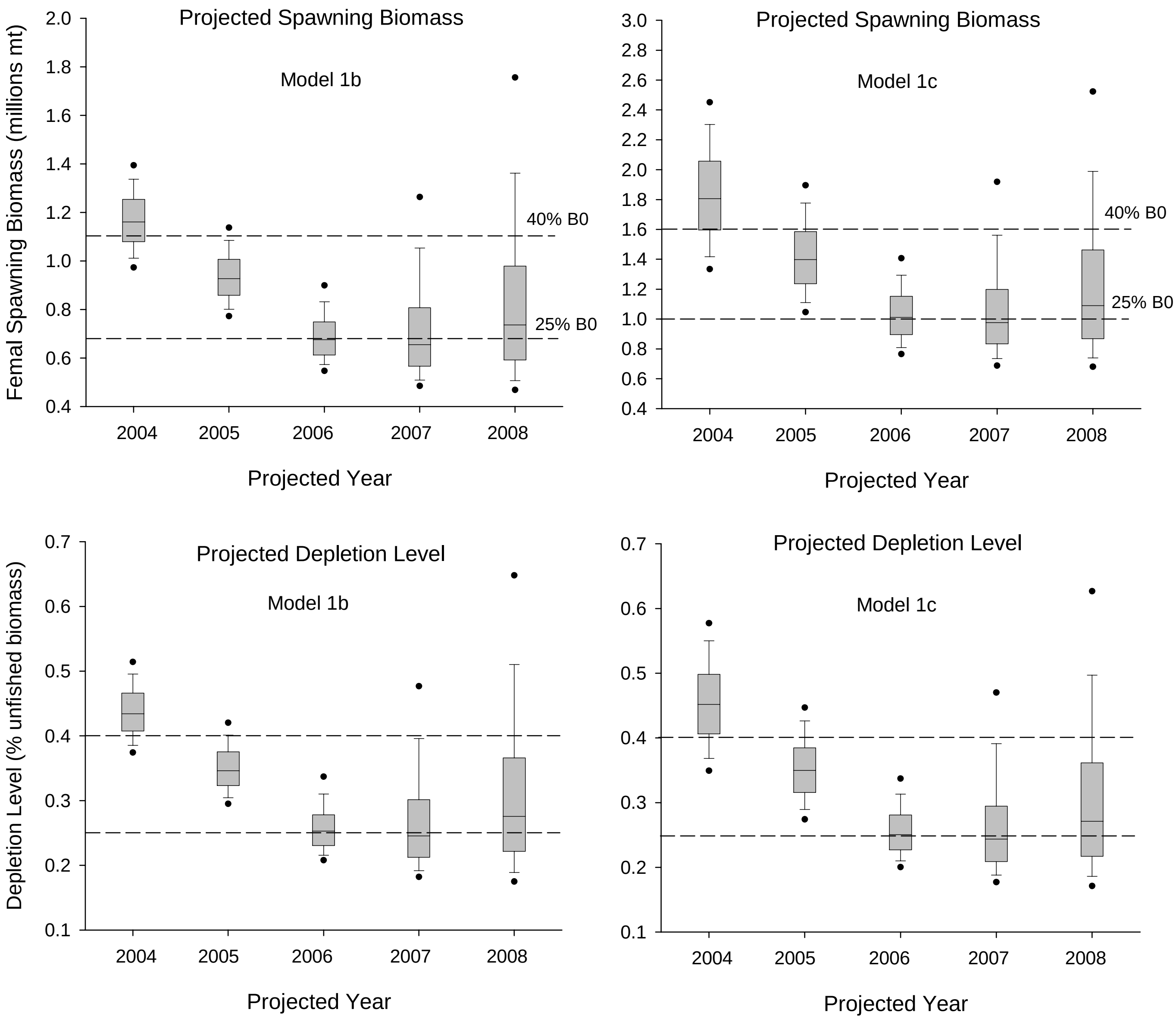


Figure 33. Uncertainty in projected 2004-2008 female spawning biomass and the depletion level (% unfished biomass) under the F40% (40-10) harvest rate policy from Final models 1b and 1c. Boxplots shown are based on 2,500,000 Markov Chain Monte Carlo samples. Table 14 provides projection results from F45% (40-10) and F50% (40-10) harvest rate policies.

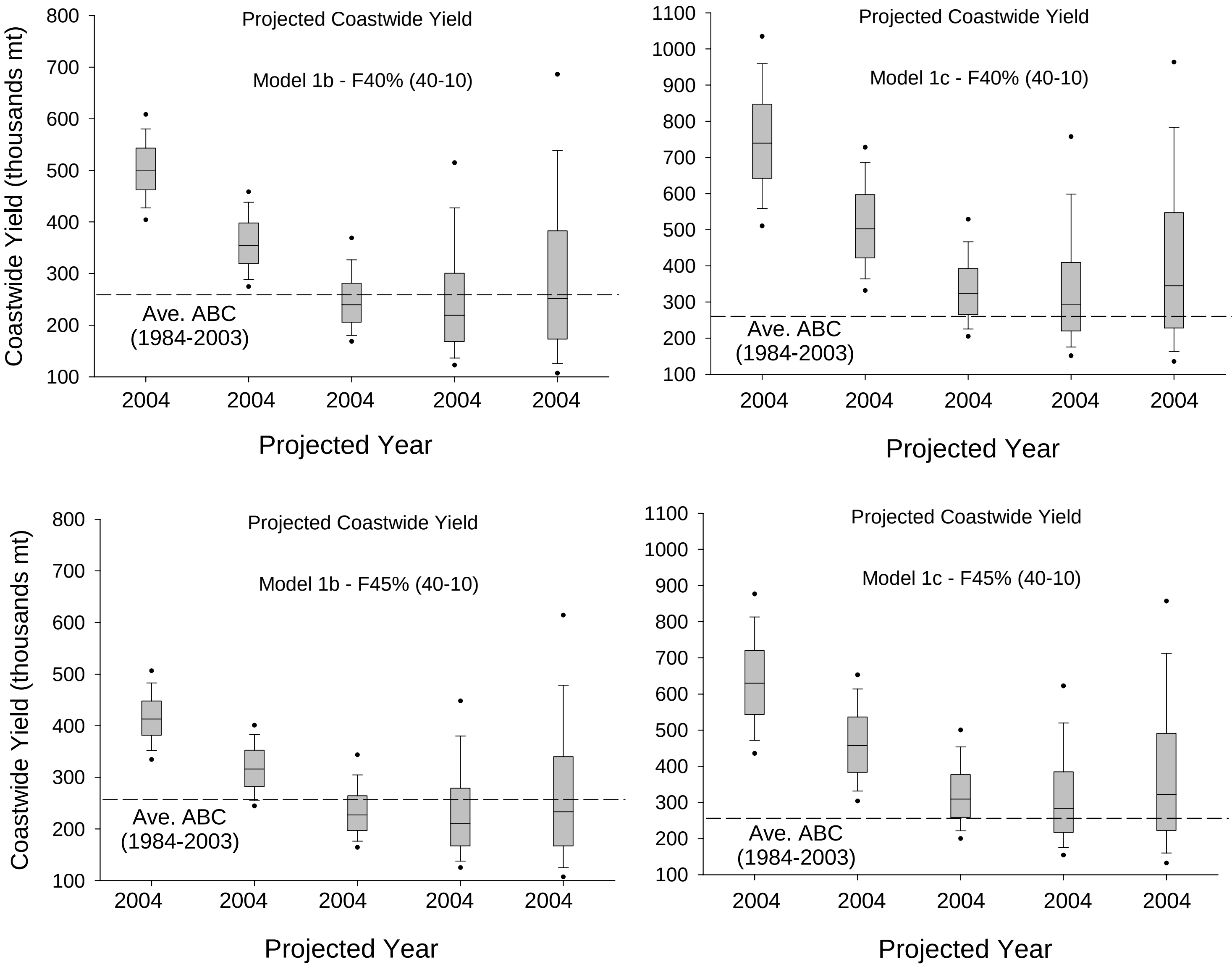


Figure 34. Uncertainty in projected 2004-2008 coastwide yield under the F40% (40-10) and F45% (40-10) harvest rate policies for Final Models 1b and 1c. Boxplots shown are based on based on 2,500,000 Markov Chain Monte Carlo samples.

APPENDIX 1: REVISED EXPANSION FACTOR CALCULATION AND APPLICATION

A. Biomass by region (from Dorn) -35db/kg

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989	1992
Mont.	1	108.087	579.841	56.203	770.292	209.437	
Eureka	2	360.944	182.783	252.265	192.205	360.454	
S. Col.	3	274.138	82.113	303.477	273.846	303.690	
N.C / Van.	4	194.741	338.295	330.198	367.099	254.378	
Canada	5	191.382	162.402	258.725	284.316	104.603	
	Total	1129.292	1345.434	1200.868	1887.758	1232.562	2577.615
	Inshore limit	91 m	55 m	55 m	55 m	55 m	
	Offshore limit	457 m	457 m	366 m	366 m	366 m	
	Northern limit	50 N	50 N	49.5 N	49.5 N	50 N	51.7 N
	Survey used	1995	1995	1998	1995	2001	1998

B. 1992 deep water expansion factors by region

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989
Mont.	1	1.82	1.82	2.02	2.02	2.02
Eureka	2	3.32	3.32	4.71	4.71	4.71
S. Col.	3	1.45	1.45	1.77	1.77	1.77
N. C/Van.	4	1.35	1.35	1.41	1.41	1.41
Canada	5	1.55	1.55	1.26	1.26	1.68

1995 deep water expansion factors by region

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989
Mont.	1	2.40	2.40	3.53	3.53	3.53
Eureka	2	3.39	3.39	3.87	3.87	3.87
S. Col.	3	1.86	1.86	2.05	2.05	2.05
N. C/Van.	4	1.20	1.20	1.24	1.24	1.24
Canada	5	1.59	1.59	1.33	1.33	1.92

1998 deep water expansion factors by region

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989
Mont.	1	1.16	1.16	1.28	1.28	1.28
Eureka	2	1.57	1.57	2.10	2.10	2.10
S. Col.	3	1.55	1.55	1.95	1.95	1.95
N. C/Van.	4	1.23	1.23	1.26	1.26	1.26
Canada	5	1.24	1.24	1.29	1.29	1.95

2001 deep water expansion factors by region

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989
Mont.	1	2.10	2.10	2.54	2.54	2.54
Eureka	2	2.04	2.04	2.29	2.29	2.29
S. Col.	3	1.11	1.11	1.14	1.14	1.14
N. C/Van.	4	1.00	1.00	1.00	1.00	1.00
Canada	5	1.00	1.00	1.00	1.00	1.00

C. Average deep water expansion factors by region

Strata	Strata No.	Survey Year 1977	1980	1983	1986	1989
Mont.	1	1.87	1.87	2.34	2.34	2.34
Eureka	2	2.58	2.58	3.24	3.24	3.24
S. Col.	3	1.49	1.49	1.73	1.73	1.73
N. C/Van.	4	1.20	1.20	1.23	1.23	1.23
Canada	5	1.35	1.35	1.22	1.22	1.64

D. Total acoustic backscattering cross section

Strata	Strata No.	1977	1980	1983	1986	1989
				Survey Year		
Mont.	1	804125	4313790	523778	7178661	1951828
Eureka	2	3704827	1876134	3254209	2479437	4649843
S. Col.	3	1627766	487567	2085702	1882058	2087166
N.C / Van.	4	925835	1608318	1612517	1792723	1242251
Canada	5	1024075	869005	1255760	1379970	681450

E. Mean acoustic backscatter per fish at 20 log L - 68

Strata	Strata No.	1977	1980	1983	1986	1989
			Survey Year			
Mont.	1	0.003756	0.003242	0.002673	0.002418	0.003405
Eureka	2	0.004146	0.003675	0.002662	0.003914	0.003520
S. Col.	3	0.004780	0.004824	0.002939	0.003238	0.003940
N. C/Van.	4	0.005318	0.005450	0.003469	0.003923	0.004108
Canada	5	0.006021	0.006011	0.004686	0.004560	0.004306

F. Total numbers of fish at 20 log L - 68

Strata	Strata No.	1977	1980	1983	1986	1989
			Survey Year			
Mont.	1	214083499	1330518547	195967560	2968869791	573140560
Eureka	2	893591551	510514894	1222263772	633404855	1321119034
S. Col.	3	340553090	101070657	709724996	581202708	529792311
N. C/Van.	4	174106292	295090548	464839305	456936452	302364752
Canada	5	170082952	144558788	268005234	302597273	158242442

G. Northern expansion factors by survey year.

	1995 Survey Year				1998 Survey Year			
Age	Total	>49.5 deg N	ratio	smoothed	Total	>49.5 deg N	ratio	smoothed
2	152.77	0.00	1.00	1.04	78.47	0.28	1.00	1.00
3	34.79	2.56	1.08	1.10	159.74	7.47	1.05	1.12
4	207.18	37.90	1.22	1.17	205.54	52.74	1.35	1.25
5	482.16	73.50	1.18	1.23	257.17	47.28	1.23	1.33
6	57.50	7.31	1.15	1.27	20.24	5.50	1.37	1.43
7	21.87	12.85	2.42	1.32	87.88	43.96	2.00	1.52
8	1108.29	264.65	1.31	1.36	135.43	33.04	1.32	1.55
9	33.26	18.79	2.30	1.43	16.85	4.43	1.36	1.60
10+	448.06	146.50	1.49	1.49	226.47	92.69	1.69	1.64

	2001 Survey Year				Years
Age	Total	>49.5 deg N	ratio	smoothed	Averaged
2	367.73	0.00	1.00	1.02	1.03
3	77.82	0.13	1.00	1.05	1.10
4	60.96	19.41	1.47	1.08	1.18
5	72.83	3.83	1.06	1.10	1.24
6	38.59	1.29	1.03	1.10	1.29
7	43.42	2.46	1.06	1.09	1.35
8	24.72	3.09	1.14	1.09	1.39
9	15.31	0.87	1.06	1.09	1.45
10+	33.17	2.68	1.09	1.09	1.51

H. Example worksheet for northern biomass expansions based on average ratios.

	Stratum No.						Mean		Average	Expanded
AGE	1	2	3	4	5	Total	Weight	Biomass	Ratio	Biomass
2	0	0	0	816736	192687	1009423	0.271	273345	1.026	280430.935
3	188583025	1192297408	670366901	362324677	53610890	2467182901	0.325	802722741	1.103	885730104
4	1621952	20995523	6102971	5960324	5728096	40408865	0.394	15909804	1.181	18787734
5	547115	690990	2221568	5879468	6050080	15389219	0.472	7259236	1.244	9027992.87
6	3755544	4304632	20335634	57409094	123745065	209549968	0.641	134358596	1.292	173617662
7	286414	374654	1831111	6093108	13209532	21794819	0.674	14689196	1.347	19791909.7
8	351480	1128301	1603756	6286885	14369096	23739519	0.775	18391170	1.387	25512742
9	241900	209373	1144396	5833438	10507331	17936438	0.798	14313051	1.450	20750145.1
10	215313	1176283	4030564	6919787	22096365	34438311	0.840	28926546	1.512	43744001.7
11	126197	85785	506683	1579119	5866690	8164474	0.894	7299668	1.512	11038880.7
12	184049	1000824	1200394	2638819	4567339	9591426	0.784	7516705	1.512	11367093.6
13	54572	0	381019	3024160	6517139	9976889	0.862	8596829	1.512	13000505.5
14	0	0	0	73690	1544924	1618614	1.011	1636370	1.512	2474590.69
15	0	0	0	0	0	0	1.011	0	1.512	0
Total	195967560	1222263772	709724996	464839305	268005234	2860800867		1.062E+09		1235123792

STAR Panel Report on the Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003.

Overview

On February 2nd-4th a joint Canada-US Pacific Hake STAR Panel met in Seattle, WA to review the stock assessment by Helser et al (2004). The Panel operated according to terms of reference for STAR Panels, but the Panel attempted to adhere to the spirit of the Canada-US Pacific Hake treaty. Both a Panel member and advisor from Canada participated in the review (see List of Attendees). The revised stock assessment and the STAR Panel review will be forwarded to the Pacific Fishery Management Council, council advisory groups, and to Canadian DFO managers and the PSARC Groundfish Sub-committee. The STAT Team was represented at the meeting by Thomas Helser, Richard Methot and Guy Fleischer. Public questions were entertained during the meeting.

The STAR Panel members received a draft of the assessment 10 days prior to the meeting, which was sufficient time to adequately review the assessment. The meeting commenced on February 2, 2004 with introductions followed by a presentation by Guy Fleischer covering the 2003 acoustic survey. After the acoustic survey presentation, Tom Helser presented a detailed description of the stock assessment. Panel discussion continued until the meeting was adjourned February 4th, 2004.

The 2004 assessment used an age structured assessment model developed in AD Model Builder similar to Dorn et al (1998). Major differences between the 2003 assessment and the 2001 assessment included: 2003 acoustic biomass and age composition data, 2002 – 2003 fishery age composition and catch, and 2002-2003 SWFSC juvenile survey data. The initial age structure in the model was extended back from 1973 to 1966. Deep water and northern expansion factors calculated from the 1995-2001 acoustic surveys were applied to the 1977-1992 surveys to correct for restricted survey areas in those years. The new expansion factors were based on age-specific hake distribution in later surveys with adequate spatial coverage and took into account the different geographic distribution of the stock under El Nino, La Nina, and typical years.

While there is room for improvement in the assessment model, as detailed in our recommendations, the Panel generally concurred with methods used in the assessment. The STAR Panel considered the stock assessment document complete and suitable for use by the Council and advisory bodies for ABC projections. The two models carried forward for ABC projections were defined by differences in assumed acoustic survey catchability (q=0.6 and 1.0) and were intended to serve as plausible lower and upper bounds on stock status. STAR Panel voted to view both models (q=1, and 0.6) as equally likely, but the decision was a compromise, with some diversity of opinion among Panel members (see Areas of Disagreement). The STAR Panel commends the STAT team for a well-written document and especially for their cooperation in performing the many additional analyses requested during the meeting (see list of new analyses requested by the STAR Panel).

Summary of stock status

Our understanding of the level of abundance of Pacific hake was changed by this assessment, although the pattern of the stock trajectory is very similar to past assessments. The previous hake assessment in 2002, estimated spawning stock size to be at 20% of unfished in 2001. Because the stock was estimated to be below B25%, Pacific hake were declared overfished in 2001. New information in the 2003 assessment includes fishery age composition in 2002 and 2003, but more importantly, the results of the 2003 acoustic survey. The increase in biomass in the 2003 acoustic survey and the dominance of the 1999 year class in both fishery and survey data suggest that the 1999 year class is even higher than previously estimated. The revised northern expansion factors derived from surveys in 1995-2001 suggested that biomass was higher in earlier years of the modeled time period. In addition, changes in the model structure accounted for some of the estimated increase in biomass in those earlier years. These changes produced a fairly significant difference between the current assessment and previous assessments, though estimates of overall trend and current stock depletion were robust (Figure 1).

Stock size in 2003 was estimated to be 2.7 to 4.2 million t. for models with fixed acoustic survey q= 1.0 and 0.6, respectively. A q =1.0 implied that the acoustic survey produces an estimate of absolute biomass, while a q= 0.6 implied that the acoustic survey biomass estimate were on average lower than stock biomass. Both model scenarios allowed dome-shaped selectivity for the acoustic survey, thus allowing for even lower effective q levels for young and old fish.

Stock depletion in 2003 was estimated to be 47% of unfished for a model with an acoustic survey q =1.0 and 51% of unfished for a q= 0.6. Estimates of stock depletion in 2001 in the current assessment ranged from 27-31% of unfished, indicating that the stock approached, but did not drop below the B25% overfished threshold. Under both assumptions of catchability, the stock has rebuilt to levels above B40% in 2003.

Mature biomass was projected to decline from 2004 to 2007 to below 30% of unfished due to the absence of strong recruitment after the 1999 year class. A sharp increase followed by a gradual declined is a typical pattern of biomass variability for a stock with highly variable recruitment. Lower harvest rates would lessen the projected stock decline but not reverse it.

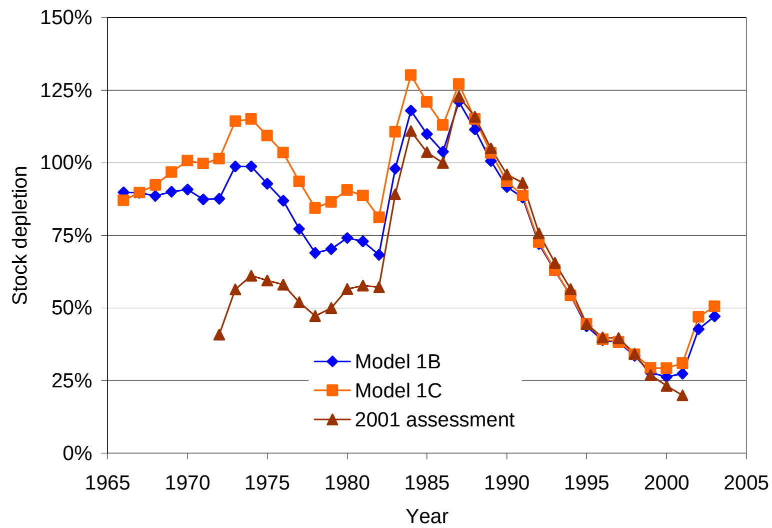


Figure 1. Estimates of stock depletion in the 2003 and 2001 Pacific hake stock assessments.

List of New Analyses Requested by the STAR Panel

A number of new analyses and model runs were requested by the STAR Panel and completed at the meeting by the STAT team. The following list describes each request, followed by the reason for the request and outcomes of the analysis.

Request: The Panel requested that the STAT team use the Jolly-Hampton method to calculate sampling CVs for the 2003 acoustic survey biomass. Reason: to get a better estimate of the sampling variability of the acoustic survey. Outcome: Post-stratification estimates of sampling CV = 0.37.

Request: The STAR Panel requested that model option 5 (from the draft assessment document) be structured to estimate acoustic survey selectivity in 3 periods. Each period grouped as years consisting of El Nino, La Nina and all other years. This model was referred to option 5a. Reason: More objective method to deal with changes in acoustic selectivity. Outcome: Small improvement in fit to acoustic age-composition from separating out only the El Nino years, but not all 3 (El Nino, La Nina and others).

Request: The STAR Panel requested that option 5 (from the draft assessment document) be structured to increase the acoustic survey CVs to 0.5 from 1977-1989 and O.1 from 1992-2003 (Model 5b). Reason: more realistic estimates of uncertainty for those early years.

Request: The STAR Panel requested that Option 5 (from the draft assessment document) be structured to increase the acoustic survey CVs to 0.5 from 1977-1989 and 0.3 from 1992-2003 (Model 5c). Reason: The assumed CVs were too small given the errors associated with survey method. Outcome: The inflated CVs were more internally consistent, as measured by mean square error in model fit to the acoustic survey.

Request: The STAR Panel requested that option 5 (from the draft assessment document) be structured to remove 1986 acoustic biomass and age composition data (Model 5d). Reason: The change in signal strength in pre- and post survey calibrations makes the 1986 estimate highly questionable and potentially biased. Outcome: Small changes to the model results.

Request: The STAR Panel requested that Option 4 (from the draft assessment document) be restructured to include a single acoustic selectivity, a biomass CV=0.5 for years 1977-1989 and CV=0.3 for years 1992-2003, and acoustic *q* estimated (model 4a). Reason: Explore the possibility of using an estimated acoustic *q* instead of fixed. Outcome: the estimates of *q* are low, but the fit to the survey are better.

Request: The STAR Panel requested that Option 4 (from the draft assessment document) be structured to remove 1986 acoustic biomass and age compositions (Model 4b). Reason: Calibration problems in the acoustic gear make the 1986 estimate potentially biased. Outcome: the estimate for q was slightly higher than for Model 4a, but was still unrealistically low.

Request: The STAR Panel requested that Option 4 (from the draft assessment document) be structured to estimate acoustic *q*, assume full selectivity for all ages, and remove survey age composition data and, the 1986 acoustic survey biomass. Reason: The age-composition of the acoustic survey may not be representative of the acoustic gear. Outcome: the estimate for q dropped relative to Model 4b and the overall fit to the data deteriorated.

Request: The STAR Panel requested that Option 4 (from the draft assessment document) be structured to assign effective sample sizes to the US fishery age composition = 400 (Model 6a). Reason: Increasing the effective weight on the age compositions was done to determine if that resulted in a directional movement of the standard deviation of the standardized residuals. Outcome: Increasing the effective sample sizes resulted in an increase in the standardized residuals and the STAR Panel agreed to adjust the effective weights on the other age composition datasets.

Request: The STAR Panel requested that Option 4 (from the draft assessment document) be structured to replace the random walk in the fishery age selectivity with 3 periods of constant selectivity (1966-79, 80-89, and 90-2003) based on changes in the fishery. Reason: To determine if a reduction in the number of parameters resulted in degradation in fits to the age-composition data. Outcome: Problems arose in the age-composition fits when the random walk was removed that were deemed unacceptable.

Request: The STAR Panel requested a model structured (model 1a) as acoustic survey *q*=1, adjust input variances in the model to be consistent for all age compositions (300 US and 130 Canada commercial fisheries and 60 for acoustic), survey acoustic biomass CV= 0.5 (1977-1989) and CV=0.3 (1992-2003), random walk in commercial fisheries selectivity and remove the 1986 acoustic data (biomass and age composition). The SWFSC midwater juvenile survey CV=1.1. Reason: The STAR Panel wished to produce an internally consistent model based on the weightings that preserved the historical use of acoustic *q* =1, and assigned realistic CVs to both the acoustic biomass estimates and the SWFSC juvenile index. Outcome: this model did not provide good fits to the 1977-1989 survey biomass estimates.

Request: The STAR Panel requested a model structured (model 1b) as model 1a but with CV= 0.2 (1977-1989) and CV=0.1 (1992-2003). Reason: The STAR Panel wished to produce an internally consistent model based on the weightings that preserved the historical use of acoustic *q* =1, with lower CVs on the acoustic biomass series so that the model would follow the same trend as the acoustic biomass estimates. Outcome: this model provided the best fits to the survey acoustic biomass indices with the q=1 assumption.

Request: The STAR Panel requested a model structured (model 2a) to estimate acoustic *q*, acoustic biomass CV=0.5 (1977-1989) and CV=0.3 (1992-2003), remove 1986 acoustic data (biomass and age composition), the acoustic survey age composition is decoupled from the survey biomass and a uniform selectivity is imposed on the acoustic survey. The SWFSC midwater juvenile survey CV=1.1. Reason: The STAR Panel wished to produce an internally consistent model based on the weightings that estimated *q*, and gave realistic CV to the acoustic biomass. Outcome: The estimate of acoustic survey was *q* =0.28, which was considered implausible by the Panel

Request: The STAR Panel requested a change to the above request that structured the model (Model 2b) to estimate acoustic *q*, acoustic biomass CV=0.5 (1977-1989) and CV=0.3 (1992-2003), remove 1986 acoustic data (biomass and age composition), the acoustic survey age composition was removed and a uniform selectivity is imposed on the acoustic survey. The SWFSC midwater juvenile survey CV=1.1. Reason: The STAR Panel wished to produce an internally consistent model based on the weightings that estimated *q*, and gave realistic CV to the acoustic biomass but without the acoustic age composition data. Outcome: The estimate of acoustic survey was *q* =0.21, and that was agreed upon by all participants as unrealistically low.

Request: The STAR Panel requested a model with acoustic survey *q* =0.6(model 1c), tune the input variances in the model to be consistent for all age compositions (300 US and 130 Canada commercial fisheries and 60 for acoustic), and survey acoustic biomass CV= 0.5 (1977-1989) and CV=0.3 (1992-2003), random walk in commercial fisheries selectivity and remove the 1986 acoustic data (biomass and age composition). The SWFSC midwater juvenile survey CV=1.1. Reason: Establish a upper bound of stock status. Outcome: This run provided improved fit to the acoustic biomass survey indices.

Request: Panel and STAT team agree to use Model 1b and 1c to provide a range bounding the knowledge of stock status.

Request: The Panel requests the STAT team do projections using MCMC output from both Model 1b and 1c using both F40% and F45% harvest rates.

Request: The Panel requested that the STAT team provide a decision table using the different Models as states of nature and the F40% and F45% harvest rates as management decisions.

Request: The STAR Panel requested that standard deviation of the standardized residuals be calculated for each data source. Reason: A diagnostic of model fit.

Technical merits and deficiencies

Acoustic survey

The acoustic-trawl survey data were used in the assessment to provide biomass indices and estimates of proportion at age. The surveys are triennial from 1977 to 2001, with the latest survey in 2003. The surveys from 1977 to 1989 cover a smaller depth range than the later surveys and the 1977 to 1992 surveys do not go as far north as the later surveys. Deep water and northern expansion factors were applied to the appropriate surveys in an attempt to make the whole time series consistent.

The survey design appeared to have been relatively consistent from year to year (with the exceptions of coverage). Transects were typically east to west generally running between 50 m and 1500 m depth contours. Transects were allowed to be extended to deeper water if fish densities were high near the normal stopping point. Transects were done during the day with most trawling during the day for target identification and collection of biological samples.

Merits of the time series include:

- The survey area covers a very large proportion of the adult hake distribution (i.e., areal availability is near to 1).
- Hake form large (mainly) midwater aggregations during the time of the survey so marks are easily identified and there is limited undersampling in the “dead zone” near the bottom.
- Sampling intensity was generally good with 80-100 transects in all years.

There were also some important considerations when the survey data are used in stock assessment models:

- The length target strength relationship for hake is based on a small number of in situ measurements. These were made during the night (from low density marks) when tilt angle distributions and swimmbladder inflation levels could differ from those during the day in high density marks (where most the biomass is found). Thus there is the potential for significant bias in the indices when they are used as *absolute* abundance.

- No routine calculations of variance are made for the survey estimates (biomass or proportions at age). The variance assumptions made in an assessment model must therefore be based on model residual patterns and somewhat arbitrary decisions.
- The proportion at age data are derived from the target identification trawls. These are necessarily *targeted* on marks seen on the acoustic transects. It is not clear that the resulting age samples are representative of the population. However, the triennial bottom trawl survey age frequencies are very similar to the acoustic survey age frequencies which does suggest the survey samples are representative.
- The precision of the biomass indices will vary from survey to survey.
- The precision of the proportions at age will vary from survey to survey and will have a complex error structure.
- The biomass indices are correlated with the estimates of proportion at age (in a complicated way).
- The pre and post survey calibration constants for the 1986 survey differed by a significant factor. Application of the post-cruise value would have led to a 48% increase in the hake biomass. In previous assessments, the conservative estimate was used. The reasons for this are not entirely clear to the current Panel and all 1986 survey data were removed from the final runs.
- The 2003 acoustic survey used the W.E. Ricker for the entire survey. Earlier surveys used the Miller Freeman for the U.S. portion of the survey (1995-2001), or for the entire survey (1977-1992). Inter-vessel comparisons between the Miller Freeman and the W.E. Ricker during previous acoustic surveys have not found large differences in the summed acoustic backscatter along transects between the two vessels, though the power to detect moderate differences is low.
- Midway through the 2003 survey, it was found that the face of the transducer on the W.E. Ricker was encrusted with barnacles. Based on calibrations before and after their removal, the signal loss due to biofouling was 0.61 dB, implying a change of acoustic backscatter of ~30%. This signal loss was corrected for, but additional uncertainty is associated with that portion of the 2003 biomass estimate as a result of this correction.

Catch and catch at age

Total catch was available from 1966-2003 by nation and fishery. The accuracy of the total catch estimates was not considered by the Panel, but they are believed to be accurate from 1977-2003. In the earlier period the total catch may have been underestimated.

There has been extensive sampling of the commercial catch, with catch at age estimates for the U.S. fishery from 1973-2003 and for the Canadian fishery from 1977-2003. Some adjustments for ageing error were made to these data by accumulating numbers at age for some cohorts in some years. The Panel did not consider these specific adjustments or the question of ageing error in general. However, plots of the estimated proportions at age very clearly show the progression of strong cohorts (so ageing error is perhaps a minor issue).

Estimates of variance for the proportions at age data are not reported in the assessment. As with the acoustic data this requires that model assumptions with regard to variance be based on model output and somewhat arbitrary decisions.

Recruitment indices

The SWFSC midwater trawl survey targeting pelagic juvenile rockfish was used to provide a recruitment index from 1983-2003. This survey covers a small geographic area relative to the distribution of the juvenile hake. However, the indices have been shown to have a significant correlation to model estimates of recruitment.

Differences between this time series and a shorter recruitment time series over a wider area (PWCC-NMFS midwater trawl survey) were noted. It is not clear whether the two time series are contradictory (as they are both very imprecise). The Panel did not consider whether it was appropriate to include the PWCC-NMFS indices in the assessment runs.

Biological parameters

Year specific weights at age were used in all years for each fishery and survey because of significant variation in the observed weight at age. A constant and age independent estimate of natural mortality was used. A constant female maturity at age vector was also used. The Panel did not consider the derivation or use of these estimates in any detail.

Stock assessment model and estimation procedure

The single-sex age structured model uses standard population dynamics equations. The Canadian and U.S. fisheries are modeled as distinct year-round fisheries. Fishing selectivity patterns are year specific (constrained by a random walk) to allow for changes in fleet composition and shifts of fish distribution (across the border). The acoustic time series is modeled using a single selectivity pattern which applies to both the biomass indices and the estimated proportions at age.

The estimation procedure is essentially maximum likelihood with Bayesian extensions for estimating parameter uncertainty. The initial runs presented to the Panel all assumed the acoustic biomass indices were absolute (acoustic catchability, $q = 1$). This assumption has been made for all previous hake assessments (although it was questioned in the 2002 STAR Panel meeting). Runs where q was estimated in the model had been done (but not presented) and they suggested values of q substantially less than 1 (and consequently much higher biomass).

The Panel supported the use of the general modeling and estimation procedure but had concerns about some aspects of the approach. The major concern was the assumption of

q = 1. It was suggested that the alternative approach of estimating q should be more fully explored with results being presented to the meeting. The STAT Team presented the results of approximately 20 runs which included several with q freely estimated. After exploration of residual patterns and diagnostic statistics from these runs, the meeting selected four runs for further evaluation: models 1a, 1b (q = 1); and runs 2a, 2b (q estimated).

Run 1a used variance weightings assumptions that were consistent with model residuals (standard deviation of standardized residuals near to 1). However, the predicted biomass from the run was substantially higher than the observed biomass for the early part of the acoustic time series (1977-1989). In run 1b the acoustic biomass indices were given greater weight to encourage a better fit to the early part of the time series (consistent with the assumption of q = 1 over all years). This did improve the fit to the time series, but made the model residuals inconsistent with the variance assumption. Nevertheless it was considered by the meeting to represent the best model run based on the assumption of q = 1.

Runs 2a and 2b gave reasonable fits to the whole acoustic time series but produced estimates of q which were considered implausibly low. This judgment was made after deriving plausible lower and upper bounds for q (0.55-1.25) based on four factors: a real availability, vertical availability, target identification, and target strength. In order to provide a credible alternative to run 1b, the meeting adopted run 1c which had a fixed q = 0.6 (a variation of run 1a). This provides a credible value of q without unduly compromising the fit to the data.

Neither of runs 1b and 1c was entirely satisfactory. Each derives from an approach which has been compromised to some extent in order to achieve credible results (a better fit in one case and an acceptable value of q in the other). The meeting considered that the best approach to use in the future is to develop a Bayesian prior on q. There was insufficient time to do that during this meeting.

Harvest policy

The Panel did not address the issue of appropriate harvest rates for Pacific hake. The recent US-Canada hake agreement specifies F40% with an 40-10 adjustment as the default harvest rate. The harvest policy review Panel also recommended an F40% harvest rate, citing a meta-analysis by Dorn et al (1998) of hake stocks world-wide that suggested harvest rates in the F40%-F45% range could be considered appropriate proxies for FMSY, depending on the level of risk aversion. The high recruitment variability of hake results in rapid increases and subsequent declines in abundance and yield. Based on stock projections, it is apparent that the stock may decline to near or below the depleted threshold (25% unfished) without the recommended harvest rate ever being exceeded. We concur with the assessment authors that a new examination of the harvest policy that takes into account this variability is needed for this highly fluctuating stock.

Areas of Major Uncertainty

While there is uncertainty in both data and the model structure, the Panel concluded that the major source of uncertainty lies in the assumption of acoustic survey *q*. The STAR Panel and STAT Team attempted to estimate acoustic *q*, but the resulting estimates were deemed unlikely by all participants and were therefore not brought forward. An ad hoc approach of determining bounds to *q* was developed based on expert opinion about the magnitude of error in the major sources of uncertainty in acoustic surveys (Table 1). Those bounds ranged q=0.55- 1.3. The Panel and STAT team concluded that q>1 was unlikely and thus bounded uncertainty using q=0.6 and q=1. The Panel and STAT team concluded that we did not have sufficient information at the meeting to determine *q* more precisely.

Table 1. Upper and lower bound on the uncertainty in estimated biomass from selected components of the acoustic survey. Upper and lower bounds of acoustic *q* are a product of these values

Source of Error	Lower bound	Upper bound
Area availability	0.95	1
Vertical availability	0.8	0.95
Target identification	0.9	1.1
Target strength	0.8	1.2

Areas of Disagreement

The only source of disagreement among STAR Panel members and STAT team members was the appropriate weighting to give the model that fixed q=1 and q=0.6. The Panel and STAT team agreed that *q* was uncertain and viewed the equal weightings on both models as a compromise. We note here, however, that some Panel members supported higher weighting on the q=1 scenario, and other members preferred a higher weighting on q=0.6.

Research Recommendations:

General recommendation for data: all data (primarily the acoustic survey data, fishery and age composition data) used in the assessment should be critically evaluated. Data that are determined to be biased or suspect should be dropped. For example, the consistency of the ageing data between years and between laboratories should be reviewed. This work should be fully documented so that the reasoning for the decisions is preserved.

1. Acoustic survey recommendations:

a. Determine whether there are differences in survey performance between the WE Ricker & Miller Freeman. These include differences in mid-water and bottom trawl efficiency as well as differences in acoustic capabilities between the vessels. Analyze the available data to determine if we can continue to accept the null hypothesis that there is no difference in survey performance between these vessels.

b. Perform a detailed meta-analysis across all survey years: compare spatial distributions of hake across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years.

c. Generate appropriate estimates of variability for every survey year.

d. Review the methods used to estimate proportions at age for the acoustic survey with particular regard to the representativeness of trawl samples.

2. Estimation of target strength:

   a. Evaluate the current target strength for possible biases, particularly the use of nighttime experiments which are applied to daytime survey transects. Explore alternative methods for estimating target strength.

   b. Assess the value of the recent Canadian hake target strength observations and, if these are assessed to be useable, add these into the target strength model.

   c. Commission the acquisition of additional in-situ observations to increase the model sample size.

3. Model enhancements:

   a. Add in bias correction for log-normal distribution in appropriate likelihoods.

   b. Recode the model so that projections are done as a post-MCMC procedure.

   c. Develop an informed prior for the acoustic *q*. This prior should be used in the model when estimating the q parameter

   d. Consider the development of a sex-structured model.

   e. Investigate alternative methods to model annual variability in fishery selectivity. Identify the covariates that influence fishery selectivity.

   f. Investigate the interaction of the dome-shaped selectivity functions with the fixed value of M. This investigation should include determining whether there is a trade-off between M and the declining limb of the selectivity function. Investigate the possibility of age-specific M.

   g. Investigate alternatives to applying a single estimated acoustic selectivity based on trawl samples to the acoustic biomass indices.

4. The STAR Panel had difficulty completing its assigned task during a three day review. At least a full week is needed for a more thorough review of the input data and the assessment model.

List of Attendees

STAT team members present
Thomas Helser (Northwest Fisheries Science Center)
Richard Methot (NMFS Office of Science and Technology)
Guy Fleischer (Northwest Fisheries Science Center)

Star Panel members:
Kevin Piner, (chair, NOAA/NMFS, Southwest Fisheries Science Center)
Jeff Fargo, (Fisheries and Oceans, Science Branch)
Martin Dorn, (SSC, NOAA, NMFS, Alaska Fisheries Science Center)
Patrick Cordue, (CIE reviewer)

STAR Panel Advisors:
Xi He, (GMT, NOAAA/NMFS, SWFSC)
Rod Moore, (GAP, West Coast Seafood Processors)
Paul Starr (Industry Consultant Canada, Canadian Groundfish Research and Conservation Society)

List of Public Attendees
Vera Agostini (University of Wahington)
Ian Stewart (University of Washington)
Vidar Wespestad (Pacific Whitting Conservation Cooperative)
Rick Dunn (Trident)
Owen Hamel (NOAA/NMFS, Northwest Fisheries Science Center)
Steve Joner (Makah Tribe)
Mike Buston (Leader Fishing)

E.5.b
Pacific Whiting Management
March 2004

PERSPECTIVES OF THE CANADIAN GOVERNMENT REGARDING THE 2004 PACIFIC HAKE(WHITING) FISHERY

The Government of Canada presents its compliments to the Pacific Fishery Management Council (PFMC) and would like to thank the PFMC for this opportunity to express its views on the 2004 Pacific hake (whiting) fishery.

The Government of Canada is pleased that Canada and the United States signed a new treaty for the joint management of this important shared resource in Seattle on November 21, 2003. Canada remains committed to bringing this new agreement into force as soon as possible, and hopes that both countries will be able to manage the 2004 fishery within the spirit of the treaty.

Canada would like to thank the members of the STAT team, the STAR Panel and the STAR Panel Advisors for their work in preparing the *Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003* and the *STAR Panel Report* on the stock assessment. Canada has used these documents as part of its internal procedures for developing its views on the 2004 fishery, and has the following comments to offer.

With respect to the harvest rate, Canada is of the view that the F-40 percent rate should be used in 2004. This would be consistent with the treaty, which specifies F-40 with a 40/10 adjustment as the default harvest rate, and would be the most appropriate choice given the current status of the resource.

Canada is also of the view that the total allowable catch (TAC) should be derived from the model using a value of Q=1.0, which would be consistent with the approach that has been adopted in previous years. At this point and based on the information available, Canada believes that it would be premature to adopt a different Q value. While Canada agrees that the true value of Q might be different from 1.0, Canada is convinced that more research and analysis is required before a different value could be employed in the stock assessment model. Canada also favours adopting a risk-neutral approach to setting the coast-wide yield for 2004 at the level of 514,441 metric tons. Finally, Canada would also like to apply the harvest sharing provisions of the treaty to the 2004 fishery, with Canada taking of 26.12 percent of a commonly adopted coast-wide TAC.

SCIENTIFIC AND STATISTICAL COMMITTEE STATEMENT ON PACIFIC WHITING MANAGEMENT

Dr. Martin Dorn, Scientific and Statistical Committee (SSC) representative on the whiting Stock Assessment and Review (STAR) Panel, gave an overview of the STAR Panel report. Dr. Thomas Helser, lead assessment scientist on the Stock Assessment (STAT) Team, was also present for SSC deliberations and responded to questions concerning the assessment. Mr. Jeff Fargo gave a Canada Department of Fisheries and Oceans perspective on the assessment. Mr. Fargo noted that recruitment to the stock since 1999 is apparently very low, and that stock size is projected to decline 55% in the next three years. Regarding the appropriateness of models with survey catchabilities (q) of 1.0 and 0.6, Mr. Fargo noted that many parameters are affected by a change in the value that is assumed for survey catchability, and the behavior of the whiting model is complex. Mr. Fargo underscored the importance of taking a risk-averse approach to managing whiting.

The SSC accepts the STAR Panel conclusion that acoustic survey catchability (q) is the major source of uncertainty in the whiting assessment. Catchability is a critical assessment parameter that determines the scaling of survey estimates to population biomass. Although all previous whiting assessments have been based on the assumption that q=1.0, the current assessment brought forward two models (q=1.0 and q=0.6) to provide plausible lower and upper bounds on uncertainty.

The unconstrained model estimate of q was approximately 0.3, which was considered implausible by the STAR Panel. Consideration of the likely lower and upper bounds on selected components of acoustic survey q suggested that catchability could be bounded by range q=0.55-1.3. While development of a prior for acoustic survey q is a substantial improvement in the whiting assessment, the SSC is concerned these ranges were put together rapidly during the review meeting. A more thorough and systematic approach to developing a prior for acoustic survey q using Monte Carlo simulations would increase confidence in the approach. A more structured approach would also allow focused research on the major components of catchability (such as acoustic target strength) to be included in the assessment. The SSC also has reservations about the process used to select models with q=1.0 and q=0.6. While q=0.6 is slightly above the lower bound of q=0.55, similar considerations should have resulted in a q=1.25 for the upper bound, not q=1.0. In addition, the SSC is concerned that emphasis on upper and lower bounds does not take into account the greater likelihood that the true value is in the center of the range.

Estimates of stock depletion in 2003 ranged from 47% to 51% of unfished spawning stock biomass. Therefore, regardless of which model is correct, Pacific whiting is estimated to be above the rebuilding target of $B_{40\%}$. The Council may want to consider a request that National Marine Fisheries Service (NMFS) re-evaluate Pacific whiting's status as an overfished stock in light of the current assessment.

The SSC recommends the decision table (Table 13 in the stock assessment, Exhibit E.5.a) be used to evaluate the consequences of alternative optimum yield (OY) options for 2004. In this table, three-year projections of stock biomass and depletion are given when management actions are based on the q=0.6 or q=1 model, and the true state of nature is either consistent with that decision or not. Of particular interest are the lower left and upper right diagonal entries in the table, where management actions are based on assuming the incorrect model. When the OY is based on the q=0.6 model, and the true state of nature is the q=1.0 model, it is possible to reduce the stock to 18% of unfished biomass by 2006.

Although significant declines in stock size are projected for 2004-2006 for all scenarios in Table 13, actual declines will be reduced if the entire OY is not harvested, as is likely due to bycatch constraints. This possibility is considered in Table 13 by including scenarios with a constant U.S. catch of 250,000 tons in 2004-2006, while the Canadian catch was assumed to be the Canadian share of the $F_{40\%}$ OY. Since runs based on assuming the incorrect state of nature were not included in the table, the SSC requested that Dr. Helser do these two runs and report back to the SSC. If management actions are incorrectly based on a q=0.6 model (i.e., the true state of nature is q=1.0), there is a greater than 50% chance the stock will decline below the overfished threshold in 2006. In contrast, if management actions are based on q=1.0 model, the stock has a greater than even chance of being above the overfished threshold in 2006 regardless of the true state of nature.

Finally, the SSC notes that presentation of uncertainty by means of two contrasting models does not facilitate the council decision-making process. Current Terms of Reference for STAR Panels do not request the Panel to endorse a single model. Terms of Reference will be revised to give greater emphasis and guidance for selecting a preferred model. However, an important task of the STAR Panel is appraisal of assessment uncertainty, a responsibility that may preclude the Panel from unduly limiting model alternatives.

PFMC
03/11/04

GROUNDFISH ADVISORY SUBPANEL STATEMENT ON PACIFIC WHITING MANAGEMENT

The Groundfish Advisory Subpanel (GAP) met with the Groundfish Management Team to discuss the 2004 stock assessment on Pacific whiting and 2004 management measures for the whiting fishery. The GAP was also made aware of the draft recommendations from the Scientific and Statistical Committee (SSC) although it has not seen the final SSC report.

Management decisions for the 2004 whiting fishery are especially complex due to a number of factors:

- The whiting Stock Assessment Review (STAR) Panel forwarded two stock assessment models with equal likelihood, which result in significantly different biomass estimates and future projections.
- The U.S. and Canada are signatories to a treaty governing Pacific whiting, but that treaty has not yet been subject to the advice and consent of the U.S. Senate nor implemented in the U.S. through domestic legislation.
- The U.S. has pledged to follow the "spirit" of the treaty and agreed to the allocation split of the coastwide harvestable biomass between the U.S. and Canada, but is also required to meet the mandates of existing U.S. law and the regulations implementing the groundfish fishery management plan.
- Whiting was designated as "overfished" as a result of the 2001 stock assessment, but has been shown under the 2003 stock assessment to not only be rebuilt, but also never to have reached the overfished level to begin with.
- The U.S. optimum yield (OY) is further constrained by the range analyzed in the environmental impact statement for the 2004 groundfish fishery and the need to minimize bycatch of widow rockfish in the whiting fishery.
- The U.S. fishery has several different components that start at different times and that have allocations established by law and regulation.

The first step that must be taken is to determine the coastwide acceptable biological catch (ABC) or total allowable catch as the number is referred to in the treaty. This number forms the basis of the allocation split between the U.S. and Canada, is supposed to be mutually agreed to by the U.S. and Canada, and is derived from the stock assessment.

The difference in the two stock assessment models forwarded by the STAR Panel involves the value assigned to acoustic q. One model continues the past practice of setting $q = 1$, thereby assuming all whiting within the acoustic "footprint" are accounted for. The GAP believes this value is so highly improbable that it should be rejected. Target returns from acoustic sampling of whiting routinely miscount fish which are traveling vertically within the water column, fish which have just changed depth, and thus, deflated their swim bladders, fish which are at the wrong angle relative to the acoustic beam, and fish which are located close to the ocean bottom. All of these factors are acknowledged by survey scientists at the Northwest Fisheries Science Center.

The second stock assessment model is structurally similar to the first, but the model was allowed to estimate the value of *q* within certain constraints. This model produced a value of $q = .6$. This model also fit the data more closely than the previous model. It takes into account the lack of accuracy in acoustic sampling noted above and was preferred by the acoustic scientist who served as the independent reviewer on the STAR Panel.

Because no single model has been endorsed by either the STAR Panel or the SSC, the GAP recommends that an ABC value equivalent to $q = .8$ under an $F_{40\%}$ harvest policy be adopted as an interim measure. This value would recognize the uncertainty surrounding the value of *q* while being more precautionary than the second model.

The GAP also notes that an informal discussion with our colleagues in the Canadian government revealed their support for the $q = 1$ model on an interim basis as a precautionary move, with the understanding that extensive study be made quickly of the true value of *q*. While the GAP cannot endorse the Canadian recommendation on which model to use, it strongly concurs with the need to quickly resolve the question of the value of *q*.

Once the ABC is established, the Council must determine the OY value for the U.S. share of the allocation. In no case should the OY exceed 250,000 mt this year, in order to avoid delays in getting the fishery started on April 1st in California and off-shore of Oregon on May 15th. After discussion with the GMT on various options for accounting for widow rockfish bycatch, the GAP believes an OY of 250,000 mt can be set without exceeding allowable widow catch. The GAP notes that substantial efforts have been made by all fishing sectors to avoid widow bycatch, including use of reporting, fleet-wide broadcasts of areas to be avoided due to widow concentration, and restricting deliveries of vessels to shore plants when those vessels have operated in higher bycatch areas. These efforts have resulted in minimal widow rockfish bycatch in 2003.

The GAP also notes that a U.S. OY of 250,000 mt will dampen the projected decline of the whiting biomass, which at the moment is largely being driven by a strong 1999 year class. If our Canadian colleagues decide to not fully harvest their share of the resource, the dampening effect will be improved, although this is a domestic decision for Canada.

The GAP believes the recommendations it is making are suitably precautionary, promote conservation while allowing an economic benefit to coastal communities, meet the spirit of the treaty, are scientifically defensible, avoid bycatch to the extent practicable, and should be adopted.

PFMC
03/11/04

GROUNDFISH MANAGEMENT TEAM (GMT) REPORT ON PACIFIC WHITING MANAGEMENT

The GMT's discussions primarily focused on developing alternatives and recommendations for setting the harvest level for the 2004 whiting fisheries while providing protection for overfished widow rockfish. The GMT reviewed the SSC's statement on the models used in the Pacific whiting assessment and the STAR panel's conclusions relative to the acoustic survey catchability (q). The GMT believes that the whiting ABC should be set based on the results in the assessment, and did not believe we could offer additional insight as to the true state of nature. Therefore, the GMT recommends the Council consider the two options at the F40% level of 514,441 mt (q=1.0) and 780,758 mt (q=0.6) in setting the 2004 ABC for whiting.

The GMT has developed the following recommendations and management alternatives for the Council's consideration regarding Pacific whiting fisheries:

Recommended Management Approach

The GMT recommends that the Council set the whiting OY at the level projected to be accommodated with the available widow rockfish. The GMT recognizes that this approach may result in forgoing harvestable surplus of whiting, but believes that the assumptions regarding widow bycatch rates in the whiting fisheries warrant precautionary management. The GMT believes that this management strategy will require the monitoring of widow bycatch and stresses the need for real-time updates of widow catches in all whiting fishery sectors.

State GMT members committed to evaluate the inclusion of widow rockfish into the "penalty box" provisions that currently are in place for yellowtail rockfish in state shoreside whiting EFPs. This provision assesses foregone fishing days on vessels that exceed a specified rate of yellowtail rockfish bycatch in their whiting operation. The evaluation of including widow will be done at the series of meetings held along the coast that are mandatory for fishers in order to participate in the shoreside whiting EFP fishery.

Scorecard Update

The GMT reviewed the 2004 bycatch scorecard and reduced the widow catch estimate for the limited entry fixed gear fisheries from 30 mt to 5 mt. After tallying the amount of widow projected to be taken in the non-whiting fisheries, the GMT identified a remainder of 225 mt of widow available in the scorecard. Following the guidance of the Council from last fall to hold the non-whiting fisheries "harmless" relative to achieving widow rockfish rebuilding targets, the GMT recommends that an additional 5 mt be set aside as a "buffer" in the scorecard. The GMT feels that the buffer is needed to accommodate uncertainty in the catch estimate projections to avoid early attainment of the widow OY. This would provide 220 mt of widow rockfish to set the whiting OY.

Widow Bycatch Projection Alternatives

In the bycatch scorecard for 2003, the GMT applied the average bycatch rates for 1998-2001 for each sector to project catch estimates. For the current 2004 scorecard, the GMT applied the 1998-2003 (2003 at-sea data through September 25, 2003) average bycatch rates for each sector to project catch estimates for all overfished species, except widow rockfish. The GMT believes that the same methodology for determining the bycatch rate used to project 2004 catches should be applied across all whiting sectors and for all overfished species.

The GMT did not reach consensus on the approach to calculate the widow bycatch projections, and has two alternatives for Council consideration–one that applies a weighted average to more recent years and another that applies a straight average bycatch rate for the same time period. In both cases, the years 2000-2003 were used. Given the recent increase in the whiting biomass resulting from a very strong 1999 year class, as well as increasing rockfish avoidance behavior in the fishery, the GMT feels it is appropriate to consider a recent time series during which these factors have come more into play in assessing widow bycatch. Therefore, the team's recommendation proposes using the recent four-year average rather than the five-year average that was previously used. (The attached graph depicts the widow bycatch rates in the whiting fishery for the past six years.) After the Council chooses a bycatch projection methodology, the resulting bycatch estimates will be presented in an updated scorecard.

Factors for consideration include whether widow bycatch is directly proportional to whiting abundance (Alt.1), or whether bycatch is a more random event (Alt. 2). Alternative 1 recognizes there may have been behavior changes to avoid widow rockfish in recent years; however, this option also assumes that the behavioral change will continue in 2004. Alternative 2 is more consistent with the current management approach and attempts to smooth out random bycatch events. Another factor is relative to precautionary management–the alternatives in Table 1. are arranged in order from highest to lowest risk.

Table 1. Options for setting the whiting OY using widow bycatch rates. (Note: Option 1 would set the whiting OY above the maximum OY adopted by the Council of 250,000 mt; option 1a constrains the OY at the maximum level and back calculates the estimated widow impacts.)

		All Sectors (mt)		Sector Allocations (mt)			
	Annual Calculation Weighting	Widow	Total	Shoreside	MS	C/P	Tribal
1	40 ('03) 30 ('02) 20 ('01) 10 ('00)	220	260,343	93,804	62,002	87,837	35,000
1a	Same as Option 1	211	250,000	90,510	59,520	84,320	32,500
2	Average 4-Year (2000-2003)	220	205,782	73,399	49,142	69,618	30,000

<u>Other Management Alternatives</u>
The GMT also considered the following alternatives, but has received guidance from NOAA General Counsel that these options would not be available for 2004. The GMT believes that these alternatives should be considered for 2005-06 management:

- Set a hard bycatch cap for widow rockfish in the whiting fishery, which may or may not include allocations among whiting sectors

- Close widow "hotspot" areas to the whiting fishery - ODFW has analyzed ways to avoid areas of higher widow bycatch in the shoreside whiting fishery. The use of a widow rockfish conservation area for the whiting fishery, or a series of smaller “hotspot” areas were examined. As another example, the widow rockfish assessment identified that widow catch rates in the whiting fishery are highest near the 200 m isobath, largely tapering off within five nm. The GMT suggests that the industry use this information to voluntarily avoid fishing areas with higher bycatch rates in the short-term (2004), until this option can be further explored. This information will be presented at the shoreside EFP meetings. For the longer-term, additional work in this area might provide a useful tool for managing bycatch in the whiting fishery.

Other Issues for Consideration

- How the proposed management measure alternatives would be applied to the treaty whiting fishery (i.e., the maximum OY of 250,000 may constrain the treaty whiting fishery in the absence of a conservation concern for whiting)?

- What would be the National Marine Fisheries Service’s inseason action mechanism to close the whiting fisheries if a widow harvest guideline is approached outside the Council meeting process?

- Monitoring of widow bycatch assumes that all widow caught is subsequently landed. The GMT notes that the vessel camera suveillance effort for shoreside vessels planned by NMFS may not be implemented until July.

GMT Recommendations

1. Adopt a whiting ABC based on the assessment results at the F40% level
2. Set aside a 5 mt widow “buffer” (as a minimum) in the bycatch scorecard
3. Choose a bycatch projection methodology (alternatives described on page 2)
4. Set the whiting OY at the level projected to be accommodated with available widow rockfish (220 mt) and specify the sector allocations of whiting
5. Include bycatch caps and widow “hotspot” areas as management options for the whiting fishery in 2005-06
6. Confirm NMFS authority to close and identify the inseason action mechanism (e.g., a conference call) if a widow harvest guideline is approached outside the Council meeting process

Handout
3-12-04

Exhibit E.5.c
Supplemental GMT Report 2
March 2004

Table. Estimated mortality (mt) of overfished West Coast groundfish species by fishery in 2004.

3/12/2004 8:07

Fishery	Bocaccio a/	Canary	Cowcod	Dkbl b/	Lingcod c/	POP	Whiting d/	Widow	Yelloweye
Limited Entry Groundfish									
Trawl- Non-whiting e/	45.0	9.8	0.6	100.7	78.4	68.1		1.5	0.4
Fixed Gear	13.4	0.5	0.1	1.5	12.7	0.2		5.0	0.1
Whiting									
At-sea whiting motherships		0.9		1.4	0.3	1.7	51,720	211.0	0.0
At-sea whiting cat-proc		1.3		7.6	0.4	10.1	73,270		0.4
Shoreside whiting		0.4		0.5	0.7	0.4	90,510		0.0
Tribal whiting		4.7		0.0	0.5	1.5	32,500		0.0
Open Access									
Groundfish directed	10.6	0.3	0.1		62.5				0.6
CA Halibut	0.1			0.0	2.0	0.0			
CA Gillnet f/	0.5			0.0		0.0		0.0	
CA Sheephead f/				0.0		0.0		0.0	0.0
CPS- wetfish f/	0.3								
CPS- squid g/									
Dungeness crab f/	0.0		0.0	0.0		0.0			
HMS f/		0.0	0.0	0.0					
Pacific Halibut f/	0.0		0.0	0.0		0.0		0.0	0.5
Pink shrimp	0.1	0.5	0.0	0.0	0.5	0.0		0.1	0.1
Ridgeback prawn	0.1	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Salmon troll	0.2	1.6	0.0	0.0	0.3	0.0		0.0	0.2
Sea Cucumber	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Spot Prawn (trap)									
Tribal									
Midwater Trawl		2.3		0.0	0.1	0.0		40.0	0.0
Bottom Trawl		0.5		0.0	9.0	0.0		0.0	0.0
Troll		0.5		0.0	1.0	0.0			0.0
Fixed gear		0.3		0.0	15.0	0.0		0.0	2.3
Recreational Groundfish									
WA		2.5			73.0				3.5
OR		7.0			101.3			2.0	3.3
CA (N) h/		0.5			195.0			1.0	0.1
CA (S) h/	62.8	7.6	1.8		151.8			0.4	1.3
Research: Based on 2 most recent NMFS trawl shelf and slope surveys, the IPHC halibut survey, and LOAs with expanded estimates for south of Pt. Conception.									
	2.0	1.0		1.6	3.0	3.0		1.5	1.1
Non-EFP Total	135.1	42.2	2.6	113.3	707.5	85.0		262.5	14.0
EFPs i/									
CA: NS FF trawl	10.0	0.5	0.5		20.0				0.5
OR: DTS j/		0.1		6.0		18.0			0.1
WA: AT trawl		1.5		3.0	4.5	8.5		5.5	0.5
WA: dogfish LL		0.1		0.5	2.0	0.5		0.5	1.0
WA: pollock k/		0.1		0.5			1,000	1.5	0.1
EFP Subtotal	10.0	2.3	0.5	9.5	26.5	27.0	1,000	7.5	2.2
TOTAL	145.1	44.5	3.1	122.8	734.0	112.0		270.0	16.2
2004 OY	250	47.3	4.8	240	735	444	250,000	284	22
Percent of OY	58.0%	94.1%	64.6%	51.2%	99.9%	25.2%		95.1%	73.5%
Key	[shaded] = either not applicable; trace amount (<0.01 mt); or not reported in available data sources.								

a/ South of 40°10' N. lat.

b/ Darkblotched harvest limit ("2004 OY" in this table) is the ABC of 240 mt, which is lower than the projected OY of 272 mt under the *Medium OY* alternative.

c/ Lingcod total reflects total catch, not mortality.

d/ Whiting is rebuilt according to the assessment adopted at the March 2004 Council meeting.

e/ Using observer data, all estimates from the Hastie trawl bycatch model.

f/ Mortality estimates are not hard numbers; based on the GMT's best professional judgement.

g/ Bycatch amounts by species unavailable, but bocaccio occurred in 0.1% of all port samples and other rockfish in another 0.1% of all port samples (and squid fisheries usually land their whole catch). In 2001, out of 84,000 mt total landings 1 mt was groundfish. This suggests that total bocaccio was caught in trace amounts.

h/ These estimates have not been revised pending GMT review of the estimation methodology.

i/ Values are proposed EFP bycatch caps, not estimates of total mortality. The EFP is terminated inseason if the cap is projected to be attained early.

j/ The darkblotched rockfish and Pacific ocean perch caps are not defined yet for this EFP but are expected to be lower than the placeholders in this scorecard.

k/ Whiting impacts are deducted from the shoreside sector only.