NATIONAL MARINE FISHERIES SERVICE REPORT ON COASTAL PELAGIC SPECIES MANAGEMENT

National Marine Fisheries Service (NMFS) Southwest Region will briefly report on recent developments relevant to coastal pelagic species (CPS) fisheries and issues of interest to the Council including an update on the status of current fisheries and Amendment 12 to the CPS Fishery Management Plan regarding krill management.

<u>Council Task:</u>

Discussion.

<u>Reference Materials</u>:

1. Agenda Item F.1.a, NMFS Report: NMFS Southwest Regional Office Report.

<u>Agenda Order</u>:

a. NMFS Activity Reports — Mark Helvey/Gary Sakagawa
b. Reports and Comments of Advisory Bodies
c. Public Comment
d. Council Discussion

PFMC
05/21/07

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802- 4213

MAY 2 5 2007 150409SWR2006SF00072:JBL

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 12 to the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP). The National Marine Fisheries Service (NMFS) published a Notice of Availability regarding the adoption of Amendment 12 to CPS FMP on February 26, 2007 (72 FR 8335). NMFS expects to publish a proposed rule to implement Amendment 12 in the near future.

As you know, Amendment 12 to the CPS FMP would amend the FMP to provide protection for all species of krill off the West Coast (i.e., California, Oregon and Washington). Amendment 12 would add all species of krill as a management unit species under the CPS FMP and would place krill under a newly established "prohibited harvest species" category. This new category would differ from the existing "prohibited species" definition in the FMP because “prohibited harvest species” may not be taken by any fishery or gear type in the U.S. EEZ. Optimum yield (OY) for krill would be set at zero and the harvest of krill would be prohibited. In contrast, “prohibited species” may not be taken and retained incidentally by CPS fishery participants, but are legally harvested under provisions in other Council FMPs and Federal regulations. Under Amendment 12, no exempted fishing permits (EFPs) would be issued under the EFP procedures of the CPS FMP to allow individuals to harvest krill as an exception to the prohibition of harvest. These actions would fully achieve the objectives of the amendment to the extent practicable, recognizing that environmental conditions and the responses of krill and other resources to changes in environmental conditions are beyond the control of the Council.

NMFS has considered the potential for development of a krill fishery and the potentially drastic effects a fishery could have on krill resources and on the fish and other species, such as birds and mammals, that are dependent on, or that are sensitive to, the abundance and availability of krill. NMFS agrees with the Council that it is critical to take preventive action at this time to ensure that a krill fishery will not develop that could potentially disrupt krill stocks, and in turn impact the living marine resources that directly or indirectly depend on them. Amendment 12 is a strong attempt to incorporate ecosystem conservation principles into fishery management programs by protecting, to the extent practicable, krill resources, which are an integral part of that ecosystem.

NMFS appreciates the Council's ongoing efforts in taking a precautionary approach to fisheries management in the California Current ecosystem.

Sincerely,

for Rodney R. McInnis
Regional Administrator

Comments and Responses

Comment 1: Two commenters offered strong support for the interim action.

Response: Comment noted.

Comment 2: One commenter noted that NMFS " should have seen the [ETAA] issue coming."

Response: Framework 18 included a mechanism to adjust the ETAA trips. The Council and NMFS included the provision to adjust ETAA measures in the event that the biomass estimates were overestimated in Framework 18 initially. The Framework 18 mechanism was determined to be not as effective as the interim action in addressing the uncertainty in the projections, but the issue was anticipated.

Classification

Because this interim rule merely extends the interim action already in place, for which public comment was accepted and considered, NMFS finds it is impracticable and contrary to the public interest to provide any additional notice and opportunity for public comment under 5 U.S.C. 553(b)(B) prior to publishing the interim rule. Waiving prior notice and comment allows the ETAA interim measures to remain in place, thereby reducing the potential for overfishing the scallop resource and preventing excessive scallop mortality. For these reasons, the need to extend these measures to assure that overfishing does not occur also constitutes good cause under authority contained in 5 U.S.C. 553(d)(3), to waive the 30-day delayed effective date, and extend the interim action upon publication. This interim rule has been determined to be not significant for purposes of Executive Order 12866. This interim rule is exempt from the procedures of the Regulatory Flexibility Act because the rule is issued without opportunity for prior notice and opportunity for public comment.

Dated: May 23, 2007.

Samuel D. Rauch III

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

[FR Doc. E7–10370 Filed 5–29–07; 8:45 am]

BILLING CODE 3510–22–S

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 660

[Docket No. 061127309–7100–02; I.D. 110706D]

RIN 0648–AU72

Fisheries Off West Coast States; Coastal Pelagic Species Fisheries; Reporting Requirements and Conservation Measures

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

ACTION: Final rule.

SUMMARY: This action implements new reporting and conservation measures under the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP). The purpose of this action is to prevent interactions between CPS fisherman and southern sea otters, as well as establish methods for fishermen to report these occurrences when they occur. These reporting requirements and conservation measures require CPS fishermen/vessel operators to employ avoidance measures when southern sea otters are present in the area they are fishing and to report any interactions that may occur between their vessel and/or fishing gear and sea otters.

DATES: Effective June 29, 2007, except for § 660.520 which contains information collection requirements that have not been approved by OMB. NOAA will publish a document in the **Federal Register** announcing the effective date.

ADDRESSES: Copies of Amendment 11 and its Environmental Assessment/ Regulatory Impact Review may be obtained from the Southwest Regional Office by contacting Rodney R. McInnis, Regional Administrator, Southwest Region, NMFS, 501 West Ocean Blvd., Suite 4200, Long Beach, CA 90802–4213.

Written comments regarding the burden-hour estimates or other aspects of the collection-of-information requirements contained in this action may be submitted to the Southwest Regional Office and by e-mail to *David__Rostker@omb.eop.gov* or fax to (202) 395–7285

FOR FURTHER INFORMATION CONTACT: Joshua B. Lindsay, Southwest Region, NMFS, (562) 980–4034.

SUPPLEMENTARY INFORMATION: The CPS FMP, which was implemented by publication of the final rule in the **Federal Register** on December 15, 1999 (64 FR 69888), regulates commercial fishing for CPS in the Exclusive Economic Zone (EEZ) off the West Coast; 3–200 nautical miles off the coastlines of Washington, Oregon, and California. This action implements new reporting requirements and conservation measures under the CPS FMP. Southern sea otters are listed as threatened under the Endangered Species Act (ESA) and depleted under the Marine Mammal Protection Act (MMPA), providing them strict protection under these laws. Known interactions between CPS fishing operations and southern sea otters are extremely rare. Data gathered from this action will prove valuable in determining whether such interactions are as rare as believed or whether stronger measures are necessary to ensure protection of this species. This action stems from a biological opinion (BO) issued by the U.S. Fish and Wildlife Service (USFWS) regarding the implementation of Amendment 11 to the CPS FMP.

Background

In accordance with the regulations implementing the ESA, NMFS initiated an ESA section 7 consultation with the USFWS regarding the possible effects of implementing Amendment 11 (71 FR 36999) to the CPS FMP. USFWS determined that formal consultation was necessary on the possible effects to the threatened southern sea otter. USFWS completed a biological opinion (BO) for this action and concluded that it was not likely to jeopardize the continued existence of the southern sea otter. The requirements and conservation measures put forth in this action stem from this BO and are an attempt to provide further conservation efforts for southern sea otters. These reporting requirements and conservation measures require all CPS fishermen and vessel operators to employ avoidance measures when sea otters are present in the fishing area and to report any interactions that may occur between their vessel and/or fishing gear and otters.

Specifically, these new measures and regulations are:

1. CPS fishing boat operators and crew are prohibited from deploying their nets if a southern sea otter is observed within the area that would be encircled by the purse seine.
2. If a southern sea otter is entangled in a net, regardless of whether the animal is injured or killed, such an occurrence must be reported within 24 hours to the Regional Administrator, NMFS Southwest Region.

3. While fishing for CPS, vessel operators must record all observations of otter interactions (defined as otters within encircled nets or coming into contact with nets or vessels, including but not limited to entanglement) with their purse seine net(s) or vessel(s). With the exception of an entanglement, which will be initially reported as described in #2 above, all other observations must be reported within 20 days to the Regional Administrator.

When contacting NMFS after an interaction, fishermen are required to provide information regarding the location, specifically latitude and longitude, of the interaction and a description of the interaction itself. If available, location information should also include: Water depth; distance from shore; and, relation to port or other landmarks. Descriptive information of the interaction should include: whether or not the otters were seen inside or outside the net; if inside the net, had the net been completely encircled; did contact occur with net or vessel; the number of otters present; duration of interaction; otter's behavior during interaction; and, measures taken to avoid interaction.

For further background information on this action please refer to the preamble of the proposed rule (71 FR 70941).

Comments and Responses

NMFS received two public comments on the proposed rule. These comments are addressed here:

Comment 1: One comment stated that due to the strict protections provided to southern sea otters by the MMPA, incidental take of southern sea otters could not be authorized under the ESA and that it was necessary for NMFS to amend the proposed rule to reflect this. The comment also stated that self-reporting has not always proved effective with regard to marine mammal interactions with fisheries and that this rule should include a mandatory neutral observer program. However, to the extent that self-reporting would be required, that it be made as easy as possible for the fishermen.

Response: This final rule does not authorize the take of southern sea otters within CPS fisheries. The purpose of this final rule is to further protect this threatened species. Sea otters have not been documented to have been injured or killed in CPS fisheries and due to the very small overlap of CPS fisheries in the EEZ off the West Coast and the distribution of southern sea otters, the likelihood that such an event will occur is low. However, the BO prepared by USFWS determined that the possibility of interactions between sea otters and the fishery does exist. Therefore, NMFS decided that the requirements recommended by USFWS to reduce possible interactions with, and provide protection for, southern sea otters, would be a prudent conservation measure. NMFS currently places observers on CPS vessels operating in the Monterey Bay region and will continue to do so.

Comment 2: The commenter stated that after an interaction it would be unnecessary for the fisherman to provide location information other than latitude and longitude. The commenter also suggests that the requirement to report non-entanglement interactions is unclear and unnecessary.

Response: Under § 660.520(a)(3), fishermen will only be required to provide the latitude and longitude of where the interaction took place. NMFS asks that other location information that is readily available be provided as well, but it is not required. With regards to the reporting of non-entanglement interactions, it is not the intent of this final rule to require fishermen to report casual observations of sea otters. This action only requires fishermen to report when sea otters occur within encircled nets or come into contact with fishing gear or the vessel. This information could prove valuable to both fishermen and/or the conservation of sea otters as it will establish a record of the presence or absence of sea otter interactions. If interactions are occurring, location information will be important in determining areas where further conservation efforts may be needed.

No changes were made to the regulatory text from the proposed rule.

Classification

The Administrator, Southwest Region, NMFS, determined that this action is necessary for the conservation and management of the CPS fishery and that it is consistent with the Magnuson-Stevens Fishery Conservation and Management Act and other applicable laws.

This final rule contains a collection-of-information requirement subject to review and approval by the Office of Management and Budget (OMB) under the Paperwork Reduction Act (PRA). This requirement has been submitted to OMB for approval. Public reporting burden for this otter interaction requirement is estimated to average 10 minutes per individual per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding these burden estimates or any other aspect of this data collection, including suggestions for reducing the burden, to NMFS (see **ADDRESSES**) and by e-mail to *David__Rostker@omb.eop.gov* or fax to (202) 395–7285.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

This final rule has been determined to be not significant for purposes of Executive Order 12866.

The Chief Counsel for Regulation of the Department of Commerce certified to the Chief Counsel for Advocacy of the Small Business Administration during the proposed rule stage that this action would not have a significant economic impact on a substantial number of small entities. The factual basis for the certification was published in the proposed rule and is not repeated here. No comments were received regarding this certification. As a result, a regulatory flexibility analysis was not required and none was prepared.

List of Subjects in 50 CFR Part 660

Administrative practice and procedure, American Samoa, Fisheries, Fishing, Guam, Hawaiian Natives, Indians, Northern Mariana Islands, Reporting and recordkeeping requirements.

Dated: May 23, 2007.

Samuel D. Rauch III

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

■ For the reasons set out in the preamble, NMFS amends 50 CFR part 660 as follows:

PART 660—FISHERIES OFF WEST COAST STATES AND IN THE WESTERN PACIFIC

■ 1. The authority citation for part 660 continues to read as follows:

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

■ 2. In § 660.505, paragraph (n) is added to read as follows:

§ 660.505 Prohibitions.

* * * * *

(n) When fishing for CPS, deploy a net if a southern sea otter is observed within the area that would be encircled by the purse seine net.

■ 3. Section 660.520 is added to read as follows:

§ 660.520 Reporting requirements.

(a) *Otter interaction.* (1) If a southern sea otter is entangled in a net, regardless of whether the animal is injured or killed, the vessel operator must report this interaction within 24 hours to the Regional Administrator.

(2) While fishing for CPS, vessel operators must record all observations of otter interactions (defined as otters within encircled nets or coming into contact with nets or vessels, including but not limited to entanglement) with their purse seine net(s) or vessel(s). With the exception of an entanglement, which must be initially reported as described in paragraph (a)(1)of this section, all other observations must be reported within 20 days to the Regional Administrator.

(3) When contacting NMFS after an interaction, vessel operators must provide the location (latitude and longitude) of the interaction and a description of the interaction itself. If available, location information should also include water depth, distance from shore, and relation to port or other landmarks. Descriptive information of the interaction should include: whether or not the otters were seen inside or outside the net; if inside the net, had the net been completely encircled; whether any otters came in contact with either the net or the vessel; the number of otters present; duration of interaction; the otter's behavior during interaction; measures taken to avoid interaction.

(b) [Reserved]

[FR Doc. E7–10379 Filed 5–29–07; 8:45 am]

BILLING CODE 3510–22–S

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 679

[Docket No. 070213033–7033–01]

RIN 0648–XA45

Fisheries of the Economic Exclusive Zone Off Alaska; Pacific Cod in the Bering Sea and Aleutian Islands

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

ACTION: Temporary rule; modification of a closure.

SUMMARY: NMFS is opening directed fishing for Pacific cod by catcher vessels less than 60 feet (18.3 meters (m)) length overall (LOA) using pot or hook-and-line gear in the Bering Sea and Aleutian Islands management area (BSAI). This action is necessary to fully use the 2007 total allowable catch (TAC) of Pacific cod specified for catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI.

DATES: Effective 1200 hrs, Alaska local time (A.l.t.), May 27, 2007, through 2400 hrs, A.l.t., December 31, 2007. Comments must be received at the following address no later than 4:30 p.m., A.l.t., June 8, 2007.

ADDRESSES: Send comments to Sue Salveson, Assistant Regional Administrator, Sustainable Fisheries Division, Alaska Region, NMFS, Attn: Ellen Sebastian. Comments may be submitted by:

- Mail to: P.O. Box 21668, Juneau, AK 99802;
- Hand delivery to the Federal Building, 709 West 9th Street, Room 420A, Juneau, Alaska;
- FAX to 907–586–7557;
- E-mail *inseason-akr@noaa.gov* and include in the subject line and body of the e-mail the document identifier: bspclt60re2 (E-mail comments, with or without attachments, are limited to 5 megabytes); or
- Webform at the Federal eRulemaking Portal: *http://www.regulations.gov*. Follow the instructions at that site for submitting comments.

FOR FURTHER INFORMATION CONTACT: Jennifer Hogan, 907–586–7228.

SUPPLEMENTARY INFORMATION: NMFS manages the groundfish fishery in the BSAI exclusive economic zone according to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (FMP) prepared by the North Pacific Fishery Management Council under authority of the Magnuson-Stevens Fishery Conservation and Management Act. Regulations governing fishing by U.S. vessels in accordance with the FMP appear at subpart H of 50 CFR part 600 and 50 CFR part 679.

NMFS closed directed fishing for Pacific cod by catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI under § 679.20(d)(1)(iii) on March 30, 2007 (72 FR 15848, April 3, 2007). The fishery was reopened on April 30, 2007 (72 FR 18920, April 16, 2007) and was closed again on May 15, 2007 (72 FR 27980, May 18, 2007).

NMFS has determined that as of May 22, 2007, approximately 30 metric tons of Pacific cod remain in the 2007 Pacific cod TAC allocated to catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI. Therefore, in accordance with § 679.25(a)(2)(i)(C) and (a)(2)(iii)(D), and to fully use the 2007 TAC of Pacific cod specified for catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI, NMFS is terminating the previous closure and is opening directed fishing for Pacific cod by catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI. The opening is effective 1200 hrs, A.l.t., May 27, 2007, through 2400 hrs, A.l.t., December 31, 2007.

Classification

This action responds to the best available information recently obtained from the fishery. The Assistant Administrator for Fisheries, NOAA (AA), finds good cause to waive the requirement to provide prior notice and opportunity for public comment pursuant to the authority set forth at 5 U.S.C. 553(b)(B) as such requirement is impracticable and contrary to the public interest. This requirement is impracticable and contrary to the public interest as it would prevent NMFS from responding to the most recent fisheries data in a timely fashion and would delay the opening of the Pacific cod fishery by catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI. Immediate notification is necessary to allow for the orderly conduct and efficient operation of this fishery, to allow the industry to plan for the fishing season, and to avoid potential disruption to the fishing fleet and processors. NMFS was unable to publish a notice providing time for public comment because the most recent, relevant data only became available as of May 22, 2007.

The AA also finds good cause to waive the 30-day delay in the effective date of this action under 5 U.S.C. 553(d)(3). This finding is based upon the reasons provided above for waiver of prior notice and opportunity for public comment.

Without this inseason adjustment, NMFS could not allow the fishery for Pacific cod by catcher vessels less than 60 feet (18.3 m) LOA using pot or hook-and-line gear in the BSAI to be harvested in an expedient manner and in accordance with the regulatory schedule. Under § 679.25(c)(2), interested persons are invited to submit written comments on this action to the above address until June 8, 2007.

This action is required by § 679.25 and is exempt from review under Executive Order 12866.

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

National Marine Fisheries Service
Coastal Pelagic Species

Fishery Actions:

Pacific Mackerel: 2005-2006 Landings: The Pacific mackerel season began on July 1, 2006 and ends on June 30, 2007. The 2006-2007 Pacific mackerel harvest guideline was 19, 845 mt with a directed fishery of 13,845 mt and a reserve of 6,000mt. As of May 23, 2006, ~7,500 mt of Pacific mackerel has been landed.

Pacific Sardine: 2007 Harvest Guideline: The 2007 Pacific sardine harvest guideline is 152,564 mt. Under the allocation scheme established by Amendment 11, 35 percent or 53,397 mt of the harvest guideline was released coastwide on January 1. As of May 23, ~24,000 mt has been landed. On July 1, 40 percent or 61, 025 mt of the harvest guideline, plus any portion not harvested from the initial allocation will be released.

Regulatory Actions:

Krill Amendment: NMFS submitted a letter to the Council approving Amendment 12 to Coastal pelagic Species (CPS) Fishery Management Plan (FMP). NMFS expects to publish a proposed rule to implement Amendment 12 in the near future. Amendment 12 to the CPS FMP amends the FMP to provide protection for all species of krill off the West Coast (i.e., California, Oregon and Washington).

Sardine Allocation Amendment: The last unfinished portion of Amendment 11 was completed with publication of the final rule to implement new reporting requirements and prohibitive measures under the CPS FMP. The purpose of the rule was to comply with the terms and conditions set forth in the incidental take statement of a biological opinion issued by the U.S. Fish and Wildlife Service regarding the implementation of Amendment 11 to the CPS FMP and its effects to the threatened southern sea otter and to provide further conservation efforts for southern sea otters.

PACIFIC MACKEREL STOCK ASSESSMENT AND HARVEST GUIDELINE FOR 2007-2008

The Council is scheduled to review the current Pacific mackerel stock assessment and adopt a harvest guideline for the 2007-2008 Pacific mackerel fishing season, which opens July 1, 2007.

Full assessments for Pacific mackerel typically occur every third year, necessitating a three-year cycle for the Coastal Pelagic Species (CPS) Stock Assessment Review (STAR) process. The National Marine Fisheries Services, Southwest Fisheries Science Center, took the lead in developing a new full assessment of Pacific mackerel for the 2007-2008 fishing season (Agenda Item F.2.b, Attachment 1). The full assessment was reviewed during a May 1-4, 2007 STAR Panel meeting in La Jolla, California. The STAR Panel and the assessment team agreed on an assessment for use in managing the upcoming Pacific mackerel season and recommended additional analyses for review at the next CPS STAR Panel meeting schedule for September 18-21, 2007. The full report of the STAR Panel can be found under Agenda Item F.2.b, Attachment 2.

On May 8-10, 2007, the Coastal Pelagic Species Management Team (CPSMT), and the Coastal Pelagic Species Advisory Subpanel (CPSAS), held meetings to review the Pacific mackerel stock assessment and STAR Panel report. CPSMT and CPSAS statements with recommendations on the harvest guideline and management measures for 2007-2008 are included in the reference materials under Agenda Item F.2.c. The Scientific and Statistical Committee (SSC) will prepare a supplemental statement at the June meeting.

The CPSMT has completed a draft of the seventh annual Status of the Pacific Coast CPS Fishery and Recommended Harvest Guidelines – Stock Assessment and Fishery Evaluation (SAFE) – 2007 document (Agenda Item F.2.b, Attachment 3). Stock assessment and management recommendations can be found in Chapter 3 and Chapter 9. Once adopted, the 2007 Pacific Mackerel Stock Assessment and Stock Assessment Review Panel report will be included in the 2007 CPS SAFE.

Council Action:

Adopt Pacific Mackerel Assessment and a Harvest Guideline for the 2007/2008 Fishery.

Reference Materials:

1. Agenda Item F.2.b, Attachment 1: *Assessment of the Pacific Mackerel (Scomber japonicus) Stock for U.S. Management in the 2007-2008 Season.*
2. Agenda Item F.2.b, Attachment 2: *Pacific Mackerel, Stock Assessment Review Panel Report.*
3. Agenda Item F.2.b, Attachment 3 *Draft Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches – Stock Assessment and Fishery Evaluation 2007* (**electronic copy on Council Briefing Book CD**).
4. Agenda Item F.2.c, CPSMT Report.
5. Agenda Item F.2.c, CPSAS Report.
6. Agenda Item F.2.c, Supplemental SSC Report

Agenda Order:

a. Agenda Item Overview — Mike Burner
b. NMFS Report — Emmanis Dorval
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. **Council Action:** Approve Stock Assessment and Harvest Guideline

PFMC
05/23/07

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Agenda Item F.2.b
Attachment 1
June 2007

PACIFIC MACKEREL (*Scomber japonicus*) STOCK ASSESSMENT FOR U.S. MANAGEMENT IN THE 2007-08 FISHING SEASON

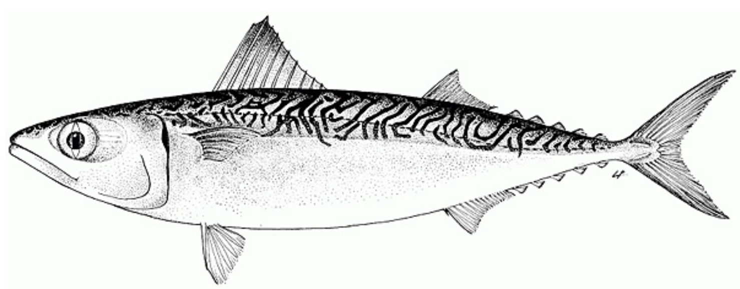
by

Emmanis Dorval, Kevin T. Hill, Nancy C. H. Lo, and Jennifer D. McDaniel
NOAA Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California, 92037

Submitted to

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, Oregon 97220-1384

May 23, 2007



Dorval, E., K. T. Hill, N. C. H. Lo, and J. D. McDaniel. 2007. Pacific mackerel (*Scomber japonicus*) stock assessment for U.S. management in the 2007-08 fishing season. Pacific Fishery Management Council, June 2007 Briefing Book, Agenda Item F.2.b, Attachment 1. 170 p.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADAPT	adaptive framework (age-structured, ‘tunable’ VPA)
ADEPT	ADAPT model modified for Pacific mackerel
ADMB	automatic differentiation model builder
ASAP	age structured assessment program
CA	California
CAA	catch-at-age
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CDFG	California Department of Fish and Game
CICIMAR-IPN	Centro Interdisciplinario de Ciencias Marinas – Instituto Politécnico Nacional (La Paz, Baja California, México)
CPFV	commercial passenger fishing vessel (or ‘partyboat’)
CPS	Coastal Pelagic Species
CPSMT	Coastal Pelagic Species Management Team
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPUE	catch per unit of effort
CTD	Conductivity Temperature Depth instrument
CV	coefficient of variation
FMP	fishery management plan
GAM	generalized additive model
GLM	generalized linear model
GUI	graphical user interface
HG	harvest guideline
IMECOCAL	Investigaciones Mexicanas de la Corriente de California
CRIP-INP	Centro Regional de Investigación Pesquera – Instituto Nacional de la Pesca
MSY	maximum sustainable yield
MX	Mexico
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PFMC	Pacific Fishery Management Council
Ph	Larval production at hatching
RecFIN	Recreational Fishery Information Network
SAFE	Stock Assessment and Fishery Evaluation document
SCB	Southern California Bight
SS2	Stock Synthesis 2 (population assessment model)
SSB	spawning stock biomass
SSC	Scientific and Statistical Committee
STAR	Stock Assessment Review (Panel)
STD	Standard Deviation
SWFSC	Southwest Fisheries Science Center (NMFS)
VPA	virtual population analysis
WAA	weight-at-age

PREFACE

A Pacific mackerel stock assessment is conducted annually in support of the Pacific Fishery Management Council (PFMC) process, which ultimately establishes a harvest guideline ('HG' or quota) for the Pacific mackerel fishery that operates off the U.S. Pacific coast. The HG for mackerel applies to a fishing/management season that spans from July 1st and ends on June 30th of the subsequent year (i.e., a 'fishing year' basis). The primary purpose of the assessment is to provide an estimate of current abundance (in biomass), which is used in a harvest control rule for calculation of annual-based HGs. For details regarding this species' harvest control rule, see Amendment 8 of the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), section 4.0 (PFMC 1998).

The last updated assessment and quota-setting process was completed in May 2006—setting a 2006-07 'fishing year' (July1, 2006 – June 30, 2007) quota of 19,845 mt. In May 1-4, 2007, the PFMC, in conjunction with NOAA Fisheries (Southwest Fisheries Science Center), organized a Stock Assessment Review (STAR) in La Jolla, California, to provide external peer review of the methods used for assessment of Pacific mackerel. The following assessment report was initially prepared in draft form for the STAR Panel' consideration, and is updated here for the PFMC's current management cycle. The STAR Panel Report for Pacific mackerel (PFMC 2007) included recommendations for improving the input data, model configuration and selection. Many of these recommendations are incorporated into this updated 2007 assessment which, ultimately, is to be reviewed by the Science and Statistical Committee (SSC) of the PFMC in June 2007. Finally, in May 8-10, 2007, the assessment presented here was reviewed by the PFMC's CPS Management Team (CPSMT) and the CPS Advisory Subpanel (CPSAS). Electronic versions of model programs, input data, and displays (tables and figures) can be obtained from the authors directly.

EXECUTIVE SUMMARY

Stock

Pacific mackerel (*Scomber japonicus*) in the northeastern Pacific range from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California. They are common from Monterey Bay, California, to Cabo San Lucas, Baja California, but are most abundant south of Point Conception, California. There are possibly three spawning stocks along the Pacific coasts of the U.S. and Mexico: one in the Gulf of California, one in the vicinity of Cabo San Lucas, and one extending along the Pacific coast north of Punta Abreojos, Baja California. The latter "northeastern Pacific" stock is harvested by fishers in the U.S. and Baja California, Mexico, and is considered in this assessment.

Catches

Catches in the assessment were a combination of U.S and Mexico commercial catches and U.S recreational catches. The Mexican commercial fishery for Pacific mackerel is primarily based in Ensenada and Magdalena Bay, Baja California. The Mexican purse seine fleet has slightly larger vessels, but is similar to southern California's with respect to gear (mesh size) and fishing practice. Demand for Pacific mackerel in Baja California increased in the late 1940's. Mexican landings remained stable for several years, rose to 10,725 mt in 1956-57, then declined to a low of 100 tons in 1973-74. Catches were then negligible until the early-1980s. Landings of Pacific mackerel in Ensenada peaked twice, first in 1991-92 at 34,557 mt, and again in 1998-99 at 42,815 mt. The Ensenada fishery has been comparable in volume to the southern California fishery since 1990.

Table of catches (1996-2006).

Fishing Year	USA - Commercial Catch (mt)	Mexico- Commercial Catch (mt)	Recreational - CPFV Catch (mt)	Recreational - non-CPFV Catch (mt)	Total Catch (mt)
96	9,788	14,089	320	366	24,563
97	23,413	26,860	104	700	51,076
98	19,578	42,815	108	322	62,823
99	7,170	8,587	55	97	15,910
00	20,936	6,530	78	248	27,792
01	8,436	4,003	51	520	13,010
02	3,541	10,328	22	232	14,123
03	5,972	5,728	28	295	12,023
04	5,012	5,624	23	537	11,195
05	4,572	8,024	13	543	13,151
06	8,192	8,024	5	403	16,623

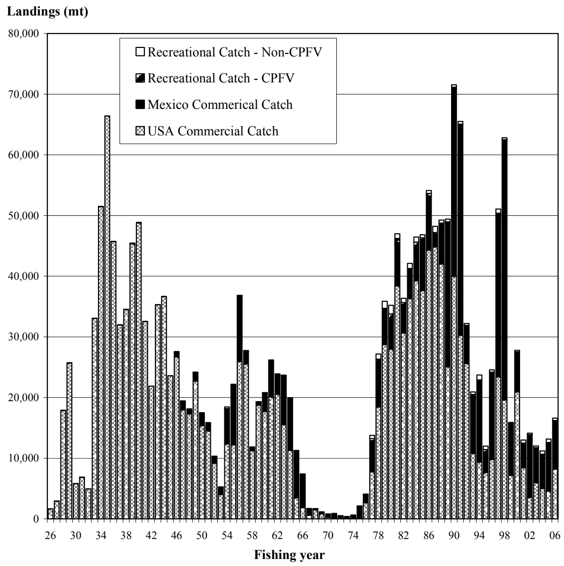

Figure of commercial and recreational landings (mt) of Pacific mackerel in California (CA) and Baja California (MX), from 1926-06.

Data and assessment:
The last assessment of Pacific mackerel was completed in 2006 for U.S. management in the 2006-07 fishing year. The current assessment includes catch data (1926-2006), Aerial spotter survey index data (1963-2001), CPFV recreational CPUE (1935-2006), and CalCOFI larval production at hatching (1951-2006). The final model, recommended by the 2007 STAR Panel, integrates these data into an Age-Structured-Assessment Program (ASAP, V.1.3.2). However, the assessment consists of several ASAP model scenarios (to ensure continuity with previous assessment and one Stock Synthesis (V.2.00c) model scenario that was not supported by the STAR Panel.

Unresolved Problems and Uncertainties:
The assessment suffers from a lack of biological and relative abundance data from Mexico. In particular, there is currently no true fishery-independent index of relative abundance for the whole stock. Further, despite close agreement of many of the outputs from the ASAP and SS2 model runs (i.e., additional model runs performed during the STAR Panel), diagnostics and outputs from the SS2 modeling runs revealed that SS2 model invariably ran up against the harvest rate limit in a number of years. This problem could not be resolved during the STAR, and the Panel and the stock assessment team (STAT) agreed that an updated version of the ASAP should form the basis of this assessment. Nevertheless, the Panel recommended that future stock assessments continue to examine the possibility of using SS2 as an alternative to the ASAP platform. Although analyses presented to the Panel suggested that SS2 and ASAP lead to similar outcomes when configured in a similar manner, SS2 deals better with indices that are not tied to a fishery, can include age-reading error, and allows weight-at-age in the catch to differ from weight-at-age in the population.

Spawning Stock Biomass

After a period of low abundance (1940-1977) spawning stock biomass (SSB) increased in the late 1970s reaching a peak of 662,372 mt in 1982. Since 1982 SSB has declined, reaching an estimate of 86,777 mt in 2007. A table of SSB estimated in the last 10 years is presented below.

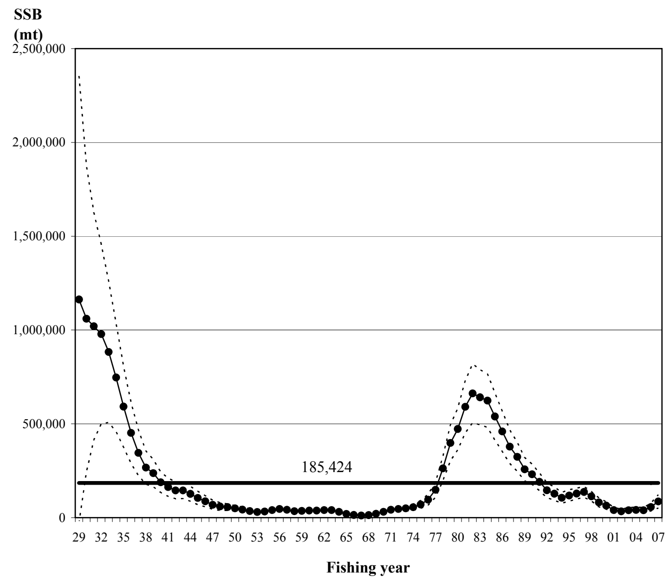

Figure of estimated spawning stock biomass (SSB, in mt) of Pacific mackerel generated from the ASAP-E1 model (1929-07). The confidence interval (± 2 STD) associated with this time series is also presented. Estimated 'virgin' SSB (185,424 mt) from stock-recruit relationship is presented as a bold horizontal line.

Recruitment

Recruitment was modeled following a standard Beverton & Holt stock-recruit relationship. Steepness was estimated to be 0.31 and Sigma-R (σ_R) was fixed to 0.7. Predicted recruits in the model showed large year classes in 1976, 1978, and 1980-1982, but low level of recruitment throughout the 1990s and the early 2000s. The number of recruits estimated by the model is presented in a table below.

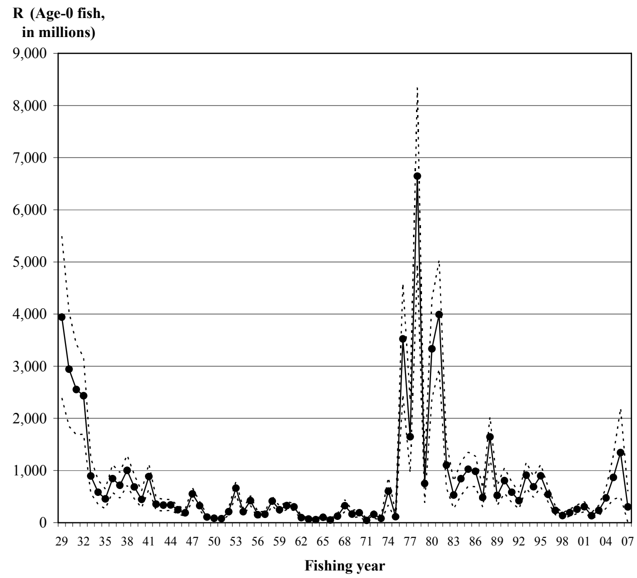

Figure of estimated recruitment (age-0 fish in millions, R) of Pacific mackerel generated from the ASAP-E1 model (1929-07). The confidence interval (± 2 STD) associated with this time series is also presented.

Management performance

Since 2000 Pacific mackerel has been managed based on a Federal Management Plan (FMP) harvest policy, stipulating that maximum sustainable yield (MSY) control rule for this species should be set to an Harvest Guideline (HG):

HARVEST = (BIOMASS-CUTOFF) x FRACTION x STOCK DISTRIBUTION,

where HARVEST is the HG, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS (Ages 1+) assumed in U.S. waters (PFMC 1998). Harvest guidelines under the federal FMP are applied to a July-June fishing season.

Age 1+ Biomass was low from the late 1940s to the early 1970s, reaching a peak in 1982, and since then generally declined reaching 359,290 mt in 2007. However, landings of Pacific mackerel have been consistently below the HGs since 2001.

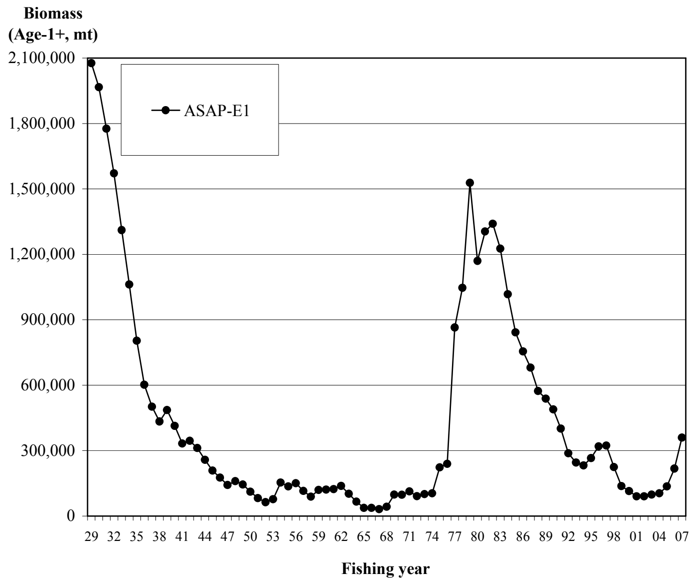

Figure of estimated biomass (Age-1+ fish, in mt) of Pacific mackerel generated from the ASAP-E1 model (1929-07).

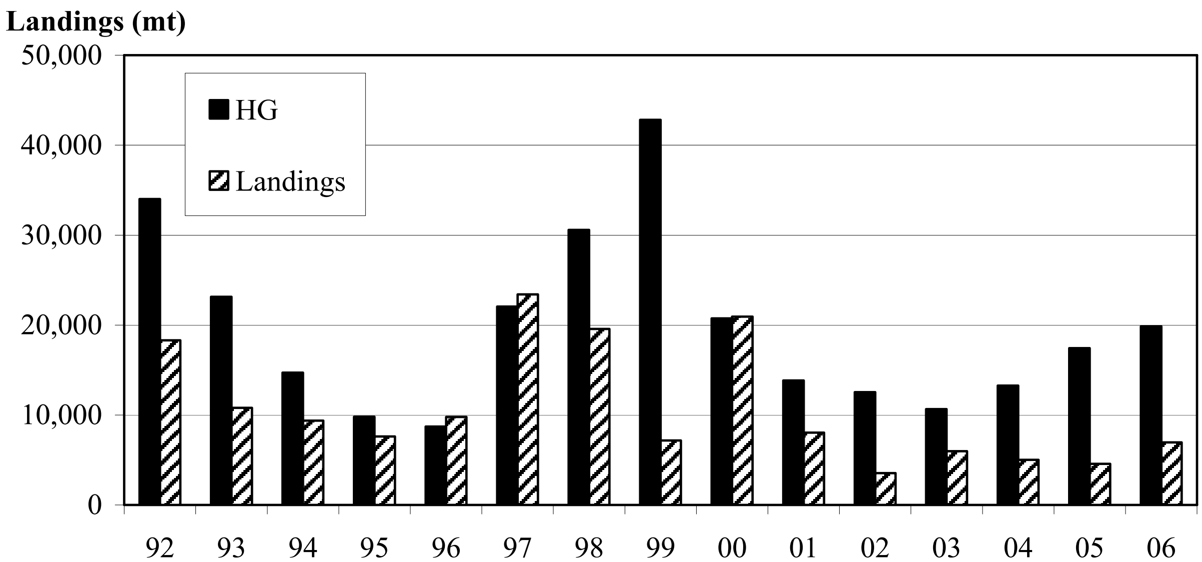

Figure of commercial landings (California directed fishery in mt) and quotas (HGs in mt) for Pacific mackerel (1992-06 Fishing seasons).

Table of estimated recruitment, Age 1+ biomass and spawning stock biomass (1996-2007)

Fishing Year	Recruits (Age-0)	Biomass (Age-1+)	SSB
96	541,059	319,197	128,394
97	235,404	323,042	137,003
98	135,354	224,066	113,751
99	190,579	137,303	81,273
00	255,315	113,862	64,071
01	305,743	90,098	40,164
02	133,326	90,134	33,739
03	233,929	98,091	39,714
04	472,241	104,183	41,169
05	866,391	135,903	39,433
06	1,343,580	217,724	56,496
07	302,694	359,290	86,777

Harvest Guideline for the 2007-08 Fishing Season

Biomass (Age-1+)	Cutoff (mt)	Fraction	Distribution	2007-08 Harvest Guideline (mt)
359,290	18,200	30%	70%	71,629

INTRODUCTION

Distribution

Pacific mackerel (*Scomber japonicus*; a.k.a. 'chub mackerel' or 'blue mackerel') in the northeastern Pacific range from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California (Hart 1973). They are common from Monterey Bay, California, to Cabo San Lucas, Baja California, but are most abundant south of Point Conception, California. Pacific mackerel usually occur within 30 km of shore, but have been captured as far as 400 km offshore (Fitch 1969; Frey 1971; Allen et al. 1990; MBC 1987).

Migration

Pacific mackerel adults are found in water ranging from 10.0 - 22.2°C (MBC 1987), and larvae may be found in water around 14°C (Allen et al. 1990). As adults, Pacific mackerel move north in summer and south in winter between Washington and Baja California (Fry and Roedel 1949, Roedel 1949): northerly movement in the summer is accentuated during El Niño events (MBC 1987). There is an inshore-offshore migration off California, with increased inshore abundance from July to November and increased offshore abundance from March to May (Cannon 1967; MBC 1987). Adult Pacific mackerel are commonly found near shallow banks. Juveniles are found off sandy beaches, around kelp beds, and in open bays. Adults are found from the surface to 300 m depth (Allen et al. 1990). Pacific mackerel often school with other CPS, particularly jack mackerel and Pacific sardine.

During the last two decades, the stock has more fully occupied the northernmost portions of its range in response to a warm oceanographic regime in the northeast Pacific Ocean, and Pacific mackerel have been found as far north as British Columbia, Canada (Ware and Hargreaves 1993; Hargreaves and Hungar 1995). During summer months, Pacific mackerel have become common incidental catch in commercial whiting and salmon fisheries off the Pacific northwest. In addition, they are taken by recreational anglers on CPFVs. Pacific mackerel sampled from Pacific northwest incidental fisheries are generally older and larger-at-age than those captured in the southern California fishery (Hill 1999).

Life History

Pacific mackerel found off the Pacific coast of the U.S. is the same species found elsewhere in the Pacific, Atlantic, and Indian oceans (Collette and Nauen 1983). Synopses of the biology of Pacific mackerel are available in Kramer (1969) and Schaefer (1980).

There are possibly three spawning stocks in the northeastern Pacific: one in the Gulf of California, one near Cabo San Lucas, and one along the Pacific coast north of Punta Abreojos, Baja California. Spawning occurs from Point Conception, California to Cabo San Lucas, from three to 320 km offshore (Moser et al. 1993). Off California, spawning occurs from late April to September at depths to 100 meters. Off central Baja California, spawning occurs year round, peaking from June through October. Around Cabo San Lucas, spawning occurs primarily from late fall to early spring. Pacific mackerel seldom spawn north of Point Conception (Fritzsche 1978; MBC 1987), although young-of-year mackerel have been recently reported as far north as Oregon and Washington.

Like most coastal pelagic species, Pacific mackerel have indeterminate fecundity and seem to spawn whenever sufficient food is available and appropriate environmental conditions prevail. Individual fish may spawn eight times or more per year and release batches of 68,000 eggs per spawning. Actively spawning fish appear capable of spawning every day or every other day (Dickerson et al. 1992).

Pacific mackerel larvae eat copepods and other zooplankton including fish larvae (Collette and Nauen 1983; MBC 1987). Juvenile and adult mackerel feed on small fish, fish larvae, squid, and pelagic crustaceans such as euphausids (Clemmens and Wilby 1961; Turner and Sexsmith 1967; Fitch 1969; Fitch and Lavenberg 1971; Frey 1971; Hart 1973; Collette and Nauen 1983). Pacific mackerel larvae are subject to predation from a number of invertebrate and vertebrate planktivores. Juvenile and adults are eaten by larger fishes, marine mammals, and seabirds. Principal predators include porpoises, California sea lions, pelicans, and large piscivorous fishes such as sharks and tunas. Pacific mackerel school as a defense against predation, often with other pelagic species, including jack mackerel and Pacific sardine.

Dynamics of the Pacific mackerel population have been thoroughly described by Parrish and MacCall (1978). Pacific mackerel experience cyclical periods of abundance ('boom-bust') typical of other small pelagic species (e.g. sardine, anchovy) with short life spans and high intrinsic rates of increase. Analyses of mackerel scale-deposition data (Soutar and Issacs 1974) indicate that periods of high biomass levels such as during the 1930s and 1980s are relatively rare events that might be expected to occur, on average, about once every 60 years MacCall et al. 1985). Pacific mackerel recruitment is variable over space and time, and loosely linked to spawning biomass. Reproductive success, measured as spawning biomass divided by number of recruits, is highly variable and somewhat cyclic, with periods of roughly three to seven years.

Stock Structure and Management Units

There are possibly three spawning stocks along the Pacific coasts of the U.S. and Mexico: one in the Gulf of California, one in the vicinity of Cabo San Lucas, and one extending along the Pacific coast north of Punta Abreojos, Baja California (Collette and Nauen 1983; Allen et al. 1990; MBC 1987). The latter "northeastern Pacific" stock is harvested by fishers in the U.S. and Baja California, Mexico, and is considered in this assessment.

The PFMC manages the northeastern Pacific stock as a single unit, with no area- or sector-specific allocations. The PFMC's harvest control rule does, however, prorate the seasonal HG by a 70% portion assumed to reside in U.S. waters (PFMC 1998).

Fishery Description

Pacific mackerel are currently harvested by three fisheries: the California commercial fishery, a sport fishery based primarily in southern California, and the Mexican commercial fishery based in Ensenada and Magdalena Bay, Baja California. In the commercial fisheries, Pacific mackerel are landed by the same boats that catch Pacific sardine, anchovy, jack mackerel, and market squid. There is no directed fishery for mackerel in Oregon or Washington, however, small amounts (100-300 $mt \cdot yr^{-1}$) are taken by whiting trawlers and salmon trollers. Pacific northwest catch peaked at 1,800 mt following the major El Niño event of 1997-98.

The history of California's Pacific mackerel fishery has been reviewed by Croker (1933, 1938), Roedel (1952), and Klingbeil (1983). Pacific mackerel supported one of California's major fisheries during the 1930s and 1940s and again in the 1980s and 1990s. During the early fishery, Pacific mackerel were taken by lampara and pole and line boats, which were replaced in the 1930s by the same purse seine fleet that fished for sardine. Before 1929, Pacific mackerel were taken incidentally, in relatively small volumes, with sardine and sold as fresh fish (Frey 1971). Canning of Pacific mackerel began in the late 1920s and increased as greater processing capacities and more marketable packs were developed. Landings decreased in the early 1930s due to the economic depression and a decline in demand, and then rose to a peak of 66,400 mt in 1935-36. During this period, Pacific mackerel was second only to Pacific sardine in annual landings. Harvests subsequently underwent a long-term decline and, for many years, demand for canned mackerel was steady and exceeded supply. Supply reached record low levels in the early 1970s, at which time the State of California implemented a moratorium on the directed fishery.

Following the mackerel population recovery in the late 1970s, the moratorium was lifted and the fishery subsequently ranked third in volume of California finfish landings through the 1990s. The market for canned mackerel fluctuated due to availability and economic conditions. Domestic demand for canned Pacific mackerel eventually waned and the last mackerel cannery in California closed in 1992. At present, most Pacific mackerel is used for human consumption or pet food, with a small but increasing amount sold as fresh fish.

Pacific mackerel are often taken by recreational anglers in considerable numbers, though seldom as a target species (Young 1969). During 1980 through 1989, California's recreational catch averaged 1,500 mt per year and Pacific mackerel was numerically the most important species taken in the California CPFV fleet during the period of 1978 through 1989. Pacific mackerel is also harvested in California's recreational fishery as bait for directed fishing on larger pelagic species. Pacific mackerel is also caught by anglers in central California but in very modest amounts. The statewide sport harvest constitutes a small fraction (two to four percent by weight) of the total landings.

The Mexican fishery for Pacific mackerel is primarily based in Ensenada and Magdalena Bay, Baja California. The Mexican purse seine fleet has slightly larger vessels, but is similar to southern California's with respect to gear (mesh size) and fishing practice. The fleet operates in the vicinity of port and also targets other small pelagic species. Demand for Pacific mackerel in Baja California increased after World War II. Mexican landings remained stable for several years, rose to 10,725 mt in 1956-57, then declined to a low of 100 tons in 1973-74. Catches were then negligible until the early-1980s. Landings of Pacific mackerel in Ensenada peaked twice, first in 1991-92 at 34,557 mt, and again in 1998-99 at 42,815 mt. The Ensenada fishery has been comparable in volume to the southern California fishery since 1990. In Baja California, Pacific mackerel are either canned for human consumption or reduced to fish meal.

Management History

The state of California first applied management measures to Pacific mackerel in 1970, after the stock had collapsed in the mid-1960s. A moratorium was placed on the fishery in 1970, with a small allowance for incidental catch in mixed loads. In 1972, legislation was enacted which imposed a landing quota based on the age one-plus biomass. A series of successful year classes in the late 1970s initiated a recovery, and the fishery was reopened under a quota system in 1977. During the recovery period from 1977 to 1985, various adjustments were made to quotas for directed take of Pacific mackerel and to incidental catch limits.

State regulations enacted in 1985 imposed a moratorium on directed fishing when the total biomass was less than 18,200 mt, and limited the incidental catch of Pacific mackerel to 18 percent during moratoriums. The fishing season was set to extend from July 1 to June 30 of the following year. Seasonal quotas, equal to 30 percent of the total biomass in excess of 18,200 mt had been allowed when the biomass was between 18,200 and 136,000 mt, and there was no quota limitation when the total biomass was 136,000 mt or greater.

A federal fishery management plan (FMP) for CPS, including Pacific mackerel, was implemented by the PFMC in January 2000 (PFMC 1998). The FMP's harvest policy for Pacific mackerel, originally implemented by the State of California, is based on MacCall et al.'s (1985) simulation analyses, with the addition of a proration to nominally account for stock assumed in U.S. waters. The current maximum sustainable yield (MSY) control rule for Pacific mackerel is:

HARVEST = (BIOMASS-CUTOFF) x FRACTION x STOCK DISTRIBUTION,

where HARVEST is the HG, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS (Ages 1+) assumed in U.S. waters (PFMC 1998). Harvest guidelines under the federal FMP are applied to the same July-June fishing season initially established by California.

California's recreational catch of Pacific mackerel is included within the U.S. HG, but there are no other restrictions (e.g. size or bag limits) on this fishery. Total annual harvest of Pacific mackerel by the Mexican fishery is not regulated by quotas, but there is a minimum legal size limit of 255 mm. International management agreements between the U.S. and Mexico have not yet been developed.

Management Performance

From 1985 to 1991, the biomass exceeded 136,000 mt and no state quota restrictions were in effect. State quotas for 1992-93 through 1999-00 fishing seasons averaged roughly 24,000 tons. More recently, HGs have been lower, generally below 15,000 mt. The HG established for 2006-07 was 19,845 mt (Crone et al. 2006), from which only 6,956 mt were landed as of Feb. 2007. From a management context, the fishery has failed to fully utilize seasonal HGs since 2001-02. Average yield since 2001-02 has been 5,680 mt (Table 1).

ASSESSMENT

Biological Data

Weight-at-length

Pacific mackerel weight-at-length was modeled using port sample data collected by CDFG from 1962 to 2006 (see '**Fishery Data**' section). The following power function was used to determine the relationship between weight (kg) and fork length (cm) for both sexes combined:

$$W_L = a\ (L^b),$$

where W_L is weight-at-length L, and a and b are the estimated regression coefficients. Weight-at-length parameters estimated for the 1962-2006 period were: a = 3.12517E-06 and b = 3.40352 (n = 95,761; Corr. R^2 = 0.971). To account for changes in weight-at-length over time, parameters were estimated for specific time periods and applied as time-varying parameters (five time blocks) in SS2. See Table 2 for time-specific parameters.

Growth

The von Bertalanffy growth equation was used to model the relationship between fork length (cm) and fractional age (nominal age + 0.5) for Pacific mackerel collected by the CDFG from 1962 to 2006:

$$L_A = L_\infty\ (1 - e^{-K(A-to)}),$$

where L_A is the length-at-age A, L_∞ ('L-infinity') is the theoretical maximum length of the fish, K is the growth coefficient, and t_o ('t-zero') is the theoretical age at which the fish would have been zero length. The best estimate of von Bertalanffy parameters for Pacific mackerel was: L_∞ = 39.3 mm, K = 0.342494, and t_o = -1.75187 (n = 95,761; Corr. R^2 = 0.732). To account for changes in growth over time, parameters were estimated for specific time periods and applied as time-varying parameters (five time blocks) in SS2. See Table 2 for time-specific parameters.

Maximum Age and Size

The largest recorded Pacific mackerel was 63.0 cm FL and weighed 2.9 kg (Hart 1973; Roedel 1938), but the largest Pacific mackerel taken by commercial fishing (CA) was 47.8 cm FL and 1.72 kg. The oldest recorded age for a Pacific mackerel was 14 years, but most commercially caught Pacific mackerel are less than four years old.

Maturity Schedule (ASAP)

Normalized net fecundity-at-age (fraction mature x spawning frequency x batch fecundity; Table 3) was used to interpret CalCOFI ichthyoplankton data and calculate spawning stock biomass (SSB) in this assessment. Fraction mature was estimated by fitting as logistic regression model to age and fraction mature data in Dickerson et al. (1992). Spawning frequency was estimated by fitting a straight line to age and spawning frequency data from the same study. Following Dickerson et al. (1992), batch fecundity per gram of female body weight was assumed constant.

Natural Mortality

Natural mortality rate (*M*) was assumed to be 0.5 yr^{-1}, all ages and both sexes, for all ASAP and SS2 model runs. Parrish and MacCall (1978) estimated natural mortality for Pacific mackerel using early catch curves (*M* = 0.3-0.5), regression of *Z* on *f* (*M* = 0.5), and comparative studies of maximum age (*M* = 0.3-0.7; Beverton 1963) and growth rate (*M* = 0.4-0.6; Beverton and Holt 1959). They considered the regression of *Z* on *f* to be the most reliable method, and the estimate (*M* = 0.5) falls within the mid-range of other estimates.

As requested by the 2007 STAR Panel, a series of ASAP models were run to test sensitivity to a range of natural mortality rates. Results of these runs are discussed in the 'Uncertainty and Sensitivity Analyses' section. No changes to the *M*=0.5 assumption were indicated. So, for purposes of this assessment, the annual rate of natural mortality (*M*) was fixed 0.5 yr^{-1}, which means that 39% of the stock would die of natural causes each year in the absence of fishing (Parrish and MacCall 1978).

Fishery Data

Overview

Fishery data for assessing Pacific mackerel include landings (California commercial, California recreational, and Mexico commercial), and port sample (biological) data from California's commercial fishery. CDFG has collected biological data on Pacific mackerel landed in southern California fishery (primarily San Pedro) since 1929. Samples have also been collected from the Monterey fishery when available. For this assessment, raw sample data were available from 1939 through 2006. Biological samples include whole body weight, fork length, sex, maturity, and otoliths for age determination. CDFG currently collects 12 random port samples per month (25 fish per sample) to determine age composition and weights-at-age for the directed fishery. Mexican port sampling data have been collected by INP-Ensenada since 1989, but were not available to the authors, so California commercial data are assumed to be representative of the combined commercial fisheries. Lack of Baja California port sampling data is not a serious problem for some years when Mexican catches are low. However, in recent years Baja California and California catches have been roughly equal in volume, so lack of Mexican data may affect results. A listing of CDFG sample sizes relative to total landings from 1939-40 to present is provided in Table 4.

Pacific mackerel were aged by CDFG biologists using annuli in whole sagittae. Historically, a birth date of May 1 was used to assign year class (Fitch 1951). For reasons unknown, the protocol changed to a July 1 birthdate in 1976-77 (when the resource rebounded and fishery sampling resumed). This change coincided with a change in the management season from a May 1 opening to July 1 opening.

Fishery inputs were compiled by 'biological year' based on the birthdates used to assigned age. Therefore, data prior to 1976-77 were aggregated in the 'biological year' of May 1 ($year_x$) through April 30 ($year_{x+1}$), and data from 1976-77 forward were aggregated July 1 ($year_x$) through June 30 ($year_{x+1}$). The 'biological year' used in this assessment is also synonymous with the 'fishing year' referred to in this document and with 'fishing season' as reported in the historical literature. That is, the change in birthdate assignment from May 1 to July 1 coincided with a change in the management season in the mid-1970s, and historical sources of landings and biological data reflect this change.

Landings

The assessment uses commercial and recreational landings in California and commercial landings in Baja California from 1926-27 through 2006-07. Seasonal aggregate landings are presented in Table 5 and Figure 1.

California commercial landings of Pacific mackerel were obtained from a variety of sources based on dealer landing receipts (CDFG), in some cases augmented with port sampling for mixed load portions. Data from 1926-27 to 1961-62 were obtained from Parrish and MacCall (1978). Monthly landings for the period May 1962 to Sept. 1976 were obtained from CDFG fish bulletins recovered to an electronic database format (PFEL 2005). Raw landing receipt data for Pacific mackerel from 1976 to 1991 are of marginal quality, owing to the large quantities of Pacific mackerel landed as mixed loads with jack mackerel. During this period, many processors reported either species as 'unspecified' mackerel on landing receipts. For these years, mackerel landings receipts were augmented with shoreside 'bucket' sampling of mixed loads to estimate species compositions. CDFG reported these data in two forms: 1) annual stock status reports to the California legislature, and 2) single page 'CDFG Wetfish Tables'. Both sources are considered more accurate than PacFIN or other landing receipt-based statistics for this period. Data sources from late 1976 to present are as follows: Oct – Dec 1976 are from Klingbeil and Wolf (1986); Jan - Dec 1977 are from Wolf and Worcester (1987); Jan 1978 – Dec 1981 are from Jacobson et al. (1994a); Jan 1982-Feb 2007 are from CDFG Wetfish Tables. Landings for March-June 2007 were substituted with corresponding months from 2006. Pacific mackerel landings from 1976-1981 were only reported by quarterly increments so, for purposes of weighting catch-at-age estimates for this period (following section), we apportioned quarters to months using monthly 'unspecified mackerel' landings from the PFEL LAS database (PFEL 2005).

California recreational landings (mt) from 1980 to present (2-month 'wave' resolution) were obtained directly from Pacific RecFIN estimates. Historical estimates (pre-1980) of total recreational catch were derived from CPFV logbook data collected since 1936 (Hill & Schneider 1999). CPFV catch (number) was converted to metric tons using and assumed average weight of 0.453 kg (1 lb.) per individual, based on RecFIN samples and consistent with Parrish and MacCall (1978). CPFV tonnage was expanded to total recreational tonnage using wave-specific ratios from RecFIN. Nominal amounts of recreational removals were assumed for 1926-35 and 1941-46 when no recreational statistics were available.

Baja California data include landings from commercial purse seine fisheries in Ensenada, Cedros Island, and Magdalena Bay. Ensenada landings were compiled as follows: 1946-47 through 1969-70 (May-Apr) data are from Parrish and MacCall (1978); 1970-71 through 1975-76 (May-Apr) data are from Schaefer (1980); quarterly data from Jul 1976 through Dec 1986 are from Jacobson et al. (1994); monthly data from Jan 1987 through Nov 2003 were provided by INP-Ensenada (Garcia and Sánchez, 2003; Celia Eva-Cotero, INP-Ensenada, pers. comm.); monthly landings from Dec 2003 through Dec 2004 were not available, so were substituted with corresponding months from the previous year. Ensenada landings in 2005, available from Cota et al. (2006a), was apportioned into monthly catch using ratios from the previous few years. Ensenada landings for Jan-Jun 2006 were taken from Cota et al (2006b). Monthly landings data for the Cedros Island (Jan 1981 - Dec 1994) and Magdalena Bay (Jan 1981 – May 2003) fisheries were provided by Roberto Felix-Uraga (CICIMAR-IPN, La Paz, pers. comm.). The fishery off Cedros Island ceased in 1994. Magdalena Bay landings for June 2003 through June 2007 were substituted with corresponding months from the previous year. Monthly-resolution catch statistics for Mexico were not available for all seasons so, for purposes of weighting catch-at-age estimates (following section), aggregate catch data (season or quarter) were apportioned to months by inflating the corresponding California data.

Small volumes (100 to 300 $mt \cdot yr^{-1}$) of Pacific mackerel are taken incidentally in other fisheries (e.g. whiting, salmon troll, sardine) off Oregon and Washington. Biological samples collected from these fisheries (Hill 1999) indicate age and size structures that are much older and larger than the directed fishery off California, so this catch is not included in the assessment.

<u>Catch-at-age (ASAP)</u>
Various sources were used to reconstruct a catch-at-age time series for Pacific mackerel. Age data for 1929 to 1932 and 1935 to 38 were derived from CDFG length composition data using Tomlinson's unpublished NORMSEP program (Parrish and MacCall 1978). Ages for all other biological years in this assessment were based on otolith data available from the literature or contemporary fishery databases. See 'Fishery Data / Overview' section (above) for details regarding birthdate assumptions. Sample sizes for developing catch-at-age estimates (1939-40 to present) are provided in Table 4.

Age compositions for 1929-30 to 1938-39 (May-April) were taken from Parrish and MacCall (1978) and adjusted according to our total landing estimates for this period, using weight-at-age data from Prager and MacCall (1988) (see also 'Weight-at-age' section).

Age compositions for the period 1939-40 to 1961-62 (May-April) were based on year class, age, and length data recovered from the historical literature (Fitch 1951, Fitch 1953a, Fitch 1953b, Fitch 1955, Fitch 1956, Fitch 1958, Hyatt 1960, Parrish and Knaggs 1971, Parrish and Knaggs 1972) and now available in a database individual-level resolution by biological year. Lengths were converted to weights using the weight-length relationship published by Fitch (1951). Age compositions were estimated by using the proportions-at-age and average weights-at-age to calculate tonnage per age group. Tons per age was converted to numbers at age using average fish weights for each biological year.

Age compositions from 1962-63 to 2006-07 were developed using CDFG port sample databases, coupled with pooled monthly landings for the three respective fisheries (see 'Landings' section). While no directed sampling for Pacific mackerel took place during the fishing moratorium (1970-1976), Pacific mackerel samples were collected from the jack mackerel fishery during this period. From 1962-63 onward, estimates of catch-at-age were weighted to take into account variation in sample size relative to total landings. Sample percent-by-weight for each age class was calculated by dividing the total weight of fish-at-age by the total weight of fish sampled in each month. Landed weight of fish in each age class was estimated as the product of metric tons landed and the percent-by-weight in the fishery sample. Numbers-at-age in the monthly landings were then calculated by dividing the landed weight-at-age by the average individual weight-at-age for the month. For months with landings but no fishery sample taken, data were substituted by summing sample information (i.e., fish numbers, weights, and sample weights) from the two adjacent (previous and following) months. Finally, numbers-at-age were summed across months to provide the catch-at-age for each biological year (May-April prior to 1976-77; July-June for 1976-77 to present).

Catch-at-age data compiled for ASAP input are provided in Table 6, and proportions-at-age are displayed in Figure 2. For years where age sampling was carried out (i.e. 1929-30 to 2006-07), an effective sample size (λ) of 45 was used. Effective sample size was set to zero for cases with landings but no samples (2007-08).

Weight-at-age (ASAP)

A year-specific weight-at-age matrix based on fishery samples was developed for use in the ASAP model. This matrix was used to calculate SSB and age 1+ biomass from modeled population estimates. Weight-at-age data are presented in Table 7. While it is possible that the population weight-at-age of Pacific mackerel differs from that derived from fishery samples, fishery-independent data do not exist to explore this question.

Weights-at-age from 1929-30 to 1938-39 were obtained from Prager and MacCall (1988). Weights-at-age from 1939-40 to 1961-62 were calculated from the historical database based on various sources (see ‘Catch-at-age’ section above), again, noting that weights were converted from lengths in the original source using the length-weight relationship published by Fitch (1951). Weights-at-age from 1962-63 to 2006-07 were obtained directly from CDFG port sample databases.

Length composition (SS2)

The SS2 model uses length composition for the commercial (US-Mexico) and the recreational (US-Private, Party, Charter, and Rental boats) fisheries. Time series of length distribution for the commercial fishery were derived from CDFG port sampling data collected from 1939 to 2006. Pacific mackerel length composition for the recreational fishery was developed from the Marine Recreational Fisheries (RecFIN) database using angler examined catch data from 1992 to 2006.

Length composition for both fisheries were derived using 1-cm bin length (Fork length), with the smallest bin equal to 4 cm and the largest equal to 60 cm. The 60-cm bin includes fish whose sizes are equal or greater than 60 cm. Number of length samples observed at each bin were weighted by 25, which is the average number of samples collected by CDFG by boat and trip. For each fishery, annual size distributions were developed in proportion, including both males and females data.

Observed length distribution data compiled for the SS2 model are presented in Figure 3 and 4. For the commercial fishery effective sample size was estimated to be 72, whereas for the recreational fishery the effective sample size was estimated to be 102.

Indices of Relative Abundance

Overview

Fishery-independent survey data used in the ASAP and SS2 models include 1) aerial sightings by spotter pilots, 2) larval production at hatching (P_h) from the CalCOFI program, 3) CPUE indices from CPFV logbooks. Survey data for Pacific mackerel vary in quality with respect to over space and time, but no single index is proposed to be superior with respect to comprehensiveness or sampling design. Strengths and weaknesses of each survey will be briefly addressed in the following sections (see 2007 STAR Panel Report).

Aerial Spotter Survey

Pilots employed by the fishing fleet to locate Pacific mackerel (and other pelagic fish) schools report data for each flight on standardized logbooks and provide them under contract to NOAA Fisheries. In this assessment 'Spotter' data for Pacific mackerel were calculated for year effects estimated using a Delta-Generalized Linear Model (Delta-GLM) (see Lo 2007, Appendix I). The 2007 STAR Panel determined that an alternative Generalized-Addive Model proposed by Lo (2007, Appendix I) was inconsistent with the assumptions related to how indices of abundance are included in stock assessment models. For the preferred Delta-GLM model Spotter data were aggregated using July to June annual period, for example, the estimate for 1993 was based on data collected from July 1992 to June 1993. Estimates of relative abundance (*I*) and their coefficients of variations were computed as:

$$\hat{I} = \hat{D}A$$

$$CV(\hat{I}) = CV(\hat{D})$$

where *A* is the total number of blocks covered by spotter pilots within the "traditional area covered by spotter pilot" each year; and *D* is the density of Pacific mackerel for each year.

In this assessment, the spotter index covers the period 1962-63 through 2001-02 (Figure 5, Appendix I). After the year 2000, there was rapid decline in both the number of active pilots and total logbooks returned, as well as a southward shift in effort to offshore areas off of Baja California. Although data from 2004 through 2006 were available, the 2007 STAR Panel recommended that these data be dropped from the assessment (see 2007 STAR Panel Report). The 2004-06 data were derived from a new sampling design (see Appendix I) and during this period the pilots did not fully comply with the requirements of the design. The 2007 STAR Panel questioned the validity of combining these data with the 1962-01 period, and proposed to further investigate the new time series data before they can be used in future assessments (see 2007 STAR Panel Report).

In the ASAP model, the selectivity pattern applied for this index is such that all age groups (ages 0-8+) were fully selected (Figure 6). This is based on the assumption that spotter pilots will record all fish schools sighted (including age-0 fish), not only those schools reported to the wetfish fleet. In the SS2 model the selectivity of this index was set to mirror the commercial fishery selectivity (Figure 7).

Commercial Passenger Fishing Vessel Logbook CPUE

California Fish and Game Code has required CPFV skippers to provide records of catch and effort data to CDFG since 1936. In the past, Pacific mackerel has been among the top five species reported on CPFV logs both in southern California and statewide. We utilized an historical logbook database (Hill and Barnes 1998, Hill and Schneider 1999) which summarizes CPFV catch and effort by month and Fish and Game statistical blocks (10 nautical mile squares). In the 2005 assessment, a single statewide index of relative abundance was developed and standardized using a Generalized Linear Model (GLM; Hill and Crone 2005, Crone et al. 2006). For the current assessment we also develop a single state wide index of relative abundance, but we use a Delta-Generalized Linear Model (Delta-GLM, described below) approach to model the year effect. Also, the new index of abundance is developed based on fishing year, contrary to the old approach that used calendar year. Length data from the Recreational Fisheries Information Network (RecFIN) database were used outside the model to estimate a fixed selectivity pattern for use in ASAP models. In the SS2 model the selectivity of this index was set to mirror the recreational fishery selectivity.

To account for potential changes in catchability associated with the CPFV fleet over time, a Delta-GLM model was used to 'standardize' the data and separate effects from critical factors (e.g., spatial-temporal). That is, by incorporating year as a factor, the Delta-GLM generates estimates of annual standardized catch rate and its variance that can be generally interpreted as a relative index of abundance of the population. Technical issues concerning the Delta-GLM analysis follow:

(1) data were combined within year/quarter/fleet strata (i.e., the overall, statewide fishery was partitioned into a northern and southern 'fleet' based on latitude/longitude spatial fishing 'blocks');

(2) CPUE was calculated (number of fish/1,000 angler-hours fishing) for each spatial/temporal stratum;

(3) Fishing years 1935-36 to 2006-07 were used in the analysis, with the exception of a few years that were omitted due to missing data (e.g., 1941-42 to 1945-46);

(4) latitude/longitude blocks were combined into broader spatial areas based on the fishing practices of the northern and southern CPFV fleets, i.e., historically, the southern fleet has exerted the vast amount of fishing pressure associated with this overall fishery (Pt. Conception was used as the 'north/south' delimiter to partition the two regional fleets);

(5) The Delta-GLM method models the probability of obtaining a zero catch and the catch rate, given the catch rate is non-zero, separately (Stefansson 1996, Maunder and Punt 2004). In this assessment we estimate the probability of a positive observation using a binomial distribution and a logit link function. Then, the mean response for positive observations was estimated assuming a gamma distribution for the error term. The basic model for positive observations included the log of mean catch rate (μ) as a function of three main effects (fishing year i, quarter j, and fleet k),

$$\log_e(\mu_{ijk}) = U_R + Y_i + Q_j + F_k + \varepsilon_{ijk},$$

where μ_{ijk} is the mean catch rate (number of fish/1000 angler-hours) in year i, quarter j, and fleet k. The fishing year effect is denoted by Y_i (i=1, 2, ..., I; I=67 fishing years). The quarter of the year effect is denoted by Q_j (j=1, 2, ..., J; J=4 quarters). The fleet effect is denoted as F_k (k=1, ..., K; K=2 fleets). The error term is denoted ε_{ijk}, where for each combination of indices, ε_{ijk} is an *iid* and gamma distributed. Finally, the reference cell is denoted as UR (R=1 reference cell, i.e., year=2004, quarter=4, and fleet=south);

(6) no temporal/spatial interactions (e.g., year and fleet or quarter and fleet) were included in the final Delta-GLM model, given such interactions had little effect on increasing the amount of variability in mean catch rate as a function of the suite of explanatory variables (i.e., minor improvement of R^2 statistic, see Hill and Crone 2005, Crone et al. 2006).

(7) We used a Delta-GLM function written in R codes (pers. Comm. (E.J. Dick, NMFS SWFSC, Fisheries Ecology Division) to estimate catch rates for the CPFV data. The major feature of this function is that it estimates the coefficients of variation for the relative index of abundance using a Jacknife (Leave-one-out) method. However, because the CPFV data are very extensive (78,376 observations) we could not estimate the year effect for the survey simultaneously with the coefficients of variation. In the current assessment we first estimate the year effect using all available data; then we resample the data by fishing year, and estimate the coefficient of variation for each of the fishing years. Likewise, our estimates of coefficients of variation are based on 200 bootstrap samples (with replacement), taken in each fishing year from 1935-36 to 2006-07. Finally, Figure 8 compares year-effect estimated from the Delta-GLM to estimates from the GLM used in Hill and Crone (2005) for the CPFV time series data (see also Figure 5).

CalCOFI Larval Survey

CalCOFI ichthyoplankton data from 1951 to 2006 were compiled and an annual index of daily larval production at hatching (per 10 m^2) for the Southern California Bight was calculated (Figure 5, Appendix II). Past assessments of Pacific mackerel (Hill and Crone 2005, Crone et al. 2006) used a CalCOFI larval index based on “Proportion positive bongo net tows.” However, because of the implementation of the SS2 model (which does not allow 0 values), and also based on the recommendation of the 2006 SSC report (see SSC 2006), it was necessary to develop the new larval production index (Lo et al. 2007, Appendix II). Data from all available years were used, but data were filtered to include only cruises from April through July, peak spawning months for Pacific mackerel . The filtered data grid included standard CalCOFI lines (line 93-line 77)). A weighted-non linear regression was used to estimate larval production at hatching (i.e., P_{h}) in years with sufficient catch-length data:

$$P_t = P_h \exp(\alpha t)$$

However, in years where only one or two length classes had positive catches in the survey, P_h was estimated by inverting the mortality curve for Pacific mackerel larvae, following the equation below:

$$\hat{P}_h = \overline{P}_L \times \exp(-\hat{\alpha} t_L)$$

where P is the mean daily larval production at length L =2.5 mm, t_L is the age at 2.5 mm length, and $\alpha$is the overall mean mortality rate estimate. For further details on the development of this index and its variance we refer the reader to Appendix II (Lo et al. 2007). Coefficients of variations used as input in the models for this index were approximated as the square root of $\log(1+CV^2)$.

During the 2007 STAR Panel we compared coastwide larval densities to larval densities off Mexico and larval densities for the Southern California Bight (SCB, i.e., using data derived from CalCOFI surveys that covered Mexico and the SCB (1951-1984)). We found that the CalCOFI index (i.e. SCB index) could be a good proxy for coastwide-relative abundance of Pacific mackerel in periods of high abundance, otherwise the index could contribute little information on the coast-wide status of spawning stock biomass (Figures 9a and 9b). Nevertheless the 2007 STAR Panel recommended to use the new index in this stock assessment. For both modeling platforms the modeled selectivity pattern used the normalized net fecundity ogive described above in 'Maturity Schedule' and provided in Table 3 and in Figure 10.

History of Modeling Approaches

Parrish and MacCall (1978) were the first to provide population estimates for Pacific mackerel using a traditional VPA. The ADEPT model (the 'ADAPT' VPA modified for Pacific mackerel; Jacobson 1993 and Jacobson et al 1994b) was used to evaluate population status and establish management quotas for approximately 10 years. The assessment conducted in 2004 (for 2004-05 management) represented the final ADEPT-based analysis for this stock (see Hill and Crone 2004a). The forward-simulation model 'ASAP' was reviewed and adopted for Pacific mackerel at the 2004 STAR Panel (Hill and Crone 2004b). ASAP was implemented for assessment and management advice in the 2005-06 and 2006-07 seasons (Hill and Crone 2005; Crone et al. 2006).

ASAP Model Description

<u>Overview</u>
The Age-Structured Assessment Program model ('ASAP'; Legault and Restrepo 1999, Appendix C) is based on the AD Model Builder (ADMB) software environment, a high-level programming language that utilizes C++ libraries for nonlinear optimization (Otter Research 2001). The general estimation approach used in the ASAP is that of a flexible forward-simulation that allows for the efficient and reliable estimation of a large number of parameters. The population dynamics and statistical principles of ASAP are well established and date back to Fournier and Archibald (1982) and Deriso et al. (1985).

The following is a brief description of estimation methods employed in the ASAP model. Readers interested in further details and model equations should refer to Legault and Restrepo (1999).

- Model estimation begins in the first year of available data with an estimate of the population abundance-at-age.

- The spawning stock for that year is calculated and the associated recruitment for the next year is determined via the stock-recruitment relationship (in this case, based on a Beverton-Holt model). Recruitment variability is accommodated by accounting for divergence from the estimated central tendency (expected value).

- Each cohort estimated in the initial population abundance at age is then reduced by the total mortality rate and subsequently, projected into the next year/age combination. This process of estimating recruitment and projecting the population forward continues until the final year of data is reached.

- Total mortality rates (Z) used to decrease cohort abundances over time represent the sum of natural mortality (M) and the fishing mortalities (F) from all fisheries.

- The Fs for each fishery are assumed to be separable into age (commonly referred to as selectivity) and year (commonly referred to as F-multipliers). The product of selectivity-at-age and the year specific F-multiplier equals the F for each fishery/year/age combination.

- The added structure of time-varying selectivity can be incorporated via the estimation of random walks.

- Predicted catch in weight- and catch-at-age are estimated using Baronov's catch equation and user-provided mean weights at age and natural mortality.

- The method of maximum likelihood serves as the foundation of the overall numerical estimation. Sources of data are compartmentalized into various likelihood components, depending on the level of structure of the overall, fully-integrated population model. Generally, the ASAP model can include up to nine likelihood components and a few penalties.

- The tuning indices are assumed to represent changes in the population over time for specific age ranges and can be measured in numbers or weight.

- Given the large number of parameters, it is possible to fit both the catch-at-age and the abundance indices relatively well, but often at the expense of producing somewhat unrealistic trends in other stock parameters of interest (e.g., recruitment, selectivity, and catchability). Constraints and penalty functions can be employed to the constrain estimation to more feasible regions of parameter space.

- Because the number of parameters can be large and highly nonlinear, it is often difficult to estimate all parameters simultaneously in one run of the model. In practice, the minimization usually proceeds in phases, where groups of parameters are estimated simultaneously, while the remaining parameters are maintained at their initially assigned (starting) values. Once the objective function is minimized for a particular phase, more parameters are evaluated in a step-wise fashion. Estimation within additional phases continues until all parameters are estimated. For this assessment, parameters were estimated in the following order: Phase (1): Selectivity in 1^{st} Year, Fmult in 1^{st} Year, Catchability in 1^{st} Year, Stock-Recruitment Relationship, and Steepness; Phase (2): N in 1^{st} year; Phase (3): Fmult Deviations, Recruitment Deviations; Phase (4): Selectivity Deviations.

Assessment Program with Last Revision Date

ASAP version 1.3.2 (compiled 14 Sept. 2004) was used for all runs presented in this paper. ASAP was implemented using NFT GUI version 2.7 (compiled 4 Mar. 2005).

Likelihood Components and Model Parameters

Likelihood components in the final ASAP base model ('Base-E1') are listed in Table 8, and included: (1) fit to catch; (2) fit to catch-at-age; (3) fits to three indices; (4) stock-recruit fit; (5) penalty for recruitment deviations; and (6) an F penalty.

Convergence Criteria

The iterative process for determining numerical solutions in the model was continued until the difference between successive likelihood estimates was < 0.0001. The number of function evaluations ranged from 800 to 10,000, depending on the model configuration and initial values. Fidelity of model convergence was explored by modifying selected initial values (stock size at the beginning of the time series, catchability coefficients associated with indices of abundance, etc.) and then comparing the likelihoods and estimates of key management parameters.

Critical Assumptions and Consequences of Assumption Failures

In the ASAP-E1 model, we assumed that the commercial fishery selectivity parameters vary through time, but that Sigma-R and natural mortality rate were constant. Increasing Sigma-R from 0.25 (value used in the 2004 model) to 0.7 led to a more productive stock and higher SSB and Age 1+ biomass, particularly during the peaks of abundance. Although to a lesser extent, blocking the commercial selectivity resulted in significant differences between the 2004 and 2007 biomass estimates. In retrospect, harvest guidelines for the 2005 and 2006 fishing season would have been higher, had these stock assessments used a higher Sigma-R value. The 2007 STAT and STAR Panel agreed that a Sigma of 0.7 better reflects the life history and dynamics of Pacific mackerel, and better meets the expectation of model runs in term of uncertainties in recruitment and stock abundance. Finally, natural mortality (M) was assumed to be 0.5 yr^{-1} for all ages and Figures 34 and 35 show the effects of varying M from 0.35 to 0.7 on estimates of Age 1+ biomass and recruitment from the ASAP-E1 model.

SS2 Model Description

Overview

The Stock Synthesis 2 (SS2, Methot 2005, 2007) is based on the AD Model Builder software environment, which is essentially a C++ library of automatic differentiation code for nonlinear statistical optimization (Otter Research 2001). The model framework allows the integration of both size and age structure, and with multiple stock sub-areas (Methot 2005). Hence, the model is closely similar to A-SCALA (Maunders and Watters, 2003); Multifan (Fournier et al. 1990);

Multifan-CL (Fournier, Hampton and Siebert, 1998). The latest version SS2.V2.00c was released in March 2007, and is maintained through the NOAA Fisheries Toolbox (NFT 2007). The general estimation approach used in the SS2 model derives goodness of fit to the model in term of quantities that retain the characteristics of the raw data. The model tends to incorporate all relevant sources of variability and estimates goodness of fit in term of the original data, potentially allowing that final estimates of model precision capture most relevant sources of uncertainties (see Methot 2005).

The SS2 model comprises three sub-models: 1) A population dynamics sub-model, where abundance, mortality and growth patterns are incorporated to create a synthetic representation of the true population; 2) An observation sub-model that defines various processes and filters to derive expected values for different type of data; 3) A statistical sub-model that quantifies the difference between observed data and their expected values and implement algorithms to search for the set of parameters that maximizes the goodness of fit. Another layer of the model is the estimation of management quantities, such as short term-forecast of the catch level given a specified fishing mortality policy. Finally, these sub-models and layer are fully integrated and the SS2 model use forward-algorithms, which begin estimation prior or in the first year of available data and continues forward up to the last year of data (see Methot 2005).

Assessment Program with Last Revision Date

SS2 Version 2.00c , compiled March 27, 2007, is used in this report. SS2.V2.00c is also implemented through NFT's GUI (NFT 2007). The reader is referred to Methot (2005, 2007) for a complete description of SS2's population dynamics model.

Likelihood Components and Model Parameters

In the SS2-C1 model we assumed that both growth and selectivity parameters vary through time. Further, because the main objective of this model is to show that SS2 can mimic ASAP estimates of the most important fisheries parameters, all growth parameters were fixed in each of the blocks, whereas some of the selectivity parameters were freely estimated and others were fixed. In addition, size selectivity for the commercial fishery and the spotter survey index was assumed to follow a double normal pattern (a new feature in SS2.V2.00c) with six parameters, and a two parameter logistic curve was assumed for the recreational fishery and CPFV index. We set the expected larval production survey index to be equal to spawning biomass (i.e., population fecundity). In that respect, Maturity-at-age was assumed to be a logistic function (Figure 10, see also, Methot 2007), following the equation :

$$mat = \frac{1}{(1+\exp(slope * age(\inf lexion)))}$$

and the number eggs produced is expressed as:

$$Eggs = 0.88 * BodyWeight - 0.025$$

For all fishery and surveys, age selectivity was conditioned on size selectivity. Further, the fraction of the season elapsed before catch rates are measured or surveys are conducted were set up to: 0.33 for the commercial fishery and the spotter survey index; 0.25 for the recreational fishery and the CPFV index, and 0.75 for the Larval production at hatching (P_h).

Convergence Criteria

The convergence criterion for maximum gradient was set to 0.000001 in SS2 model runs. Fidelity of model convergence was briefly explored by changing particular 'starting' values for multiple parameters and evaluating the converged 'minimum' values, i.e., evaluating 'global' vs. 'local' convergence properties of the multi-dimensional numerical estimation method.

Model Selection and Evaluation

ASAP Model Scenarios

A primary goal of this assessment was to compare Pacific mackerel population analyses from the ASAP to SS2 model. For brevity, several ASAP model scenarios and results are presented in this report as basic summaries to examine the effect of different data treatments and ultimately for comparison to the an SS2 model described in following sections. To show continuity from previous assessments, we developed a series of ASAP models that range from an update of the assessment as described in Hill and Crone (2005) and Crone et al. (2006), to one that is more similar to the SS2 base model (that is, as far as such a comparison can be made). The changes included strict updates to fishery and index data, introduction of new index methods (described elsewhere in this report), application of inverse weighting to index observations (model CVs) to account for uncertainty in year-to-year estimates, and an increase in the age structured component from 6+ to 8+ years. Each ASAP model scenario was based on the modifications from the previous model, and is described here:

Run name	*Description*
ASAP-2006	final model from 2006 assessment (see Crone et al. 2006)
ASAP-A1	strict update of ASAP-2006 assessment, with updated fishery data and indices using old index methods; no changes to parameterization.
ASAP-B1	same as ASAP-A1, using new index methods; index CVs fixed at 0.3.
ASAP-B2	same as ASAP-B1, with index CVs based on index model CVs
ASAP-B3	same as ASAP-B2, but CVs based on the approximation: $\sigma^2 = \ln(1+CV^2)$.
ASAP-C1	same as ASAP-B3, but plus group increased from age 6+ to 8+.
ASAP-E1	same as ASAP-C1, but Sigma-R changed from 0.25 to 0.7.

SS2 Model (SS2-C1) Scenario

The SS2-C1 model is a two fisheries (commercial and recreational), one season and one gender (female) model. This model includes all three available indices (i.e., CPFV, aerial spotter survey, and Larval production at hatching(P_h)). The P_h index was cast as the spawning biomass survey, CPFV as a relative index of abundance (CPUE), and the aerial spotter survey as a relative index of total biomass. Catch data (in mt) for the recreational and commercial fisheries cover the 1926-2006 period. Length data for the commercial fishery span from 1939 to 2006, whereas the recreational length composition covers the 1992-2006 fishing seasons. Season is defined in the model as the fishing year, corresponding to May-April for the 1926 to 1975 and July-June for the 1976 to 2006 period.

Model Scenario Comparison

ASAP Model Results (Pre-2007 STAR Panel)
Summary results from the above ASAP models are provided in Table 9 and in Figures 11-13. With the exception of ASAP-B1, each of the models was able to converge. Each model provided estimates of Recruitment, SSB, and Total (1+) Biomass that lay well within the range of uncertainty of the other model runs. A comparison of some basic model outputs is provided in Table 9. Objective functions from ASAP models B2 through C1 (new indices and CV methods) were slightly lower than ASAP-2006 and ASAP-A1. Estimates of B-zero were similar among all scenarios, ranging from 201,736 mt to 219,733, but slightly lower for B2, B3, C1. Beverton-Holt steepness (*h*) was slightly higher in models B2, B3, and C1 in comparison to 2006 and A1. Peak SSB and Total Biomass is slightly higher during the peak period but lower in 2006 in comparison to the 2006 and A1 models (Table 9). This change is probably due to differences in the magnitude of change between the old and new index methods. A comparison of ASAP-C1 to SS2 results is made in the SS2 section of this report.

SS2-C1 Model Results (Pre-2007 STAR Panel)

Indices of Relative Abundance
The observed estimates for the suite of relative ('tuning') indices of abundance and model fits are presented in Figure 14-16. For all indices, coefficients of variations (CVs) were rescaled in the SS2-C1 model, by assuming a multiplicative effect for the year- to- year variability in the magnitude of relative abundance estimates (i.e., CVs for each index were multiplied by a factor to approximate the overall expectation in variance of the model). Observed values for the three surveys are compared in Figure 5.

Selectivity Estimates
Time-varying selectivity estimated for the commercial fishery and the aerial spotter index is presented in Figure 7. Selectivity parameters estimated from SS2-C1 are similar to ASAP model estimates (see "ASAP-E1 Selectivity Results Section" for a complete description of these time-varying patterns). The selectivity curve estimated for the recreational fishery and the CPFV index is presented in Figure 17.

Harvest Rate
The estimated harvest rate time series for the SS2-C1 model is presented in Figure 18. Maximum harvest rate estimated by this model was approximately equal to 0.51.

Biomass of Age 1+
The estimated time series of population biomass ('B', age 1+ fish) for the SS2-C1 model is compared to ASAP-C1 results in Figure 19. Note that estimate of Age-1+ biomass from both modeling platforms was closely similar.

Spawning Stock Biomass
The estimated time series of SSB for the SS2-C1 model is compared to ASAP-C1 results in Figure 20. Note that SSB estimated from SS2-C1 were higher then 1971-2001' ASAP-C1 estimates, however results from both models were closely similar from 2002 to 2006.

Recruitment
The estimated time series of recruitment ('R'; abundance of age-0 fish) for the SS2-C1 model is compared to ASAP-C1 results in Figure 21. In most years number of recruits estimated by SS2-C1 was higher than ASAP-C1 model estimates.

ASAP Final Base Model E1 Results

Overview
The final ASAP base model (E1) was generally similar to previous Pacific mackerel assessments but did incorporate some key changes, including those recommended by the 2007 STAR Panel. Changes from previous ASAP-based assessments (Hill and Crone 2005; Crone et al. 2006) include the following:

- Additional year of catch, catch-at-age, and weight-at-age data;
- Plus group for age data increased from 6+ to 8+ years;
- Effective sample size for age comps iteratively adjusted from 15 to 45;
- Fishery selectivity estimated for three time blocks: 1929-69; 1970-77; 1978-06;
- New index methods (final STAR versions) were included, with inverse-weighting of observations based on model CVs;
- Survey timings were adjusted to better match timing of data collection;
- Sigma-R for the spawner-recruit model was increased from 0.25 to 0.7 (2007 STAR Panel recommendation)

Catch
ASAP model fit to catch data is displayed in Figure 22. The observed and predicted time series essentially overlay each other, indicating precise fit to this data source.

Catch-at-age
Effective sample size for the California catch-at-age data was iteratively adjusted and ultimately set to λ=45 for all years (Figure 23). Pearson residuals for the catch-at-age fits are displayed in Figure 24. Residual patterns were random, with no obvious trends over age or time. Catch-at-age proportions contributed to 44% of the total model likelihood (Table 8).

Indices of Abundance
Model fits to the three indices of relative abundance are displayed in Figures 25-27.
Trends in the residual patterns were apparent for all three indices. This is an indication of tension in trend and overall magnitude of change among the three indices. All three time series have peaks and lows during the same approximate periods of time, however, the magnitude of change for the Aerial Spotter and CalCOFI indices is far greater than that shown for the CPFV index. Index fits contributed to 46% of the total model likelihood (Table 8).

Selectivity Estimates

Fishery selectivities (S_{age}) estimated for the three time blocks are displayed in Figure 28. Generally speaking, selectivities followed a dome-shaped pattern for the two periods of directed fishing (1929-1969 and 1978-2006), with the latter period having a wider shape (i.e. more fish of the youngest and oldest ages selected). This difference reflects changes in utilization among the two eras; fishing primarily for canneries in the early period and a broader range of markets (including pet food) in the latter. During the moratorium (1970-1977), CPS seiners captured Pacific mackerel incidental to other CPS target species (esp. jack mackerel) and tended to be smaller and younger (Figure 28).

Fishing Mortality Rate

The fishing mortality multiplier is displayed in Figure 29, and fishing mortality-at-age is displayed in Figure 30. Fmult increased steadily throughout the historic fishery, peaking at close to 0.7 by the mid-1960s. For the recent period, Fmult peaked at 0.54 in 1998 (an El Nino season) when the stock was relatively low but availability was high for the Ensenada fishery.

Biomass of Age 1+ stock for PFMC Management

Stock biomass (Ages 1+) time series for PFMC management is displayed in Table 11. Stock biomass peaked at 1.52 million mt in 1979, declined to a low of about 90,000 mt in 2001, increasing again in the recent most years. While the trend in stock biomass was generally similar to past assessments, the magnitude increased due to changes in Sigma-R and higher estimates of recruitment throughout the time series (see 'Recruitment' and 2007 STAR Panel Report). Age 1+ biomass is projected to be 359,290 mt as of July 1, 2007.

Spawning Stock Biomass

A time series of SSB is provided in Table 10 and Figure 31. SSB peaked at 662,372 mt in 1982, declining precipitously to the current level of 86,777 mt. B_0 is estimated to be 185, 424 mt.

Recruitment

Recruitment time series (age-0 abundance) are presented in Table 11 and displayed in Figure 32. The recruitment trend is similar in pattern to that of previous assessments, with large year-classes in 1976, 1978, 1980, 1981, and 1982. The primary difference from previous assessments (Hill and Crone 2005; Crone *et al.* 2006) is the overall magnitude of the recruitment estimates – a direct effect of increasing Sigma-R from 0.25 to 0.7.

Stock-Recruit Relationship

Fit to the stock-recruitment relationship is displayed in Figure 33. In general, estimated recruitment was loosely constrained to a stock-recruitment relationship in the baseline model (Beverton-Holt model; Sigma-R= 0.7). Compensatory productivity ('steepness' parameter) of the population at low adult stock sizes was estimated to be h=0.31 – a very low value for small pelagic species, but similar in range to past assessments for this stock.

Uncertainty and Sensitivity Analyses

We performed various sensitivity tests to investigate potential effects of assumptions on parameter estimation from model runs. In this section we present the results of sensitivity analyses for the ASAP-E1 model and for parameters whose uncertainties are most likely to affect management guidelines for Pacific Mackerel, i.e., Sigma-R(σ_R), natural mortality (M), and the indices of relative abundance used in the assessment.

Sensitivity of ASAP-E1 Model Results to Sigma-R
We varied σ_R from 0.25 to 1 and compared the root mean square error (RMSE) for recruitment residuals and the pre-specified σ_R. We found that the peaks of abundance were highly sensitive to the value assumed for σ_R. The STAR Panel and the STAT agreed that the best value of σ_R to use in the assessment was 0.7. A σ_R of 0.7 is considerably higher than the assumed value (0.25) in the 2004 -2006 assessment models, but reflects better the life history characteristics of Pacific mackerel and meets better the overall expectation of the model for recruitment deviations.

Sensitivity of ASAP-E1 Model Results to M
We varied M from 0.35 to 0.7 and the results of the sensitivity tests are presented in Figure 34 and 35. As expected Age-0 abundance and Age-1+ biomass increased with increasing M. However, the magnitude of difference was higher during peaks of abundance, and the model results were less stables for M between 0.55 and 0.6 (See also Table 11). Both the STAR Panel and the STAT agreed that an M= 0.5 was the most appropriate value to be used in the assessment.

Sensitivity of ASAP-E1 Model Results to Indices
This sensitivity was performed by dropping one of the three relative abundance indices. Recruit abundance and Age-1+ biomass estimated for these tests are presented in Table 11 and Figures 36 and 37. Again, dropping one of the indices has the most effects during peaks of abundance and on estimates for the most recent years (i.e., 2004-2007). For the 2004-07 period (i.e., a period with no aerial spotter data) the results show that the CalCOFI larval production at hatching tends to decrease Age-1+ biomass estimates, whereas the CPFV index tends to increase these levels of biomass.

Comparison of base-run results to previous assessments
Age 1+ biomass and SSB estimated from the 2006 ASAP model and 2004 ADEPT model are compared to ASAP-E1 estimates in Figures 38 and 39.

HARVEST CONTROL RULE FOR U.S. MANAGEMENT IN 2007-08

In Amendment 8 to the CPS FMP (PFMC 1998), the recommended maximum sustainable yield (MSY) control rule for Pacific mackerel was:

HARVEST = (BIOMASS-CUTOFF) x FRACTION x DISTRIBUTION,

where HARVEST is the U.S. HG, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that should be taken by all fisheries, and DISTRIBUTION (70%) is the average fraction of total BIOMASS assumed in U.S. waters. CUTOFF and FRACTION values applied in the Council's harvest policy for mackerel are based on analyses published by MacCall et al. (1985). BIOMASS (359,290 mt) is the estimated biomass of fish age 1 and older for the whole stock projected for July 1, 2007. Based on this formula, the 2007-08 HG would be 71,629 mt (Table

12). Figure 40 presents commercial landings and quotas for Pacific mackerel from 1992 to 2006. The recommended HG for the 2007-08 fishing season is 361% higher than the 2006-07, HG, and higher than the maximum yield since 1992-03 (mt).

RESEARCH AND DATA NEEDS

CDFG has sampled California's Pacific mackerel fishery for age composition and size-at-age for many decades, and the current stock assessment model incorporates a complete time series of landings and age composition data beginning in 1929. Ensenada landings have rivaled California's for the past decade, but the stock assessment does not include real biological data from the Mexican fishery. Mexican landings are included in the assessment, but must be pooled with the southern California catch. INP-Ensenada has collected biological samples (size, sex, otoliths) since 1989, but the data have not been available for U.S. stock assessments. There is a need to establish a program of data exchange with Mexican scientists (INP) to fill this information gap. The MexUS-Pacifico (NMFS-INP) meetings are the most appropriate forum for such an exchange.

There is a lack of population-wide biological data for Pacific mackerel. Representative population sampling is required to reduce uncertainty regarding the maturity schedule, fecundity, and growth. The maturity schedule used in the current assessment was developed more than 20 years ago, during a period of high population abundance, and could be vastly different now. The fishery weights-at-age from southern California are assumed to represent weights-at-age for the whole population.

Fishery-independent survey data for measuring changes in mackerel spawning biomass are generally lacking. The current CalCOFI sampling pattern provides information on mackerel egg distributions in the Southern California Bight, the extreme northern end of the spawning area. Mexican research institutions have conducted a number of egg and larval surveys off of Baja California in recent years (IMECOCAL program). Access to this data would enable us to continue the historical CalCOFI time series, which begins in 1951. This information could be incorporated directly into the assessment model.

CPFV logbook data for Baja California blocks should be explored as a potential new index of CPUE. Due to difference in trips types and effort recorded for these trips, the data should be analyzed separately from the existing CPFV index.

The MSY control rule utilized in the Pacific mackerel federal CPS-FMP was developed in the mid-1980s using the historical time series of abundance. The harvest control rule should be re-examined using new data and simulation methods. Given substantial amounts of additional sample data have accumulated since the initial research that was undertaken to formally establish this harvest strategy, it would be prudent to conduct further simulation modeling work to address particular parameters included in the overall control rule (including ‘cutoff,’ ‘fraction,’ and ‘distribution’ values).

In addition to the above, the 2007 STAR Panel for Pacific mackerel made the following specific recommendations in their report (following bullets excerpted from the report; redundancies to the above points have been removed):

- Age-reading studies should be conducted to construct an age-reading error matrix for inclusion in future (SS2) assessments.

- The next assessment should continue to examine the possibility of using SS2 as the assessment platform. The analyses presented to the Panel suggested that ASAP and SS2 lead to similar outcomes when configured in a similar manner. However, SS2 deals better with indices that are not tied directly to a fishery, can include age-reading error, and allows weight-at-age in the catch to differ from weight-at-age in the population. In principle, it should be easier to represent uncertainty using the MCMC algorithm for assessments based on SS2.

- The SS2 assessment model runs performed during the 2007 STAR panel were based on fitting to age-composition data for the commercial fishery. Future SS2 assessments should consider fitting to the length composition and the conditional age-at-length information. This will require estimating time-varying growth curves and may require multiple time-steps within each year.

- The construction of the spotter plane index is based on the assumption that blocks are random within region (the data for each region is a "visit" by a spotter plane to a block in that region). The distribution of density-per-block should be plotted or a random effects model fitted in which block is nested within region to evaluate this assumption (e.g. examine whether certain blocks are consistently better or worse than the average).

- The CalCOFI data should be reviewed further to examine the extent to which CalCOFI indices for the SCB can be used to provide information on the abundance of the coastwide stock.

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Table 1. Commercial landings (California directed fishery) and quotas or HGs for Pacific mackerel. Units are metric tons. Incidental landings from Pacific northwest fisheries are not included, but typically range 100 to 300 mt per year.

Fishing Year	Quota or HG[/a]	Landings
92	34,010	18,307
93	23,147	10,793
94	14,706	9,372
95	9,798	7,615
96	8,709	9,788
97	22,045	23,413
98	30,572	19,578
99	42,819	7,170
00	20,740	20,936
01	13,837	8,039
02	12,535	3,541
03	10,652	5,961
04	13,268	5,012
05	17,419	4,572
06	19,845	6,956

[/a] California Quotas 1992-03 through 1998-99. PFMC HGs 1999-00 onward.
[/b] 2006-07 landings as of Feb, 2007 (CDFG wetfish tables).

Table 2. Pacific mackerel growth parameters estimated from CDFG port samples collected from 1962 to 2006.

Weight-at-length

Time Block	*a*	*b*	N	Corr. R^2
1926-61 (1962-06 estimate)	3.12517E-06	3.40352	95,761	0.971
1962-68	3.60340E-06	3.37410	5,598	0.984
1969-77	3.84101E-06	3.35245	7,104	0.967
1978-89	2.62897E-06	3.45186	45,957	0.971
1990-06	3.53906E-06	3.36574	37,102	0.971

Length-at-age (von Bertalanffy)

Time Block	*Linf*	*K*	*t0*	N	Corr. R^2
1926-61 (1962-06 estimate)	39.3	0.342494	-1.75187	95,761	0.732
1962-68	42.5	0.279912	-2.22289	5,598	0.906
1969-77	41.0	0.415795	-1.55281	7,104	0.668
1978-89	37.4	0.425483	-1.23346	45,957	0.699
1990-06	40.7	0.292865	-2.07671	37,102	0.848

Table 3. Normalized net fecundity [a] calculations for Pacific mackerel.

Age (yrs)	Observed Fraction Mature	Predicted Fraction Mature	Observed Spawning Frequency (% spawning day-1)	Predicted Spawning Frequency (% spawning day-1)	Net Fecundity (eggs g-1)	Normalized Net Fecundity (eggs g-1)
0	0.000	0.000	0.000	0.000	0.000	**0.000**
1	0.214	0.487	0.000	1.380	0.672	**0.074**
2	0.867	0.636	3.900	3.520	2.240	**0.246**
3	0.815	0.763	6.800	5.660	4.320	**0.474**
4	0.851	0.855	9.900	7.800	6.670	**0.733**
5	0.882	0.916	7.700	9.940	9.110	**1.000**
6+	0.882	0.916	7.700	9.940	9.110	**1.000**

[a] Observed fraction mature and observed spawning frequency from Dickerson et al. (1992). Predicted fraction mature from logistic regression. Predicted spawning frequency from linear regression. Normalized net fecundity is adjusted to a maximum value of 1.0. Batch fecundity assumed constant.

Table 4. Sample sizes for Pacific mackerel sampled from southern California's commercial fishery by the CDFG. Sample sizes relative to total tonnage (all sectors) are provided as fish per 1,000 mt.

Fishing Year	Landings (mt)	# Fish Sampled	Fish per 1,000 mt	Fishing Year	Landings (mt)	# Fish Sampled	Fish per 1,000 mt
39	45,454	1,524	34	73	401	239	596
40	48,868	2,258	46	74	634	179	282
41	32,597	2,445	75	75	2,149	1,326	617
42	21,922	1,287	59	76	4,092	2,202	538
43	35,341	2,250	64	77	13,751	1,943	141
44	36,694	1,520	41	78	27,173	3,810	140
45	23,638	2,088	88	79	35,612	3,491	98
46	27,616	2,637	95	80	34,252	6,711	196
47	19,437	1,397	72	81	46,778	5,067	108
48	18,125	631	35	82	36,124	4,764	132
49	24,189	1,835	76	83	41,422	2,694	65
50	17,493	1,019	58	84	45,819	2,394	52
51	15,857	911	57	85	46,567	2,607	56
52	10,326	397	38	86	54,024	3,000	56
53	5,266	447	85	87	47,632	4,150	87
54	18,465	811	44	88	49,080	4,479	91
55	22,201	572	26	89	49,309	3,583	73
56	36,835	1,011	27	90	71,551	2,121	30
57	27,753	931	34	91	65,505	1,689	26
58	11,875	903	76	92	32,168	2,015	63
59	19,332	755	39	93	20,807	2,740	132
60	20,823	488	23	94	23,128	4,357	188
61	26,199	422	16	95	11,371	2,718	239
62	23,901	205	9	96	24,316	2,222	91
63	23,703	205	9	97	50,477	2,722	54
64	19,988	268	13	98	62,568	2,261	36
65	11,279	111	10	99	15,863	1,674	106
66	7,405	1,944	263	00	27,647	1,919	69
67	1,713	720	420	01	12,561	2,114	168
68	1,695	2,145	1,265	02	13,948	2,150	154
69	1,168	498	426	03	11,756	1,599	136
70	835	150	180	04	10,796	2,547	236
71	911	344	378	05	13,151	2,300	175
72	532	223	419	06	16,623	2,424	146

Table 5. Landings of Pacific mackerel by fishery (1926-06).

Fishing Year	USA -Commercial Catch (mt)	Mexico-Commercial Catch (mt)	Recreational - CPFV Catch (mt)	Recreational - non-CPFV Catch (mt)	Total Catch (mt)
26	1,630	0	6	11	1,647
27	2,928	0	6	11	2,945
28	17,874	0	6	11	17,891
29	25,716	0	6	11	25,734
30	5,809	0	6	11	5,826
31	6,873	0	6	11	6,890
32	4,922	0	6	11	4,939
33	33,055	0	6	11	33,072
34	51,467	0	6	11	51,484
35	66,400	0	6	11	66,417
36	45,697	0	6	11	45,714
37	31,954	0	13	21	31,988
38	34,502	0	22	38	34,562
39	45,341	0	42	70	45,454
40	48,786	0	30	52	48,868
41	32,547	0	0	13	32,561
42	21,872	0	0	13	21,886
43	35,291	0	0	13	35,305
44	36,644	0	0	13	36,657
45	23,588	0	0	13	23,601
46	26,715	851	1	15	27,582
47	17,975	1,262	75	124	19,437
48	17,329	515	103	178	18,125
49	22,708	1,352	48	81	24,189
50	15,372	2,029	34	58	17,493
51	14,472	1,320	24	41	15,857
52	9,171	1,052	38	64	10,326
53	4,005	1,177	31	53	5,266
54	12,342	5,681	163	278	18,465
55	12,200	9,798	76	127	22,201
56	25,938	10,725	64	108	36,835
57	25,509	2,034	78	132	27,753
58	11,238	449	70	117	11,875
59	18,725	495	39	73	19,332
60	17,724	2,981	42	75	20,823
61	20,094	5,964	52	88	26,199
62	20,527	3,231	58	85	23,901
63	15,517	7,966	86	134	23,703
64	11,283	8,618	33	54	19,988
65	3,442	7,615	84	138	11,279
66	1,848	5,290	97	169	7,405
67	619	948	56	90	1,713
68	1,492	107	37	60	1,695
69	809	201	58	100	1,168
70	277	400	61	98	835
71	90	500	118	203	911
72	28	200	118	186	532
73	52	100	95	154	401
74	43	471	47	73	634
75	141	1,809	75	124	2,149
76	2,654	1,271	69	97	4,092
77	7,748	5,165	314	524	13,751
78	18,446	7,372	501	854	27,173
79	28,755	5,150	804	1149	35,858
80	27,972	4,546	1,277	1409	35,203
81	38,407	7,155	665	757	46,985
82	30,626	4,329	693	723	36,371
83	36,309	4,264	700	844	42,118
84	39,240	5,761	612	855	46,468
85	37,615	8,197	524	492	46,828
86	44,298	8,965	386	474	54,123
87	44,838	2,120	245	1020	48,223
88	41,968	6,608	181	507	49,265
89	25,063	23,724	167	451	49,406
90	39,974	30,961	230	386	71,551
91	30,268	34,557	252	429	65,505
92	25,584	6,170	135	329	32,217
93	10,787	9,524	196	413	20,920
94	9,372	13,302	226	837	23,737
95	7,615	3,368	439	574	11,996
96	9,788	14,089	320	366	24,563
97	23,413	26,860	104	700	51,076
98	19,578	42,815	108	322	62,823
99	7,170	8,587	55	97	15,910
00	20,936	6,530	78	248	27,792
01	8,436	4,003	51	520	13,010
02	3,541	10,328	22	232	14,123
03	5,972	5,728	28	295	12,023
04	5,012	5,624	23	537	11,195
05	4,572	8,024	13	543	13,151
06	8,192	8,024	5	403	16,623

Table 6. Catch-at-age from ASAP models (1929-06).

Fishing Year	0	1	2	3	4	5	6	7	8+
29	9	12,434	22,467	20,819	5,208	3,875	3,198	1,273	507
30	0	1,393	7,164	4,838	1,916	670	44	17	7
31	0	957	9,991	6,190	1,307	753	371	148	59
32	0	144	3,222	5,845	1,394	940	489	195	77
33	0	4,620	19,017	31,887	23,363	8,277	2,731	1,087	433
34	0	4,894	53,354	35,598	40,808	15,508	5,669	2,257	898
35	0	10,872	12,737	61,704	63,820	33,633	6,206	2,470	983
36	0	2,248	20,404	17,399	33,062	35,159	5,252	2,091	832
37	129	1,476	2,592	8,035	15,910	26,039	7,865	3,131	1,246
38	772	11,577	31,967	16,528	4,309	10,884	6,608	2,631	1,047
39	1,803	23,228	23,713	33,698	11,094	6,310	3,744	1,525	485
40	3,199	18,453	59,415	27,594	17,025	2,514	686	114	0
41	638	18,397	31,228	28,818	6,522	922	71	71	0
42	0	28,455	10,343	15,109	6,149	1,096	143	48	0
43	426	14,144	62,073	10,523	7,413	1,022	170	85	0
44	0	20,800	20,685	35,320	8,873	1,613	230	0	58
45	2,034	15,337	12,076	8,920	8,320	4,825	1,930	600	391
46	3,290	16,673	20,262	11,041	6,704	4,287	1,819	1,097	548
47	7,427	4,646	10,460	9,228	6,068	3,508	1,896	695	221
48	2,723	37,273	9,107	3,662	4,037	1,408	657	282	94
49	566	21,983	36,329	9,173	3,071	1,980	808	121	81
50	44	6,588	17,066	17,154	3,183	531	398	44	44
51	1,031	4,005	6,860	11,816	11,301	674	238	79	79
52	510	324	1,992	1,992	8,709	4,679	93	46	0
53	11,077	2,069	1,339	1,380	568	812	771	0	0
54	694	47,800	10,177	2,159	1,234	0	308	154	0
55	15,608	17,731	25,097	10,738	1,124	125	250	125	375
56	420	54,867	22,555	19,093	8,812	315	0	0	0
57	1,996	7,915	30,079	10,875	8,535	3,029	1,308	344	0
58	11,505	2,666	4,595	7,401	3,157	1,438	912	0	0
59	1,690	46,897	7,774	3,633	2,450	1,014	254	0	0
60	1,629	12,726	17,002	10,181	5,091	1,731	1,324	0	0
61	7,345	28,680	15,564	14,690	5,771	1,224	525	0	0
62	739	23,299	12,554	10,472	7,072	1,421	187	0	0
63	284	6,843	18,432	10,339	8,843	2,842	425	0	0
64	1,389	7,716	6,521	9,629	10,969	4,240	715	0	0
65	13,074	1,265	767	1,701	5,525	8,677	1,563	0	0
66	3,689	8,093	1,458	1,168	992	2,240	1,220	91	0
67	4,530	1,003	88	632	228	163	192	45	4
68	7,418	499	221	353	89	86	68	52	37
69	46	2,354	606	221	71	61	9	0	0
70	1,405	3,004	0	0	0	0	0	0	0
71	0	2,853	224	10	12	8	0	0	0
72	1,319	197	293	318	9	7	0	0	0
73	50	547	153	33	75	88	49	2	2
74	2,154	769	244	39	13	0	0	0	0
75	130	6,335	90	66	2	4	2	0	0
76	13,974	164	1,763	1	23	0	27	0	0
77	11,071	36,734	78	287	0	0	0	0	0
78	73,773	18,837	28,598	1,166	1,006	257	0	0	0
79	27	102,762	14,944	15,204	222	675	0	0	0
80	63,978	3,376	77,514	8,221	7,379	407	126	0	0
81	19,073	45,822	10,974	69,210	4,792	3,067	76	123	0
82	16,129	36,225	33,231	9,921	31,045	2,318	768	0	0
83	2,841	2,812	44,336	40,174	6,319	17,770	251	0	0
84	2,875	533	9,589	48,965	25,204	6,271	7,986	198	0
85	3,251	17,478	5,189	16,256	50,114	10,704	1,389	1,047	0
86	18,857	44,528	23,016	5,276	9,002	25,599	7,435	1,024	1,085
87	18,059	71,920	32,698	5,326	2,862	3,517	4,718	2,064	849
88	104,977	15,168	36,143	13,133	2,849	1,943	2,574	4,155	3,178
89	21,821	161,291	8,376	6,715	4,513	2,718	2,543	867	1,677
90	29,559	19,434	43,284	11,974	16,878	19,588	8,229	6,546	8,187
91	27,181	91,782	21,912	21,684	10,412	9,327	6,709	3,023	4,448
92	11,121	30,147	12,343	9,853	10,637	8,100	5,594	2,629	1,025
93	51,845	9,383	10,677	3,440	3,366	5,043	2,885	2,893	1,651
94	25,604	38,016	9,946	4,530	5,751	3,022	1,869	1,485	606
95	46,200	21,302	5,281	983	552	1,417	759	529	336
96	28,944	43,914	12,554	6,006	3,741	2,567	1,368	1,073	756
97	24,318	49,846	32,822	12,959	8,404	7,622	4,901	4,166	6,853
98	13,603	19,878	38,777	23,702	15,523	13,343	10,668	6,472	7,980
99	11,997	2,949	2,680	6,120	5,834	4,447	1,946	1,330	966
00	29,467	15,355	5,178	8,769	10,300	6,638	2,845	1,141	630
01	14,207	20,422	3,517	1,951	2,408	2,134	984	555	299
02	7,247	51,289	5,176	1,192	228	365	253	0	0
03	26,590	14,955	5,148	1,891	663	652	331	96	65
04	46,350	7,066	2,288	1,658	706	141	94	37	94
05	71,583	9,839	5,043	730	285	174	90	23	0
06	71,664	23,704	4,708	1,871	548	200	166	48	0

Table 7. Weight-at-age from the ASAP models (1929-07).

Fishing Year	0	1	2	3	4	5	6	7	8+
29	0.074	0.167	0.297	0.402	0.523	0.615	0.704	0.800	0.830
30	0.060	0.139	0.301	0.422	0.511	0.603	0.698	0.800	0.830
31	0.077	0.114	0.276	0.399	0.527	0.606	0.701	0.800	0.830
32	0.058	0.081	0.277	0.379	0.508	0.604	0.711	0.800	0.830
33	0.059	0.083	0.200	0.299	0.493	0.585	0.700	0.800	0.830
34	0.065	0.142	0.198	0.233	0.431	0.538	0.683	0.800	0.830
35	0.079	0.186	0.217	0.251	0.379	0.472	0.629	0.790	0.830
36	0.086	0.193	0.284	0.338	0.393	0.453	0.574	0.750	0.820
37	0.119	0.176	0.318	0.429	0.461	0.502	0.575	0.740	0.800
38	0.124	0.174	0.310	0.448	0.532	0.582	0.633	0.726	0.790
39	0.191	0.246	0.363	0.460	0.583	0.680	0.775	0.795	0.878
40	0.180	0.260	0.339	0.442	0.527	0.640	0.729	0.834	0.820
41	0.115	0.259	0.343	0.439	0.559	0.650	0.806	0.807	0.850
42	0.180	0.236	0.373	0.471	0.546	0.626	0.684	0.909	0.830
43	0.165	0.292	0.339	0.474	0.574	0.650	0.629	0.881	1.000
44	0.144	0.271	0.379	0.472	0.587	0.660	0.754	0.735	0.948
45	0.121	0.234	0.383	0.494	0.611	0.704	0.745	0.819	0.842
46	0.125	0.261	0.384	0.487	0.617	0.679	0.736	0.778	0.812
47	0.119	0.291	0.400	0.499	0.622	0.709	0.753	0.788	0.818
48	0.107	0.227	0.354	0.506	0.616	0.706	0.764	0.895	0.871
49	0.109	0.192	0.319	0.456	0.607	0.725	0.799	0.917	0.917
50	0.084	0.249	0.323	0.455	0.564	0.664	0.784	0.799	0.871
51	0.162	0.255	0.346	0.429	0.569	0.694	0.827	0.835	0.853
52	0.173	0.297	0.386	0.471	0.568	0.719	0.832	0.988	0.850
53	0.162	0.296	0.411	0.512	0.603	0.763	0.834	0.850	1.100
54	0.084	0.257	0.387	0.505	0.585	0.744	0.701	0.879	0.870
55	0.140	0.253	0.357	0.484	0.583	0.744	0.762	0.778	0.878
56	0.111	0.248	0.373	0.485	0.598	0.752	0.722	0.910	0.870
57	0.179	0.310	0.374	0.509	0.602	0.649	0.650	0.700	1.000
58	0.176	0.292	0.396	0.488	0.617	0.685	0.775	0.750	0.750
59	0.132	0.251	0.398	0.510	0.602	0.702	0.754	0.840	0.850
60	0.102	0.276	0.391	0.507	0.611	0.699	0.768	0.820	0.870
61	0.144	0.252	0.389	0.495	0.584	0.647	0.817	0.830	0.850
62	0.276	0.320	0.420	0.540	0.622	0.712	0.782	0.890	0.860
63	0.197	0.298	0.434	0.538	0.627	0.730	0.743	0.840	0.930
64	0.181	0.300	0.400	0.503	0.612	0.748	0.812	0.820	0.870
65	0.109	0.195	0.384	0.501	0.596	0.723	0.735	0.880	0.850
66	0.149	0.273	0.419	0.525	0.658	0.790	0.833	0.850	0.930
67	0.166	0.235	0.488	0.510	0.599	0.723	0.869	0.917	0.849
68	0.138	0.266	0.391	0.562	0.593	0.709	0.902	0.952	1.070
69	0.103	0.322	0.428	0.505	0.662	0.746	0.907	1.000	1.100
70	0.099	0.232	0.402	0.584	0.730	0.837	0.850	1.000	1.200
71	0.266	0.282	0.457	0.481	0.740	0.955	0.880	0.900	1.200
72	0.147	0.266	0.449	0.508	0.552	0.746	1.000	0.900	1.100
73	0.119	0.329	0.433	0.609	0.606	0.686	0.758	0.803	0.838
74	0.107	0.303	0.604	0.740	0.837	0.800	0.800	0.800	1.000
75	0.127	0.361	0.517	0.973	1.053	1.029	1.350	0.900	0.900
76	0.170	0.297	0.672	0.864	1.291	1.223	1.531	1.200	1.000
77	0.122	0.322	0.600	0.847	1.063	1.100	1.300	1.500	1.300
78	0.062	0.334	0.473	0.705	0.908	1.100	1.200	1.400	1.600
79	0.082	0.189	0.440	0.598	0.810	0.969	1.200	1.300	1.500
80	0.072	0.176	0.270	0.437	0.598	0.874	1.066	1.300	1.400
81	0.083	0.190	0.239	0.391	0.597	0.715	0.953	0.929	1.400
82	0.032	0.151	0.237	0.345	0.516	0.773	0.916	1.000	1.200
83	0.049	0.191	0.302	0.390	0.458	0.511	0.688	0.900	1.100
84	0.120	0.235	0.351	0.396	0.505	0.614	0.638	0.871	0.910
85	0.157	0.285	0.418	0.461	0.484	0.560	0.612	0.697	0.850
86	0.148	0.290	0.408	0.508	0.561	0.595	0.630	0.719	0.784
87	0.133	0.272	0.414	0.523	0.600	0.691	0.717	0.766	0.826
88	0.101	0.301	0.415	0.576	0.666	0.734	0.806	0.815	0.899
89	0.104	0.193	0.381	0.542	0.647	0.749	0.757	0.739	0.827
90	0.094	0.267	0.377	0.554	0.649	0.680	0.749	0.775	0.803
91	0.071	0.217	0.397	0.514	0.591	0.664	0.724	0.766	0.799
92	0.087	0.175	0.330	0.459	0.544	0.661	0.691	0.725	0.805
93	0.073	0.228	0.294	0.408	0.583	0.607	0.720	0.756	0.832
94	0.100	0.156	0.248	0.361	0.493	0.597	0.644	0.733	0.785
95	0.081	0.179	0.275	0.431	0.586	0.689	0.740	0.758	0.920
96	0.105	0.182	0.318	0.471	0.589	0.649	0.674	0.705	0.751
97	0.149	0.239	0.333	0.446	0.572	0.637	0.719	0.718	0.749
98	0.139	0.267	0.325	0.419	0.530	0.615	0.631	0.667	0.689
99	0.148	0.228	0.399	0.509	0.575	0.633	0.688	0.754	0.768
00	0.114	0.266	0.370	0.550	0.590	0.608	0.646	0.712	0.731
01	0.103	0.253	0.347	0.534	0.567	0.619	0.617	0.635	0.627
02	0.133	0.218	0.303	0.412	0.552	0.687	0.656	0.728	0.650
03	0.125	0.284	0.414	0.603	0.679	0.745	0.809	0.794	0.838
04	0.159	0.280	0.407	0.596	0.685	0.821	0.926	0.820	0.902
05	0.106	0.267	0.380	0.463	0.556	0.665	0.737	0.797	0.840
06	0.115	0.232	0.361	0.509	0.715	0.794	0.847	0.918	0.935
07	0.115	0.232	0.361	0.509	0.715	0.794	0.847	0.918	0.935

Table 8. Likelihood function components for the ASAP-E1 and sensitivity test model runs.

Component	RSS	nobs	Lambda	Likelihood	%Total Likelihood
Catch_Fleet_1	0.0201	79	100	2.00987	
Catch_Fleet_Total	0.0201	79	100	2.00987	**0.2%**
Discard_Fleet_1	0	79	0	0	
Discard_Fleet_Total	0	79	0	0	
CAA_proportions	N/A	711	see_below	524.626	**44.2%**
Discard_proportions	N/A	711	see_below	0	
Index_Fit_1 (SPOTTER)	165.434	39	1	119.525	**10.1%**
Index_Fit_2 (CPFV)	15.5464	67	1	107.834	**9.1%**
Index_Fit_3 (CalCOFI)	78.0771	37	1	318.819	**26.9%**
Index_Fit_Total	259.057	143	3	546.179	46.0%
Selectivity_devs_fleet_1	36.3896	2	0	0	
Selectivity_devs_Total	36.3896	2	0	0	**0.0%**
Catchability_devs_index_1	0	39	1	0	
Catchability_devs_index_2	0	67	1	0	
Catchability_devs_index_3	0	37	1	0	
Catchability_devs_Total	0	143	3	0	**0.0%**
Fmult_fleet_1	31.231	78	0	0	
Fmult_fleet_Total	31.231	78	0	0	**0.0%**
N_year_1	2.45627	8	0	0	
Stock-Recruit_Fit	58.803	79	1	55.5721	**4.7%**
Recruit_devs	58.803	79	1	58.803	**5.0%**
SRR_steepness	1.14554	1	0	0	
SRR_virgin_stock	4.53861	1	0	0	
Curvature_over_age	52.2818	14	0	0	
Curvature_over_time	72.7793	693	0	0	
F_penalty	1.9564	711	0.001	0.0019564	**0.0%**
Mean_Sel_year1_pen	0	9	1000	0	
Max_Sel_penalty	0.29413	1	100	0	
Fmult_Max_penalty	0	?	100	0	
Objective Function				1187.19	**100.0%**

Table 9. Comparison of results across models and scenarios.

	ASAP-2006	ASAP-A1	ASAP-B2	ASAP-B3	ASAP-C1	SS2-C1	ASAP-E1
Parameters (N)	181	183	183	183	189	96	198
Objective Function	1169.81	1207.74	932.34	1113.26	1119.50	1627.57	1187.19
B-zero	212,783	219,733	208,066	201,736	208,833	109,395	185,424
S-R Steepness	0.3585	0.3509	0.3759	0.3935	0.4061	0.4140	0.3086
Peak Recruits (1E+06)	3441.31	3207.87	3217.7	3412.22	3355.79	5338.31	6,646
Peak SSB	270,299	270,144	289,671	300,466	297,524	459,259	662,372
Peak 1+ Biomass	677,918	674,537	733,509	754,570	745,075	1,671,570	1,527,518
2006 Age 1+ Biomass	112,700	71,061	60,032	43,054	42,728	42,596	217,724

Table 10. Recruitment (Age-0 fish, in 1,000s), Biomass (Age 1+, mt), and Spawning Stock Biomass (mt) estimates from ASAP-E1 model (1929-07).

Fishing Year	Recruits (Age-0)	Biomass (Age-1+)	SSB
29	3,942,010	2,076,641	1,162,770
30	2,943,430	1,966,275	1,060,530
31	2,554,250	1,775,905	1,020,420
32	2,434,210	1,571,531	978,710
33	894,967	1,311,376	883,367
34	583,607	1,062,044	747,106
35	455,935	803,457	592,114
36	844,859	602,379	451,514
37	716,790	501,610	344,994
38	1,003,570	433,648	267,252
39	683,986	485,735	237,022
40	444,659	413,195	188,787
41	883,869	332,040	162,671
42	354,547	345,024	145,339
43	335,498	311,508	145,301
44	339,405	257,440	126,880
45	247,012	208,074	104,667
46	188,381	175,920	87,675
47	550,999	141,803	68,557
48	323,971	159,990	59,430
49	107,598	144,428	56,178
50	83,756	111,370	49,533
51	77,090	81,387	43,206
52	210,352	62,892	35,015
53	662,508	76,886	29,896
54	207,874	153,855	32,920
55	421,322	136,024	40,177
56	151,306	150,758	46,515
57	159,643	114,888	41,766
58	413,086	88,903	34,538
59	246,057	119,331	35,840
60	327,459	121,338	37,546
61	301,526	123,183	37,781
62	95,409	138,021	40,440
63	68,649	102,133	40,079
64	55,427	65,515	30,919
65	101,160	37,012	19,681
66	50,034	37,284	14,235
67	124,302	31,536	11,612
68	324,593	42,704	13,447
69	163,732	97,686	20,533
70	188,980	97,473	31,397
71	42,172	112,970	41,784
72	156,853	90,955	46,056
73	82,249	100,095	49,677
74	601,704	104,265	55,446
75	113,283	223,006	70,294
76	3,522,840	239,210	95,840
77	1,648,420	864,507	148,673
78	6,645,990	1,046,654	263,041
79	749,739	1,527,518	397,917
80	3,333,160	1,169,718	472,604
81	3,991,480	1,305,203	590,565
82	1,103,210	1,340,657	662,372
83	529,493	1,226,013	641,691
84	841,667	1,017,542	623,557
85	1,025,320	841,907	539,151
86	983,582	754,676	459,036
87	481,162	680,052	378,397
88	1,642,980	573,022	324,384
89	521,270	538,188	258,032
90	806,597	488,840	231,281
91	583,382	401,334	190,701
92	421,100	287,372	145,855
93	908,875	245,610	127,578
94	687,579	232,125	105,836
95	897,366	265,455	117,870
96	541,059	319,197	128,394
97	235,404	323,042	137,003
98	135,354	224,066	113,751
99	190,579	137,303	81,273
00	255,315	113,862	64,071
01	305,743	90,098	40,164
02	133,326	90,134	33,739
03	233,929	98,091	39,714
04	472,241	104,183	41,169
05	866,391	135,903	39,433
06	1,343,580	217,724	56,496
07	302,694	359,290	86,777

Table 11. Comparison of likelihood components and parameter estimates for sensitivity tests based on the ASAP-E1 model.

	BASE MODEL	SURVEY SENSITIVITY TEST			NATURAL MORTALITY SENSITIVITY TEST						
Likelihood Component	**E1-Base (M=0.5; 3 indices)**	**no SPOT**	**no CPFV**	**no CalCOFI**	**M=0.35**	**M=0.40**	**M=0.45**	**M=0.55**	**M=0.60**	**M=0.65**	**M=0.70**
Catch_Fleet_1	2.00987	2.1221	1.92671	0.847732	2.23729	2.21827	2.11548	1.85278	3.97118	1.49316	1.30135
Catch_Fleet_Total	2.00987	2.1221	1.92671	0.847732	2.23729	2.21827	2.11548	1.85278	3.97118	1.49316	1.30135
Discard_Fleet_1	0	0	0	0	0	0	0	0	0	0	0
Discard_Fleet_Total	0	0	0	0	0	0	0	0	0	0	0
CAA_proportions	524.626	527.134	475.263	509.928	502.662	510.241	517.593	531.309	572.286	543.583	549.111
Discard_proportions	0	0	0	0	0	0	0	0	0	0	0
Index_Fit_1 (SPOTTER)	119.525	0	90.8859	129.575	119.046	118.627	118.912	120.249	123.055	121.612	122.181
Index_Fit_2 (CPFV)	107.834	85.5177	0	95.4181	115.378	113.137	110.526	105.29	104.531	100.974	99.2433
Index_Fit_3 (CalCOFI)	318.819	330.757	303.26	0	319.077	318.902	318.906	318.554	313.566	317.164	316.033
Index_Fit_Total	546.179	416.275	394.146	224.993	553.501	550.667	548.344	544.093	541.152	539.749	537.457
Selectivity_devs_fleet_1	0	0	0	0	0	0	0	0	0	0	0
Selectivity_devs_Total	0	0	0	0	0	0	0	0	0	0	0
Catchability_devs_index_1	0	0	0	0	0	0	0	0	0	0	0
Catchability_devs_index_2	0	0	0	0	0	0	0	0	0	0	0
Catchability_devs_index_3	0	0	0	0	0	0	0	0	0	0	0
Catchability_devs_Total	0	0	0	0	0	0	0	0	0	0	0
Fmult_fleet_1	0	0	0	0	0	0	0	0	0	0	0
Fmult_fleet_Total	0	0	0	0	0	0	0	0	0	0	0
N_year_1	0	0	0	0	0	0	0	0	0	0	0
Stock-Recruit_Fit	55.5721	50.4925	64.4788	58.6725	54.6041	54.8511	55.174	56.0845	50.8916	57.521	58.4993
Recruit_devs	58.803	54.7517	65.9066	61.2757	58.031	58.228	58.4855	59.2117	55.0701	60.3574	61.1376
SRR_steepness	0	0	0	0	0	0	0	0	0	0	0
SRR_virgin_stock	0	0	0	0	0	0	0	0	0	0	0
Curvature_over_age	0	0	0	0	0	0	0	0	0	0	0
Curvature_over_time	0	0	0	0	0	0	0	0	0	0	0
F_penalty	0.0019564	0.00180446	0.000652647	0.00248601	0.000901324	0.00126393	0.00161947	0.0022736	0.000213006	0.00284291	0.00311001
Mean_Sel_year1_pen	0	0	0	0	0	0	0	0	0	0	0
Max_Sel_penalty	0	0	0	0	0	0	0	0	0	0	0
Fmult_Max_penalty	0	0	0	0	0	0	0	0	0	0	0
Total	1187.19	1050.78	1001.72	855.72	1171.04	1176.21	1181.71	1192.55	1223.37	1202.71	1207.51

Table 12. Proposed HG for Pacific mackerel for the 2007-08 management year opening July 1, 2007. See 'Harvest Guideline' section for methods used to derive the HG.

Biomass (Age-1+)	Cutoff (mt)	Fraction	Distribution	2007-08 Harvest Guideline (mt)
359,290	18,200	30%	70%	71,629

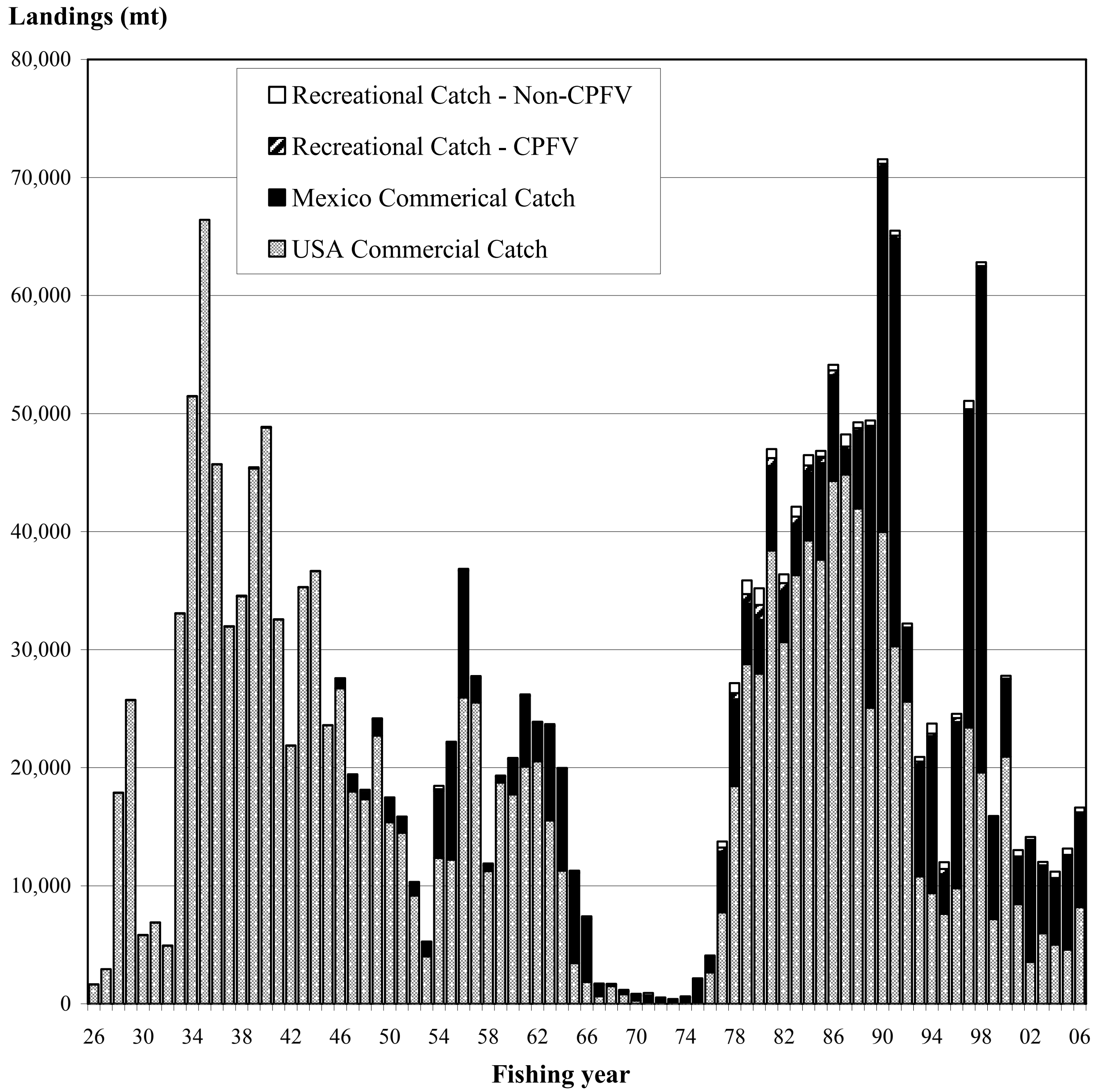

Figure 1. Commercial and recreational landings (mt) of Pacific mackerel in California (CA) and Baja California (MX) used in the ASAP and SS2-C1 models (1926-06). See Fishery Data section for description of fishing year.

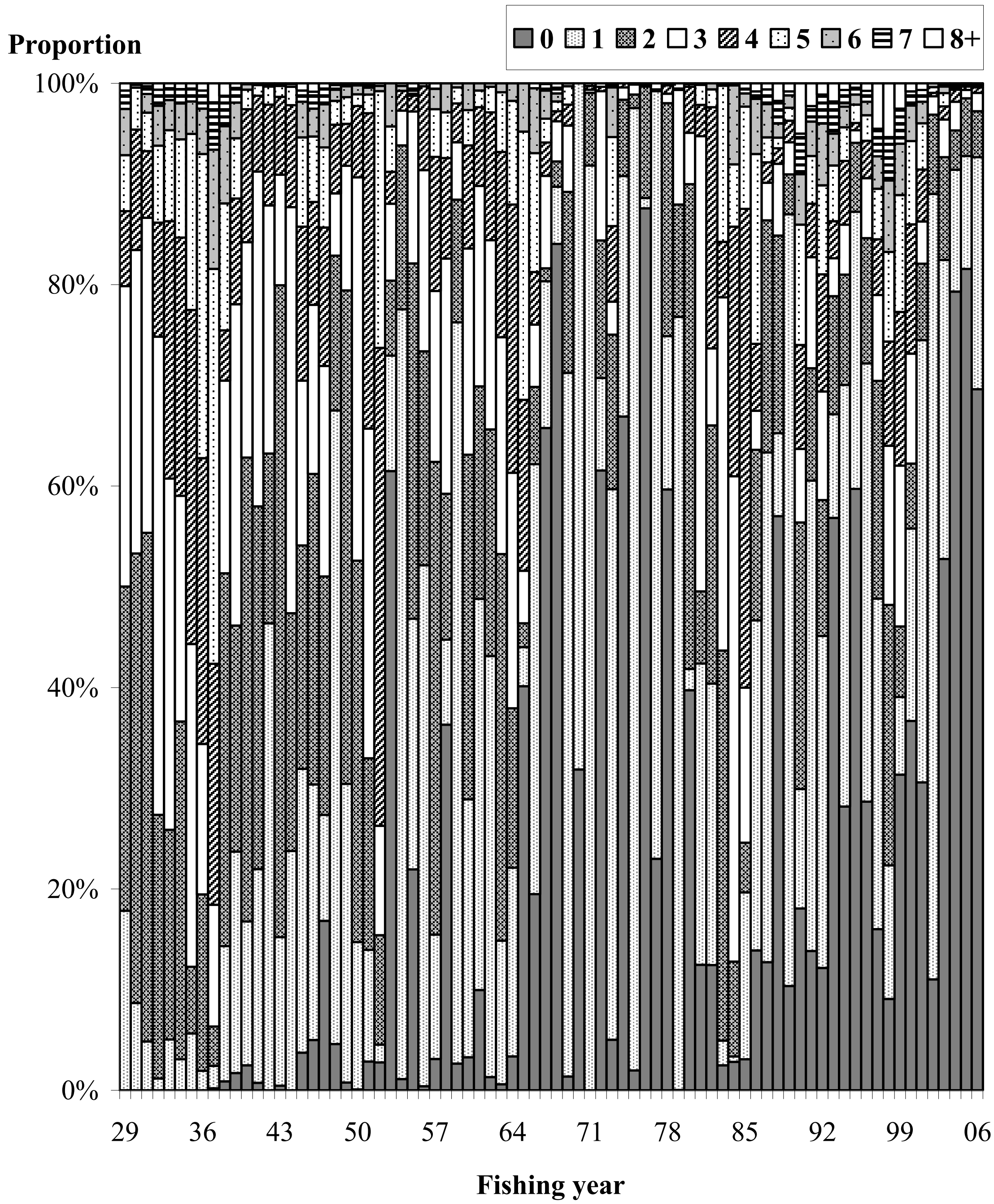

Figure 2. Pacific mackerel catch-at-age (in proportion) estimates used in the ASAP-E1 model (1926-06).

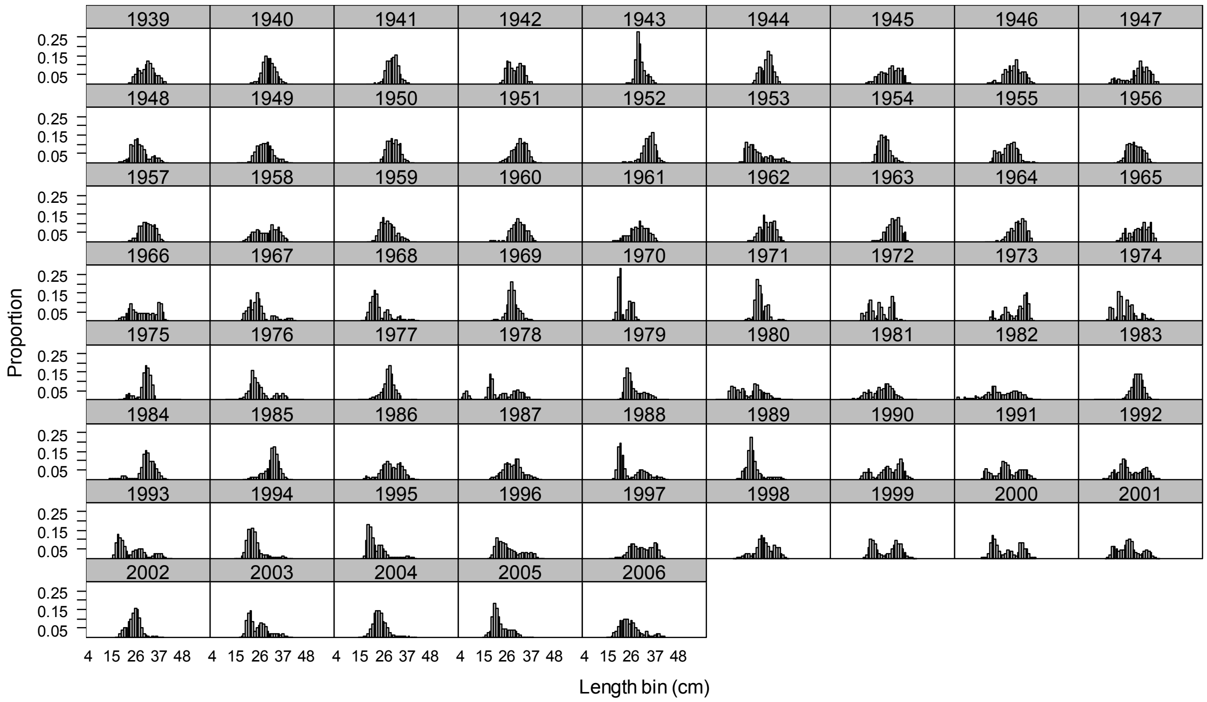

Figure 3. Whole catch lengths for the Pacific mackerel commercial fishery (1939-06). See Fishery Data section for description of fishing year.

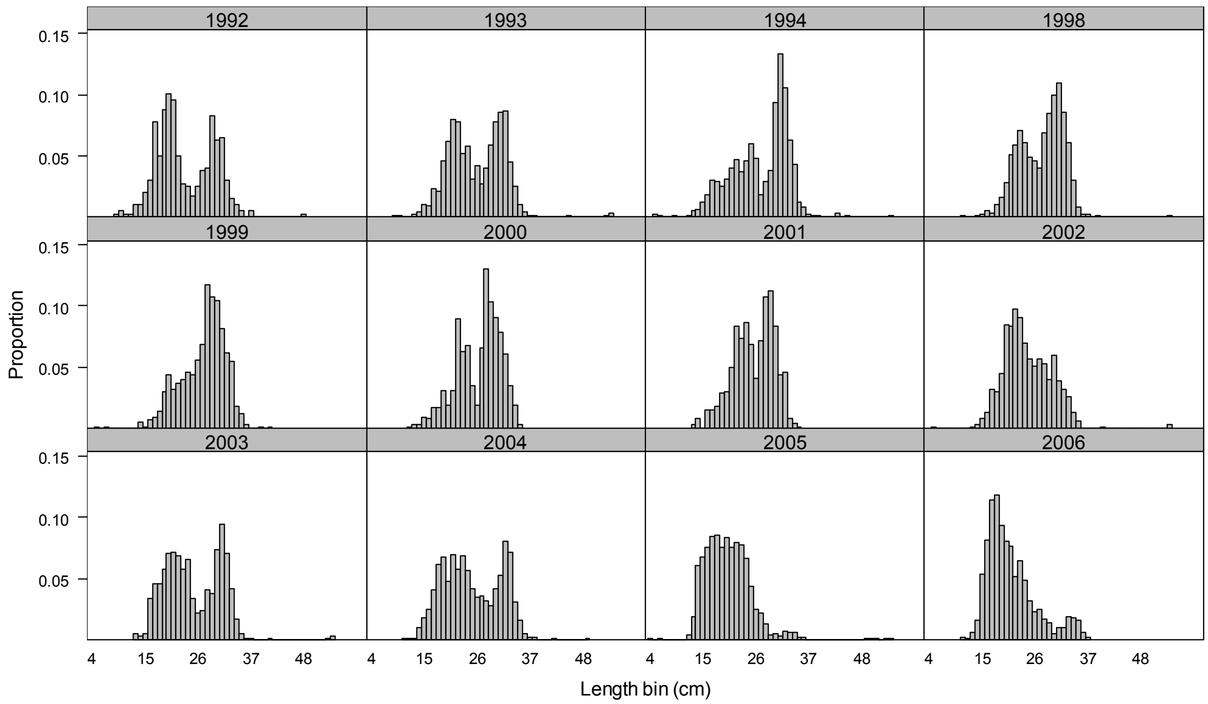

Figure 4. Whole catch lengths for the Pacific mackerel recreational fishery (1992-06). See Fishery Data section for description of fishing year.

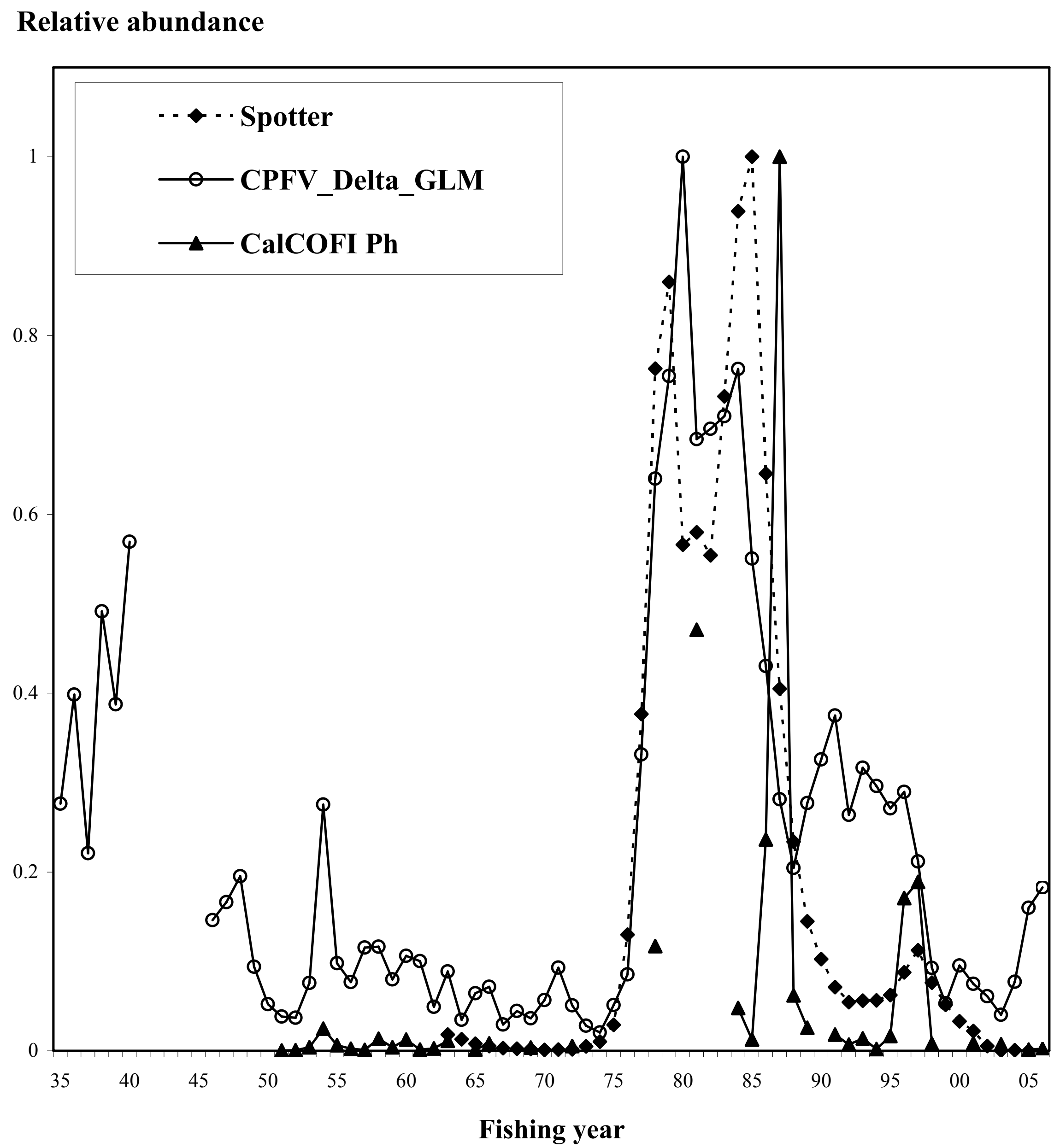

Figure 5. Indices of abundance time series for Pacific mackerel used in the ASAP-E1 (1926-07). Indices are rescaled (normalized) to a maximum of 1.

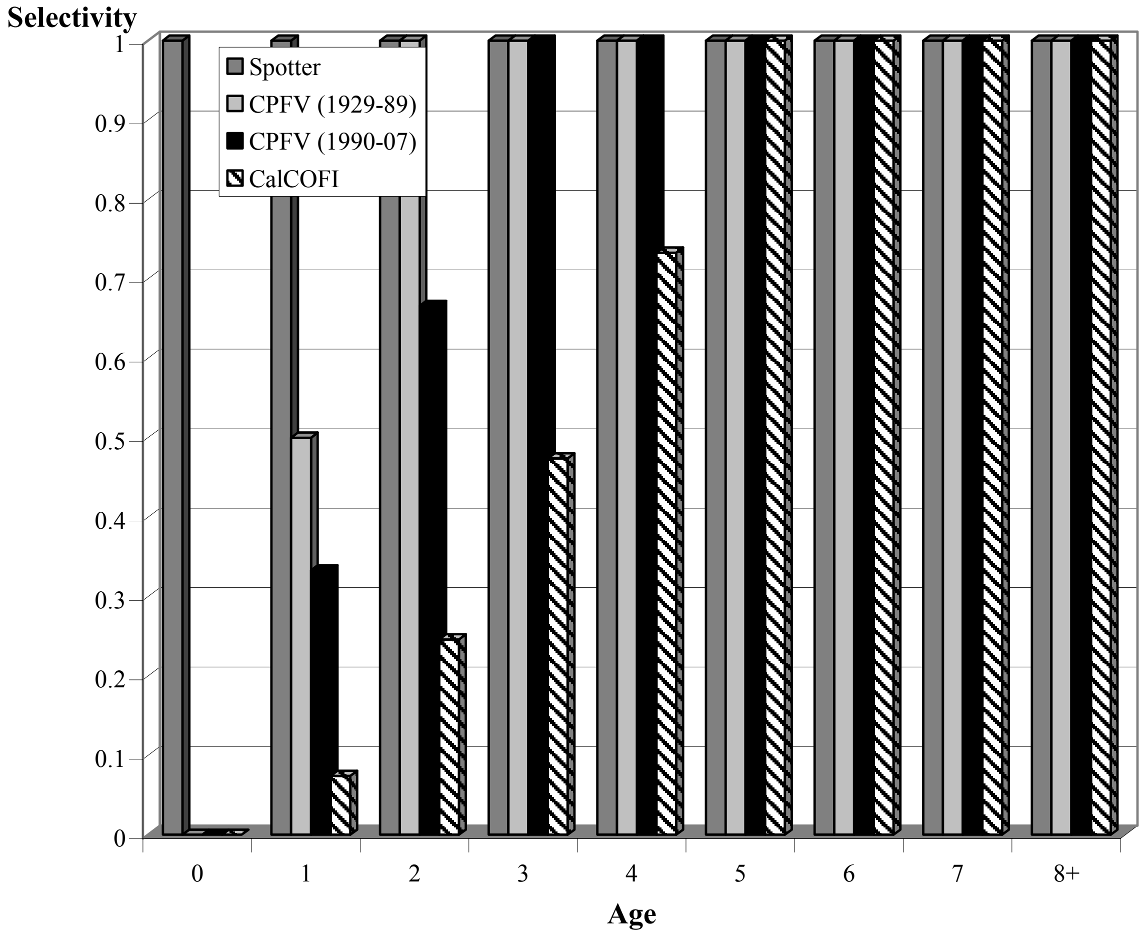

Figure 6. Assumed selectivity ogives for survey-related indices of abundance (Spotter, CPFV, and CalCOFI) from the ASAP-E1 model (1926-07). Note that CPFV ogive represents 1990-07, with ogive for 1929-89 parameterized with slightly different probabilities for ages 1 and 2.

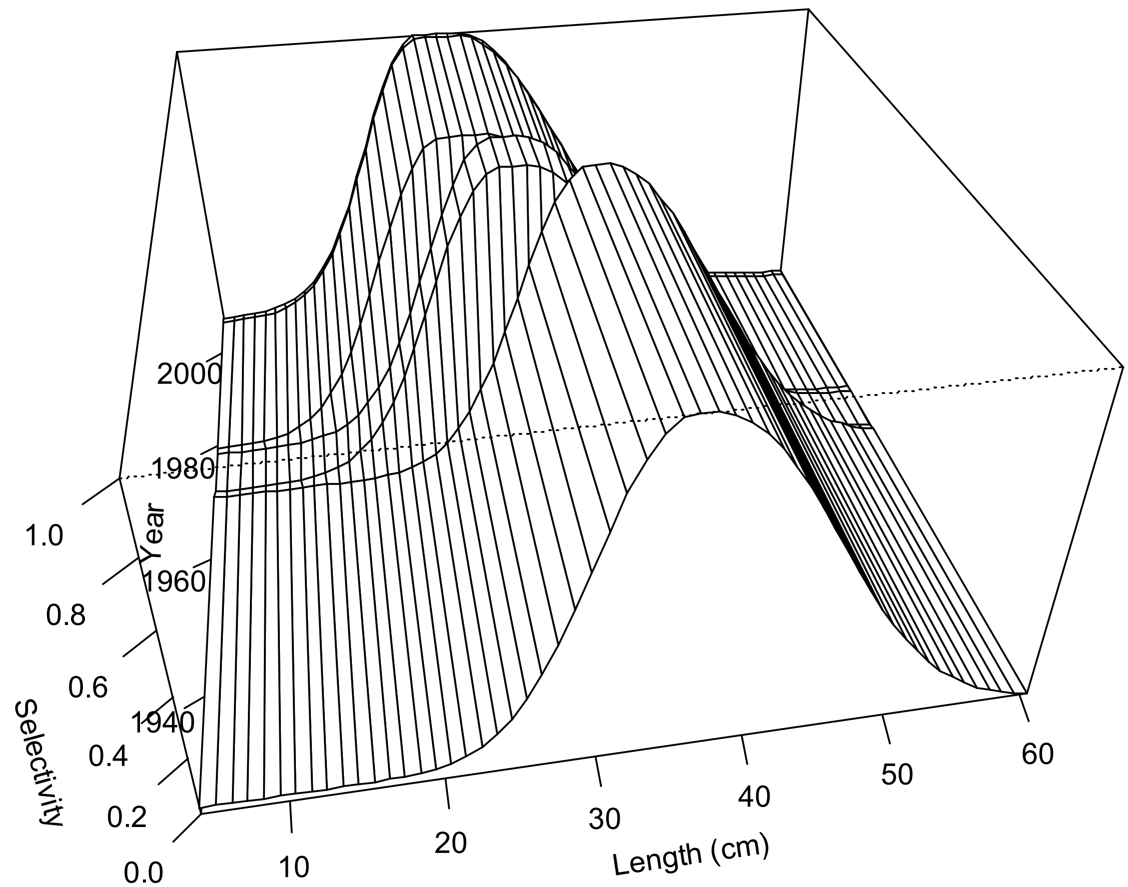

Figure 7. Time varying selectivity curves, for the Pacific mackerel commercial fishery (1926-06). See Data section for description of block designs for selectivity parameters.

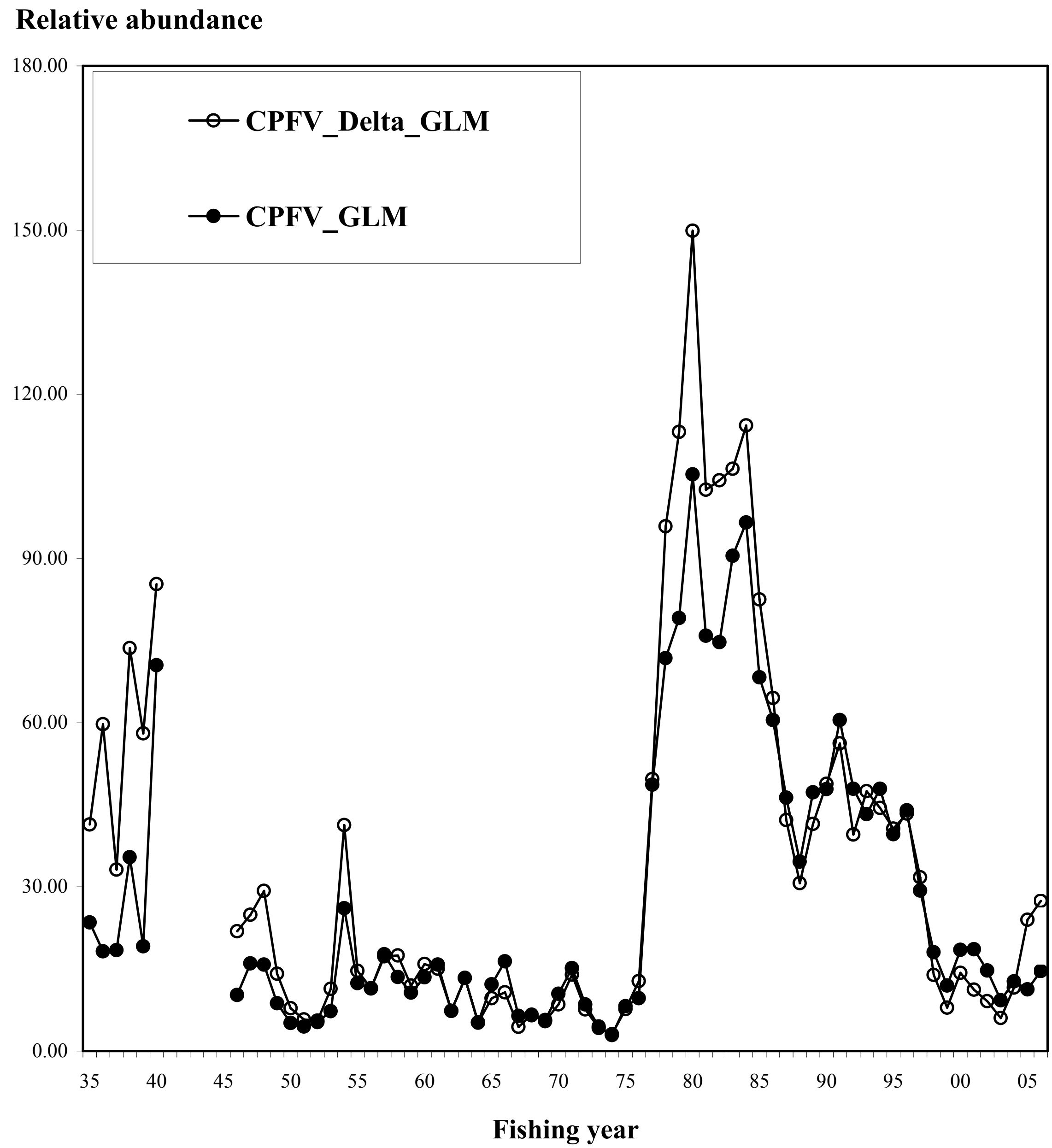

Figure 8. Indices of abundance time series for Pacific mackerel used in the ASAP-E1 model (1926-06) comparing GLM to Delta_GLM.

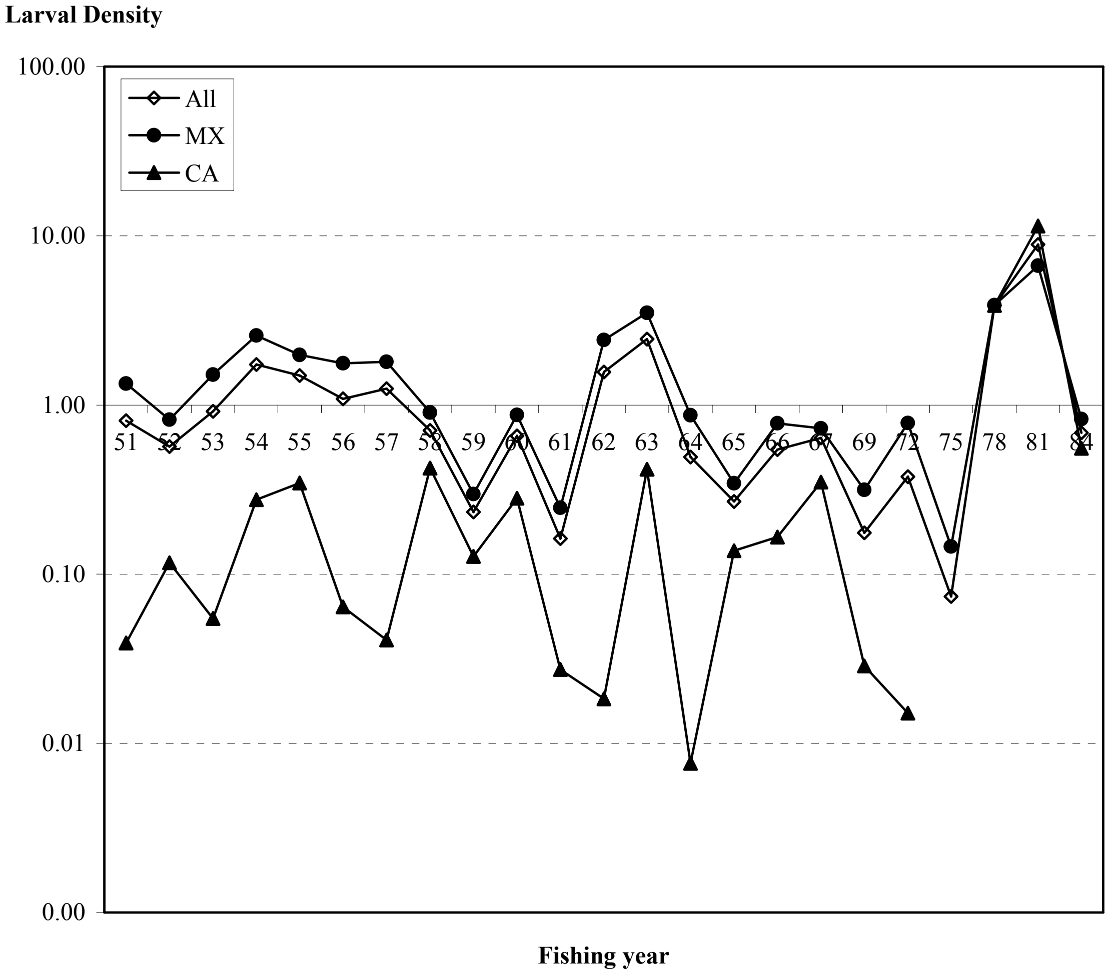

Figure 9a. Coastwide larval densities (diamonds), larval densities off Mexico (squares), and larval densities for the SCB (results based on CalCOFI surveys that covered Mexico and the SCB (1951-1984)).

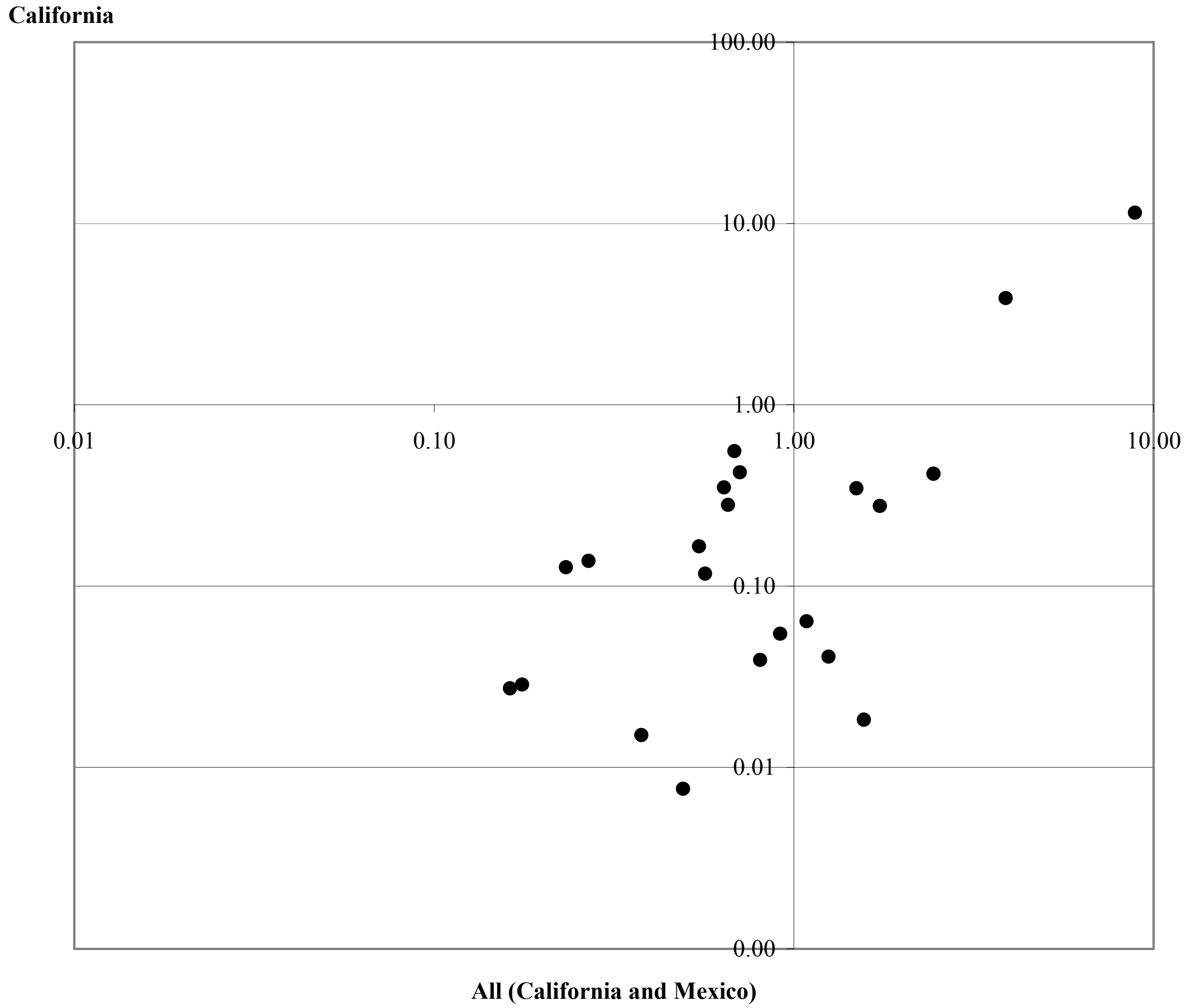

Figure 9b. Average larval densities (Mexico and the SCB) versus larval densities for the SCB based on CalCOFI surveys that covered Mexico and the SCB (1951-1984).

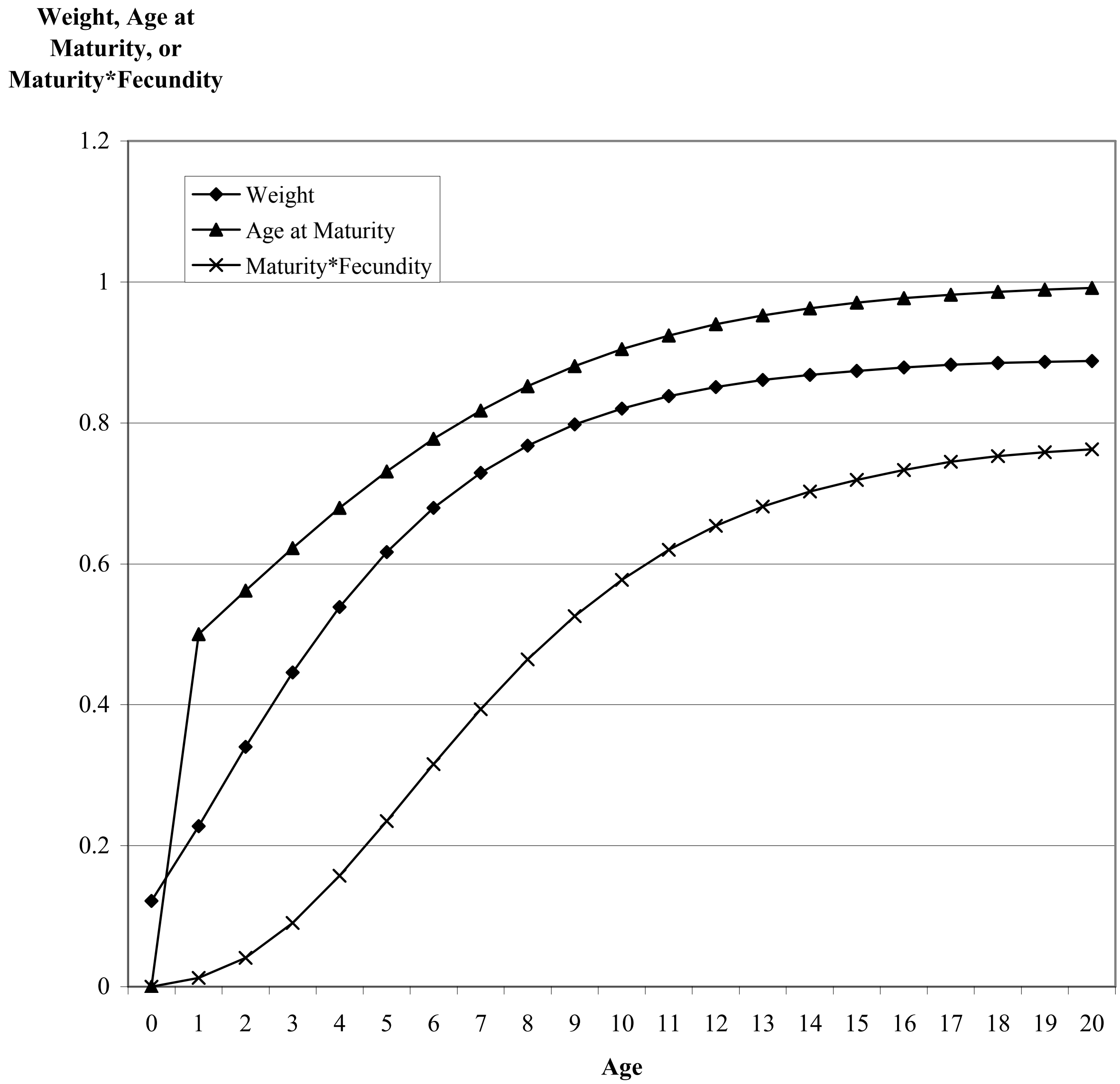

Figure 10. Maturity, fecundity, and weight-at-age curves derived from the SS2-C1 model. Fecundity was estimated as a linear function of body-weight (See Section: SS2 Model Description).

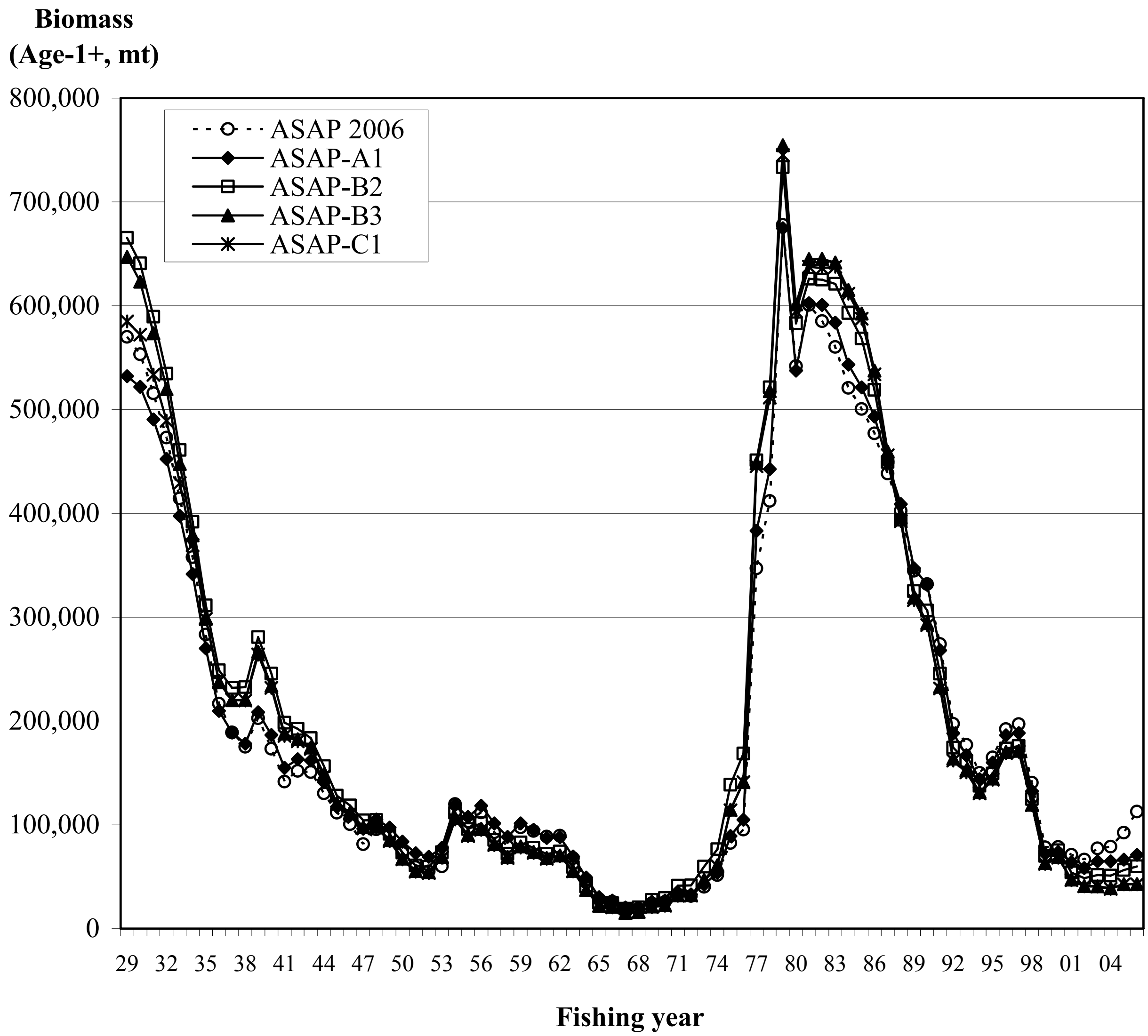

Figure 11. Estimated biomass (Age 1+ fish, in mt) of Pacific mackerel generated from the ASAP 2006, A1, B2, B3 and C1 models.

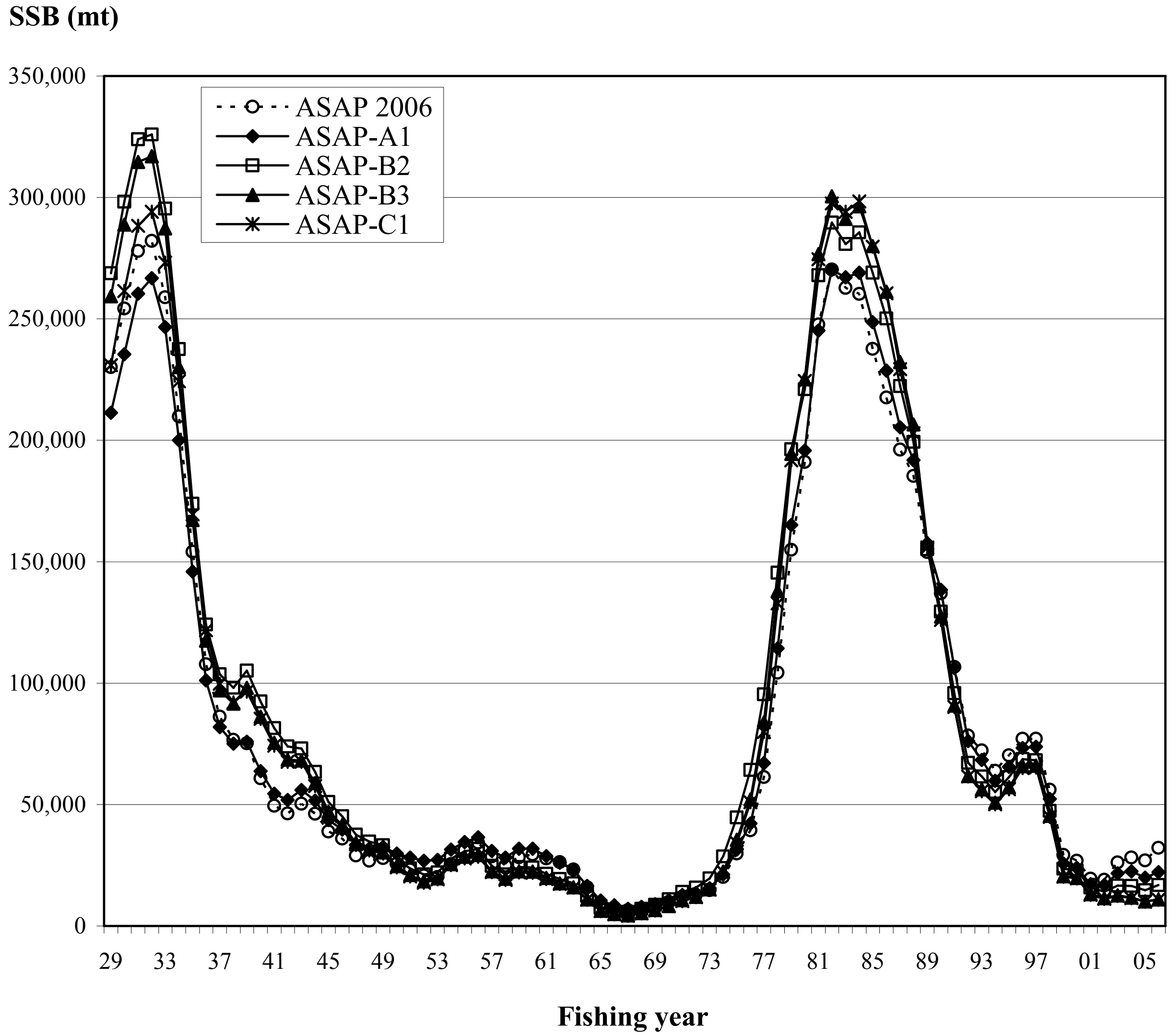

Figure 12. Estimated spawning stock biomass (SSB, in mt) of Pacific mackerel generated from the ASAP 2006, A1, B2, B3, and C1 models.

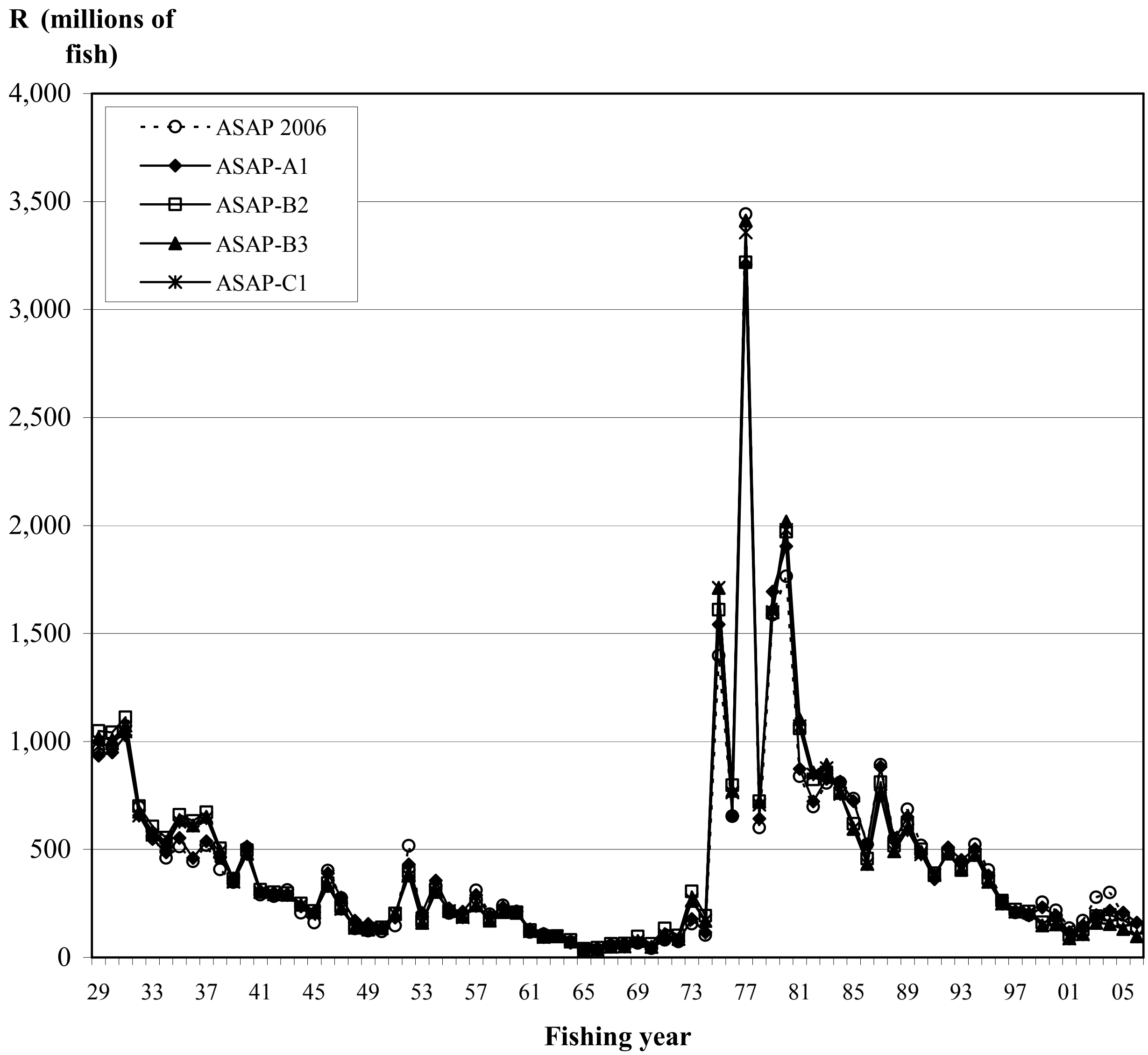

Figure 13. Estimated recruitment (Age-0 fish in millions, R) of Pacific mackerel generated from the ASAP 2006, A1, B2, B3, and C1 models.

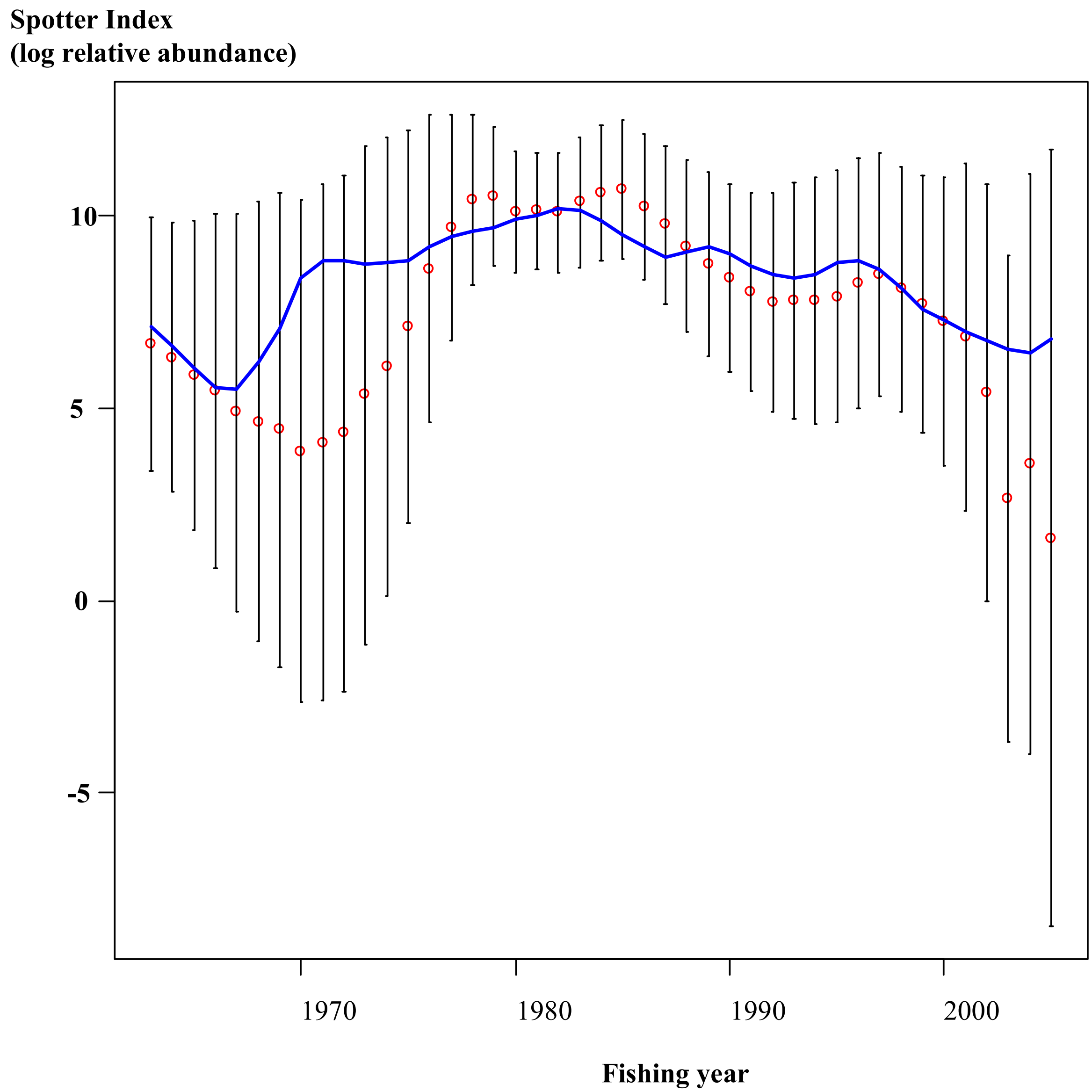

Figure 14. Relative abundance (in log scale) fits for the aerial spotter survey derived from the SS2-C1 model (1935-06). Line indicates predicted values from the SS2-C1 model. Bars are standard errors of observed values. See Data Section for a description of Fishing year.

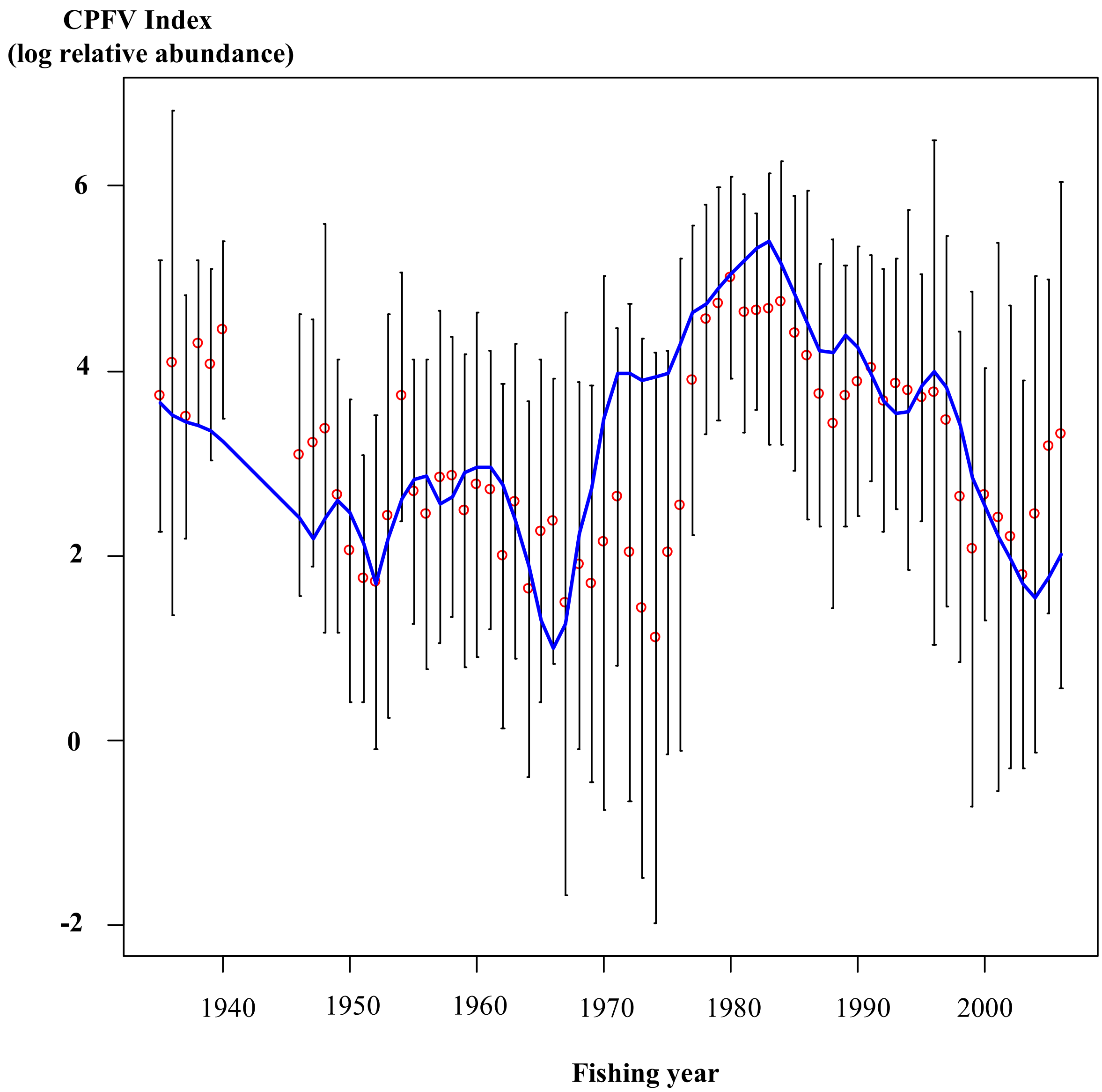

Figure 15. Catch rate (in log scale) fits of the CPFV index time series by the SS2-C1 model (1935-06). Line indicates predicted values from the SS2-C1 model. Bars are standard errors of observed values. See Data Section for a description of Fishing year.

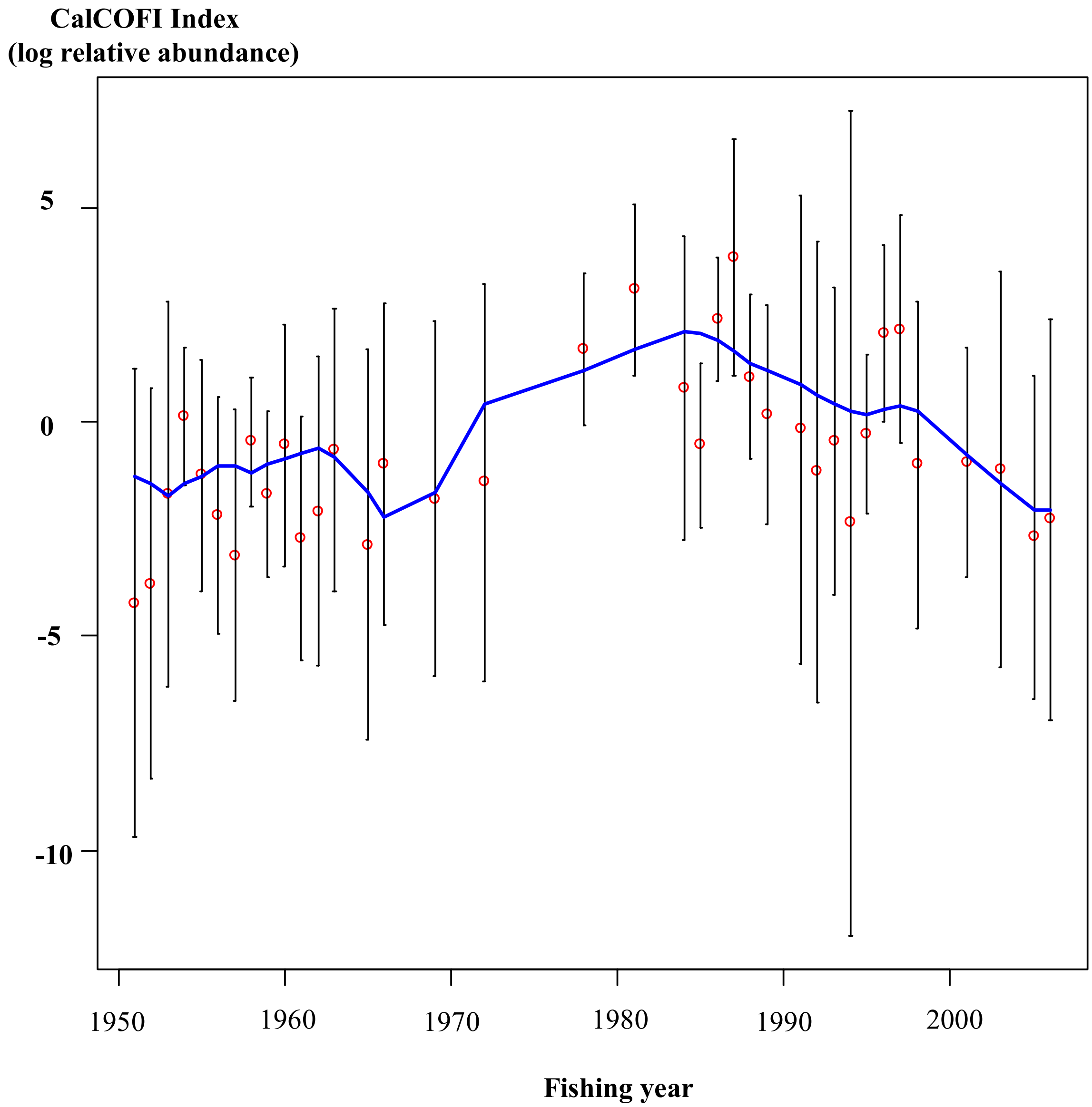

Figure 16. Daily larval production/10 m^2 (in log scale) fits derived from the SS2-C1 model (1951-06). Line indicates predicted values from the SS2-C1 model. Bars are standard errors of observed values. See Data Section for a description of Fishing year.

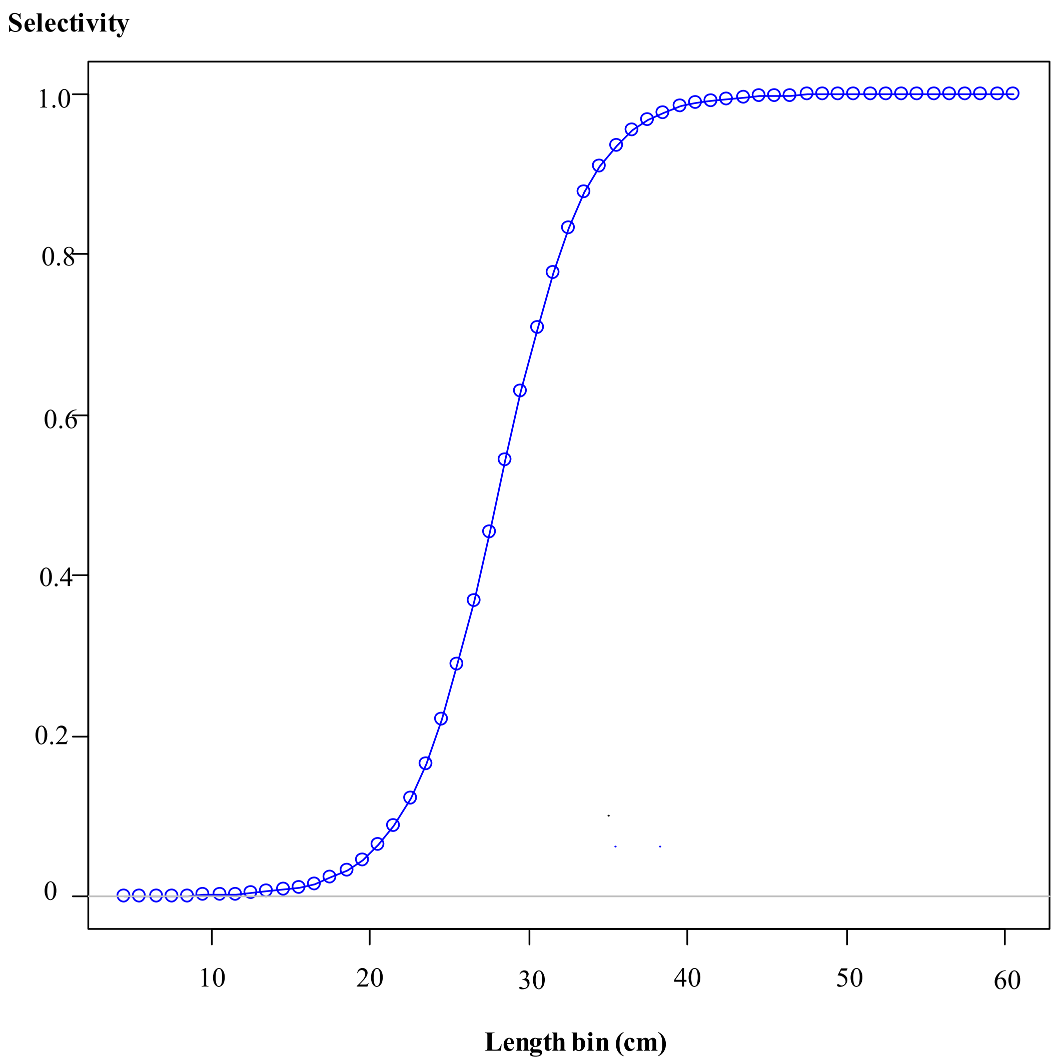

Figure 17. Size selectivity curve, for the Pacific mackerel recreational fishery and the CPFV index, derived from the SS2-C1 model (1939-06). See Data section for description of block designs for selectivity parameters.

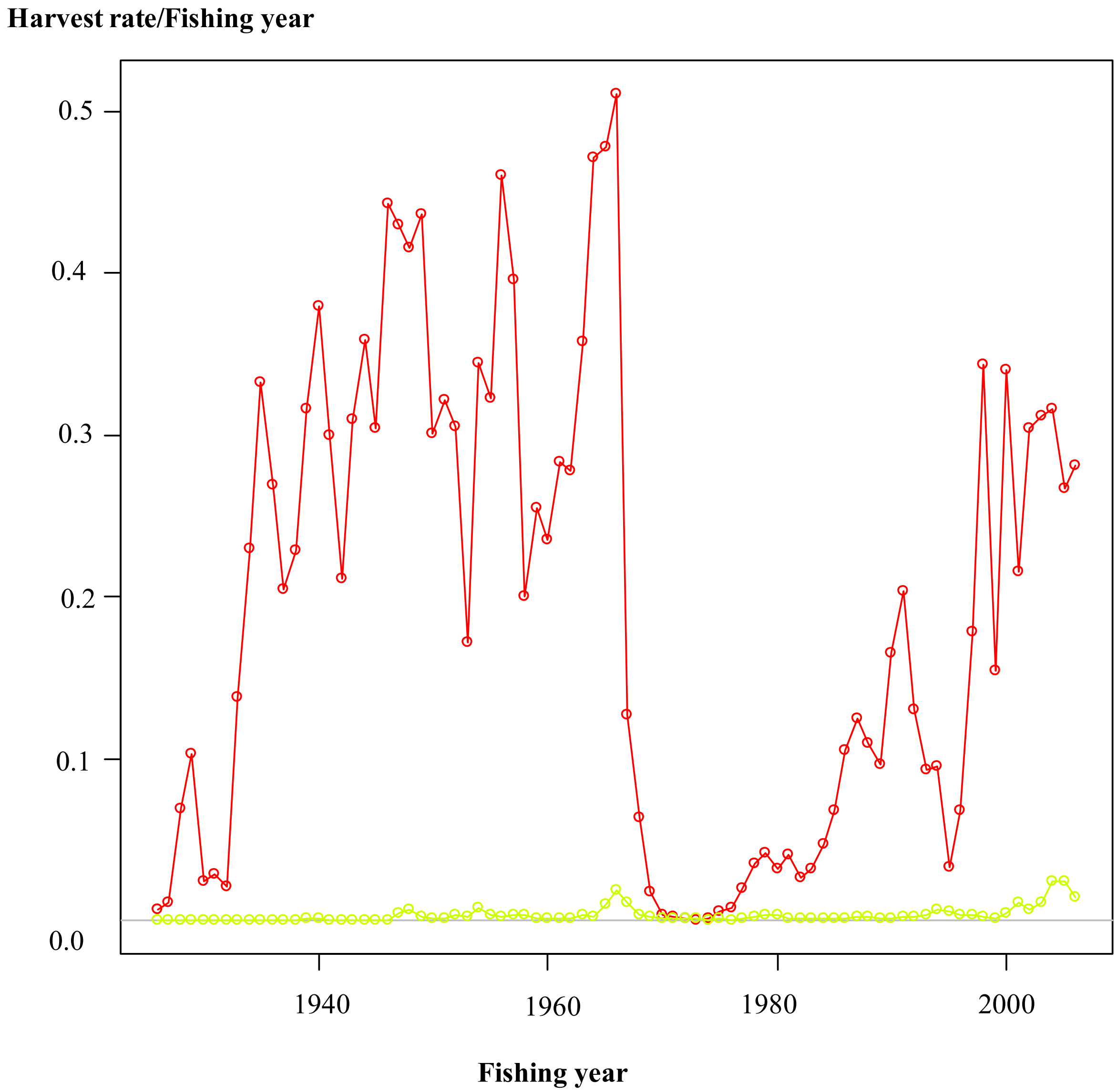

Figure 18. Harvest rate of Pacific mackerel estimated by the SS2-C1 model for the commercial (dark gray) and recreational (light gray line) fisheries (1926-06). See Data section for a description of Fishing year.

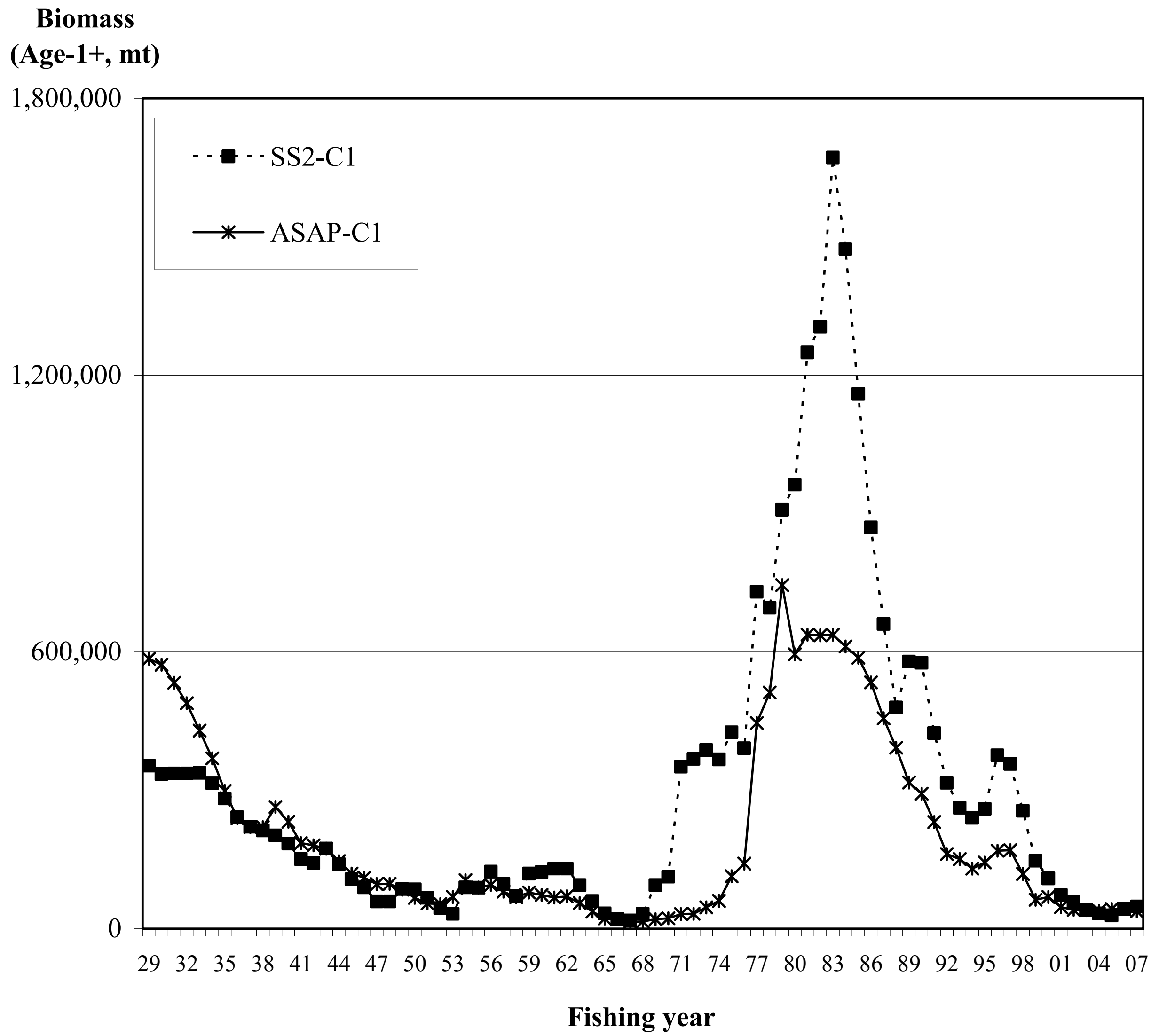

Figure 19. Estimated biomass (Age 1+ fish, B in mt) of Pacific mackerel generated from the ASAP-C1 and SS2-C1 models (1929-07).

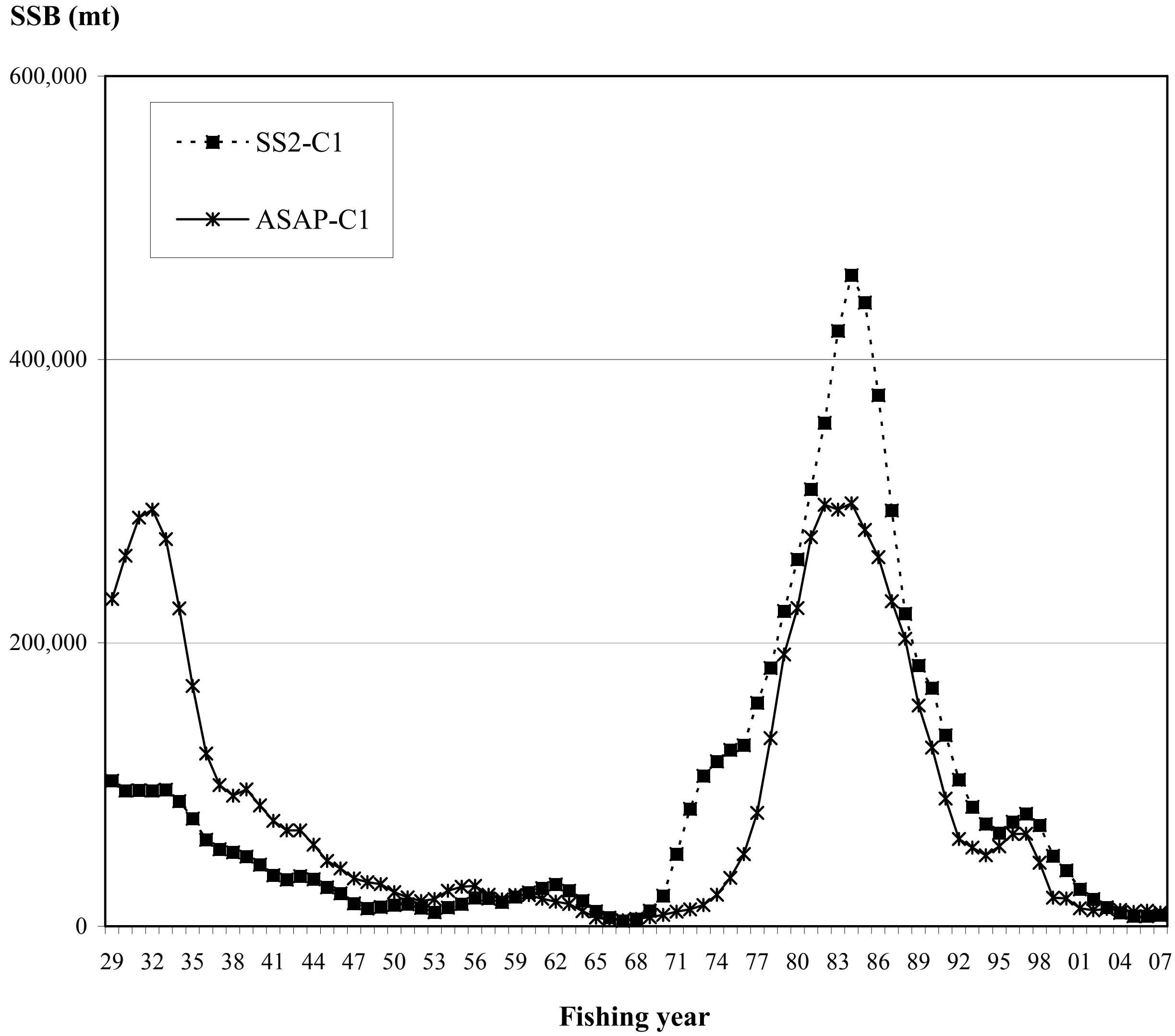

Figure 20. Estimated spawning stock biomass (SSB, in mt) of Pacific mackerel generated from the ASAP-C1 and SS2-C1 models (1929-07).

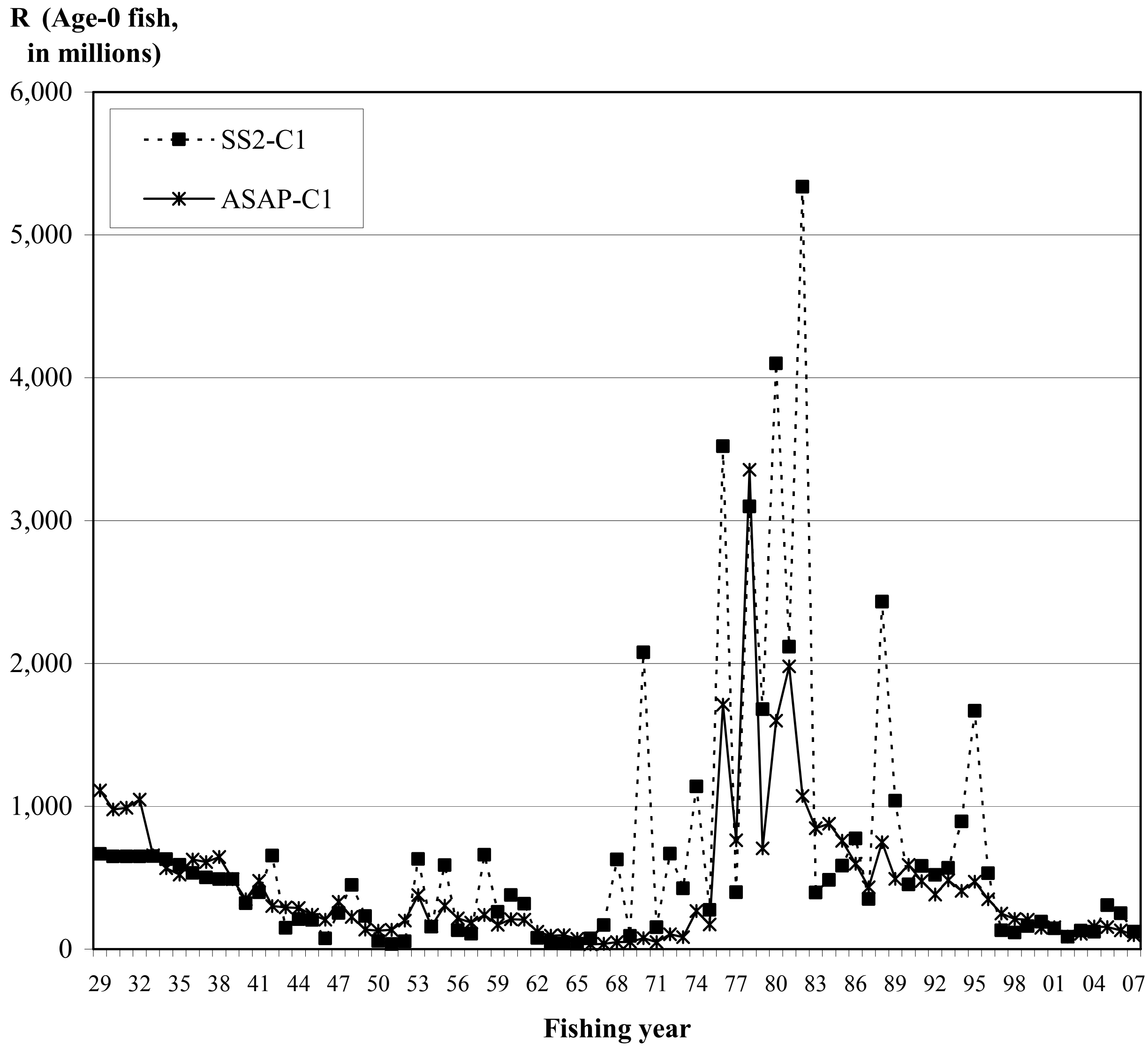

Figure 21. Estimated recruitment (Age-0 fish in millions, R) of Pacific mackerel generated from the ASAP-C1 and SS2-C1 models (1929-07).

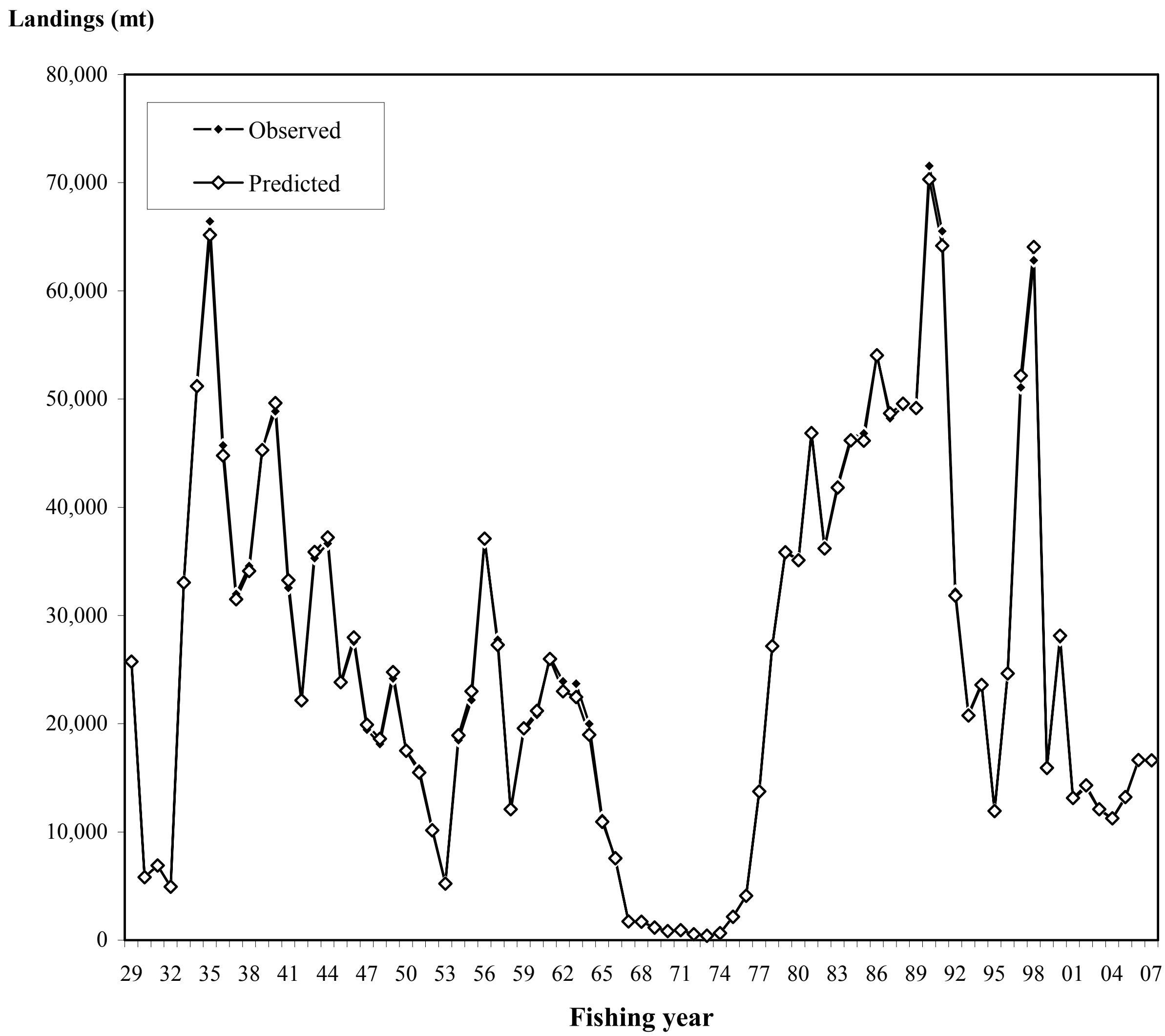

Figure 22. Observed and predicted estimates of total landings (mt) for Pacific mackerel generated from the ASAP-E1 model (1929-07).

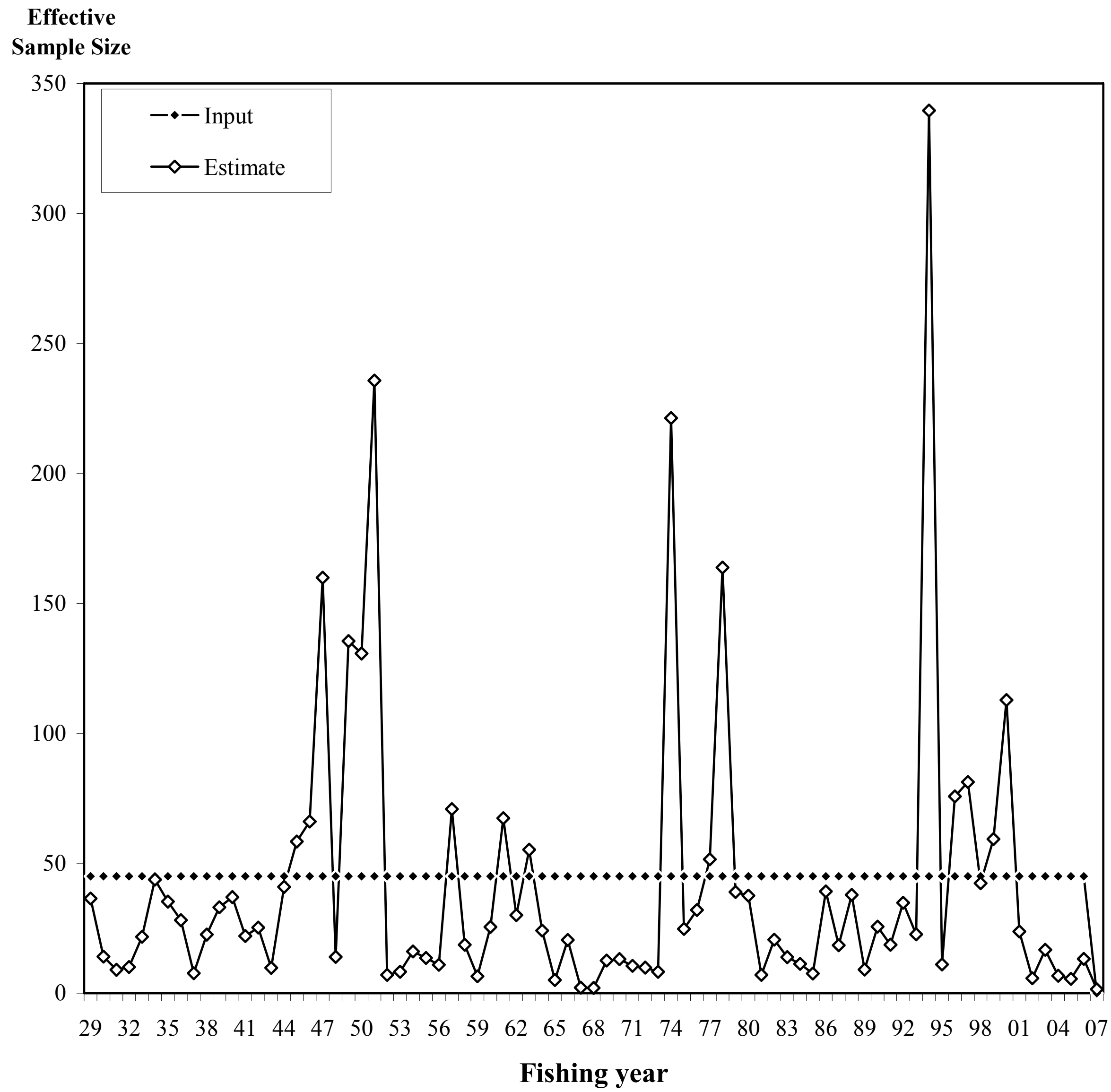

Figure 23. Effective sample sizes estimated for catch-at-age data generated from the ASAP-E1 model (1929-07). Catch-at-age data were given a lambda weighting of '45' for all years.

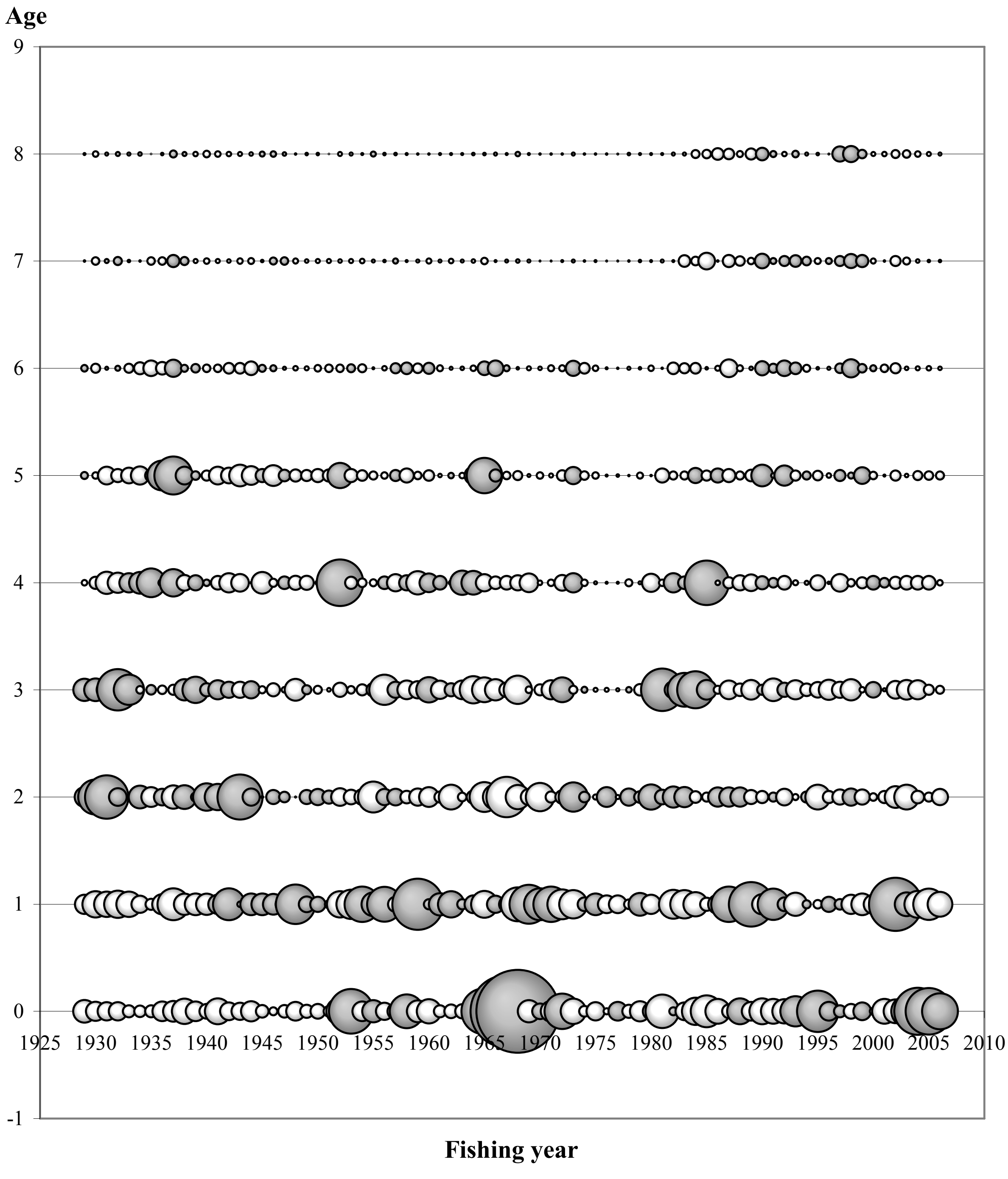

Figure 24. Pearson residual plot for Pacific mackerel catch-at-age fitted to the ASAP-E1 model (1929-07).

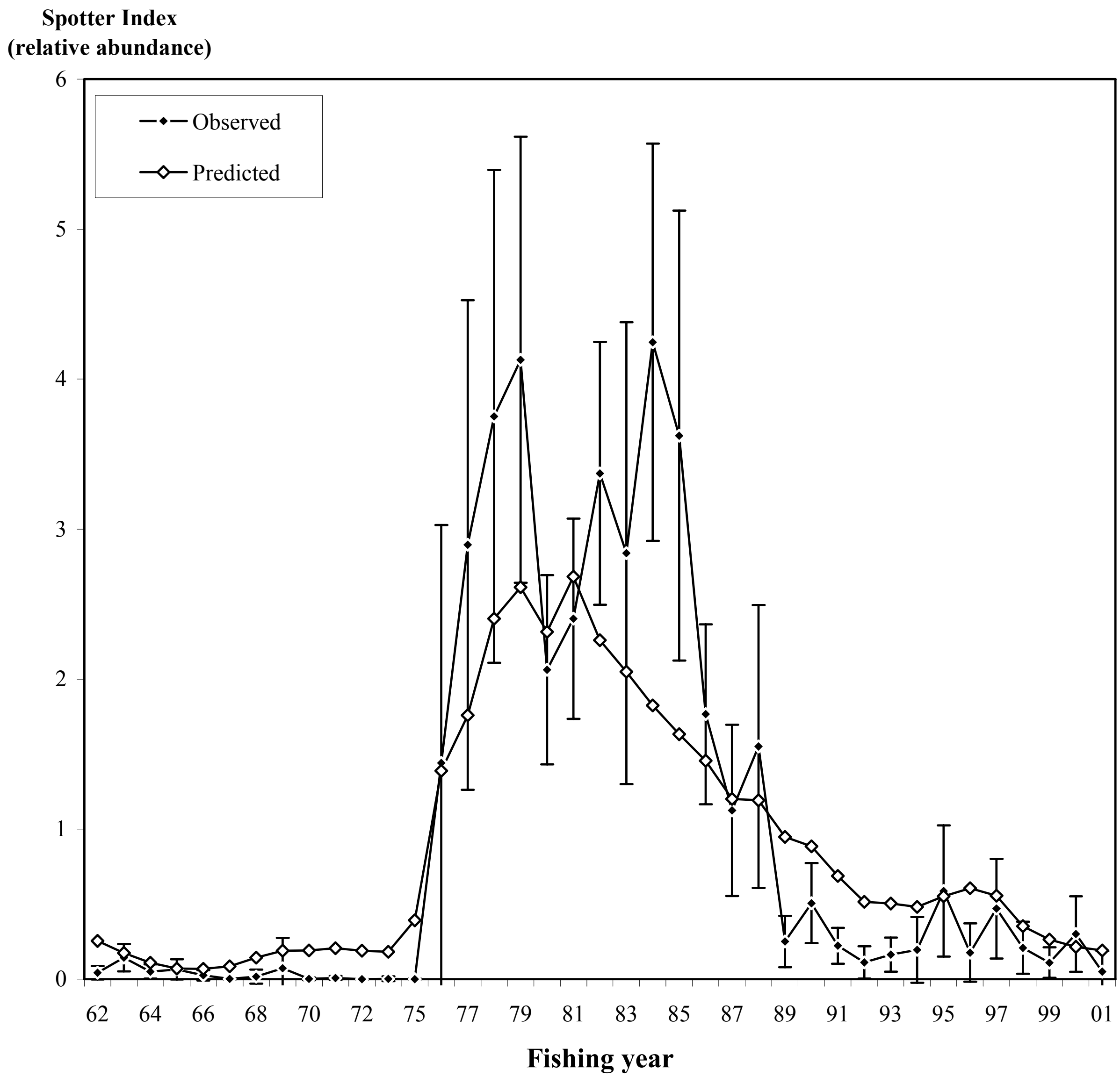

Figure 25. Observed and predicted estimates of the Spotter index of relative abundance (see Appendix 1) for Pacific mackerel generated from the ASAP-E1 model (1962-01). Bars represent ± 2 STD. *Note: Observed values were internally re-scaled by ASAP.

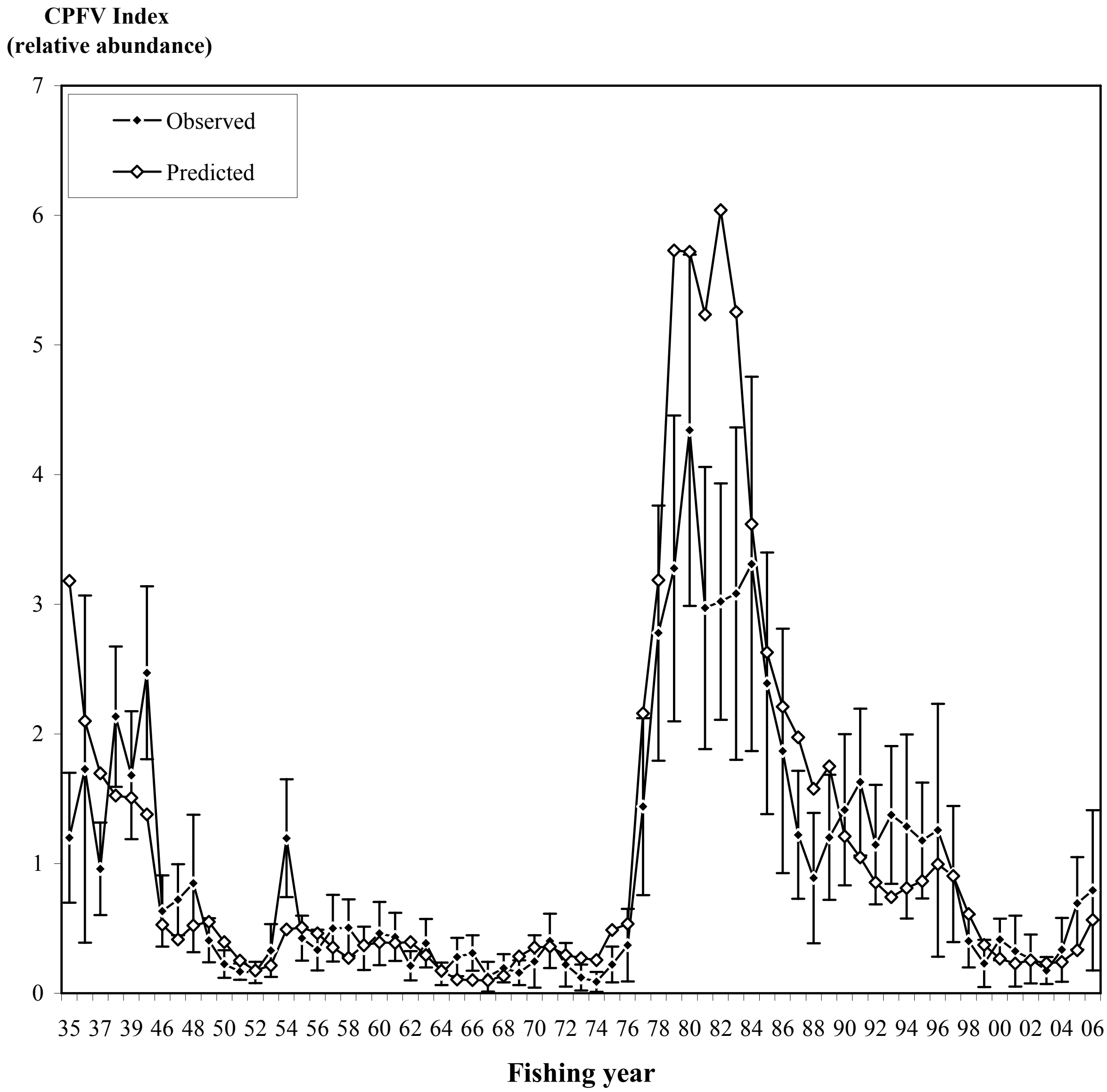

Figure 26. Observed and predicted estimates of the CPFV index of relative abundance for Pacific mackerel generated from the ASAP-E1 model (1935-06). Bars represent ± 2 STD. *Note: Observed values were internally re-scaled by ASAP.

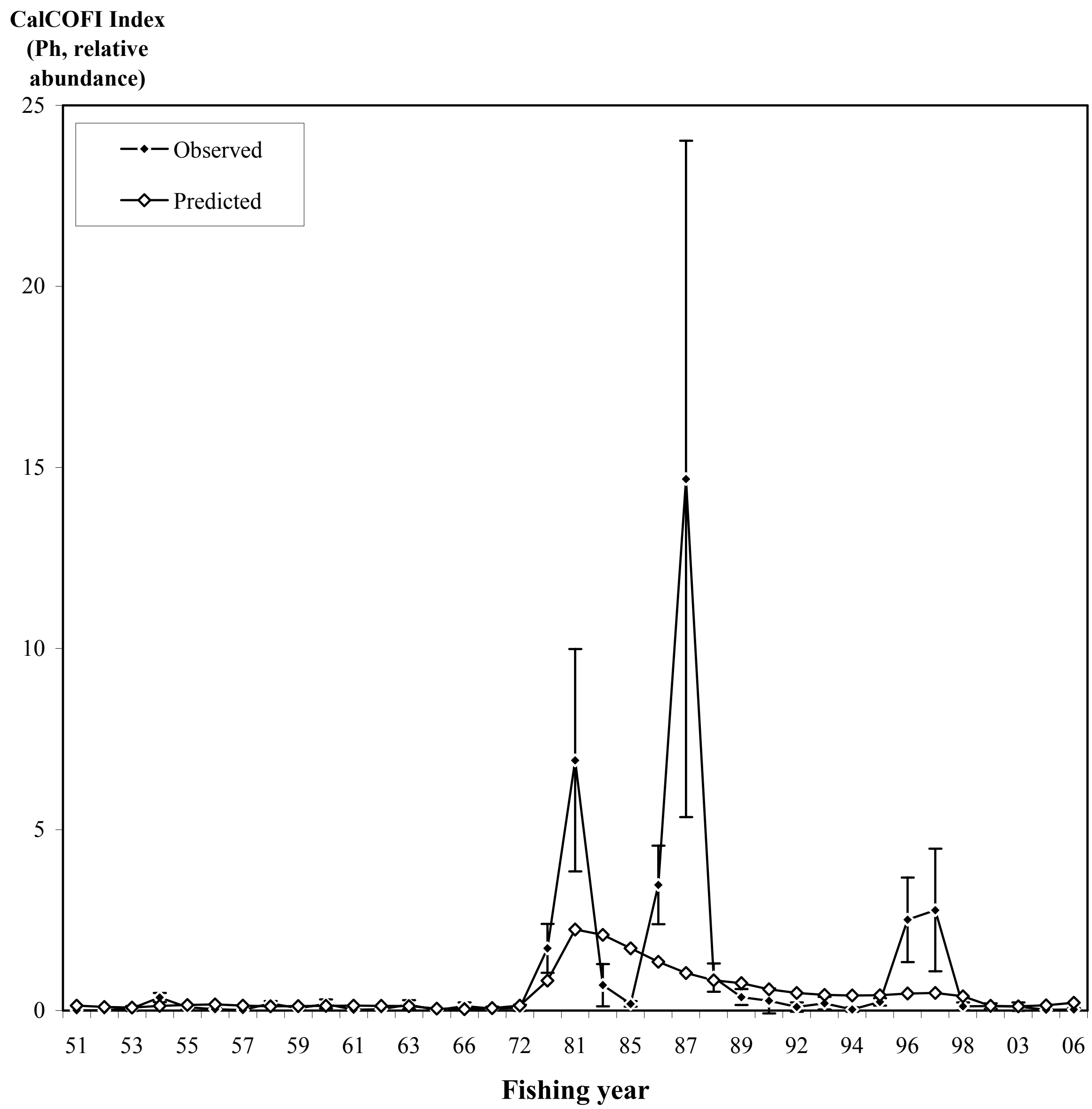

Figure 27. Observed and predicted estimates of the CalCOFI index of relative abundance (see Appendix 2) for Pacific mackerel generated from the ASAP-E1 model (1951-06). Bars represent ± 2 STD. *Note: Observed values were internally re-scaled by ASAP.

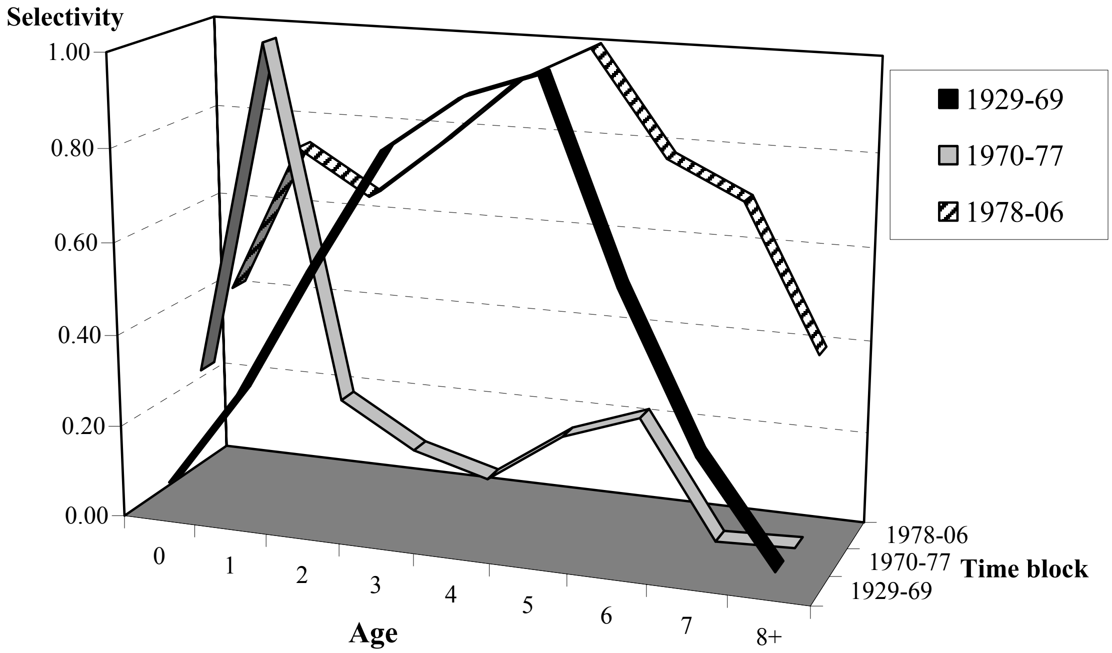

Figure 28. Estimated selectivity schedule for commercial fishery (catch-at-age) data from the ASAP-E1 model (1926-07) based on three time blocks (1929-69, 1970-77, and 1978-06).

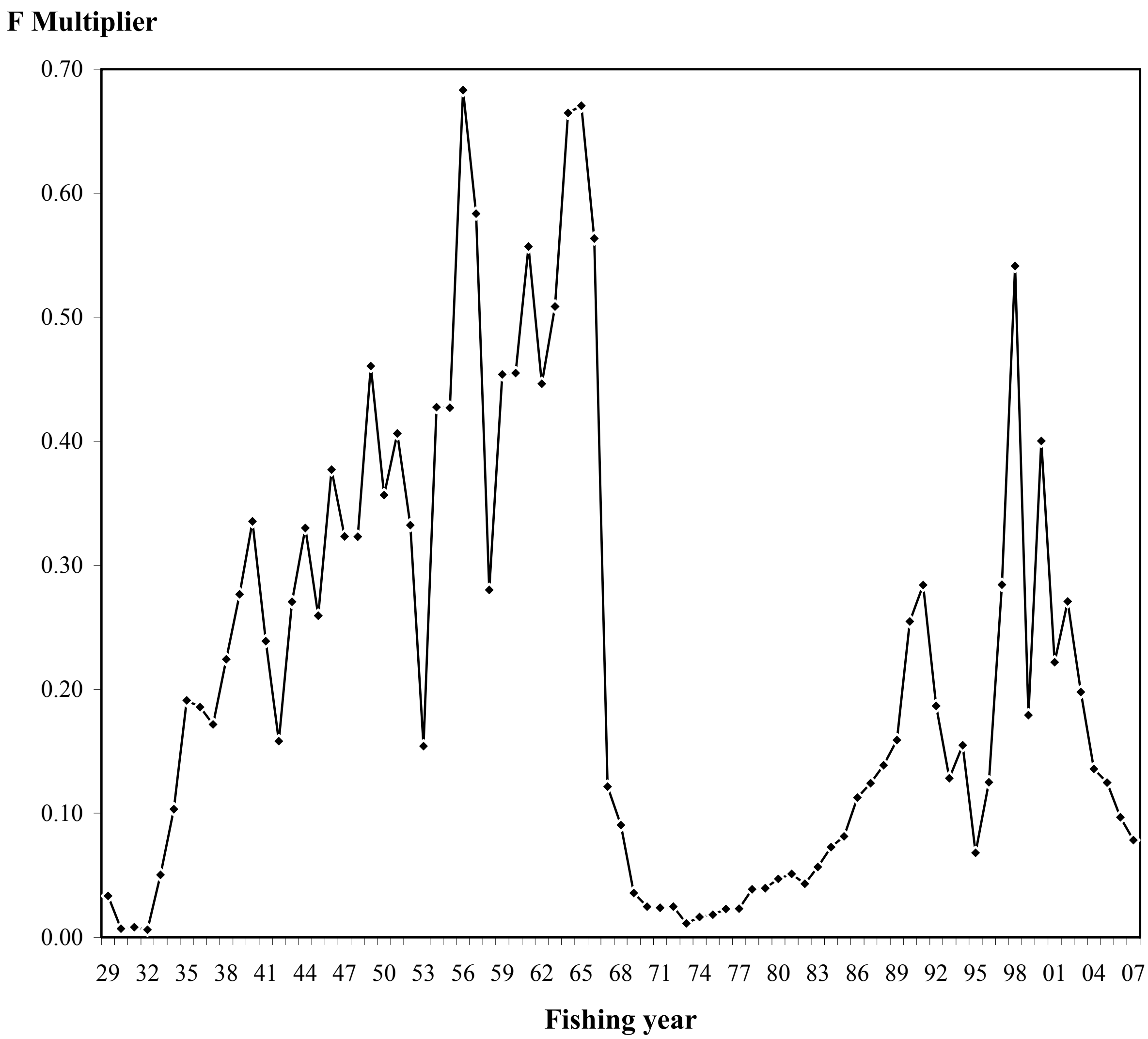

Figure 29. F multiplier for Pacific mackerel generated from the ASAP-E1 model (1929-07).

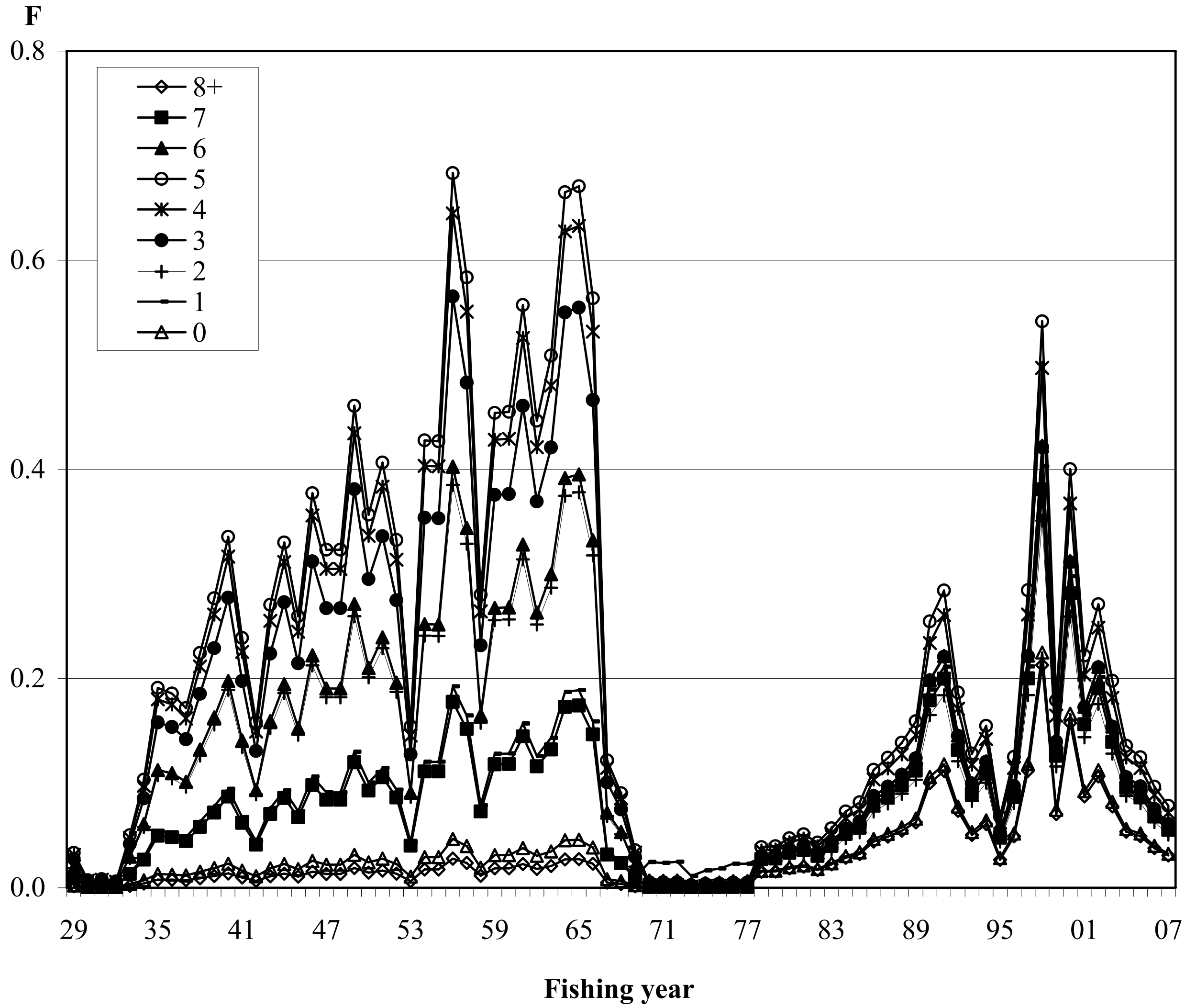

Figure 30. Estimated instantaneous fishing mortality (total) F-at-age for Pacific mackerel generated from the ASAP-E1 model (1929-07).

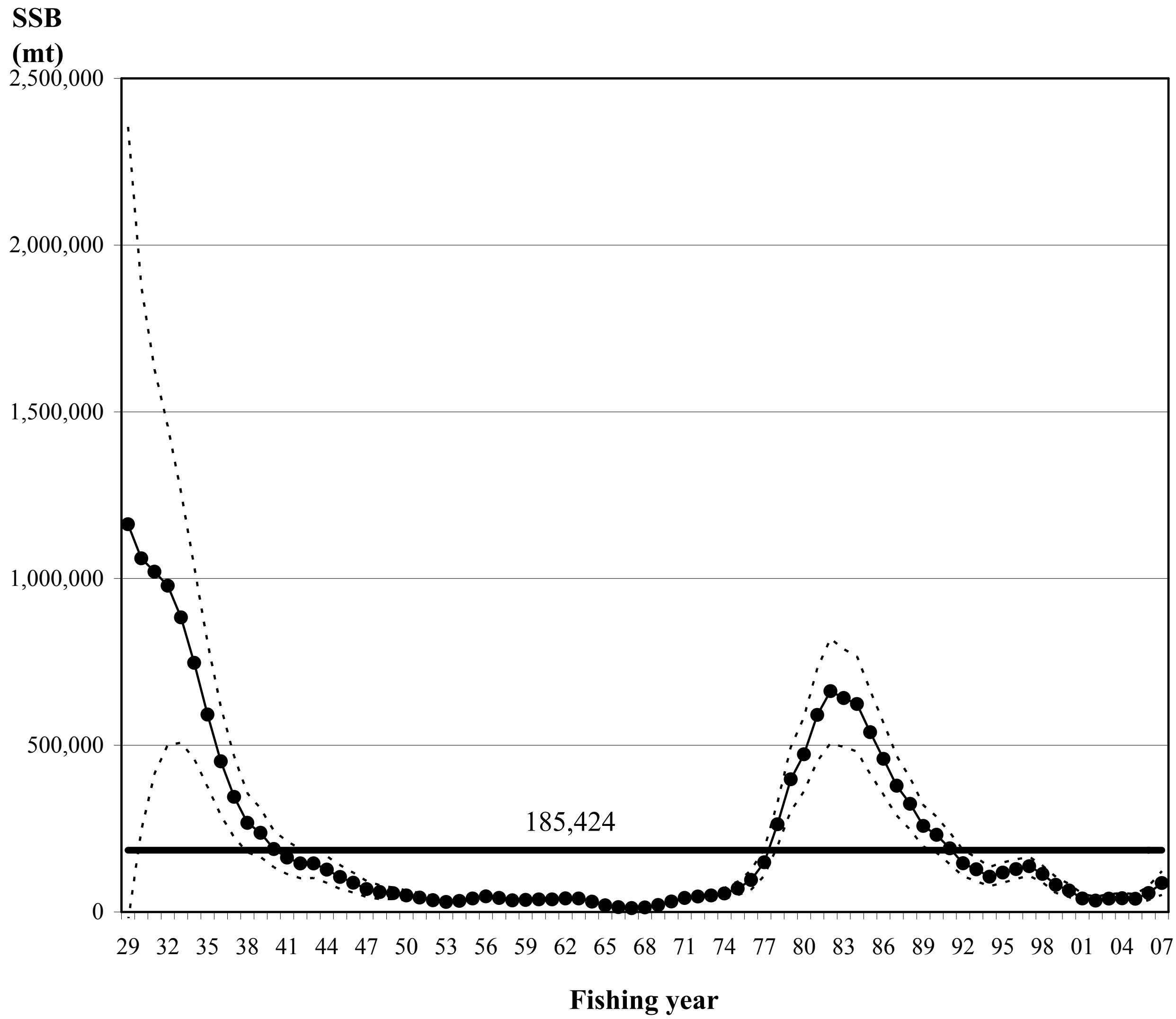

Figure 31. Estimated spawning stock biomass (SSB, in mt) of Pacific mackerel generated from the ASAP-E1 model (1929-07). The confidence interval (± 2 STD) associated with this time series is also presented. Estimated 'virgin' SSB from stock-recruitment relationship is presented as a bold horizontal line.

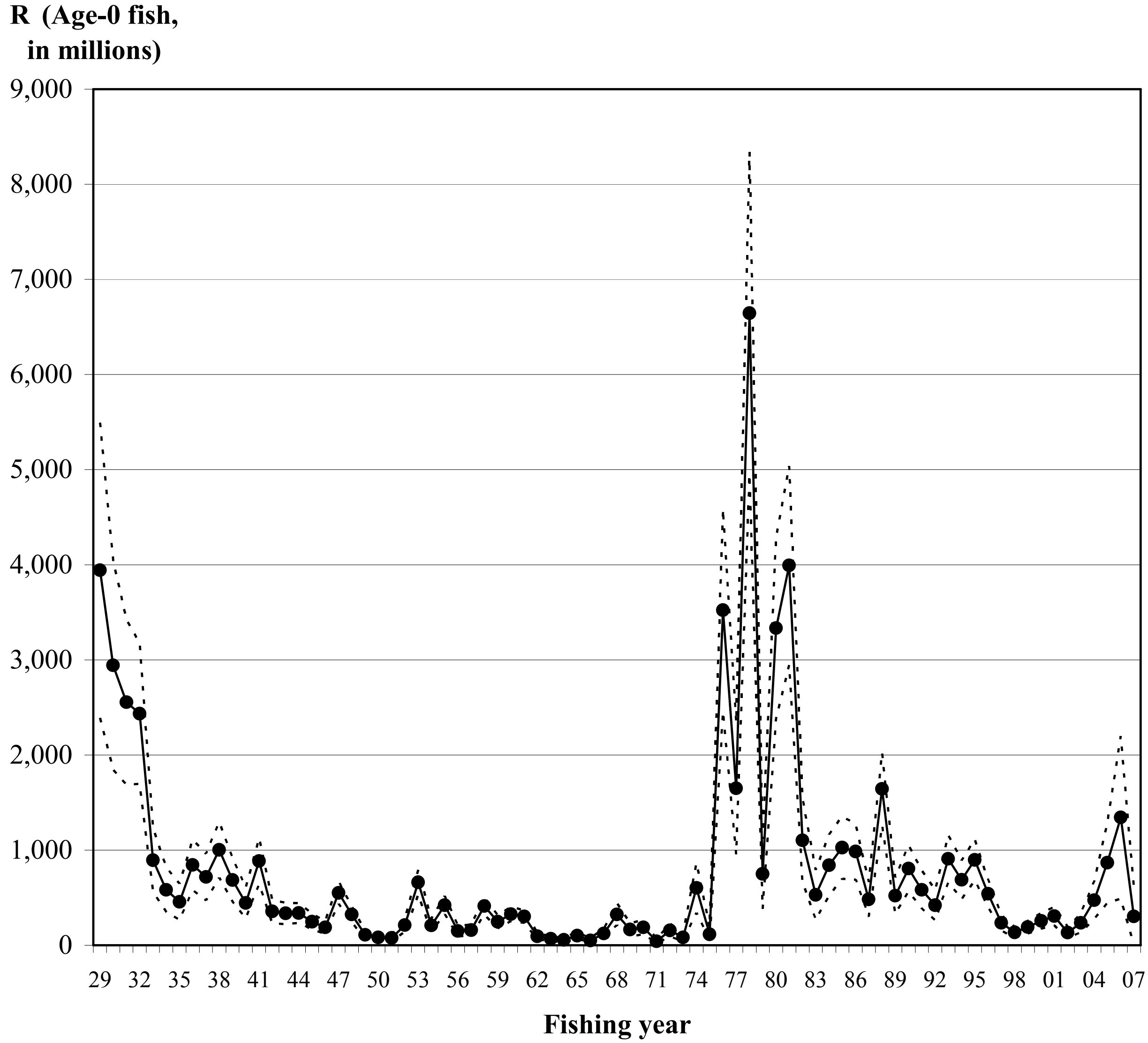

Figure 32. Estimated recruitment (age-0 fish in millions, R) of Pacific mackerel generated from the ASAP-E1 model (1929-07). The confidence interval (± 2 STD) associated with this time series is also presented.

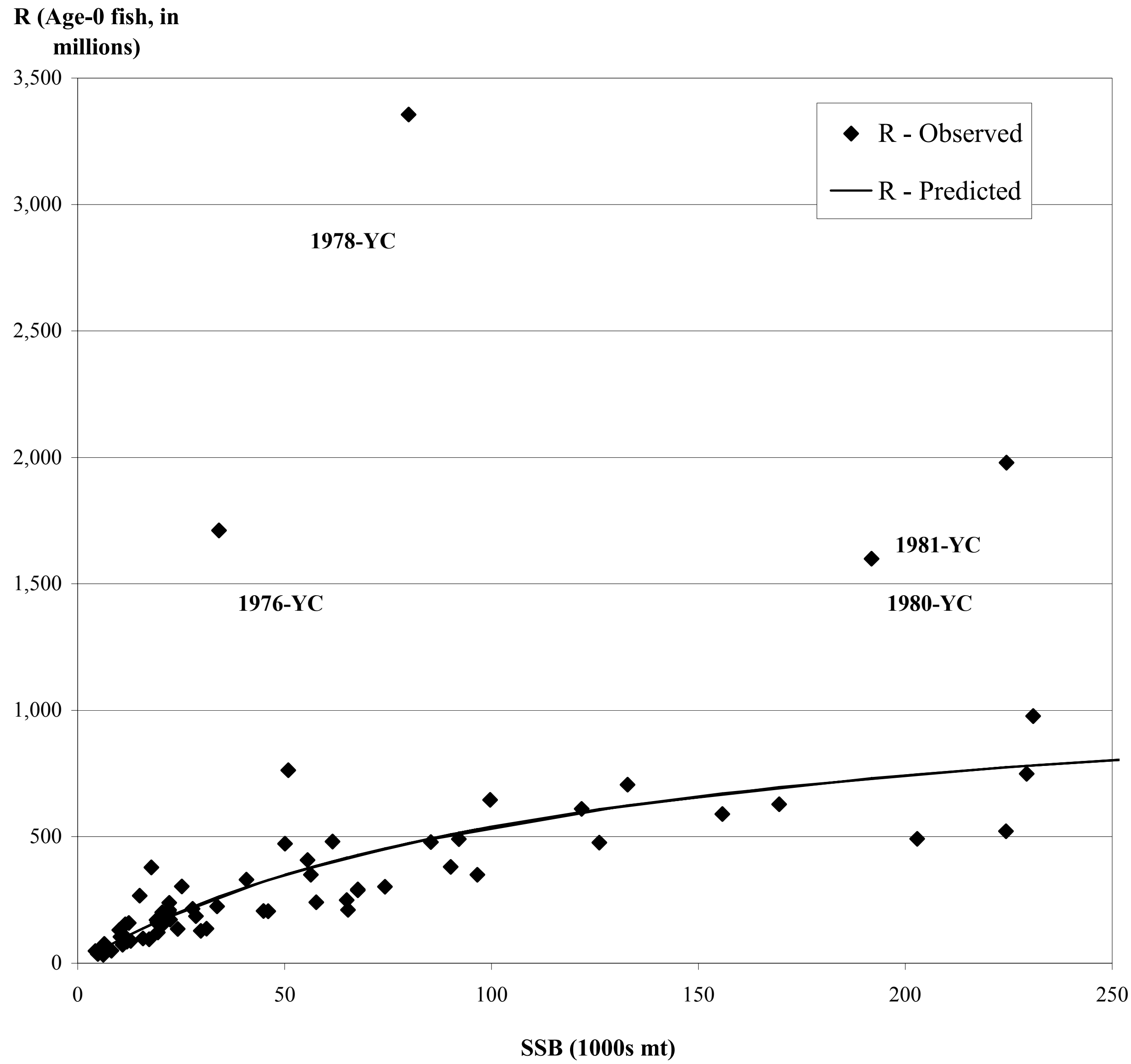

Figure 33. Beverton-Holt stock (SSB, in 1000s mt)-recruitment (Age-0 fish (R), in millions) relationship for Pacific mackerel estimated in the ASAP-E1 model (1929-07). Recruitment estimates are presented as (year+1) values. Strong year classes are highlighted. Steepness=0.31.

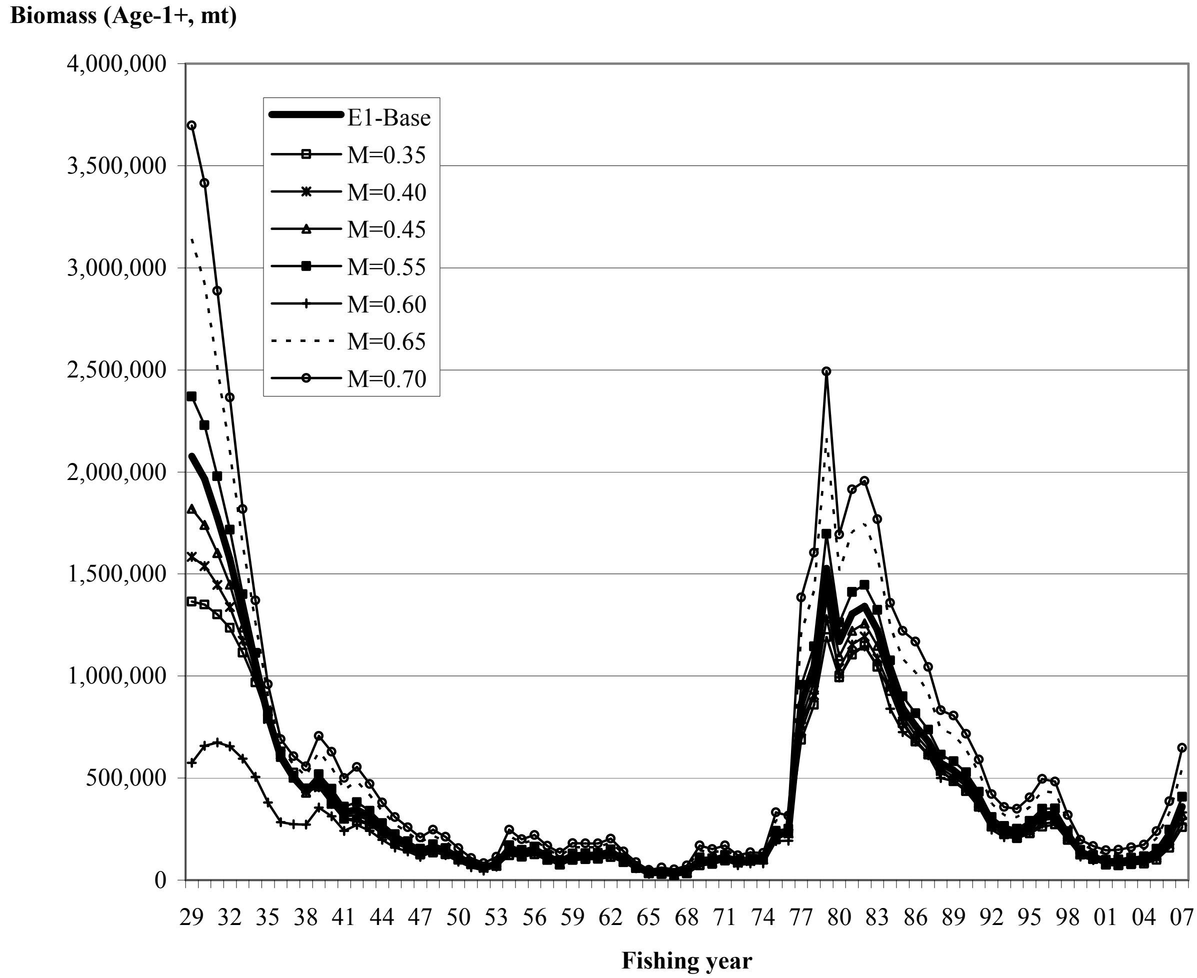

Figure 34. Biomass (Age-1+ fish) from sensitivity analysis to natural mortality generated from the ASAP-E1 model.

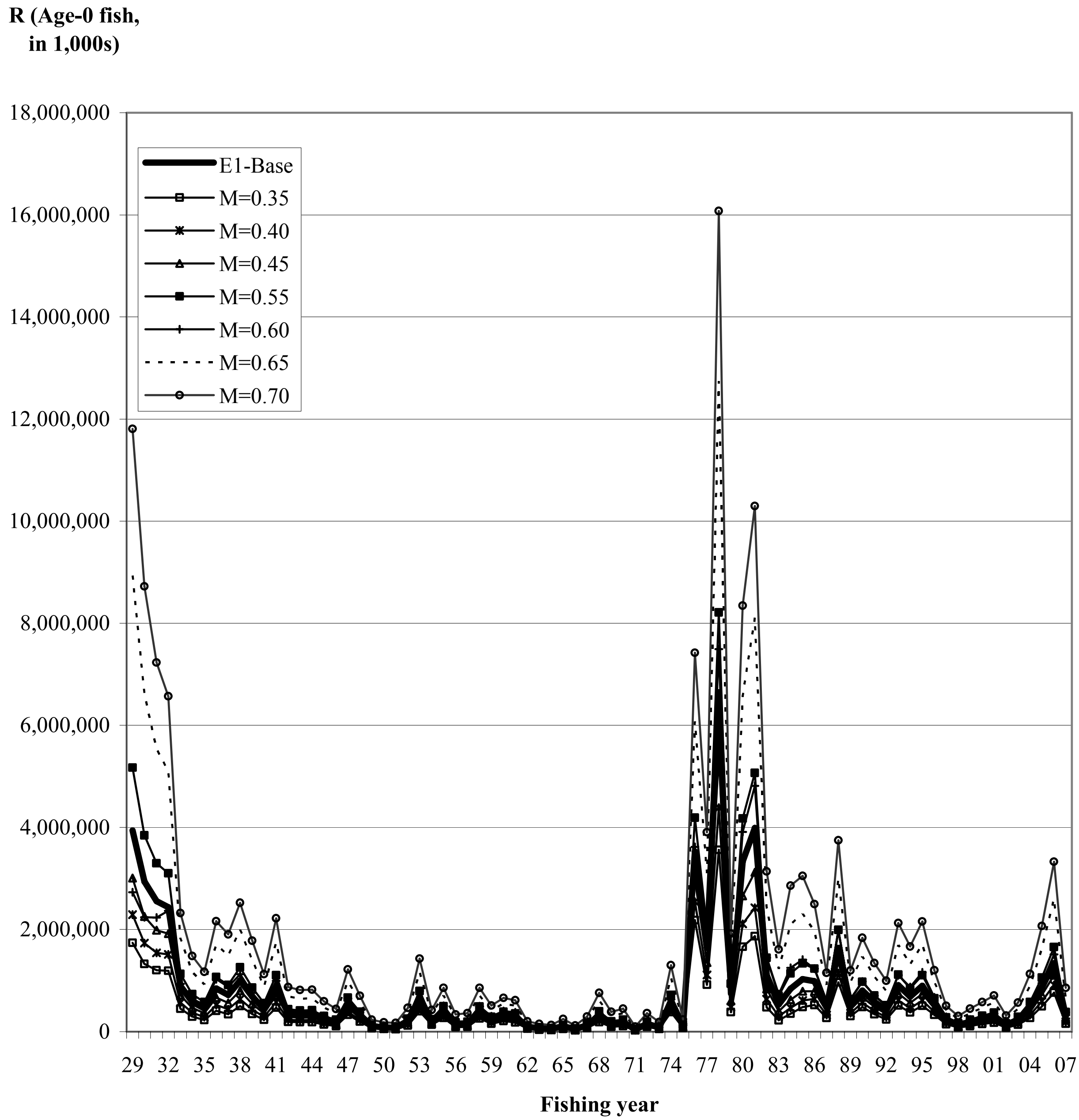

Figure 35. Recruitment (Age-0 abundance) from sensitivity analysis to natural mortality generated from the ASAP-E1 model.

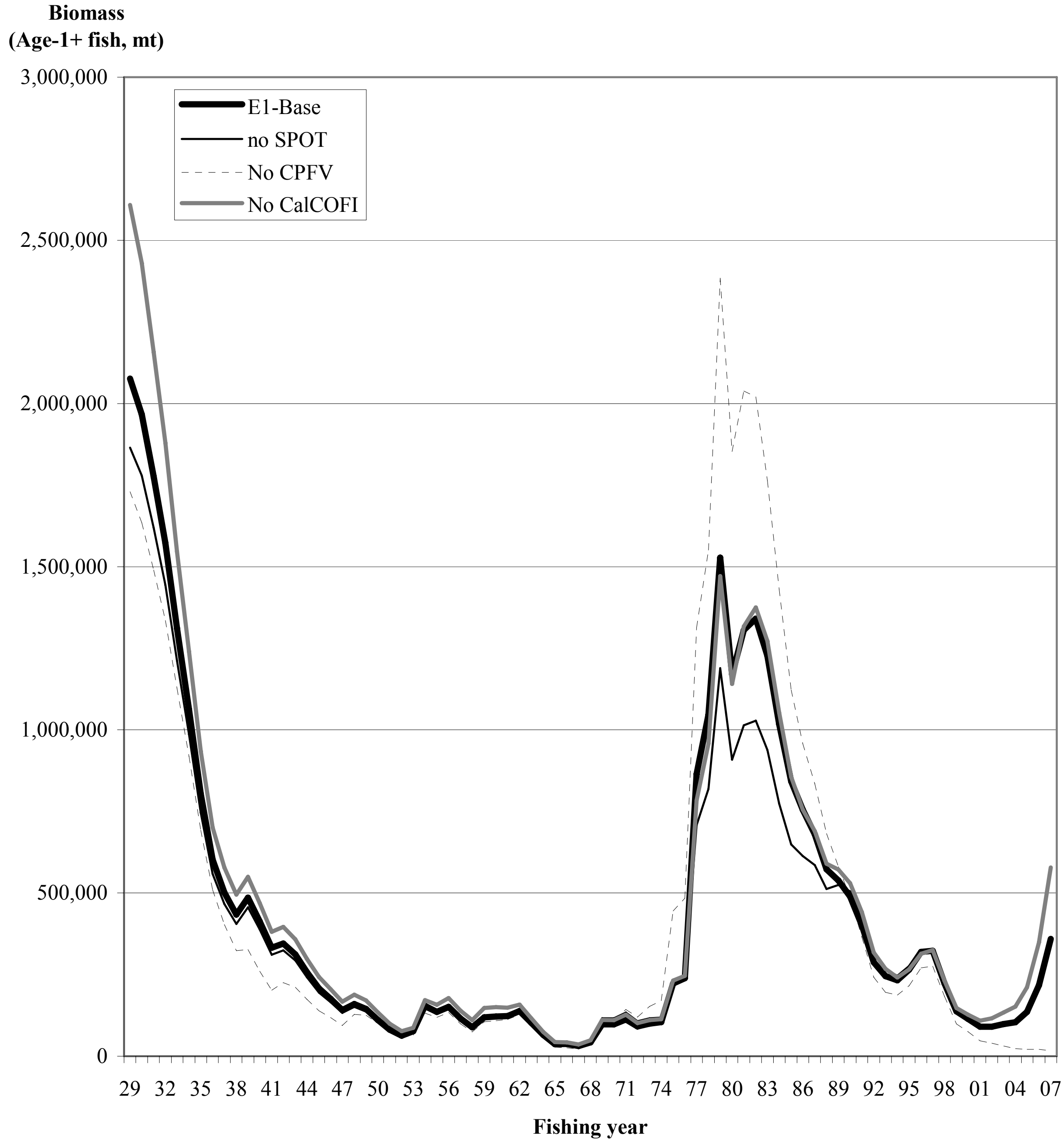

Figure 36. Biomass (Age-1+ fish) estimated from sensitivity analysis to relative abundance indices. Thin black line represents results without the spotter survey data, dashed line represents results without the CPFV survey data and gray line represents results without the CalCOFI survey data.

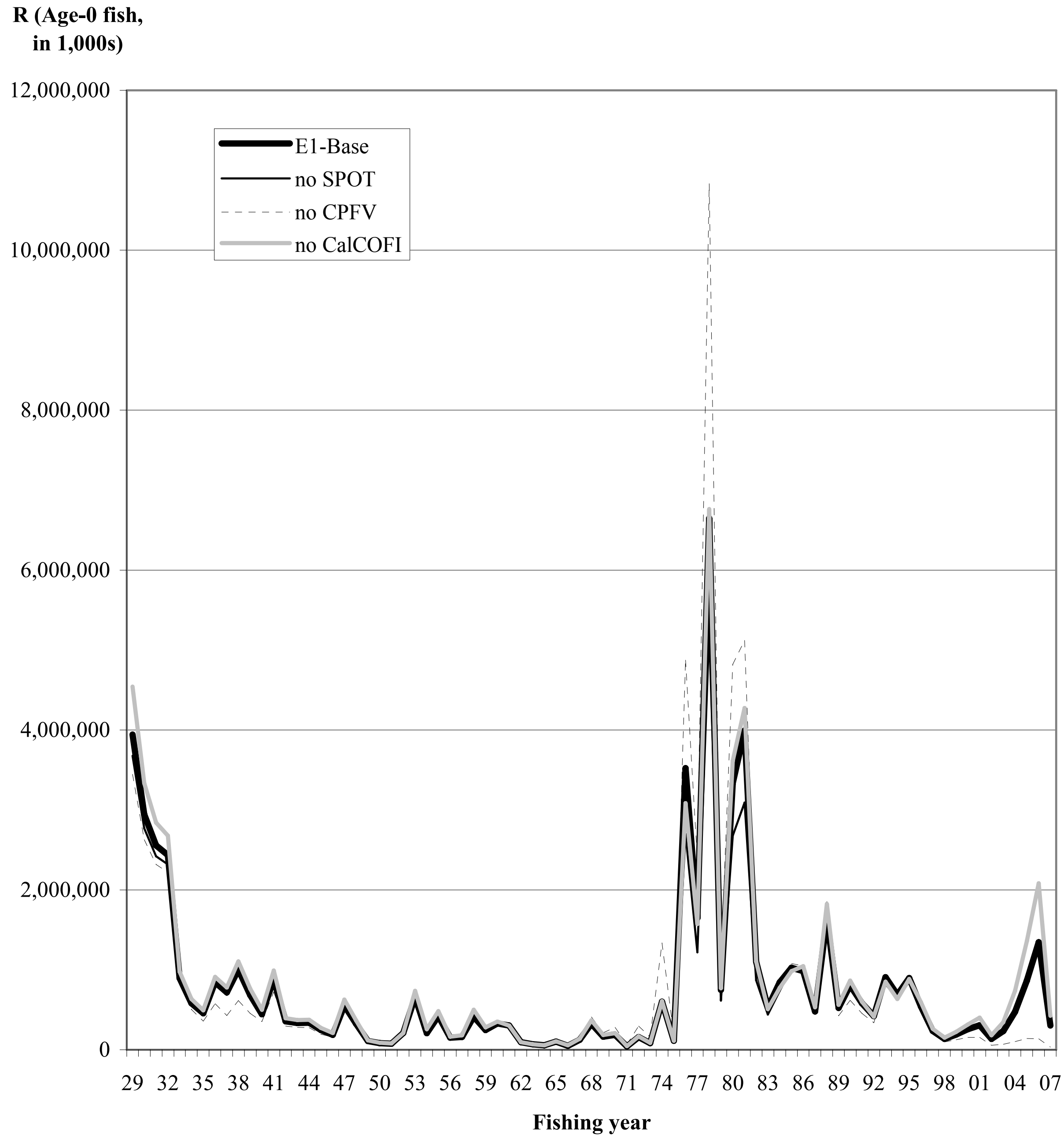

Figure 37. Recruitment (Age-0 fish) estimated from sensitivity analysis to relative abundance indices. Thin black line represents results without the spotter survey data, dashed line represents results without the CPFV survey data and gray line represents results without the CalCOFI survey data.

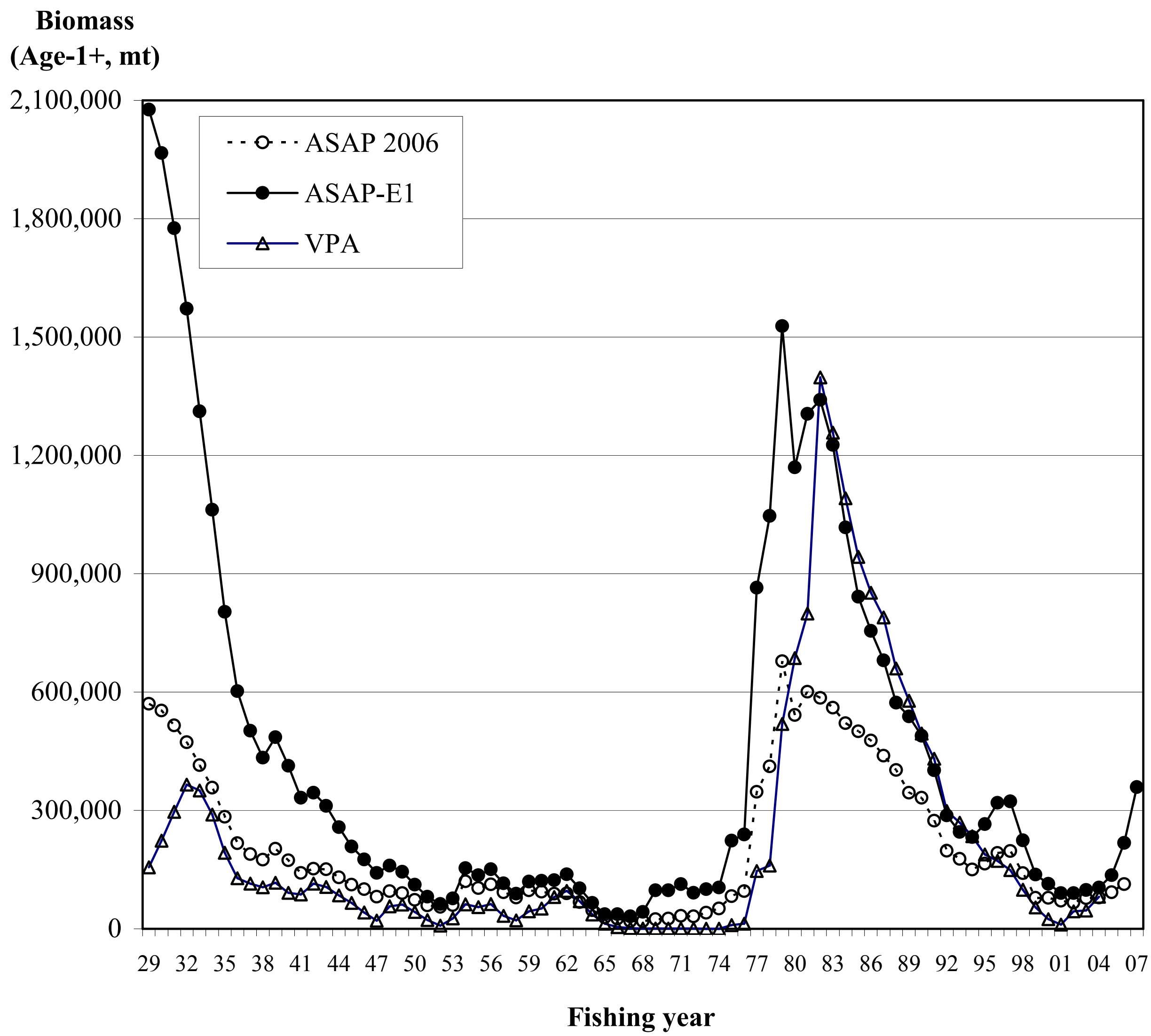

Figure 38. Estimated biomass (Age-1+ fish, in mt) of Pacific mackerel generated from the ASAP-E1, ASAP 2006, and VPA models (1929-07).

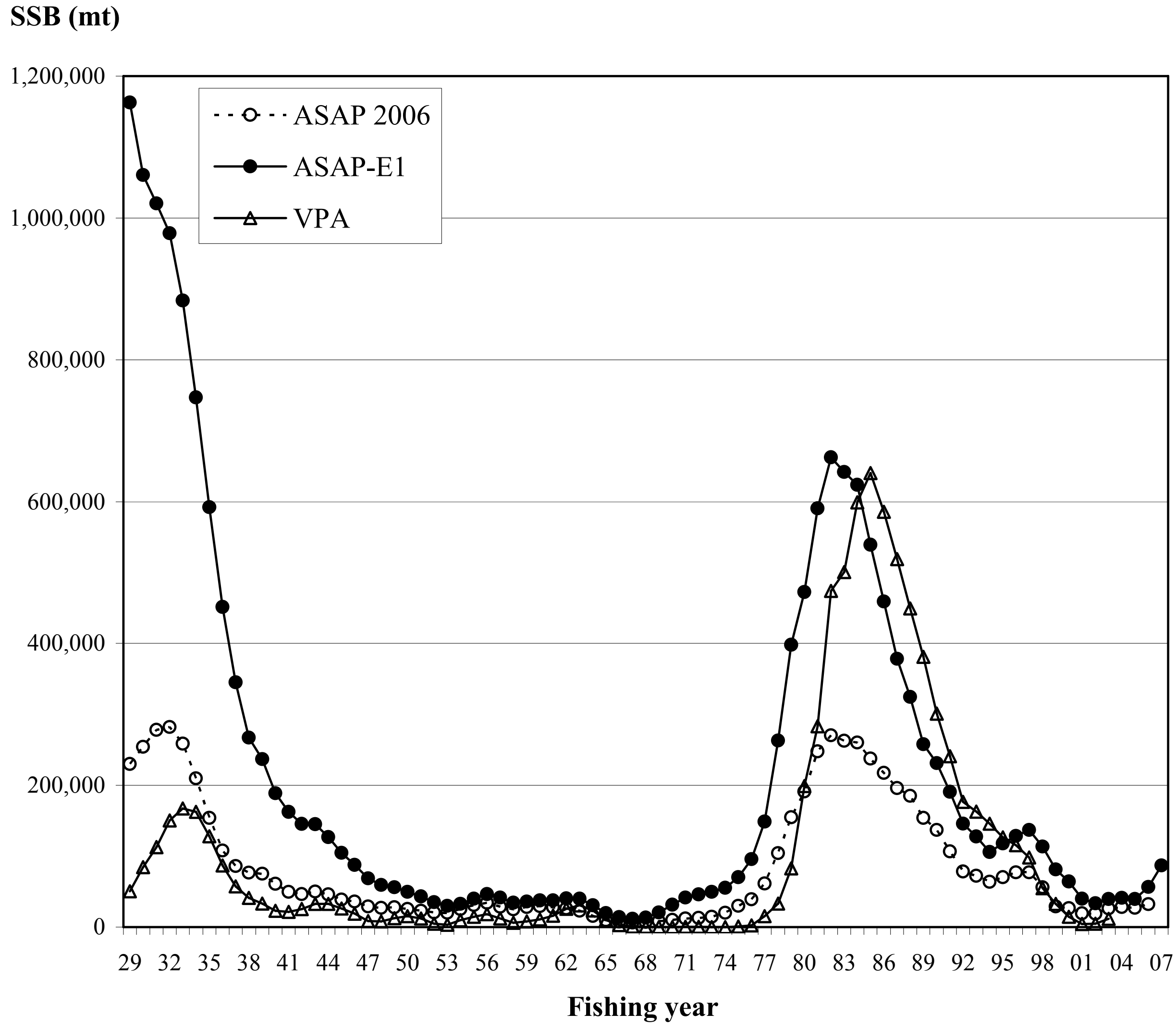

Figure 39. Estimated spawning stock biomass (SSB, in mt) of Pacific mackerel generated from the ASAP-E1, ASAP 2006, and VPA models (1929-07).

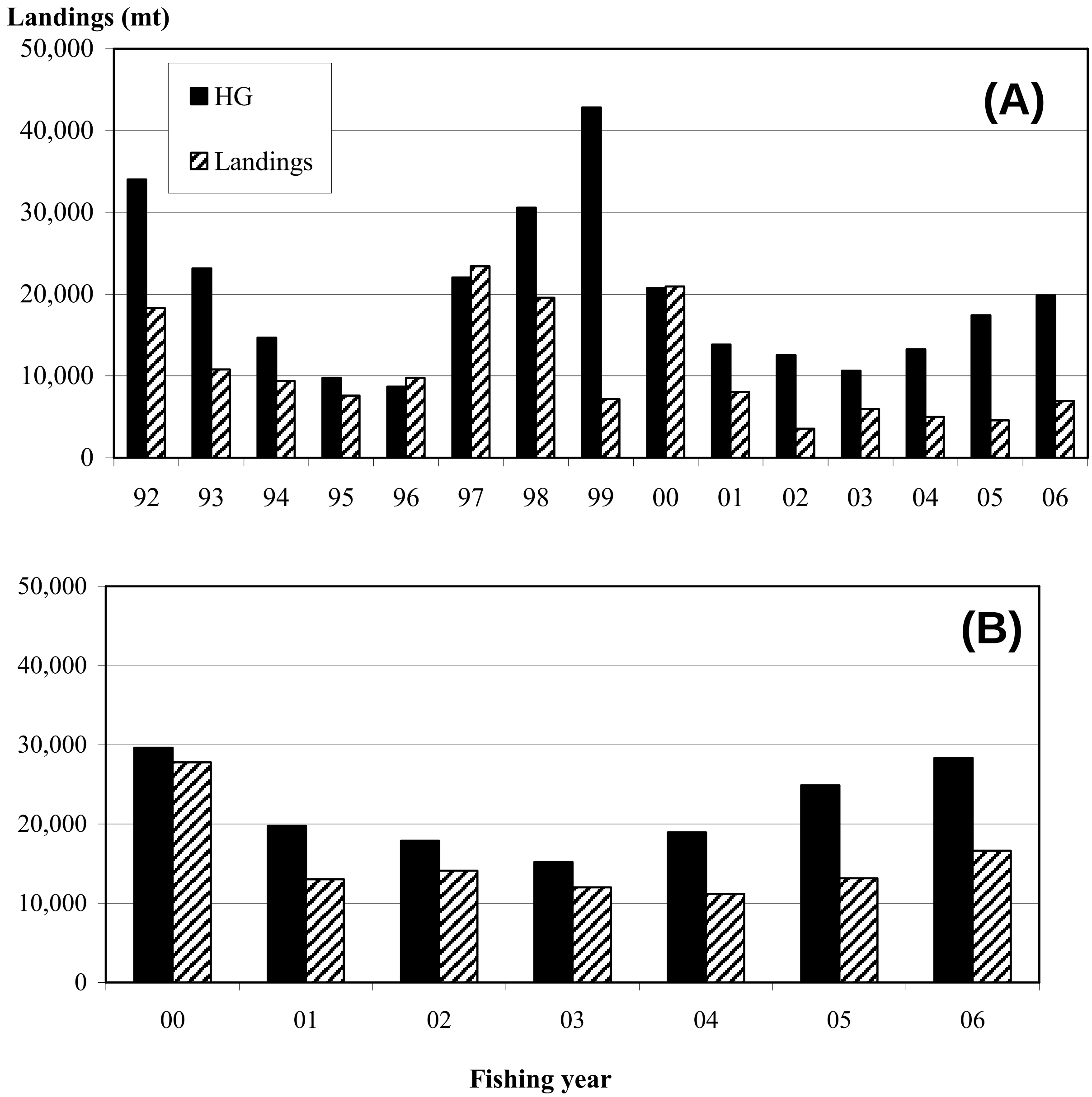

Figure 40. Commercial landings (California directed fishery in mt) and quotas (HGs in mt) for Pacific mackerel based on the harvest control rule, display (A, 1992-06 Fishing seasons). Total landings (mt) and hypothetical quotas for Pacific mackerel based on no 'U.S. Distribution' parameter in the harvest control rule (B, 2000-06 Fishing seasons). Note that incidental landings from Pacific Northwest fisheries are not included, but typically range 100 to 300 mt per year.

APPENDIX I

Spotter data analysis for the Pacific mackerel in 1963-2002 using Delta GLM

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Introduction

From 1963 to 2003 pilots, employed by the fishing fleet to locate schools of pelagic fish, reported data for each flight on standardized logbooks and provided them to NOAA Fisheries for a fee per flying hour ($1.00-5.00). These data were used to derive Spotter-based indices of abundance for pelagic fish, such as anchovy and young sardine. These indices were calculated as year effects estimated using delta log-normal linear models (LLM; Lo et al. 1992). However, after the year 2000, there was rapid decline in both the number of active pilots and total logbooks returned (Tables 1 and 2), as well as a southward shift in effort to offshore areas around Baja California. To remedy this problem, NOAA Fisheries started to contract professional spotter pilots to survey the Southern California Bight region beginning in 2004 primarily for assessment of young sardine. Newly available data from this enhanced survey were incorporated into the index, and a new time series was calculated using a delta Generalized Linear Model (GLM) for young sardine. This paper presents estimates of the spotter survey index from fishing year 1962 to 2001 for Pacific mackerel (*Scomber japonicus*) using GLM. Note a fishing year is from July of current year to June of the following year. Because of the lower number of flights with positive sightings of Pacific mackerel in the spotter survey, for comparison purposes, we also used a Generalized Additive Model (GAM) to obtain estimates of total tonnage as a relative index for the Pacific mackerel for the entire time series from fishing year 1962-2004.

The old time series had an informal design. Pilots flew the year around at night and in the day, and in areas and seasons frequented by the fishery. The pilots' searching behavior, like most fishermen, might be characterized as "adaptive", meaning that searches for target species may be concentrated in areas where schools were previously sighted. There is no doubt that a formal fishery independent survey design would provide more precise and less biased estimates than the present indices. However, by altering the design, one would lose the most valuable property of the old aerial surveys, i.e., a time series that extends back to 43 years. Regardless of its merit, a new index will have little value in stock assessment until it extends over at least 5-10 years. Clearly, the time series that ended in 2000 needs to be extended, but it would also be valuable to develop a new, more precise index with less potential bias.

The new aerial survey was based on a line transect design with regular occupation of fixed grid lines spaced at regular intervals with random starting points. Concurrently, a "simulated old survey" was implemented by employing a adaptive design to simulate fishing conditions, where having found a school the fishermen will search the vicinity to find others. After searching the pilot returned to the transect line and continued along the line. In this way we could gather information appropriate to both old and new survey designs. Factors such as month, area and day/light in the new surveys are close to those standardized conditions used in the spotter index model developed by Lo et al. (1992):

Experienced pilots under contracts flew along the predetermined track lines in March and April from San Diego to San Francisco, at a maximum of 100 nm offshore (Figure 1). However, in reality, pilots were unable to conduct all assigned surveys in March and April due to weather conditions and their flying schedules. In addition, they only flew in the daytime and not in the nighttime alone. As a result, flights in 2004 took place throughout the entire year, but during March and April in 2005. No surveys were conducted in 2006 due to unavailability of pilots during the pre-assigned survey months: March and April. This restriction will be relaxed to the first half of the year. In 2004, a total of 5 surveys by month (3,4,5,7, and 9) were accomplished from March-November, including two single-pilot flights in September and November. In 2005, we had two 3-pilot complete surveys, three 2-pilot surveys and one 1-pilot survey during March and April.

Statistical methods

Delta linear models

The relative abundance of pelagic species, like northern anchovy, or sardine can be expressed as the product of density and a measure of area:

$$\textbf{(1)}\ \boldsymbol{I = DA}$$

where $\boldsymbol{I}$ is the index of relative abundance for a given year (tons). D is density of fish (tons per block) and A is the area (blocks 10' by 10' defined by California Department of Fish and Game (Caruso et al 1979) covered by fish spotters. In the original data analysis of the relative abundance of anchovy, it was reasonable to assume that fish spotters flew over an area that was at least as large as the area occupied by the anchovy stock in each year. This is not so for the entire population of other species like Pacific sardine and Pacific mackerel. For the case of sardine, it suffices to apply to young sardines (<=2 year old). In the current analysis for sardine, units for the index *(I)* are tons of young sardine, sighted by fish spotters.

Density of fish *(D)* for each year can be expressed as the product of d and $\boldsymbol{P}$

$$\textbf{(2)}\ \boldsymbol{D = dP}$$

where d is a standardized measure of fish density (tons **per** block) for positive flights (flights during which fish of interest were seen) and P is a standardized measure of the proportion of blocks that were covered by positive flights (referred to as proportion positive) (Table 1). We used the product in order to avoid problems that arise from including a large number of zeros; therefore the distribution of D is Delta distribution.

Delta lognormal linear model(LLM)

In the original lognormal linear model, we assumed that the number of tons/block (y) or proportion positive (p) follows a lognormal distribution and varies with some covariates, i.e. log(y) or log(p+1) was a function of many covariates: year, region, season, pilot, night/day flights plus some interaction terms:

$$\log(y) \text{ or } \log(p+1) = x'B.$$

The final estimates of standardized d and P were obtained by taking anti-log of the linear equations (x'B) plus correction terms. Thus, the relative abundance for each year is

$$\hat{I} = \hat{d}\hat{P}A$$

Delta GLM model

To continue including spotter pilot data for the stock assessment, from the new datasets, we decided to switch from Delta lognormal linear model to a more flexible model, like Delta-GLM using S+, to allow us to incorporate other possible distribution of tonnages/block (y) of Pacific mackerel sighted by the pilots for the positive flights and the proportion of positive flights (p) with appropriate link functions for the expected values (d and P) respectively. As stated in Lo et al. (1992). Although we used lognormal linear models for components of the delta distribution, other linear or nonlinear models based on other statistical distributions could be used instead.

For the Delta-GLM, we chose family of Poisson and used log as the link function for the tons/block of positive flights (d), e.g. log (the expected tonnage/block) = x'B and family of Binomial and the link function of the logistic, for the proportion of positive flight (P), e.g. log(P/(1-P)) = x'B. All independent variables: year effect, day/night, season, region and survey type were treated as categorical data for the entire time series from 1962-2004(1963-2005 calendar year). For data analysis for fishing year years 1962-2002 when only data from the log books of commercial spotted pilots were used, survey index was excluded. The estimate of density of Pacific mackerel is $\hat{D} = \hat{d}\hat{P}$ with variance:

$$\mathrm{var}(\hat{D}) = \mathrm{var}(\hat{d}\hat{P}) = \hat{P}^2\,\mathrm{var}(\hat{d}) + \hat{d}^2\,\mathrm{var}(\hat{P}) - \mathrm{var}(\hat{d})\,\mathrm{var}(\hat{P})$$

where the estimated variance of estimates of d and P came directly from S+. No correction of d and P was included in the variance of D because the correlation from the data was not significant.

The final estimate of the relative abundance (I) and its CV are simply as follows.

$$\hat{I} = \hat{D}A$$

$$CV(\hat{I}) = CV(\hat{D}).$$

where A is total number of blocks within the traditional area covered by spotter pilots each year.

Two sets of time series were obtained: one for fishing years 1962-2001 and the other one from fishing years 1962-2004

Delta GAM model

For comparison purposes, as done for the delta GLM, we chose a family of Poisson distribution and used log as the link function for the number of tons/block of positive flights (d), e.g., log (of the expected tonnage/block) = x'B; whereas a family of Binomial distribution and the logistic link function, for the proportion of positive flight (P), e.g. log(P/(1-P)) = x'B. In the GAM model, the year effect was modeled by a smoothing spline fit with d.f.=12 while other independent variables: day/night, season, region and survey type were treated as categorical data.

The estimate of density of Pacific mackerel is $\hat{D} = \hat{d}\hat{P}$ with variance (Goodman 1960) stated above as for GLM. Two time series of relative abundance from GAM were computed: one for the shorter period from 1962-2001 and the other for the entire time series from 1962-2004

Results

The time series of the density (d=tonnage/block), the proportion of positives (p), the survey area (A=blocks) and the total tonnage (D) of Pacific mackerel were presented (Table 1 and Figure 2). The estimates of density (d) and proportion of positives (p) for fishing year 1962-2001 were adjusted for night time, season 2 (April-June), region 2, and pilot number 17. For the entire time series, the estimates were also adjusted for survey 1 (traditional aerial survey prior to calendar year 2004) The adjusted relative tonnages serve as the relative abundance of Pacific mackerel from spotter data set were presented using the delta-GLM (Table 1, Figure 2). For the entire period from 1962-2004, both time series of Delta-GLM and GAM were constructed for comparison purposes (Figure 3). We also presented the time series of total number of flights with sightings of Pacific mackerel and number of blocks with Pacific mackerel (Figures 4 and 5).

Discussion

The relative abundance of Pacific mackerel peaked at the mid-1980 and has been decreased since 1985 (Figure 2 and 3). Although the flight numbers were lower after 2002, the relative abundance from GLM for 1962-2004 was much smoother than that of the shorter period, in particular for the period of 1980-90 (Figure 2 and 3). The time series from GAM is much smoother than that from GLM as expected. The total number of flights decreased continuous since late 1990's (Figure 4 and 5). However total number of blocks covered has been similar except 2003 (Figure 5). So, the decrease of the relative abundance of Pacific mackerel could reflect the decline of the population rather than the coverage of the aerial survey in terms of time and space.

Because the effort has been reduced dramatically since 2001 off California, we compared the overall time (season) and space (region) between these two periods by the total number of flights (Table 2). The overall distributions between these two periods are similar. Most of the efforts were in regions 1-3 for all seasons and much of the efforts were shifted to regions 4-6 in the second half of the year (Figure 1). Thus the reduced effort does not appear to introduce much bias in terms of time and space.

The LLM was used in the past prior to 2000 (Figure 6). We compared the time series of the CVs of relative abundance for Pacific mackerel based on the LLM and GAM. The patterns of CVs estimated from the two time series have a similar shape except that the time series from LLM fluctuated more than that from Delta GAM. The CVs from LLM (Bradu and Munklak 1970) were higher than those from GAM (Figure 6) partially because the variances of the estimates from LLM included those of bias-correlation terms for the parameter estimates of lognormal distribution, which may not be so for the variance of estimates used in GAM (Lo et al. 1992, Chambers and Hastie 1992). The variance of estimates from GLM may be also underestimated as those of GAM.

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Table 1: Summary of tonnage/block for positive flights (T/B+;d), and proportion of blocks covered by positive flights(%BLK;p), relative abundance(REL_ABN;I) and associated standard errors(SE) and coefficient of variation(CV), fishing years1962-2001

F. YEAR	T/B+,d	SE_T/B+	%BLK,p	SE_%BLK	T/B	SE_T/B	BLOCKS	REL_ABN	SE_RA	CV_RA
1962	8.46	0.40	0.36	0.19	3.06	1.58	151	461.35	238.89	0.52
1963	15.91	0.40	0.52	0.17	8.29	2.65	186	1541.53	493.15	0.32
1964	9.11	0.42	0.30	0.14	2.77	1.27	198	549.34	251.73	0.46
1965	11.77	0.83	0.29	0.15	3.44	1.75	206	707.89	359.87	0.51
1966	7.08	0.69	0.17	0.12	1.24	0.83	220	272.08	182.19	0.67
1967	0.95	0.44	0.10	0.10	0.09	0.09	210	19.88	19.45	0.98
1968	17.50	4.08	0.05	0.07	0.83	1.18	215	178.55	253.51	1.42
1969	96.31	6.31	0.04	0.05	3.61	5.00	217	782.89	1084.40	1.39
1970	6.13	1.65	0.02	0.06	0.15	0.36	148	22.03	53.73	2.44
1971	4.37	0.51	0.10	0.09	0.44	0.39	176	76.70	68.28	0.89
1972	2.02	1.05	0.01	0.03	0.03	0.05	217	5.46	11.19	2.05
1973	16.10	2.17	0.01	0.02	0.13	0.37	226	28.95	83.17	2.87
1975	2.70	1.23	0.01	0.03	0.02	0.06	214	4.31	12.98	3.01
1976	270.43	3.59	0.24	0.13	64.02	35.19	242	15492.54	8516.02	0.55
1977	297.08	3.30	0.51	0.14	151.03	42.51	206	31112.79	8757.76	0.28
1978	301.07	3.17	0.58	0.13	176.07	38.56	229	40320.84	8830.43	0.22
1979	298.39	3.37	0.70	0.13	207.39	37.38	214	44380.55	8000.07	0.18
1980	156.74	1.51	0.71	0.11	111.38	17.09	199	22164.44	3400.97	0.15
1981	175.64	1.88	0.70	0.10	123.00	17.03	210	25829.50	3576.51	0.14
1982	194.90	2.00	0.74	0.10	144.37	18.70	251	36237.16	4693.99	0.13
1983	232.71	2.53	0.48	0.13	112.64	30.48	271	30524.24	8260.05	0.27
1984	227.55	2.06	0.66	0.10	149.62	23.31	305	45635.38	7108.24	0.16
1985	230.52	2.12	0.54	0.11	123.63	25.60	315	38944.25	8062.92	0.21

1986	116.19	1.12	0.61	0.10	70.82	12.01	268	18979.22	3218.51	0.17
1987	83.35	1.81	0.49	0.12	40.97	10.42	295	12087.23	3074.82	0.25
1988	121.13	1.72	0.46	0.14	55.58	16.91	300	16673.37	5072.79	0.30
1989	36.22	0.74	0.30	0.10	10.72	3.65	252	2700.95	919.88	0.34
1990	50.12	0.80	0.39	0.10	19.73	5.19	276	5445.68	1432.73	0.26
1991	25.56	0.52	0.37	0.10	9.56	2.58	250	2391.01	644.33	0.27
1992	26.35	0.95	0.16	0.08	4.12	1.98	293	1207.58	580.14	0.48
1993	21.50	0.56	0.25	0.09	5.38	1.85	328	1764.32	608.26	0.34
1994	61.99	1.84	0.12	0.07	7.41	4.16	283	2097.70	1175.93	0.56
1995	93.01	1.91	0.28	0.10	25.68	9.54	246	6317.02	2346.62	0.37
1996	45.29	1.37	0.17	0.09	7.48	4.09	255	1907.85	1041.72	0.55
1997	40.64	0.98	0.32	0.11	12.95	4.57	390	5050.92	1781.99	0.35
1998	34.66	0.94	0.20	0.08	6.94	2.89	324	2248.20	937.73	0.42
1999	20.08	0.93	0.18	0.08	3.58	1.64	332	1187.88	545.21	0.46
2000	26.54	1.03	0.43	0.18	11.42	4.80	283	3230.88	1357.19	0.42
2001	21.30	1.72	0.08	0.11	1.79	2.40	306	548.80	734.92	1.34

Table 2. Total number of flights by region (figure 1) and season prior to 2000 and after 2000.

Prior to 2000: 1963-1999

Season	**Region**					
	1	**2**	**3**	**4**	**5**	**6**
1	133	1,947	1,499	-	2	-
2	191	2,612	1,184	36	134	-
3	329	4,761	1,938	263	1,522	76
4	207	2,315	2,373	32	26	-

2000-2005

Season	**Region**					
	1	**2**	**3**	**4**	**5**	**6**
1	19	29	11	-	-	-
2	41	97	14	-	12	17
3	12	295	4	11	198	33
4	13	16	3	-	-	-

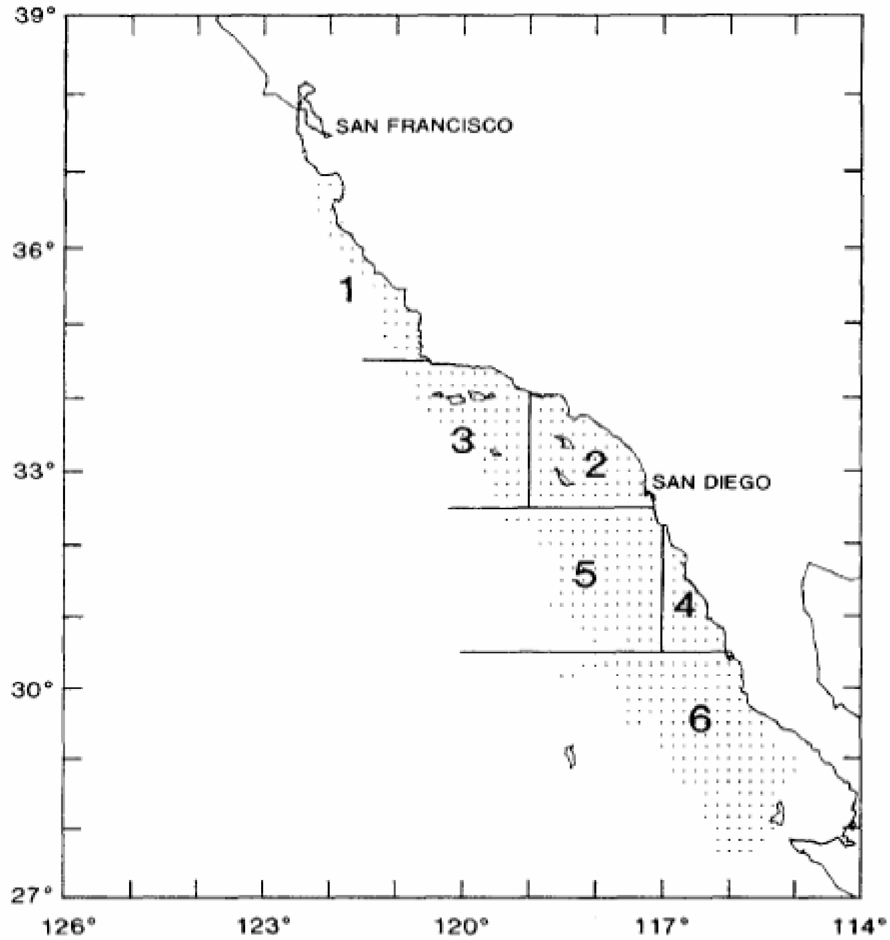

FIG. 2. Study area, regions, and blocks covered by fish spotters in 1989. Regions are outlined and denoted by numbers. Blocks are denoted by dots.

Figure 1 Study area, regions, and blocks covered by fish spotter in 1989. Regions are outlined and denoted by numbers. Blocks are denoted by dots (reproduced from Lo et al. 1992)

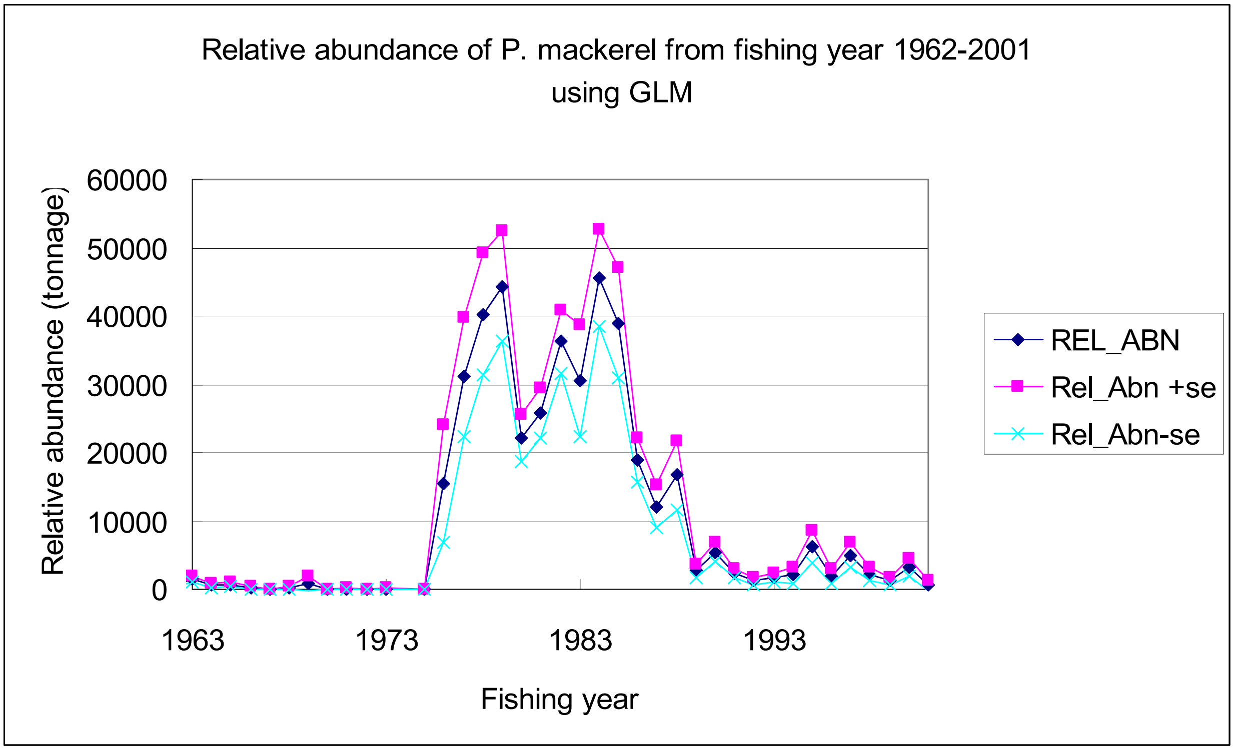

Figure 2: Time series of relative abundance (total tonnage) of Pacific mackerel from 1962-2001.

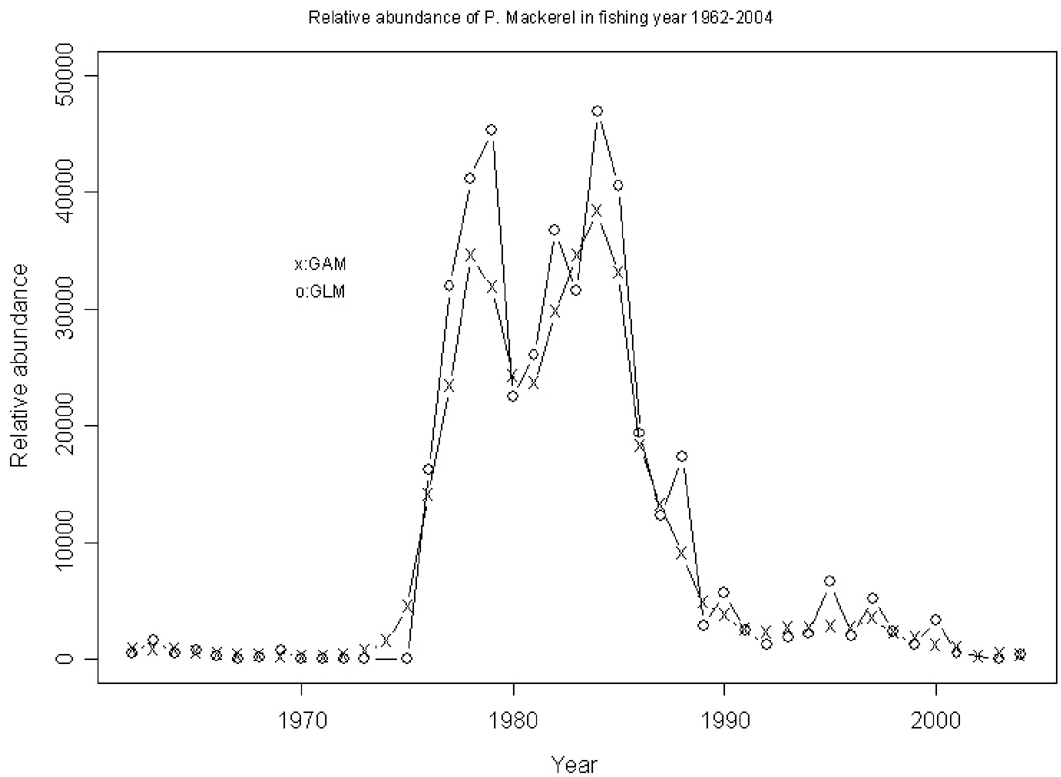

Figure 3: Time series of relative abundance (total tonnage) of Pacific mackerel using GLM (circle) and using GAM(cross) for fishing years 1962-2004

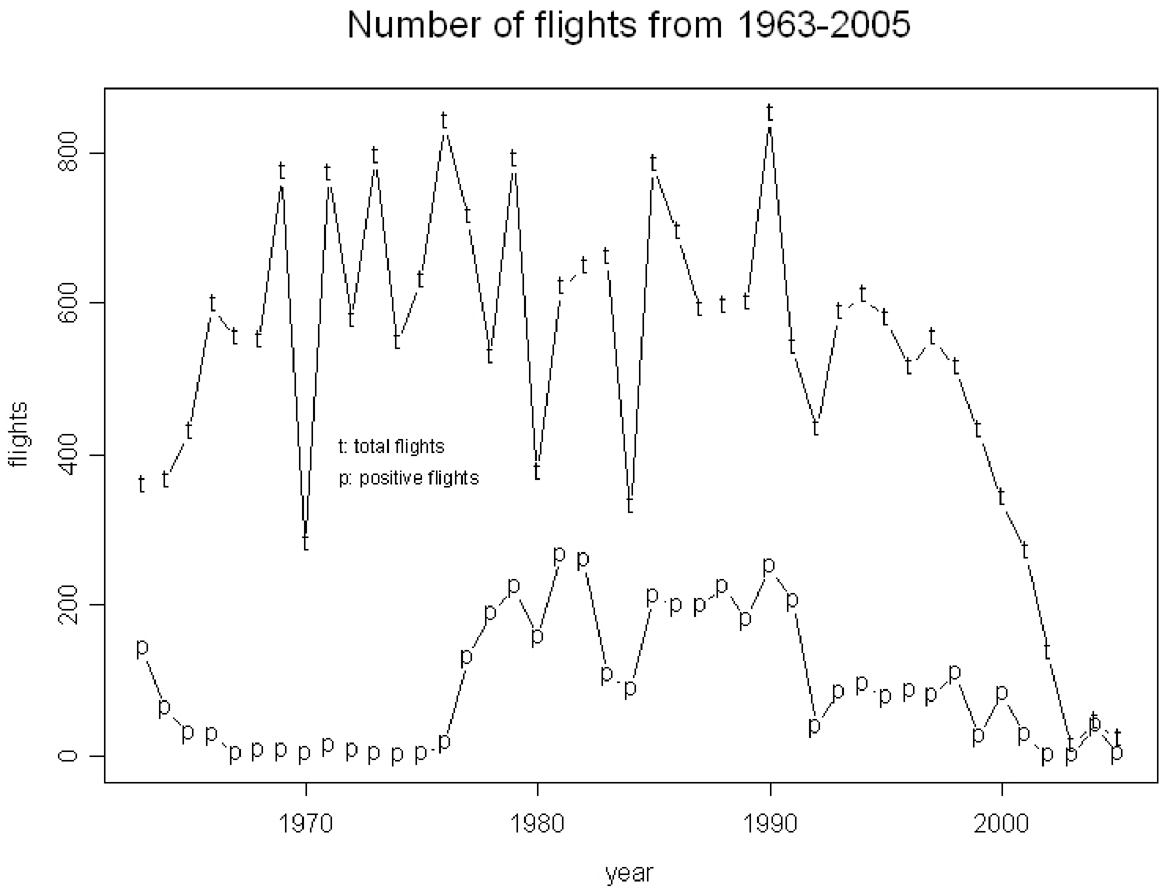

Figure 4. Total flights and number of flights with positive sightings of Pacific mackerel, 1963-2005.

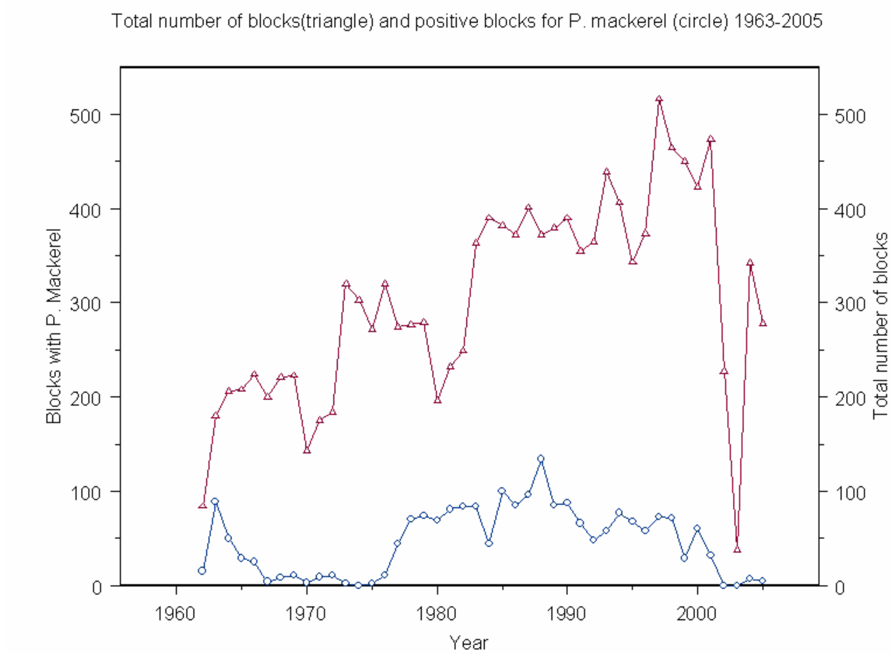

Figure 5. Total number of blocks covered (triangle)and blocks covered by flights with positive sighting (circle) of Pacific mackerel, 1963-2005

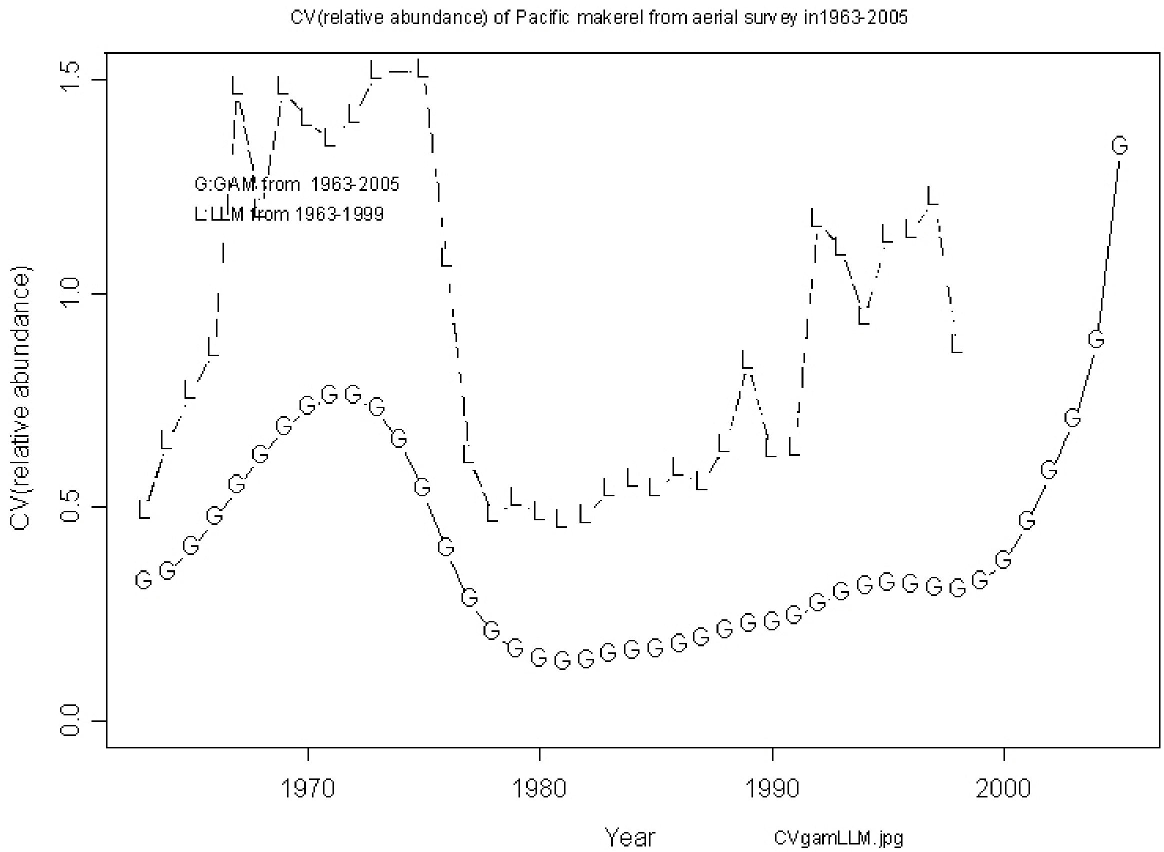

Figure 6: Time series of CV(relative abundance)(total tonnage) of Pacific mackerel from 1963-2005 using GAM and that using LLM from 1963-1999..

APPENDIX II

DAILY LARVAL PRODUCTION OF PACIFIC MACKEREL (*SCOMBER JAPONICUS*) OFF CALIFORNIA IN 1951-2006

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ABSTRACT

Daily larval production at hatching /10m^2 of Pacific mackerel (*Scomber japonicus*) from 1951-2006 was estimated based on data collected from California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys off the coast from San Diego to Avila Beach, north of Point Conception, California in April-July, the peak spawning time of Pacific mackerel off California. This area has been covered by all CalCOFI surveys. The time series showed the peak daily larval production was in 1987 with 46.39/10m^2/d, with minor peaks in 1981 and 1986. The density of daily larval production has been decreasing since 1997. The larval production was particularly low in 2003- 2006. This cost-effective fishery-independent time series should be beneficial to the assessment and better understanding of the dynamics of the Pacific mackerel population.

INTRODUCTION

The time series of Pacific mackerel larval abundance and distribution by month from 1951-56 was reported by Kremer (1960) and from 1951-84 by Moser et al (1993) for historical survey area from San Francisco to Baja California. Since 1985, the CalCOFI survey area has been reduced to primarily cover the area in the Southern California Bight (CalCOFI line 93 – line 77, Fig.1, 2, and 3).

The purpose of constructing the time series of daily larval production was to use this time series as an index for the spawning biomass in the stock assessment. Ideally, methods such as the daily egg production method (DEPM) for pelagic fishes (Lo et al. 1996) should be used to estimate spawning biomass of Pacific mackerel. This kind of method requires data on fish egg stages, duration and abundance plus the reproductive output of adult fishes (MacGregor 1966). Due to the high patchiness of Pacific mackerel eggs and larvae, and the fact that the eggs were consistently identified only in the last 10 years, it is not possible to carry out a DEPM analysis over the whole 1951-2006 time period at this moment. Fortunately, mackerel larval data from CalCOFI surveys are readily available from 1951 and comprehensive correction algorithms can be applied to reduce the possible biases of measurement, such as extrusion through the net mesh, avoidance from the net, etc. It seems reasonable to consider the larval production of Pacific mackerel as a possible index of spawning biomass (Ahlstrom 1959) as has been done for many other fish populations (Smith 1972, Lo 1986, Lo et al. 1989). In this paper, we analyzed Pacific mackerel larval data from 1951-2006 for the current CalCOFI survey area in April-July

(Fig.1). Although this area is smaller than that of the historical CalCOFI survey (Fig. 2), it encompasses the primary spawning area of Pacific mackerel off California (Moser et al. 1993).

MATERIALS AND METHODS

The CalCOFI survey was conducted annually from 1949-1966, after which it was conducted every three years through 1984, covering the area from Baja California to the north of San Francisco (Fig. 2). Starting in 1985, the survey was conducted annually but covered only the southern area from San Diego to Avila Beach, just north of Point Conception. As Pacific mackerel larvae are most concentrated in mid-Baja California in the summer and second off Southern California in Spring, for consistency of available datasets, only Pacific mackerel larval data from the CalCOFI database from April-July were used in this study (Ahlstrom 1959, Moser et al. 2001). Larvae were collected by oblique tows with a 1-m ring net to 150 m from 1951-68, and the depth was increased to 210 m in 1969. Bongo net replaced 1-m ring net in 1978. A standard haul factor used to compute number of larvae / 10m^2 was intended to account for variability in the volume of water filtered per unit of depth (Smith and Richardson 1975).

Sampler biases caused by net selectivity for small larvae and gear avoidance for larger larvae were adjusted following the method of Lo (1985). Retention rates for extrusion can be expressed as function of larval length and mesh size (Lenarz 1972; Zweifel and Smith 1981; Lo 1983) and those for avoidance can be expressed as a function of larval length and the diurnal time of capture (Hewitt and Methot 1982). All larval abundance data were adjusted to conform to the following standard condition: no extrusion, no day-night difference in avoidance, and a constant water volume filtered per unit depth. The data were then converted to daily production/10m^2 (P_t) by dividing the corrected total number of larvae in each length group by the duration (the number of days larvae remain within each length group). A set of laboratory data on larval growth conducted by Hunter and Kimbrell (1980) was used to model temperature dependent larval growth curves which were used to convert length to age from hatching.

CORRECTION FACTORS

Extrusion

There are no existing data on the length-specific extrusion rate for Pacific mackerel. Therefore, the retention coefficient of jack mackerel larvae due to extrusion was used as a proxy for mackerel. Jack mackerel larvae and Pacific mackerel larvae are approximately the same length at hatching and are morphologically similar: jack mackerel hatch at about 2-2.5mm and Pacific mackerel at about 2-3mm; morphology of both is similar in yolk sac stage. On average, Pacific mackerel tend to be just slightly longer and more robust than jack mackerel (Watson pers. Comm.). Hewitt et al. (1985) reported that only the smallest class of jack mackerel larvae (3.0 mm) are extruded to a significant degree through the 0.505 mm CalCOFI nets, with 28% of the catch in that size class retained in the net. The extrusion correction factor is equal to 1/.28 or 3.571. Although 0.55mm mesh net was used prior to 1968, the difference in extrusion of mackerel larvae is likely to be insignificant as was the case for anchovy larvae (Lo 1983).

Avoidance /evasion

The correction factor for avoidance/evasion was estimated using the algorithm developed for anchovy and Pacific hake (Lo et al. 1989, Lo in preparation). Because larvae are able to avoid or evade the net to the same degree under sufficient light, and larger larvae are better able to avoid the sampler, we used the model by Lo et al. (1989) for the retention (or capture) coefficient of mackerel larvae for a specific larval length (L) and hour of the day (h): $R_{L,h}$:

$$R_{L,h} = \left(\frac{1+D_L}{2}\right) + \left(\frac{1-D_L}{2}\right) * \cos\left(\frac{2\pi * h}{24}\right) \qquad (1)$$

where D_L is the noon/night catch ratio for length L. Data from 1951 to 1978 in the historical large area were used to model the catch ratio:

$$D_L = \frac{\bar{y}_{L,noon}}{\bar{y}_{L,night}}$$

The numerator is the mean catch at noon (11:00 AM – 1:00 PM) of larvae size L. The denominator is the mean catch in the night (9:00 PM - 3:00 AM) of larval length L. We then used an exponential curve to model the relationship between D_L and larval length, L.

Shrinkage

The shrinkage factor was based on the work on Pacific hake (Bailey 1982) which reported on the percentage of shrinkage in the standard length of first-feeding larvae due to preservatives and time of handling for Pacific hake. Shrinkage was 8.9% for formalin-preserved larvae (L). Because in regular CalCOFI surveys, formalin is the standard preservative used, a correction factor is needed to convert formalin-preserved length (L) to life length (L_L) in order to apply the larval Pacific mackerel growth curves derived from laboratory data by Hunter and Kimbrell(1980). The multiplier applied to larvae from 2.5 -11.5mm from CalCOFI surveys is 1/(1-0.089)=1.098 to convert formalin preserved-length to live length, i.e. $L_L = L * 1.098$.

GROWTH OF MACKEREL LARVAE

Growth curves

Hunter and Kimbrell (1980) reported growth data for seven groups of Pacific mackerel reared at different temperatures from 16.8 – 22.1°C. A temperature-dependent logistic growth curve was derived where the coefficient of the age was a polynomial function of temperature (Bartsch 2005):

$$L_L = \frac{28.2616}{1+\exp(-\beta_{temp} t + 2.3476)} \qquad \text{For } t<25 \text{ d} \qquad (2)$$

$$\text{where } \beta_{temp} = 0.2828 - 0.0229 temp + 0.0007 temp^2$$

where t (days) is age (d) from hatch and L_L is the life length and *temp* is temperature in ^{o}C.

To convert length to age from hatching, we inverted the equation (2) and obtained:

$$t = \frac{2.3476 - \ln(28.2616/(L*1.098) - 1)}{\beta_{temp}} \quad \text{for } 2.23\text{mm} <= L < 20\text{mm} \qquad (3)$$

where t is age after hatching and L is formalin-preserved length. Note the logistic growth curve gave minimum live length being 2.45mm for newly hatched larvae at t=0.

The larvae collected in each tow were grouped as 2.5mm (2.0mm - 3.0mm), 3.75(3.5 and 4.0mm), 4.75 (4.5 and 5.0mm),. To obtain the final age of a larva, the actual length of a larva in each length group from each tow was generated by a random selection from a uniform distribution within each length category. For the larvae in the length category of 2.5mm, age 0 was assigned for formalin-preserved length <2.45mm

Size class duration and daily larval production

The duration was estimated by the difference of the mid-ages where the mid-ages are the ages corresponding to the mid-lengths: the midpoint between two size groups. The daily larval production in each age group was the larval density in each age group divided by its duration, the time the larvae stayed in each size group.

DAILY LARVAL PRODUCTION AT HATCHING (P_h)

The daily larval production at hatching (P_h) was estimated for each year from a larval mortality curve in the form of exponential function, unlike that of northern anchovy (Lo 1985, 1986) and Pacific hake (Hollowed 1992) whose daily mortality rates decreased with age as the larvae matured. Larvae with length >11.75mm length group were excluded because few larvae of those sizes observed due to their evasion from the net is uncertain. A weighted nonlinear regression was used to obtain estimates of the coefficients for years with sufficient catch-length data:

$$P_t = P_h \exp(\alpha t) \text{……..(4)}$$

where P_t is the daily mackerel larval production at age t days from hatching, and αis the daily instantaneous mortality rate.

For most years, we fitted equation (4) to the data using a weighted nonlinear regression to estimate the P_h and α, where the weight was 1/standard deviation for each 4-day interval: 0-4, 5-8,…,17-20 d. As larvae older than 20 days occurred in few tows each year, the mortality curve was constructed based on larvae of age <=20 days at most, to avoid bias.

However due to the patchiness of larvae and their ability to avoid the net, the unweighted nonlinear regression was used for some years because the large variances in the young age categories downweighted the corresponding larval productions too much to produce reasonable estimates of P_h and mortality rate. There were also some years where only one or two length groups had positive catches, mostly small larvae say larvae <4mm, P_h was estimated by inverting the mortality curve (equation 4)

$$\hat{P}_h = \overline{P}_L \exp(-\hat{\alpha} t_L) \qquad (5)$$

and the variance of $\hat{P}_h$ was estimated by

$$\operatorname{var}(\hat{P}_h) =$$
$$\operatorname{var}(\overline{P}_L)(\exp(-\hat{\alpha} t_L))^2 + (\overline{P}_L \exp(-\hat{\alpha} t_L)(-t_L))^2 \operatorname{var}(\hat{\alpha}) - \operatorname{var}(\overline{P}_L)(\exp(-\hat{\alpha} t_L)(-t_L))^2 \operatorname{var}(\hat{\alpha})$$

where $\overline{P}_L$ is the mean daily larval production at length L=2.5mm and t_L is the associated age of 2.5mm and the over all mean mortality rate was used for $\hat{\alpha}$. (Goodman 1960)

RESULTS

Avoidance

The relationship between the mean noon/night catch ratio (D_L) and larval length (L) based on data of 1951-1978 is

$$D_L = 2.7 \exp(-0.39L) \qquad (6)$$

where the standard errors of the two coefficients are 0.47 and 0.05 respectively (Fig.4). The estimated capture rates of larvae by length and time of day (equation 1) are shown in Fig. 5.

Mortality curves and the daily larval production at hatching (P_h)

Mortality curves were constructed for years when the data are sufficient (Table 1). The mortality curve and larval production at age for 1981 are given for illustration (Fig. 6). For those years, the estimates of the daily larval production/10m^2 were the intercepts of the mortality curves (equation 4) (Table 1). An unweighed nonlinear regression was used for years 1985,1986,1988 and 1992. For other years when the data were not sufficient, an overall mortality rate was used in equation(5) for1953, 1962, 1969, 1972, 1993, 1994, 2003 and 2006.

The time series of daily larval production (P_h/10m^2) from 1951-2006 off the California coast from San Diego to north of Point Conception fluctuated with the highest peak of 46.38 larvae/day/10m^2 in 1987 and minor peaks at 1981 and 1986 (Table 1 and Fig. 7). The larval production has been declining with moderate fluctuations since 1997 in this survey area.

For comparative purposes, we computed the mean counts of larvae per $10m^2$ with correction for biases. The time series of P_h and mean counts of larvae had similar trend but the time series of simple means was more variable than that of P_h (Fig. 7 and 8). Nevertheless, the fluctuations in the time series of Pacific mackerel larvae are partially due to the fact that Pacific mackerel larvae are one of the most patchy pelagic species in the CalCOFI time series and patches can be very large and dense.

Analyses in this study were based on larval abundance corrected for all possible biases. The extrusion factor was based on Jack mackerel larval data, therefore future surveys on Pacific mackerel larvae are recommended to obtain direct measurements and to verify if the extrusion factor based on Jack mackerel larvae is reasonable to use for Pacific mackerel larvae. The avoidance correction factor was based on 1951-1978 data because including other year's data did not contribute to the modeling of the day/night ratio with the length.

The long time series of daily Pacific mackerel larval production, a cost-effective fishery-independent population index obtained yearly, is beneficial to the assessment of the Pacific mackerel population and better understanding of the dynamics of the Pacific mackerel population (Deriso and Quinn, NRC 1998).

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Table 1. Mackerel larval production at hatching (P_h), the mortality coefficient (β) and their standard errors (SE), total number of tows (n) , positive tows (n_p) larvae/10m^2(density),mean temperatures(temp) and weighted temperature(wt-temp).

year	**P_h**	**se(Ph)**	**β**	**se(β)**	**n**	**n_p**	**density <=11.75mm**	**se(density)**	**Temp**	**wt-tmep**	**Index**
1951	0.015	0.019	-0.051	0.148	128	6	0.152	0.102	14.99	16.04	1
1952	0.023	0.023	-0.013	0.123	200	7	0.256	0.115	14.51	15.76	1
1953	0.187	0.096	**-0.327**	**0.023**	244	2	0.423	0.407	13.82	15.52	4
1954	1.148	0.312	-0.629	0.069	200	17	2.183	0.890	14.58	17.03	1
1955	0.287	0.143	-0.392	0.072	194	7	2.152	1.394	14.88	15.27	1
1956	0.113	0.058	-0.342	0.097	220	5	0.257	0.208	14.43	15.10	1
1957	0.044	0.029	-0.139	0.074	223	2	0.272	0.230	17.45	18.26	1
1958	0.629	0.157	-0.287	0.039	257	26	2.934	0.779	16.40	17.00	1
1959	0.184	0.062	-0.292	0.060	271	16	0.785	0.256	15.65	17.14	1
1960	0.585	0.309	-0.338	0.087	213	6	2.327	1.582	15.37	16.76	1
1961	0.067	0.035	-0.131	0.062	110	3	0.225	0.142	15.16	17.82	1
1962	0.125	0.148	**-0.327**	**0.023**	78	2	0.279	0.196	15.14	13.51	4
1963	0.517	0.331	-0.370	0.122	125	6	3.146	1.974	15.84	16.08	2
1965	0.057	0.056	-0.233	0.171	132	4	0.320	0.193	14.54	15.49	2
1966	0.381	0.288	-0.336	0.152	213	7	1.382	0.728	16.10	16.57	2
1969	0.167	0.086	**-0.327**	**0.023**	170	2	0.366	0.312	14.71	18.04	4
1972	0.246	0.126	**-0.327**	**0.023**	73	1	0.577	0.577	15.48	15.70	4
1978	5.436	1.652	-0.280	0.037	198	34	35.729	12.459	16.00	16.00	1
1981	21.845	7.563	-0.329	0.045	209	51	84.943	26.113	15.58	17.32	1
1984	2.222	1.560	-0.494	0.112	175	10	9.515	5.751	15.79	16.67	1
1985	0.579	0.192	-0.222	0.113	53	5	2.340	1.188	14.18	14.31	3
1986	10.974	2.634	-0.519	0.271	56	15	30.586	14.484	14.72	16.07	3
1987	46.389	23.731	-0.889	0.121	66	13	83.368	53.892	15.43	14.94	2
1988	2.876	0.963	-0.157	0.097	55	13	9.832	6.776	14.42	16.07	3
1989	1.187	0.551	-0.370	0.100	123	14	4.100	1.887	16.10	17.10	1

1991	0.848	1.075	-0.009	0.209	36	4	6.372	5.911	16.66	16.10	2
1992	0.315	0.390	-0.092	0.127	132	12	1.941	1.653	16.64	16.29	3
1993	0.643	0.236	**-0.327**	**0.023**	57	2	1.623	1.162	14.78	14.66	4
1994	0.094	0.449	**-0.327**	**0.023**	91	1	0.053	0.053	15.24	15.90	4
1995	0.758	0.244	-0.221	0.042	121	11	3.209	1.312	15.61	15.80	1
1996	7.922	2.884	-0.560	0.075	60	9	13.742	8.541	15.12	15.87	1
1997	8.767	4.288	-0.821	0.103	128	13	14.960	10.659	15.98	16.98	1
1998	0.370	0.286	-0.326	0.249	161	7	1.330	0.613	16.27	14.57	2
2001	0.394	0.195	-0.148	0.399	132	3	1.697	1.160	15.22	14.76	1
2003	0.333	0.280	**-0.327**	**0.023**	128	1	0.756	0.756	15.60	14.80	4
2005	0.068	0.052	-0.039	0.076	190	10	2.162	0.842	15.12	15.19	1
2006	0.103	0.305	**-0.327**	**0.023**	147	1	0.245	0.245	13.36	15.10	4
Whole	**1.618**	**0.301**	**-0.327**	**0.023**							

Index

1. Weighted nls for age<=20 d
2. Weighted nls for age<=10 d
3. Unweighted nls for age <=20 d
4. Equation (5) using larval production at length 2.5mm

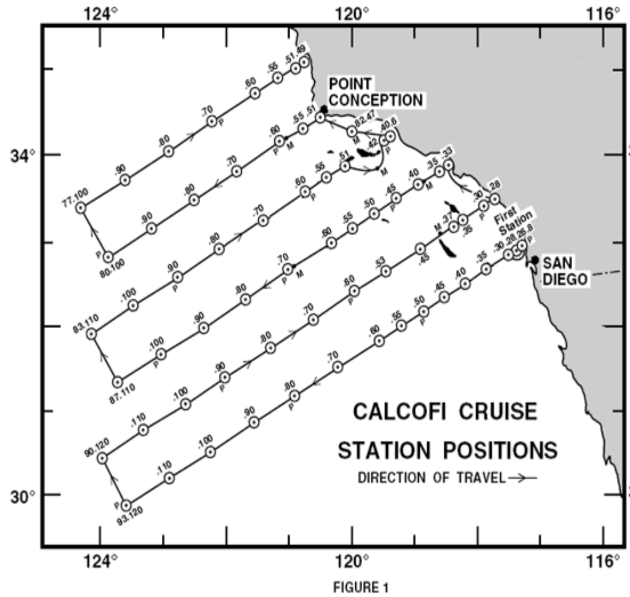

Figure 1. CalCOFI survey area from 1985-present from CalCOFI lines 93.3-76.7

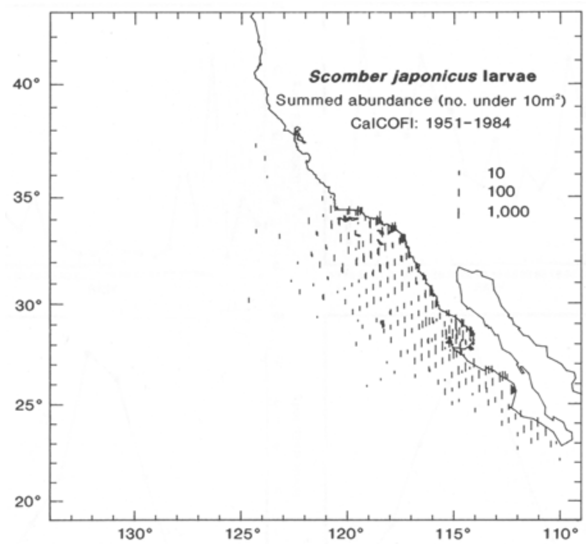

Figure 2. Total Pacific mackerel larval abundance/10m^2 from CalCOFI surveys from 1951-1984 (Moser et al. 1993).

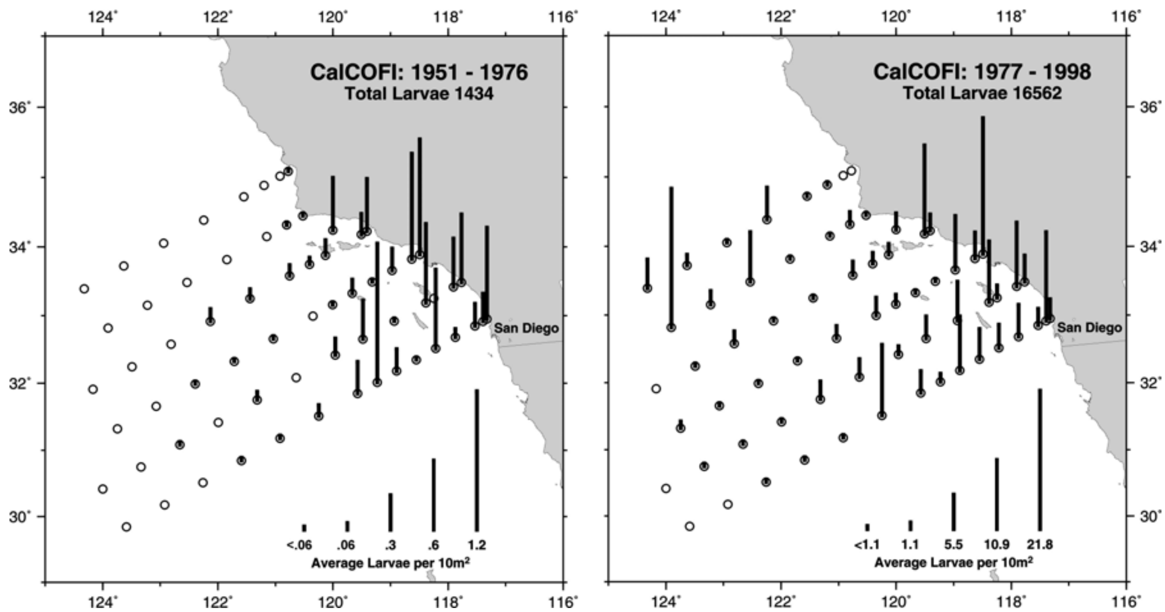

Figure 3. The average Pacific mackerel larvae/10m^2 in the current CalCOFI survey area from 1951-1976 and from 1977-1998 over all cruises (Moser et al. 2001)

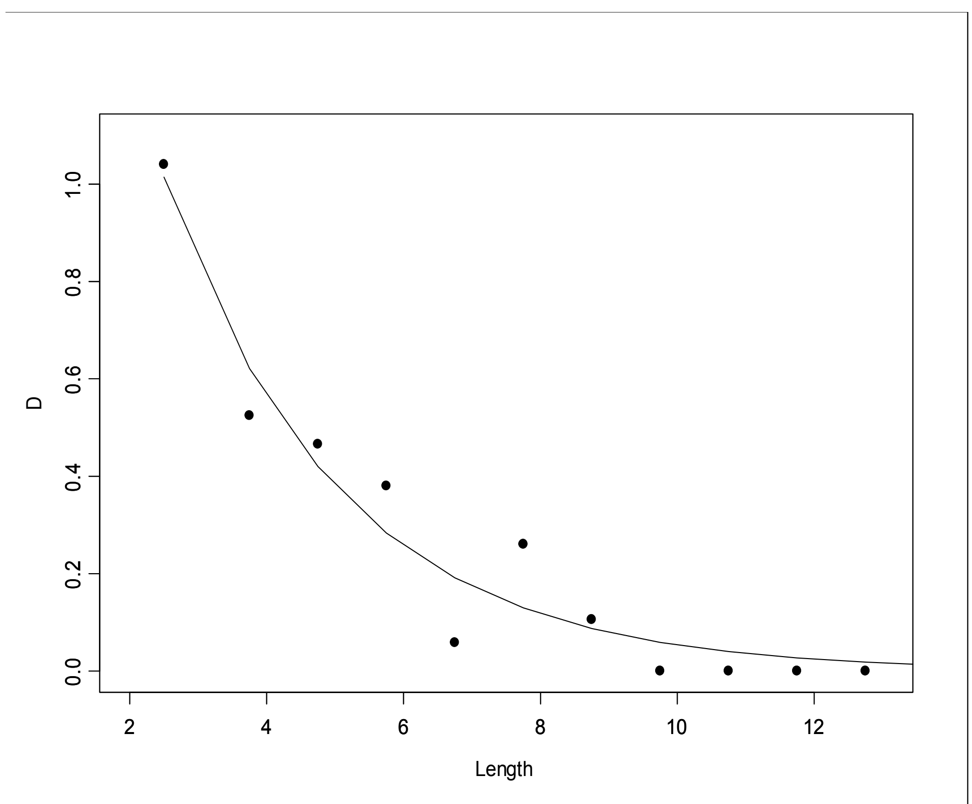

Figure 4: Noon/night catch rates of Pacific mackerel larvae (D) and larval length (mm) based on data of 1951-1978.

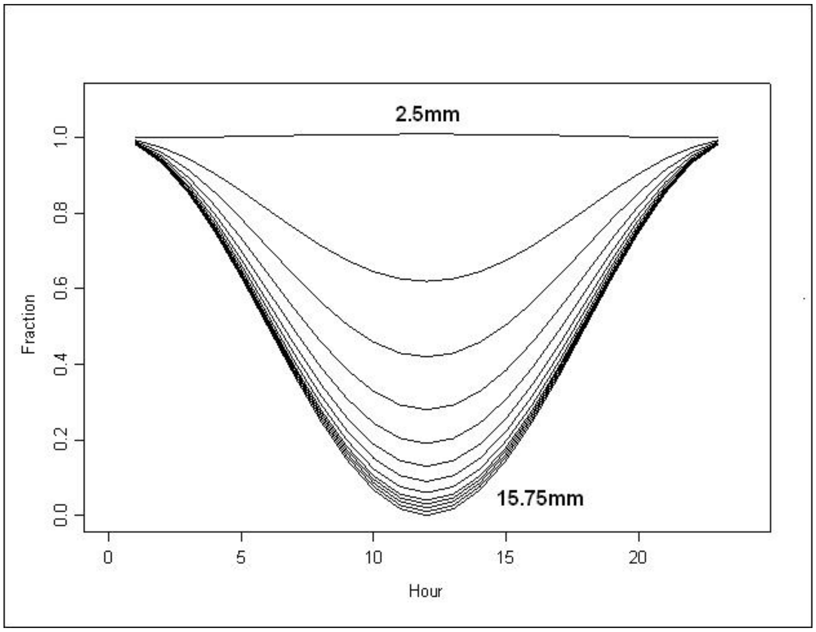

Figure 5. Fraction of Pacific mackerel larvae captured as a function of time of day for 2.5mm-15.75mm.

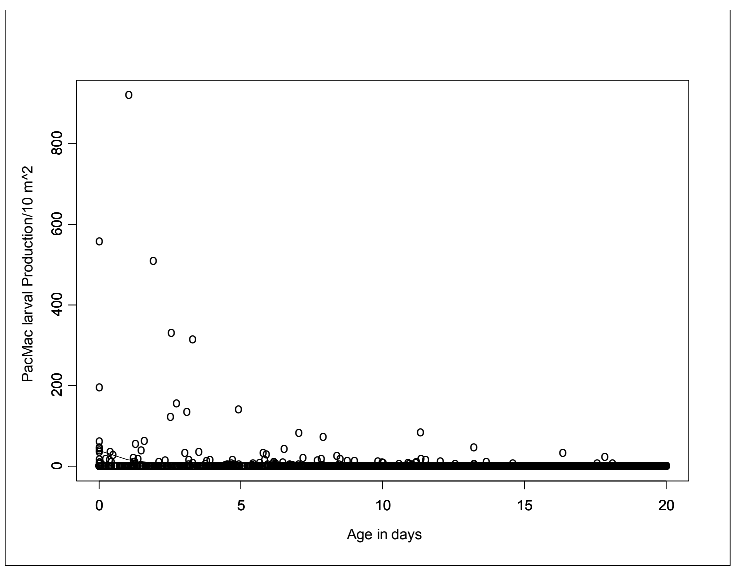

Figure 6: Daily larval production/10m^2 and age with Mortality curve (p_t=21.84 exp (-.33t)) in 1981.

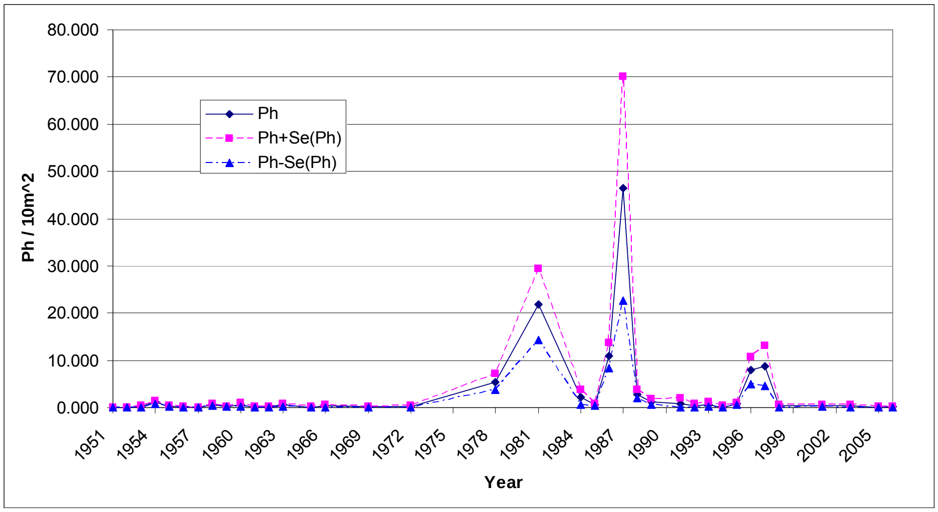

Figure 7: Mackerel larval production /10m^2 at hatching (p_h) off area from San Diego to San Francisco, in April-July from 1951 – 2006.

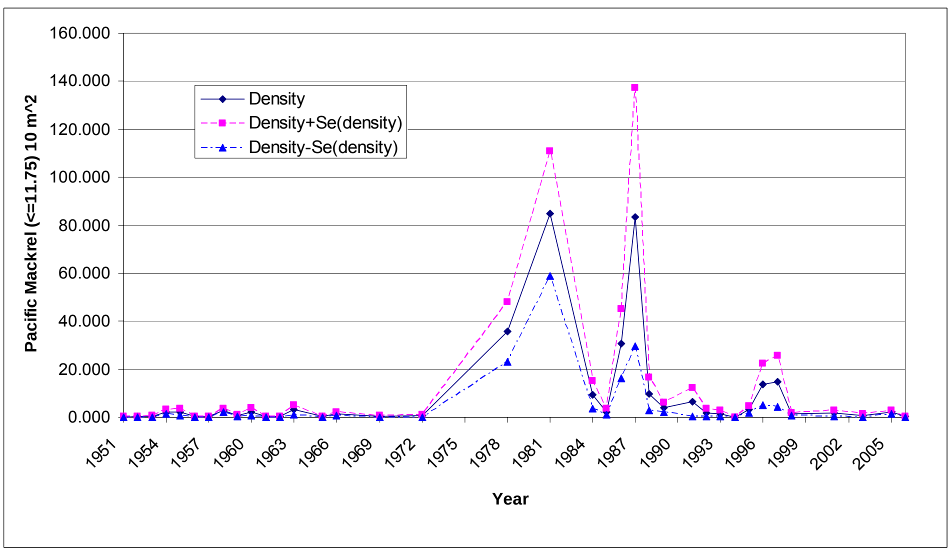

Figure 8: The time series of larval density (number/10m^2) off area from San Diego to San Francisco in 1951-2006.

APPENDIX A

DAT FILE FOR ASAP BASE MODEL E1:

```
# E1: SigmaR=0.7; M=0.5
# Number of Years
   79
# First Year
   1929
# Number of Ages
   9
# Natural Mortality Rate by Age
   0.5   0.5   0.5   0.5   0.5   0.5   0.5   0.5   0.5
# Fecundity Option
   0
# Maturity Vector
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
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   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
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   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
```

```
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
   0.00   0.07   0.25   0.47   0.73   1.00   1.00   1.00   1.00
# Weight at Age Vector
   0.074   0.167   0.297   0.402   0.523   0.615   0.704   0.800   0.830
   0.060   0.139   0.301   0.422   0.511   0.603   0.698   0.800   0.830
   0.077   0.114   0.276   0.399   0.527   0.606   0.701   0.800   0.830
   0.058   0.081   0.277   0.379   0.508   0.604   0.711   0.800   0.830
   0.059   0.083   0.200   0.299   0.493   0.585   0.700   0.800   0.830
   0.065   0.142   0.198   0.233   0.431   0.538   0.683   0.800   0.830
   0.079   0.186   0.217   0.251   0.379   0.472   0.629   0.790   0.830
   0.086   0.193   0.284   0.338   0.393   0.453   0.574   0.750   0.820
   0.119   0.176   0.318   0.429   0.461   0.502   0.575   0.740   0.800
   0.124   0.174   0.310   0.448   0.532   0.582   0.633   0.726   0.790
   0.191   0.246   0.363   0.460   0.583   0.680   0.775   0.795   0.878
   0.180   0.260   0.339   0.442   0.527   0.640   0.729   0.834   0.820
   0.115   0.259   0.343   0.439   0.559   0.650   0.806   0.807   0.850
   0.180   0.236   0.373   0.471   0.546   0.626   0.684   0.909   0.830
   0.165   0.292   0.339   0.474   0.574   0.650   0.629   0.881   1.000
   0.144   0.271   0.379   0.472   0.587   0.660   0.754   0.735   0.948
   0.121   0.234   0.383   0.494   0.611   0.704   0.745   0.819   0.842
   0.125   0.261   0.384   0.487   0.617   0.679   0.736   0.778   0.812
   0.119   0.291   0.400   0.499   0.622   0.709   0.753   0.788   0.818
   0.107   0.227   0.354   0.506   0.616   0.706   0.764   0.895   0.871
   0.109   0.192   0.319   0.456   0.607   0.725   0.799   0.917   0.917
   0.084   0.249   0.323   0.455   0.564   0.664   0.784   0.799   0.871
   0.162   0.255   0.346   0.429   0.569   0.694   0.827   0.835   0.853
   0.173   0.297   0.386   0.471   0.568   0.719   0.832   0.988   0.850
   0.162   0.296   0.411   0.512   0.603   0.763   0.834   0.850   1.100
   0.084   0.257   0.387   0.505   0.585   0.744   0.701   0.879   0.870
   0.140   0.253   0.357   0.484   0.583   0.744   0.762   0.778   0.878
   0.111   0.248   0.373   0.485   0.598   0.752   0.722   0.910   0.870
   0.179   0.310   0.374   0.509   0.602   0.649   0.650   0.700   1.000
   0.176   0.292   0.396   0.488   0.617   0.685   0.775   0.750   0.750
   0.132   0.251   0.398   0.510   0.602   0.702   0.754   0.840   0.850
   0.102   0.276   0.391   0.507   0.611   0.699   0.768   0.820   0.870
   0.144   0.252   0.389   0.495   0.584   0.647   0.817   0.830   0.850
   0.276   0.320   0.420   0.540   0.622   0.712   0.782   0.890   0.860
   0.197   0.298   0.434   0.538   0.627   0.730   0.743   0.840   0.930
   0.181   0.300   0.400   0.503   0.612   0.748   0.812   0.820   0.870
   0.109   0.195   0.384   0.501   0.596   0.723   0.735   0.880   0.850
   0.149   0.273   0.419   0.525   0.658   0.790   0.833   0.850   0.930
   0.166   0.235   0.488   0.510   0.599   0.723   0.869   0.917   0.849
   0.138   0.266   0.391   0.562   0.593   0.709   0.902   0.952   1.070
   0.103   0.322   0.428   0.505   0.662   0.746   0.907   1.000   1.100
   0.099   0.232   0.402   0.584   0.730   0.837   0.850   1.000   1.200
   0.266   0.282   0.457   0.481   0.740   0.955   0.880   0.900   1.200
   0.147   0.266   0.449   0.508   0.552   0.746   1.000   0.900   1.100
   0.119   0.329   0.433   0.609   0.606   0.686   0.758   0.803   0.838
   0.107   0.303   0.604   0.740   0.837   0.800   0.800   0.800   1.000
   0.127   0.361   0.517   0.973   1.053   1.029   1.350   0.900   0.900
   0.170   0.297   0.672   0.864   1.291   1.223   1.531   1.200   1.000
   0.122   0.322   0.600   0.847   1.063   1.100   1.300   1.500   1.300
   0.062   0.334   0.473   0.705   0.908   1.100   1.200   1.400   1.600
   0.082   0.189   0.440   0.598   0.810   0.969   1.200   1.300   1.500
   0.072   0.176   0.270   0.437   0.598   0.874   1.066   1.300   1.400
   0.083   0.190   0.239   0.391   0.597   0.715   0.953   0.929   1.400
   0.032   0.151   0.237   0.345   0.516   0.773   0.916   1.000   1.200
   0.049   0.191   0.302   0.390   0.458   0.511   0.688   0.900   1.100
   0.120   0.235   0.351   0.396   0.505   0.614   0.638   0.871   0.910
   0.157   0.285   0.418   0.461   0.484   0.560   0.612   0.697   0.850
   0.148   0.290   0.408   0.508   0.561   0.595   0.630   0.719   0.784
   0.133   0.272   0.414   0.523   0.600   0.691   0.717   0.766   0.826
   0.101   0.301   0.415   0.576   0.666   0.734   0.806   0.815   0.899
   0.104   0.193   0.381   0.542   0.647   0.749   0.757   0.739   0.827
   0.094   0.267   0.377   0.554   0.649   0.680   0.749   0.775   0.803
   0.071   0.217   0.397   0.514   0.591   0.664   0.724   0.766   0.799
   0.087   0.175   0.330   0.459   0.544   0.661   0.691   0.725   0.805
   0.073   0.228   0.294   0.408   0.583   0.607   0.720   0.756   0.832
   0.100   0.156   0.248   0.361   0.493   0.597   0.644   0.733   0.785
   0.081   0.179   0.275   0.431   0.586   0.689   0.740   0.758   0.920
   0.105   0.182   0.318   0.471   0.589   0.649   0.674   0.705   0.751
   0.149   0.239   0.333   0.446   0.572   0.637   0.719   0.718   0.749
   0.139   0.267   0.325   0.419   0.530   0.615   0.631   0.667   0.689
   0.148   0.228   0.399   0.509   0.575   0.633   0.688   0.754   0.768
   0.114   0.266   0.370   0.550   0.590   0.608   0.646   0.712   0.731
   0.103   0.253   0.347   0.534   0.567   0.619   0.617   0.635   0.627
   0.133   0.218   0.303   0.412   0.552   0.687   0.656   0.728   0.650
   0.125   0.284   0.414   0.603   0.679   0.745   0.809   0.794   0.838
   0.159   0.280   0.407   0.596   0.685   0.821   0.926   0.820   0.902
   0.106   0.267   0.380   0.463   0.556   0.665   0.737   0.797   0.840
   0.115   0.232   0.361   0.509   0.715   0.794   0.847   0.918   0.935
   0.115   0.232   0.361   0.509   0.715   0.794   0.847   0.918   0.935
# Number of Fleets
   1
#$FLEET-1
# Selectivity Start Age
   1
# Selectivity End Age
   9
# Selectivity Est. Start Age
   1
# Selectivity Est. End Age
   9
# Release Mortality
```

```
  0.0
# Number of Selectivity Changes by Fleet
  2
# Selectivity Change Years
  1970   1978
# Fleet 1 Catch at Age - Last Column is Total Weight
      9.28  12433.52  22466.85  20819.02   5208.01   3874.57   3198.38   1273.12    506.68  25733.54
         0    1392.8   7164.29    4838.4   1916.24    670.23     43.87     17.46      6.95   5825.88
         0     957.2   9990.74   6190.18   1307.12    752.89    371.31     147.8     58.82   6890.14
         0    144.48      3222   5844.95   1393.72    940.26    489.13     194.7     77.49   4938.95
         0   4620.12  19017.01     31887  23363.33      8277   2730.62   1086.93    432.58  33072.19
         0   4894.32  53353.79  35598.25  40807.82  15508.13   5669.25   2256.66    898.11  51483.81
         0  10871.51   12737.4  61704.13  63819.66  33633.06   6205.69   2470.19    983.09  66417.45
         0   2247.75  20403.77   17399.3  33062.36  35158.51   5252.24   2090.67    832.05  45714.21
    128.53    1475.8   2592.22   8035.18  15910.37  26039.26   7865.44   3130.86   1246.02  31987.62
    771.57  11577.22  31967.43  16527.64   4309.46   10883.8   6608.45   2630.51   1046.89  34561.76
   1802.77  23227.99  23713.35  33697.92  11093.97   6309.69   3744.21   1525.42    485.36  45453.99
   3199.27  18452.94  59415.03  27593.71  17024.69   2513.71    685.56    114.26         0  48868.18
    638.04  18396.72  31228.34  28817.98   6522.15    921.61     70.89     70.89         0  32560.77
         0   28454.8  10342.87  15109.17   6148.52   1096.25    142.99     47.66         0   21885.7
    426.03  14144.24  62072.75  10522.97   7412.94   1022.47    170.41     85.21         0   35304.7
         0  20800.04   20684.8  35319.73   8873.15    1613.3    230.47         0     57.62   36657.1
   2034.46  15336.68  12076.33   8920.31   8320.41   4825.32   1930.13     599.9    391.24  23601.43
   3289.73  16672.93  20261.72  11040.52   6704.06   4286.61   1819.32   1096.58    548.29  27582.46
    7426.5   4645.52  10460.31   9227.83   6067.61   3507.84   1896.13    695.25    221.22  19436.99
   2722.71  37272.92   9106.99   3661.57   4037.12    1408.3    657.21    281.66     93.89  18124.69
    565.75  21983.49  36329.33   9173.26   3071.22   1980.13    808.22    121.23     80.82  24188.91
     44.21   6587.64  17065.97   17154.4   3183.29    530.55    397.91     44.21     44.21  17493.02
   1030.94   4004.81   6859.73  11816.18  11300.71    674.08    237.91      79.3      79.3  15857.11
    509.56    324.26   1991.91   1991.91    8708.8   4678.66     92.65     46.32         0  10325.76
  11077.04   2069.34   1338.98   1379.56    568.05     811.5    770.93         0         0   5265.94
    693.87  47799.78  10176.73    2158.7   1233.54         0    308.39    154.19         0  18464.67
  15607.86  17730.53  25097.44  10738.21   1123.77    124.86    249.73    124.86    374.59  22200.87
    419.64  54867.37  22555.42  19093.43   8812.35    314.73         0         0         0  36834.99
   1996.08   7915.49  30078.85  10875.19   8534.96   3028.53   1307.78    344.15         0  27753.42
  11505.37   2665.88   4595.13   7401.32   3156.96   1438.17    912.01         0         0  11874.77
   1689.97   46896.6   7773.85   3633.43   2450.45   1013.98     253.5         0         0  19332.47
   1628.96  12726.27   17002.3  10181.02   5090.51   1730.77   1323.53         0         0  20822.52
   7344.83  28679.83  15564.05  14689.67   5770.94   1224.14    524.63         0         0   26199.2
    738.58  23298.65   12553.8  10472.06   7072.09    1421.2    186.57         0         0  23900.98
    284.46   6843.29  18432.22  10338.63   8843.01    2841.7    424.59         0         0  23702.99
   1389.15   7716.49   6521.08   9629.28  10969.27   4240.06    715.11         0         0  19987.93
  13074.05   1264.81    766.75   1700.61   5524.52   8676.71   1562.99         0         0  11279.44
   3689.34   8093.13   1457.55   1168.16    991.64   2240.26   1219.85     91.12         0   7405.18
   4530.49   1003.32     88.34    631.74    228.46    163.44     191.8     45.48       3.9   1713.31
   7417.78    499.49    221.14    353.17     89.26     85.63     68.09     51.89     37.44   1695.04
     46.32   2354.04    605.77    221.27      70.7     61.36      9.47         0         0   1168.22
   1405.04   3004.08         0         0         0         0         0         0         0    835.49
         0   2852.62    223.99       9.9     11.85       7.9         0         0         0    911.26
   1319.46    197.08    293.14       318      9.27      7.18         0         0         0       532
     50.08    546.98    153.25     32.92     74.92     88.38     49.33      2.06      2.06    400.94
   2154.23    768.64    244.31     39.29      13.1         0         0         0         0    633.81
    129.69   6334.53     89.64     65.67      1.89      3.59       1.8         0         0    2149.3
  13973.68    164.16   1763.31      0.75     22.98         0     26.91         0         0   4091.65
  11070.92  36733.93     77.95    286.78         0         0         0         0         0  13751.25
  73773.14   18836.9  28597.94   1165.54   1006.01    257.27         0         0         0  27172.62
      27.3  102761.6  14944.14  15203.87    222.15    674.58         0         0         0  35858.08
  63977.75    3375.6  77514.48   8220.94   7378.74    407.32    125.57         0         0  35203.07
  19073.13  45821.52  10973.96  69210.11   4792.33   3066.54     75.52    123.26         0  46984.54
  16128.82   36225.3  33231.45   9921.13  31045.14   2318.39    768.07         0         0  36371.39
   2841.49   2812.44  44335.77  40174.47   6319.26  17770.08    251.37         0         0  42117.51
   2874.61    532.91   9588.75  48965.24  25203.82   6271.07   7986.46    197.57         0  46468.33
   3250.53  17477.96   5188.93  16256.13  50114.46  10704.47    1388.6   1046.78         0   46827.8
  18857.41  44528.39  23015.91   5275.98   9001.56  25599.29   7434.51   1023.53   1085.34   54122.6
  18059.02  71919.59  32697.92   5325.97   2861.93   3517.06   4718.34   2063.79     848.6  48222.76
  104976.8   15168.1  36143.18  13133.26   2848.62   1942.85   2573.76   4155.11   3178.37  49264.61
   21820.5  161290.9   8376.37   6715.48   4513.48    2717.9   2542.54    866.91   1677.31  49405.81
  29559.33  19434.09  43284.43  11973.57  16877.91  19587.74   8229.01   6546.39    8186.6  71550.65
  27181.03  91781.73  21911.68  21684.28  10412.43   9327.48   6708.83   3023.18   4448.24  65504.89
   11121.1  30146.79  12343.23   9853.43  10636.66    8100.2   5593.94   2629.49   1025.04  32217.46
  51844.57   9383.17  10677.45   3439.66   3365.54   5042.96   2884.56   2893.11   1650.65   20919.9
  25603.69   38016.3   9946.38   4529.72   5751.48   3022.07   1869.19   1484.89    606.29  23737.04
  46200.33  21302.37   5280.72    982.52    552.27   1417.41    759.08    529.29    336.18  11995.83
  28943.78  43914.05  12553.55   6006.08    3740.6   2567.45   1367.78   1073.12    755.59  24562.68
  24318.16   49846.2  32821.51  12958.96   8403.64   7621.77   4900.96   4165.63   6853.01  51076.32
  13603.22  19878.34  38777.42  23702.43  15523.39  13343.25   10667.9   6471.86   7980.32  62822.66
   11997.3   2949.13   2680.44   6120.22   5834.41    4446.9   1946.44   1330.19    966.05  15909.85
  29466.53  15354.87   5178.47   8768.71  10300.19   6637.51   2844.88   1140.63    630.41   27791.9
  14207.16  20422.43   3517.09   1951.32   2407.56   2133.99    984.14    555.21    298.61  13010.41
   7247.46   51288.5   5175.57   1192.36    228.27     364.9    252.66         0         0  14122.78
  26589.82  14955.19   5147.96   1891.02    662.89    651.84    330.95      95.6     65.05  12022.88
  46349.62   7066.43   2287.65   1657.83    706.03    141.48     94.32     36.78     94.32  11195.41
  71582.68   9838.92   5043.35    729.78     285.3    174.03     89.59     22.52         0  13151.46
  71663.69  23704.07   4708.05    1870.8    548.46    200.24    166.33      48.2         0  16623.48
         0         0         0         0         0         0         0         0         0  16623.48
# Fleet 1 Discards at Age - Last Column is Total Weight
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
         0         0         0         0         0         0         0         0         0         0
```

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Fleet 1 Proportion Released at Age

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0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

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# Number of Indices
   3
#$SPOTTER
#$CPFV
#$CALCOFI
# Index Weight Flag
   2
# Index Units
   1   2   2
# Index Month
   4   5   1
# Index Start Age
   1   2   2
# Index End Age
   9   9   9
# Index Fix Age
   -1   -1   -1
# Index Selectivity Choice
   -1   -1   -1
# Index Data - Year, Index, CV, Selectivity
# INDEX - 1
    1929      -999         1         1         1         1         1         1         1         1         1         1
    1930      -999         1         1         1         1         1         1         1         1         1         1
    1931      -999         1         1         1         1         1         1         1         1         1         1
    1932      -999         1         1         1         1         1         1         1         1         1         1
    1933      -999         1         1         1         1         1         1         1         1         1         1
    1934      -999         1         1         1         1         1         1         1         1         1         1
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    1937      -999         1         1         1         1         1         1         1         1         1         1
    1938      -999         1         1         1         1         1         1         1         1         1         1
    1939      -999         1         1         1         1         1         1         1         1         1         1
    1940      -999         1         1         1         1         1         1         1         1         1         1
    1941      -999         1         1         1         1         1         1         1         1         1         1
    1942      -999         1         1         1         1         1         1         1         1         1         1
    1943      -999         1         1         1         1         1         1         1         1         1         1
    1944      -999         1         1         1         1         1         1         1         1         1         1
    1945      -999         1         1         1         1         1         1         1         1         1         1
    1946      -999         1         1         1         1         1         1         1         1         1         1
    1947      -999         1         1         1         1         1         1         1         1         1         1
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1949	-999	1	1	1	1	1	1	1	1	1	1
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1951	-999	1	1	1	1	1	1	1	1	1	1
1952	-999	1	1	1	1	1	1	1	1	1	1
1953	-999	1	1	1	1	1	1	1	1	1	1
1954	-999	1	1	1	1	1	1	1	1	1	1
1955	-999	1	1	1	1	1	1	1	1	1	1
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1957	-999	1	1	1	1	1	1	1	1	1	1
1958	-999	1	1	1	1	1	1	1	1	1	1
1959	-999	1	1	1	1	1	1	1	1	1	1
1960	-999	1	1	1	1	1	1	1	1	1	1
1961	-999	1	1	1	1	1	1	1	1	1	1
1962	461.35	0.518	1	1	1	1	1	1	1	1	1
1963	1541.53	0.32	1	1	1	1	1	1	1	1	1
1964	549.34	0.458	1	1	1	1	1	1	1	1	1
1965	707.89	0.508	1	1	1	1	1	1	1	1	1
1966	272.08	0.67	1	1	1	1	1	1	1	1	1
1967	19.88	0.979	1	1	1	1	1	1	1	1	1
1968	178.55	1.42	1	1	1	1	1	1	1	1	1
1969	782.89	1.385	1	1	1	1	1	1	1	1	1
1970	22.03	2.439	1	1	1	1	1	1	1	1	1
1971	76.7	0.89	1	1	1	1	1	1	1	1	1
1972	5.46	2.05	1	1	1	1	1	1	1	1	1
1973	28.95	2.873	1	1	1	1	1	1	1	1	1
1974	-999	1	1	1	1	1	1	1	1	1	1
1975	4.31	3.011	1	1	1	1	1	1	1	1	1
1976	15492.54	0.55	1	1	1	1	1	1	1	1	1
1977	31112.79	0.282	1	1	1	1	1	1	1	1	1
1978	40320.84	0.219	1	1	1	1	1	1	1	1	1
1979	44380.55	0.18	1	1	1	1	1	1	1	1	1
1980	22164.44	0.153	1	1	1	1	1	1	1	1	1
1981	25829.5	0.139	1	1	1	1	1	1	1	1	1
1982	36237.16	0.13	1	1	1	1	1	1	1	1	1
1983	30524.24	0.271	1	1	1	1	1	1	1	1	1
1984	45635.38	0.156	1	1	1	1	1	1	1	1	1
1985	38944.25	0.207	1	1	1	1	1	1	1	1	1
1986	18979.22	0.17	1	1	1	1	1	1	1	1	1
1987	12087.23	0.254	1	1	1	1	1	1	1	1	1
1988	16673.37	0.304	1	1	1	1	1	1	1	1	1
1989	2700.95	0.341	1	1	1	1	1	1	1	1	1
1990	5445.68	0.263	1	1	1	1	1	1	1	1	1
1991	2391.01	0.27	1	1	1	1	1	1	1	1	1
1992	1207.58	0.48	1	1	1	1	1	1	1	1	1
1993	1764.32	0.345	1	1	1	1	1	1	1	1	1
1994	2097.7	0.561	1	1	1	1	1	1	1	1	1
1995	6317.02	0.372	1	1	1	1	1	1	1	1	1
1996	1907.85	0.546	1	1	1	1	1	1	1	1	1
1997	5050.92	0.353	1	1	1	1	1	1	1	1	1
1998	2248.2	0.417	1	1	1	1	1	1	1	1	1
1999	1187.88	0.459	1	1	1	1	1	1	1	1	1
2000	3230.88	0.42	1	1	1	1	1	1	1	1	1
2001	548.8	1.339	1	1	1	1	1	1	1	1	1
2002	-999	1	1	1	1	1	1	1	1	1	1
2003	-999	1	1	1	1	1	1	1	1	1	1
2004	-999	1	1	1	1	1	1	1	1	1	1
2005	-999	1	1	1	1	1	1	1	1	1	1
2006	-999	1	1	1	1	1	1	1	1	1	1
2007	-999	1	1	1	1	1	1	1	1	1	1

INDEX - 2

1929	-999	1	0	0.5	1	1	1	1	1	1	1
1930	-999	1	0	0.5	1	1	1	1	1	1	1
1931	-999	1	0	0.5	1	1	1	1	1	1	1
1932	-999	1	0	0.5	1	1	1	1	1	1	1
1933	-999	1	0	0.5	1	1	1	1	1	1	1
1934	-999	1	0	0.5	1	1	1	1	1	1	1
1935	41.412	0.209	0	0.5	1	1	1	1	1	1	1
1936	59.696	0.387	0	0.5	1	1	1	1	1	1	1
1937	33.128	0.186	0	0.5	1	1	1	1	1	1	1
1938	73.639	0.127	0	0.5	1	1	1	1	1	1	1
1939	58.063	0.147	0	0.5	1	1	1	1	1	1	1
1940	85.304	0.135	0	0.5	1	1	1	1	1	1	1
1941	-999	1	0	0.5	1	1	1	1	1	1	1
1942	-999	1	0	0.5	1	1	1	1	1	1	1
1943	-999	1	0	0.5	1	1	1	1	1	1	1
1944	-999	1	0	0.5	1	1	1	1	1	1	1
1945	-999	1	0	0.5	1	1	1	1	1	1	1
1946	21.888	0.216	0	0.5	1	1	1	1	1	1	1
1947	24.906	0.19	0	0.5	1	1	1	1	1	1	1
1948	29.25	0.313	0	0.5	1	1	1	1	1	1	1
1949	14.111	0.209	0	0.5	1	1	1	1	1	1	1
1950	7.793	0.234	0	0.5	1	1	1	1	1	1	1
1951	5.758	0.189	0	0.5	1	1	1	1	1	1	1
1952	5.549	0.256	0	0.5	1	1	1	1	1	1	1
1953	11.365	0.31	0	0.5	1	1	1	1	1	1	1
1954	41.29	0.19	0	0.5	1	1	1	1	1	1	1
1955	14.683	0.203	0	0.5	1	1	1	1	1	1	1
1956	11.501	0.237	0	0.5	1	1	1	1	1	1	1
1957	17.313	0.256	0	0.5	1	1	1	1	1	1	1
1958	17.465	0.215	0	0.5	1	1	1	1	1	1	1
1959	11.982	0.24	0	0.5	1	1	1	1	1	1	1
1960	15.922	0.265	0	0.5	1	1	1	1	1	1	1
1961	15.009	0.214	0	0.5	1	1	1	1	1	1	1
1962	7.345	0.265	0	0.5	1	1	1	1	1	1	1

1963	13.3	0.242	0	0.5	1	1	1	1	1	1	1
1964	5.174	0.289	0	0.5	1	1	1	1	1	1	1
1965	9.66	0.263	0	0.5	1	1	1	1	1	1	1
1966	10.71	0.22	0	0.5	1	1	1	1	1	1	1
1967	4.406	0.448	0	0.5	1	1	1	1	1	1	1
1968	6.652	0.281	0	0.5	1	1	1	1	1	1	1
1969	5.455	0.304	0	0.5	1	1	1	1	1	1	1
1970	8.493	0.41	0	0.5	1	1	1	1	1	1	1
1971	13.934	0.259	0	0.5	1	1	1	1	1	1	1
1972	7.615	0.382	0	0.5	1	1	1	1	1	1	1
1973	4.178	0.413	0	0.5	1	1	1	1	1	1	1
1974	3.046	0.438	0	0.5	1	1	1	1	1	1	1
1975	7.665	0.309	0	0.5	1	1	1	1	1	1	1
1976	12.797	0.378	0	0.5	1	1	1	1	1	1	1
1977	49.681	0.237	0	0.5	1	1	1	1	1	1	1
1978	95.89	0.177	0	0.5	1	1	1	1	1	1	1
1979	113.094	0.18	0	0.5	1	1	1	1	1	1	1
1980	149.874	0.156	0	0.5	1	1	1	1	1	1	1
1981	102.548	0.183	0	0.5	1	1	1	1	1	1	1
1982	104.27	0.151	0	0.5	1	1	1	1	1	1	1
1983	106.374	0.208	0	0.5	1	1	1	1	1	1	1
1984	114.281	0.218	0	0.5	1	1	1	1	1	1	1
1985	82.501	0.211	0	0.5	1	1	1	1	1	1	1
1986	64.498	0.252	0	0.5	1	1	1	1	1	1	1
1987	42.182	0.202	0	0.5	1	1	1	1	1	1	1
1988	30.661	0.283	0	0.5	1	1	1	1	1	1	1
1989	41.511	0.201	0	0.5	1	1	1	1	1	1	1
1990	48.839	0.206	0	0.333	0.666	1	1	1	1	1	1
1991	56.214	0.174	0	0.333	0.666	1	1	1	1	1	1
1992	39.565	0.201	0	0.333	0.666	1	1	1	1	1	1
1993	47.48	0.193	0	0.333	0.666	1	1	1	1	1	1
1994	44.387	0.276	0	0.333	0.666	1	1	1	1	1	1
1995	40.647	0.19	0	0.333	0.666	1	1	1	1	1	1
1996	43.401	0.388	0	0.333	0.666	1	1	1	1	1	1
1997	31.747	0.285	0	0.333	0.666	1	1	1	1	1	1
1998	13.907	0.253	0	0.333	0.666	1	1	1	1	1	1
1999	7.936	0.396	0	0.333	0.666	1	1	1	1	1	1
2000	14.281	0.194	0	0.333	0.666	1	1	1	1	1	1
2001	11.216	0.421	0	0.333	0.666	1	1	1	1	1	1
2002	9.13	0.355	0	0.333	0.666	1	1	1	1	1	1
2003	6.041	0.298	0	0.333	0.666	1	1	1	1	1	1
2004	11.578	0.366	0	0.333	0.666	1	1	1	1	1	1
2005	23.96	0.256	0	0.333	0.666	1	1	1	1	1	1
2006	27.411	0.389	0	0.333	0.666	1	1	1	1	1	1
2007	-999	1	0	0.333	0.666	1	1	1	1	1	1

INDEX - 3

1929	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1930	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1931	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1932	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1933	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1934	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1935	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1936	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1937	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1938	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1939	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1940	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1941	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1942	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1943	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1944	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1945	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1946	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1947	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1948	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1949	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1950	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1951	0.015	0.646	0	0.074	0.246	0.474	0.733	1	1	1	1
1952	0.023	0.54	0	0.074	0.246	0.474	0.733	1	1	1	1
1953	0.187	0.533	0	0.074	0.246	0.474	0.733	1	1	1	1
1954	1.148	0.176	0	0.074	0.246	0.474	0.733	1	1	1	1
1955	0.287	0.309	0	0.074	0.246	0.474	0.733	1	1	1	1
1956	0.113	0.317	0	0.074	0.246	0.474	0.733	1	1	1	1
1957	0.044	0.398	0	0.074	0.246	0.474	0.733	1	1	1	1
1958	0.629	0.162	0	0.074	0.246	0.474	0.733	1	1	1	1
1959	0.184	0.216	0	0.074	0.246	0.474	0.733	1	1	1	1
1960	0.585	0.327	0	0.074	0.246	0.474	0.733	1	1	1	1
1961	0.067	0.329	0	0.074	0.246	0.474	0.733	1	1	1	1
1962	0.125	0.426	0	0.074	0.246	0.474	0.733	1	1	1	1
1963	0.517	0.386	0	0.074	0.246	0.474	0.733	1	1	1	1
1964	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1965	0.057	0.542	0	0.074	0.246	0.474	0.733	1	1	1	1
1966	0.381	0.442	0	0.074	0.246	0.474	0.733	1	1	1	1
1967	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1968	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1969	0.167	0.493	0	0.074	0.246	0.474	0.733	1	1	1	1
1970	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1971	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1972	0.246	0.55	0	0.074	0.246	0.474	0.733	1	1	1	1
1973	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1974	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1975	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1976	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1
1977	-999	1	0	0.074	0.246	0.474	0.733	1	1	1	1

```
    1978     5.436     0.196        0     0.074     0.246     0.474     0.733         1         1         1         1
    1979      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    1980      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    1981    21.845     0.222        0     0.074     0.246     0.474     0.733         1         1         1         1
    1982      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    1983      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    1984     2.222     0.417        0     0.074     0.246     0.474     0.733         1         1         1         1
    1985     0.579     0.213        0     0.074     0.246     0.474     0.733         1         1         1         1
    1986    10.974     0.156        0     0.074     0.246     0.474     0.733         1         1         1         1
    1987    46.389     0.318        0     0.074     0.246     0.474     0.733         1         1         1         1
    1988     2.876     0.215        0     0.074     0.246     0.474     0.733         1         1         1         1
    1989     1.187     0.291        0     0.074     0.246     0.474     0.733         1         1         1         1
    1990      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    1991     0.848     0.645        0     0.074     0.246     0.474     0.733         1         1         1         1
    1992     0.315     0.636        0     0.074     0.246     0.474     0.733         1         1         1         1
    1993     0.643     0.424        0     0.074     0.246     0.474     0.733         1         1         1         1
    1994     0.094     1.029        0     0.074     0.246     0.474     0.733         1         1         1         1
    1995     0.758     0.207        0     0.074     0.246     0.474     0.733         1         1         1         1
    1996     7.922     0.232        0     0.074     0.246     0.474     0.733         1         1         1         1
    1997     8.767     0.305        0     0.074     0.246     0.474     0.733         1         1         1         1
    1998      0.37     0.451        0     0.074     0.246     0.474     0.733         1         1         1         1
    1999      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    2000      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    2001     0.394     0.308        0     0.074     0.246     0.474     0.733         1         1         1         1
    2002      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    2003     0.333     0.549        0     0.074     0.246     0.474     0.733         1         1         1         1
    2004      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
    2005     0.068     0.444        0     0.074     0.246     0.474     0.733         1         1         1         1
    2006     0.103     0.554        0     0.074     0.246     0.474     0.733         1         1         1         1
    2007      -999         1        0     0.074     0.246     0.474     0.733         1         1         1         1
# Phase Control Data
# Phase for Selectivity in 1st Year
   1
# Phase for Selectivity Deviations
   4
# Phase for F mult in 1st Year
   1
# Phase for F mult Deviations
   3
# Phase for Recruitment Deviations
   3
# Phase for N in 1st Year
   2
# Phase for Catchability in 1st Year
   1
# Phase for Catchability Deviations
   -5
# Phase for Stock Recruitment Relationship
   1
# Phase for Steepness
   1
# Recruitment CV by Year
   0.7
   0.7
   0.7
   0.7
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   0.7
#Lambda for Each Index (cv=0.4)
   1   1   1
# Lambda for Total Catch in Weight
   100
# Lambda for Total Discards at Age
   0
# Lambda for Catch at Age by Year & Fleet
        45
        45
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         0
# Lambda for Discards at Age by Year & Fleet
         0
         0
         0
         0
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         0
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         0
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        0
# Lambda for F mult Deviations by Fleet
   0
# Lambda for N in 1st Year Deviations
   0
# Lambda for Recruitment Deviations
   1
# Lambda for Catchability Deviations by Index
   1   1   1
# Lambda for Selectivity Deviations by Fleet
   0
# Lambda for Selectivity Curvature at Age
   0
# Lambda for Selectivity Curvature Over Time
   0
# Lambda for Deviations from Initial Steepness
   0
# Lambda for Deviation from Initial log of Virgin Stock Size
   0
# NAA for Year 1
  100000  70000  50000  30000  20000  10000  5000  2500  1250
# Log of F mult in 1st year by Fleet
   -3
# log of Catchability in 1st year by index
   -7   -7   -7
# Initial log of Virgin Stock Size
   10
# Initial Steepness
   0.9
# Selectivity at Age in 1st Year by Fleet
     0.009
     0.092
     0.293
     0.703
         1
         1
         1
         1
         1
# Where to do Extras
   2
# Ignore Guesses
   0
# Projection Control Data
# Year for SSB ratio Calculation
   1929
# Fleet Directed Flag
   1
# Final Year of Projections
   2009
# Year Projected Recruits, What Projected, Target, non- directed F mult
      2008         2       0.3         1        -1
      2009         2       0.3         1        -1
# Test Value
   -23456
#####
# ---- FINIS ----
```

APPENDIX B

REPORT FILE FOR ASAP BASE MODEL E1:

```
obj_fun        = 1187.19
Component          RSS      nobs  Lambda  Likelihood
  Catch_Fleet_1        0.0200987   79   100   2.00987
Catch_Fleet_Total     0.0200987   79   100   2.00987
  Discard_Fleet_1        0   79   0   0
Discard_Fleet_Total     0   79   0   0
CAA_proportions      N/A           711    see_below      524.626
Discard_proportions      N/A           711    see_below      0
  Index_Fit_1         165.434   39   1   119.525
  Index_Fit_2         15.5464   67   1   107.834
  Index_Fit_3         78.0771   37   1   318.819
Index_Fit_Total     259.057   143   3   546.179
  Selectivity_devs_fleet_1   36.3896  2   0  0
Selectivity_devs_Total   36.3896  2   0  0
  Catchability_devs_index_1  0  39  1  0
  Catchability_devs_index_2  0  67  1  0
  Catchability_devs_index_3  0  37  1  0
Catchability_devs_Total  0  143  3  0
  Fmult_fleet_1     31.231   78   0  0
Fmult_fleet_Total   31.231   78   0  0
N_year_1           2.45627   8   0   0
Stock-Recruit_Fit   58.803  79   1   55.5721
Recruit_devs        58.803   79   1   58.803
SRR_steepness       1.14554       1 0   0
SRR_virgin_stock    4.53861      1 0  0
Curvature_over_age  52.2818   14   0   0
Curvature_over_time 72.7793   693   0   0
F_penalty           1.9564    711     0.001     0.0019564
Mean_Sel_year1_pen  0   9      1000  0
Max_Sel_penalty     0.294126        1       100 0
Fmult_Max_penalty   0        ?       100 0

 Input and Estimated effective sample sizes for fleet 1
1929  45  36.4235
1930  45  14.1065
1931  45  9.03445
1932  45  10.0344
1933  45  21.7392
1934  45  43.7267
1935  45  35.2486
1936  45  28.1357
1937  45  7.74268
1938  45  22.5496
1939  45  33.0862
1940  45  36.957
1941  45  22.0074
1942  45  25.3069
1943  45  9.81315
1944  45  40.8508
1945  45  58.3233
1946  45  66.061
1947  45  159.89
1948  45  13.9461
1949  45  135.444
1950  45  130.705
1951  45  235.666
1952  45  7.08767
1953  45  8.22747
1954  45  16.0746
1955  45  13.5809
1956  45  10.9595
1957  45  70.7721
1958  45  18.6598
1959  45  6.46058
1960  45  25.47
1961  45  67.3378
1962  45  30.0209
1963  45  55.2383
1964  45  24.0891
1965  45  5.12945
1966  45  20.5259
1967  45  2.181
1968  45  2.04551
1969  45  12.5601
1970  45  13.0982
1971  45  10.4686
1972  45  9.9036
1973  45  8.2392
1974  45  221.213
1975  45  24.7464
1976  45  32.0273
1977  45  51.5543
1978  45  163.816
1979  45  38.932
1980  45  37.5424
1981  45  7.01531
1982  45  20.6435
1983  45  13.8843
```

1984	45	11.2611
1985	45	7.60081
1986	45	39.1527
1987	45	18.4868
1988	45	37.8298
1989	45	9.11544
1990	45	25.5694
1991	45	18.6141
1992	45	34.816
1993	45	22.6914
1994	45	339.537
1995	45	11.0095
1996	45	75.7147
1997	45	81.2794
1998	45	42.3431
1999	45	59.3407
2000	45	112.848
2001	45	23.7145
2002	45	5.74643
2003	45	16.6502
2004	45	6.69053
2005	45	5.53676
2006	45	13.1955
2007	0	1.5126
Total	3510	3266.56

Input and Estimated effective Discard sample sizes for fleet 1

1929	0	1e+15
1930	0	1e+15
1931	0	1e+15
1932	0	1e+15
1933	0	1e+15
1934	0	1e+15
1935	0	1e+15
1936	0	1e+15
1937	0	1e+15
1938	0	1e+15
1939	0	1e+15
1940	0	1e+15
1941	0	1e+15
1942	0	1e+15
1943	0	1e+15
1944	0	1e+15
1945	0	1e+15
1946	0	1e+15
1947	0	1e+15
1948	0	1e+15
1949	0	1e+15
1950	0	1e+15
1951	0	1e+15
1952	0	1e+15
1953	0	1e+15
1954	0	1e+15
1955	0	1e+15
1956	0	1e+15
1957	0	1e+15
1958	0	1e+15
1959	0	1e+15
1960	0	1e+15
1961	0	1e+15
1962	0	1e+15
1963	0	1e+15
1964	0	1e+15
1965	0	1e+15
1966	0	1e+15
1967	0	1e+15
1968	0	1e+15
1969	0	1e+15
1970	0	1e+15
1971	0	1e+15
1972	0	1e+15
1973	0	1e+15
1974	0	1e+15
1975	0	1e+15
1976	0	1e+15
1977	0	1e+15
1978	0	1e+15
1979	0	1e+15
1980	0	1e+15
1981	0	1e+15
1982	0	1e+15
1983	0	1e+15
1984	0	1e+15
1985	0	1e+15
1986	0	1e+15
1987	0	1e+15
1988	0	1e+15
1989	0	1e+15
1990	0	1e+15
1991	0	1e+15
1992	0	1e+15
1993	0	1e+15
1994	0	1e+15
1995	0	1e+15
1996	0	1e+15

```
1997  0  1e+15
1998  0  1e+15
1999  0  1e+15
2000  0  1e+15
2001  0  1e+15
2002  0  1e+15
2003  0  1e+15
2004  0  1e+15
2005  0  1e+15
2006  0  1e+15
2007  0  1e+15
 Total  0  7.9e+16

Observed and predicted total fleet catch by year
 fleet 1 total catches
1929  25733.5  25741.2
1930  5825.88  5826.51
1931  6890.14  6890.51
1932  4938.95  4938.67
1933  33072.2  33026.3
1934  51483.8  51200.6
1935  66417.4  65162.1
1936  45714.2  44767
1937  31987.6  31515.6
1938  34561.8  34123.7
1939  45454  45303.2
1940  48868.2  49621.5
1941  32560.8  33260.4
1942  21885.7  22160.1
1943  35304.7  35866.8
1944  36657.1  37206.1
1945  23601.4  23820.3
1946  27582.5  27988.5
1947  19437  19896.3
1948  18124.7  18609.4
1949  24188.9  24773.1
1950  17493  17511.1
1951  15857.1  15488
1952  10325.8  10159.6
1953  5265.94  5235.93
1954  18464.7  18917.6
1955  22200.9  22998.1
1956  36835  37103.1
1957  27753.4  27264.1
1958  11874.8  12092.8
1959  19332.5  19567.7
1960  20822.5  21190.6
1961  26199.2  25973.2
1962  23901  22995.9
1963  23703  22452.1
1964  19987.9  18985.3
1965  11279.4  10930.6
1966  7405.18  7568.88
1967  1713.31  1731.05
1968  1695.04  1706.68
1969  1168.22  1171.2
1970  835.49  835.4
1971  911.26  911.775
1972  532  531.995
1973  400.94  401.037
1974  633.81  633.709
1975  2149.3  2148.25
1976  4091.65  4089.77
1977  13751.2  13732.6
1978  27172.6  27157.9
1979  35858.1  35844.3
1980  35203.1  35112.8
1981  46984.5  46839.6
1982  36371.4  36191
1983  42117.5  41808.5
1984  46468.3  46182.7
1985  46827.8  46141.2
1986  54122.6  54054.6
1987  48222.8  48690.2
1988  49264.6  49572.8
1989  49405.8  49161.9
1990  71550.6  70309.9
1991  65504.9  64165.5
1992  32217.5  31832.4
1993  20919.9  20750.8
1994  23737  23575.7
1995  11995.8  11926.2
1996  24562.7  24627.6
1997  51076.3  52164.2
1998  62822.7  64070
1999  15909.9  15923.5
2000  27791.9  28128.3
2001  13010.4  13135.2
2002  14122.8  14290.6
2003  12022.9  12100
2004  11195.4  11250.9
2005  13151.5  13208.4
2006  16623.5  16630.8
2007  16623.5  16623.5
Observed and predicted total fleet Discards by year
```

```
 fleet 1 total Discards
1929  0  0
1930  0  0
1931  0  0
1932  0  0
1933  0  0
1934  0  0
1935  0  0
1936  0  0
1937  0  0
1938  0  0
1939  0  0
1940  0  0
1941  0  0
1942  0  0
1943  0  0
1944  0  0
1945  0  0
1946  0  0
1947  0  0
1948  0  0
1949  0  0
1950  0  0
1951  0  0
1952  0  0
1953  0  0
1954  0  0
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1962  0  0
1963  0  0
1964  0  0
1965  0  0
1966  0  0
1967  0  0
1968  0  0
1969  0  0
1970  0  0
1971  0  0
1972  0  0
1973  0  0
1974  0  0
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1988  0  0
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1993  0  0
1994  0  0
1995  0  0
1996  0  0
1997  0  0
1998  0  0
1999  0  0
2000  0  0
2001  0  0
2002  0  0
2003  0  0
2004  0  0
2005  0  0
2006  0  0
2007  0  0

Index data
index number 1
units = 1
month = 4
starting and ending ages for selectivity = 1  9
selectivity choice = -1
 year, sigma2, obs index, pred index
1962  0.237696  0.0429284  0.255483
1963  0.0974896  0.143439  0.174636
1964  0.190425  0.0511159  0.110152
1965  0.229574  0.0658689  0.0709493
1966  0.370805  0.0253169  0.0684113
1967  0.672149  0.00184983  0.085403
1968  1.10406  0.016614  0.144102
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1969  1.07098  0.0728476  0.189422
1970  1.93856  0.00204988  0.192371
1971  0.583388  0.00713691  0.205613
1972  1.64914  0.000508051  0.188982
1973  2.22507  0.00269379  0.182216
1975  2.30918  0.000401044  0.392756
1976  0.264285  1.44157  1.38907
1977  0.0765202  2.89503  1.76011
1978  0.0468464  3.75184  2.40344
1979  0.0318862  4.12959  2.61365
1980  0.0231392  2.06239  2.31637
1981  0.0191367  2.40342  2.68464
1982  0.0167588  3.37185  2.25954
1983  0.0708694  2.84027  2.04952
1984  0.0240446  4.24635  1.82471
1985  0.0419564  3.62375  1.63257
1986  0.0284903  1.76601  1.45619
1987  0.0625202  1.12471  1.20059
1988  0.0883918  1.55145  1.19145
1989  0.110003  0.251322  0.948105
1990  0.0668817  0.506718  0.885703
1991  0.0703653  0.222483  0.687404
1992  0.207339  0.112365  0.514811
1993  0.112458  0.164169  0.50311
1994  0.273624  0.19519  0.482592
1995  0.12961  0.587796  0.553093
1996  0.260914  0.177525  0.606706
1997  0.117435  0.469986  0.555801
1998  0.160322  0.209194  0.352764
1999  0.191183  0.110532  0.263228
2000  0.162459  0.300632  0.215881
2001  1.02709  0.0510656  0.192274
index number 2
units = 2
month = 5
starting and ending ages for selectivity = 2  9
selectivity choice = -1
 year, sigma2, obs index, pred index
1935  0.0427539  1.1998  3.17901
1936  0.139561  1.72952  2.1
1937  0.034011  0.959791  1.69712
1938  0.0160003  2.13348  1.5258
1939  0.0213788  1.68221  1.50695
1940  0.0180609  2.47144  1.37943
1946  0.0456003  0.634143  0.530111
1947  0.0354637  0.721582  0.413427
1948  0.0934621  0.847437  0.523237
1949  0.0427539  0.408827  0.551986
1950  0.0533095  0.22578  0.394911
1951  0.0350978  0.166822  0.252111
1952  0.063478  0.160767  0.175973
1953  0.0917584  0.329269  0.215667
1954  0.0354637  1.19626  0.491537
1955  0.0403825  0.425399  0.507331
1956  0.0546482  0.333209  0.461195
1957  0.063478  0.501596  0.353534
1958  0.0451884  0.505999  0.27384
1959  0.0560022  0.347145  0.369956
1960  0.0678689  0.461295  0.392593
1961  0.0447783  0.434844  0.387378
1962  0.0678689  0.212801  0.393847
1963  0.0569133  0.38533  0.295456
1964  0.0802159  0.149902  0.173591
1965  0.0668817  0.279871  0.106
1966  0.0472652  0.310292  0.101739
1967  0.182908  0.127651  0.100705
1968  0.0759985  0.192723  0.134848
1969  0.0883918  0.158043  0.283136
1970  0.155378  0.246061  0.354081
1971  0.0649269  0.403699  0.359743
1972  0.136211  0.220623  0.295756
1973  0.15749  0.121046  0.272005
1974  0.175502  0.0882493  0.255037
1975  0.0911935  0.222072  0.488022
1976  0.133555  0.370757  0.536028
1977  0.0546482  1.43937  2.15826
1978  0.0308483  2.77814  3.18644
1979  0.0318862  3.27658  5.72933
1980  0.0240446  4.34218  5.71881
1981  0.0329405  2.97104  5.23524
1982  0.0225449  3.02093  6.03841
1983  0.0423543  3.08189  5.253
1984  0.0464293  3.31097  3.61779
1985  0.0435584  2.39024  2.62847
1986  0.0615691  1.86865  2.21007
1987  0.0399935  1.22211  1.97404
1988  0.0770434  0.888317  1.57687
1989  0.0396062  1.20266  1.75095
1990  0.0415603  1.41497  1.20968
1991  0.0298267  1.62864  1.0474
1992  0.0396062  1.14628  0.854867
1993  0.036572  1.3756  0.742572
1994  0.073414  1.28599  0.810226
1995  0.0354637  1.17763  0.865639
1996  0.140235  1.25742  0.994616
```

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1997  0.0780947  0.91978  0.904276
1998  0.0620438  0.402916  0.612273
1999  0.145671  0.229923  0.37277
2000  0.036945  0.413752  0.267003
2001  0.163174  0.324952  0.229699
2002  0.118694  0.264516  0.254145
2003  0.0850798  0.175021  0.23193
2004  0.125712  0.33544  0.240627
2005  0.063478  0.694174  0.331494
2006  0.14091  0.794157  0.566115
index number 3
units = 2
month = 1
starting and ending ages for selectivity = 2  9
selectivity choice = -1
 year, sigma2, obs index, pred index
1951  0.348765  0.00474773  0.137553
1952  0.255882  0.00727985  0.0993217
1953  0.25005  0.0591884  0.0843542
1954  0.0305059  0.36336  0.128223
1955  0.0911935  0.0908399  0.158773
1956  0.0957546  0.0357662  0.170302
1957  0.147043  0.0139267  0.141463
1958  0.0259055  0.199088  0.114757
1959  0.0456003  0.0582388  0.125101
1960  0.10159  0.185161  0.132004
1961  0.102774  0.0212065  0.136343
1962  0.166765  0.0395644  0.135138
1963  0.138889  0.163638  0.124209
1965  0.257556  0.0180414  0.0576835
1966  0.178451  0.120592  0.0409857
1969  0.217567  0.052858  0.0730744
1972  0.264285  0.0778628  0.141912
1978  0.0376965  1.72058  0.827137
1981  0.048108  6.91428  2.24081
1984  0.160322  0.703297  2.09426
1985  0.0443699  0.183262  1.716
1986  0.0240446  3.47344  1.35008
1987  0.0963315  14.6828  1.04183
1988  0.0451884  0.910298  0.833193
1989  0.0812859  0.375704  0.758548
1991  0.347854  0.268405  0.588969
1992  0.339679  0.0997023  0.489079
1993  0.165325  0.203519  0.430678
1994  0.722143  0.0297524  0.415829
1995  0.0419564  0.239919  0.425871
1996  0.0524255  2.50743  0.475267
1997  0.0889491  2.77489  0.484423
1998  0.185152  0.117111  0.394175
2001  0.0906302  0.124707  0.13343
2003  0.263441  0.1054  0.117829
2005  0.179932  0.021523  0.144407
2006  0.26767  0.0326011  0.215319

Selectivity by age and year for each fleet rescaled so max=1.0
 fleet 1 selectivity at age
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
```

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 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.0683332 0.281801 0.563647 0.827121 0.943572 1 0.589237 0.259853 0.0405972
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.271134 1 0.238564 0.144752 0.100711 0.21308 0.271807 0.0246291 0.0322787
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342
 0.415208 0.743877 0.648101 0.777872 0.917902 1 0.780118 0.70331 0.39342

Fmult by year for each fleet
1929   0.0333487
1930   0.00709957
1931   0.00812264
1932   0.00612334
1933   0.050338
1934   0.103302
1935   0.191034
1936   0.185702
1937   0.171636
1938   0.224226
1939   0.27675
1940   0.33543
1941   0.238939
1942   0.158222
1943   0.270486
1944   0.330101
1945   0.259496
1946   0.377169
1947   0.323211
1948   0.323117
1949   0.460621
1950   0.356753
1951   0.406307
1952   0.332395
1953   0.154091
1954   0.427568
1955   0.426979
1956   0.683296
1957   0.583617
1958   0.280099
1959   0.453926
1960   0.455095
1961   0.556993
1962   0.446467
1963   0.508752
1964   0.664895
1965   0.670565
1966   0.563604
1967   0.121636
1968   0.0904379
1969   0.0357032
1970   0.0246759
1971   0.0237132
1972   0.0247846
1973   0.0113076
1974   0.0163302
1975   0.018266
1976   0.0229416
1977   0.0230206
1978   0.0386454
1979   0.0397026
1980   0.0472041
1981   0.0511151
```

```
1982   0.0431779
1983   0.0567806
1984   0.0727974
1985   0.0815196
1986   0.112646
1987   0.12431
1988   0.138763
1989   0.159096
1990   0.254767
1991   0.284001
1992   0.186588
1993   0.128199
1994   0.154892
1995   0.0680853
1996   0.124947
1997   0.284448
1998   0.541481
1999   0.179172
2000   0.400174
2001   0.221915
2002   0.270912
2003   0.197854
2004   0.135725
2005   0.124693
2006   0.0967215
2007   0.0783117

Directed F by age and year for each fleet
 fleet 1 directed F at age
 0.00227883 0.00939769 0.0187969 0.0275834 0.0314669 0.0333487 0.0196503 0.00866577 0.00135387
 0.000485137 0.00200066 0.00400165 0.0058722 0.00669896 0.00709957 0.00418333 0.00184485 0.000288223
 0.000555047 0.00228897 0.0045783 0.00671841 0.0076643 0.00812264 0.00478616 0.00211069 0.000329757
 0.000418427 0.00172556 0.0034514 0.00506474 0.00577781 0.00612334 0.0036081 0.00159117 0.000248591
 0.00343976 0.0141853 0.0283728 0.0416356 0.0474975 0.050338 0.029661 0.0130805 0.00204358
 0.00705893 0.0291105 0.0582256 0.0854429 0.0974725 0.103302 0.0608692 0.0268432 0.00419376
 0.013054 0.0538336 0.107676 0.158008 0.180255 0.191034 0.112565 0.0496408 0.00775546
 0.0126896 0.0523308 0.10467 0.153598 0.175223 0.185702 0.109422 0.0482551 0.00753897
 0.0117284 0.048367 0.0967418 0.141963 0.16195 0.171636 0.101134 0.0446 0.00696793
 0.0153221 0.0631871 0.126385 0.185462 0.211574 0.224226 0.132123 0.0582659 0.00910297
 0.0189112 0.0779883 0.155989 0.228905 0.261133 0.27675 0.163071 0.0719143 0.0112353
 0.022921 0.0945244 0.189064 0.277441 0.316502 0.33543 0.197648 0.0871625 0.0136175
 0.0163275 0.0673333 0.134677 0.197632 0.225456 0.238939 0.140792 0.0620891 0.00970028
 0.0108118 0.044587 0.0891812 0.130869 0.149294 0.158222 0.0932302 0.0411144 0.00642337
 0.0184832 0.0762232 0.152459 0.223725 0.255223 0.270486 0.159381 0.0702867 0.010981
 0.0225568 0.0930225 0.18606 0.273033 0.311474 0.330101 0.194508 0.0857776 0.0134012
 0.0177322 0.073126 0.146264 0.214634 0.244853 0.259496 0.152904 0.0674307 0.0105348
 0.0257732 0.106286 0.21259 0.311964 0.355886 0.377169 0.222242 0.0980085 0.015312
 0.0220861 0.0910812 0.182177 0.267335 0.304973 0.323211 0.190448 0.0839875 0.0131215
 0.0220796 0.0910545 0.182124 0.267257 0.304884 0.323117 0.190393 0.0839629 0.0131177
 0.0314757 0.129803 0.259627 0.380989 0.434629 0.460621 0.271415 0.119694 0.0186999
 0.0243781 0.100533 0.201083 0.295078 0.336622 0.356753 0.210212 0.0927034 0.0144832
 0.0277643 0.114498 0.229014 0.336065 0.38338 0.406307 0.239411 0.10558 0.0164949
 0.0227137 0.0936692 0.187354 0.274931 0.313639 0.332395 0.19586 0.086374 0.0134943
 0.0105296 0.0434231 0.0868531 0.127452 0.145396 0.154091 0.0907964 0.0400411 0.00625569
 0.0292171 0.120489 0.240997 0.35365 0.403441 0.427568 0.251939 0.111105 0.0173581
 0.0291769 0.120323 0.240665 0.353163 0.402885 0.426979 0.251592 0.110952 0.0173342
 0.0466918 0.192553 0.385138 0.565168 0.644739 0.683296 0.402624 0.177557 0.0277399
 0.0398804 0.164463 0.328954 0.482721 0.550684 0.583617 0.343889 0.151655 0.0236932
 0.0191401 0.0789322 0.157877 0.231676 0.264294 0.280099 0.165045 0.0727847 0.0113713
 0.0310182 0.127917 0.255854 0.375451 0.428311 0.453926 0.26747 0.117954 0.0184281
 0.0310981 0.128246 0.256513 0.376419 0.429415 0.455095 0.268159 0.118258 0.0184756
 0.0380611 0.156961 0.313947 0.4607 0.525563 0.556993 0.328201 0.144736 0.0226124
 0.0305085 0.125815 0.25165 0.369282 0.421274 0.446467 0.263075 0.116016 0.0181253
 0.0347647 0.143367 0.286757 0.420799 0.480044 0.508752 0.299776 0.132201 0.0206539
 0.0454344 0.187368 0.374766 0.549948 0.627376 0.664895 0.391781 0.172775 0.0269929
 0.0458219 0.188966 0.377962 0.554638 0.632726 0.670565 0.395122 0.174248 0.0272231
 0.0385129 0.158824 0.317674 0.466169 0.531801 0.563604 0.332097 0.146454 0.0228808
 0.0083118 0.0342772 0.0685599 0.100608 0.114773 0.121636 0.0716726 0.0316076 0.0049381
 0.00617991 0.0254854 0.050975 0.074803 0.0853346 0.0904379 0.0532894 0.0235006 0.00367153
 0.00243972 0.0100612 0.020124 0.0295309 0.0336886 0.0357032 0.0210377 0.0092776 0.00144945
 0.00669047 0.0246759 0.00588678 0.00357189 0.00248513 0.00525793 0.00670707 0.000607744 0.000796505
 0.00642946 0.0237132 0.00565713 0.00343255 0.00238818 0.00505281 0.00644542 0.000584035 0.000765432
 0.00671996 0.0247846 0.00591273 0.00358764 0.00249609 0.0052811 0.00673664 0.000610422 0.000800016
 0.00306587 0.0113076 0.00269759 0.0016368 0.0011388 0.00240942 0.00307348 0.000278496 0.000364995
 0.00442766 0.0163302 0.00389579 0.00236383 0.00164463 0.00347962 0.00443865 0.000402196 0.000527116
 0.00495253 0.018266 0.00435762 0.00264405 0.00183959 0.00389211 0.00496483 0.000449875 0.000589603
 0.00622024 0.0229416 0.00547305 0.00332085 0.00231047 0.00488839 0.00623568 0.00056503 0.000740525
 0.00624168 0.0230206 0.00549191 0.0033323 0.00231843 0.00490523 0.00625717 0.000566977 0.000743076
 0.0160459 0.0287474 0.0250461 0.0300612 0.0354727 0.0386454 0.030148 0.0271797 0.0152039
 0.0164848 0.0295338 0.0257313 0.0308835 0.0364431 0.0397026 0.0309727 0.0279232 0.0156198
 0.0195995 0.035114 0.030593 0.0367188 0.0433287 0.0472041 0.0368248 0.0331991 0.018571
 0.0212234 0.0380234 0.0331278 0.039761 0.0469187 0.0511151 0.0398758 0.0359498 0.0201097
 0.0179278 0.032119 0.0279836 0.0335869 0.0396331 0.0431779 0.0336838 0.0303675 0.016987
 0.0235757 0.0422378 0.0367996 0.044168 0.052119 0.0567806 0.0442955 0.0399344 0.0223386
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Population Numbers at the Start of the Year

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 233929 72262.8 83854.2 34318.6 12471.4 3931.98 2824.67 3452.74 6843.64
 472241 130695 37831 44739.2 17846 6308.03 1956.76 1468.21 5662.17
 866391 270734 71657.8 21013.5 24416.8 9556.28 3340.43 1067.59 4065.15
 1.34358e+06 498978 149662 40088.4 11567.2 13207.9 5116.68 1838.27 2940.76
 302694 782843 281635 85259 22552.6 6419.82 7272.46 2877.87 2758.7
q by index
 index 1 q over time
1962  1.96206e-06
1963  1.96206e-06
1964  1.96206e-06
1965  1.96206e-06
1966  1.96206e-06
1967  1.96206e-06
1968  1.96206e-06
1969  1.96206e-06
1970  1.96206e-06
1971  1.96206e-06
1972  1.96206e-06
1973  1.96206e-06
1975  1.96206e-06
1976  1.96206e-06
1977  1.96206e-06
1978  1.96206e-06
1979  1.96206e-06
1980  1.96206e-06
1981  1.96206e-06
1982  1.96206e-06
1983  1.96206e-06
1984  1.96206e-06
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1986  1.96206e-06
1987  1.96206e-06
1988  1.96206e-06
1989  1.96206e-06
1990  1.96206e-06
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1991  1.96206e-06
1992  1.96206e-06
1993  1.96206e-06
1994  1.96206e-06
1995  1.96206e-06
1996  1.96206e-06
1997  1.96206e-06
1998  1.96206e-06
1999  1.96206e-06
2000  1.96206e-06
2001  1.96206e-06
 index 2 q over time
1935  2.1085e-06
1936  2.1085e-06
1937  2.1085e-06
1938  2.1085e-06
1939  2.1085e-06
1940  2.1085e-06
1946  2.1085e-06
1947  2.1085e-06
1948  2.1085e-06
1949  2.1085e-06
1950  2.1085e-06
1951  2.1085e-06
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2002  2.1085e-06
2003  2.1085e-06
2004  2.1085e-06
2005  2.1085e-06
2006  2.1085e-06
 index 3 q over time
1951  1.81657e-06
1952  1.81657e-06
1953  1.81657e-06
1954  1.81657e-06
1955  1.81657e-06
1956  1.81657e-06
1957  1.81657e-06
1958  1.81657e-06
1959  1.81657e-06
1960  1.81657e-06
1961  1.81657e-06
1962  1.81657e-06
1963  1.81657e-06
1965  1.81657e-06
1966  1.81657e-06
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1969  1.81657e-06
1972  1.81657e-06
1978  1.81657e-06
1981  1.81657e-06
1984  1.81657e-06
1985  1.81657e-06
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1987  1.81657e-06
1988  1.81657e-06
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1996  1.81657e-06
1997  1.81657e-06
1998  1.81657e-06
2001  1.81657e-06
2003  1.81657e-06
2005  1.81657e-06
2006  1.81657e-06

Proportions of catch at age by fleet
 fleet 1
Year 1 Obs  =  0.000132971 0.178158 0.321923 0.298312 0.0746246 0.055518 0.045829 0.0182423 0.00726013
Year 1 Pred =  0.0903145 0.240889 0.260924 0.219567 0.0797179 0.0463594 0.0379632 0.0177969 0.0064679
Year 2 Obs  =  0 0.0867775 0.446367 0.301453 0.11939 0.0417583 0.00273329 0.00108783 0.000433015
Year 2 Pred =  0.0646665 0.215981 0.278072 0.219666 0.142963 0.0481097 0.0155602 0.00961806 0.00536357
Year 3 Obs  =  0 0.048402 0.505194 0.313014 0.0660961 0.0380708 0.0187757 0.00747368 0.0029743
Year 3 Pred =  0.0565302 0.162734 0.263122 0.248027 0.152097 0.0918997 0.017217 0.00417933 0.00419336
Year 4 Obs  =  0 0.0117399 0.261808 0.474939 0.113249 0.0764021 0.0397449 0.0158206 0.00629655
Year 4 Pred =  0.0577546 0.151409 0.211034 0.249844 0.182814 0.104078 0.0349953 0.00492027 0.00314965
Year 5 Obs  =  0 0.0505403 0.20803 0.348817 0.255576 0.0905435 0.0298707 0.0118901 0.00473207
Year 5 Pred =  0.024622 0.166617 0.210338 0.213592 0.195888 0.132935 0.0424679 0.010783 0.00275625
Year 6 Obs  =  0 0.0307845 0.335587 0.223908 0.256675 0.0975438 0.0356587 0.0141941 0.00564898
Year 6 Pred =  0.0209993 0.0794665 0.25589 0.232301 0.18108 0.153386 0.0589024 0.0144649 0.00351004
Year 7 Obs  =  0 0.0564975 0.0661942 0.320666 0.33166 0.174786 0.03225 0.0128372 0.00510896
Year 7 Pred =  0.0242907 0.0758024 0.134168 0.305027 0.209998 0.150352 0.073097 0.0221231 0.00514107
Year 8 Obs  =  0 0.0193028 0.17522 0.149419 0.283927 0.301928 0.0451043 0.0179539 0.00714533
Year 8 Pred =  0.0687767 0.0899924 0.130104 0.160479 0.273211 0.171794 0.0703317 0.0274772 0.00783416
Year 9 Obs  =  0.001935 0.022218 0.0390255 0.120969 0.239529 0.392018 0.118413 0.0471347 0.0187587
Year 9 Pred =  0.0778695 0.222923 0.135456 0.136808 0.126556 0.196923 0.0706377 0.0231621 0.00966478
Year 10 Obs  =  0.00893818 0.134115 0.370324 0.191463 0.0499225 0.126082 0.0765549 0.0304729 0.0121276
Year 10 Pred =  0.123202 0.212847 0.281569 0.119066 0.0901369 0.0761837 0.068291 0.0197074 0.00899745
Year 11 Obs  =  0.0170716 0.219961 0.224557 0.319107 0.105056 0.0597505 0.0354563 0.0144452 0.00459618
Year 11 Pred =  0.0855346 0.300945 0.237227 0.215318 0.0675413 0.0464963 0.0228096 0.0167795 0.00734877
Year 12 Obs  =  0.0248007 0.143047 0.460585 0.213906 0.131975 0.0194862 0.00531445 0.000885742 0
Year 12 Pred =  0.0602206 0.220093 0.348629 0.185781 0.123751 0.0351275 0.0141538 0.00581812 0.00642533
Year 13 Obs  =  0.007362 0.21227 0.360327 0.332515 0.0752556 0.010634 0.000817962 0.000817962 0
Year 13 Pred =  0.128294 0.154161 0.254938 0.273411 0.106476 0.0640689 0.0104477 0.00352767 0.00467463
Year 14 Obs  =  0 0.463869 0.168609 0.246309 0.100233 0.017871 0.00233102 0.000776952 0
Year 14 Pred =  0.0529238 0.319702 0.177592 0.20378 0.162717 0.0577305 0.0197349 0.00260468 0.00321524
Year 15 Obs  =  0.00444443 0.147556 0.647556 0.109778 0.0773333 0.0106666 0.00177775 0.000888928 0
Year 15 Pred =  0.0558446 0.142243 0.395398 0.152371 0.131013 0.0955613 0.0196991 0.0054372 0.00243249
Year 16 Obs  =  0 0.2375 0.236184 0.403289 0.101316 0.0184211 0.00263156 0 0.000657919
Year 16 Pred =  0.0700053 0.164571 0.188981 0.355688 0.100714 0.0784055 0.0334493 0.0057648 0.00242146
Year 17 Obs  =  0.0373743 0.281744 0.22185 0.163872 0.152851 0.0886441 0.0354577 0.0110205 0.00718732
Year 17 Pred =  0.0635443 0.208211 0.221047 0.171605 0.23599 0.0603542 0.0270946 0.00970296 0.00245144
Year 18 Obs  =  0.0500569 0.253697 0.308305 0.167994 0.10201 0.0652256 0.027683 0.0166857 0.00834285
Year 18 Pred =  0.0599968 0.186392 0.274111 0.196362 0.111944 0.139338 0.0210174 0.00792101 0.00291784
Year 19 Obs  =  0.168217 0.105226 0.236936 0.209019 0.137437 0.079456 0.0429492 0.0157481 0.00501085
Year 19 Pred =  0.194871 0.157399 0.21789 0.213479 0.110591 0.0566773 0.0410664 0.00530765 0.00271813
Year 20 Obs  =  0.0459588 0.62916 0.153724 0.0618066 0.0681458 0.0237718 0.0110936 0.00475437 0.00158485
Year 20 Pred =  0.105107 0.423888 0.153535 0.142823 0.102033 0.0476944 0.0142544 0.00873529 0.00193072
Year 21 Obs  =  0.00763357 0.296619 0.490185 0.123773 0.0414394 0.0267176 0.0109052 0.00163574 0.00109049
Year 21 Pred =  0.0364655 0.256957 0.457007 0.109578 0.0738503 0.0474591 0.0132388 0.00341236 0.00203191
Year 22 Obs  =  0.000981302 0.146222 0.378803 0.380766 0.0706575 0.0117763 0.00883216 0.000981302 0.000981302
Year 22 Pred =  0.0360821 0.108537 0.336065 0.391438 0.0668937 0.0402609 0.0151043 0.00370242 0.00191678
Year 23 Obs  =  0.0285714 0.110989 0.19011 0.327473 0.313187 0.0186814 0.00659342 0.00219771 0.00219771
Year 23 Pred =  0.0473546 0.120755 0.160607 0.329364 0.27721 0.0425667 0.0151349 0.00489899 0.00210768
Year 24 Obs  =  0.0277779 0.0176766 0.108586 0.108586 0.474747 0.25505 0.00505068 0.00252507 0
Year 24 Pred =  0.165195 0.142617 0.161313 0.142126 0.209738 0.158336 0.0141613 0.00435078 0.00216163
Year 25 Obs  =  0.614865 0.114865 0.0743242 0.0765767 0.0315314 0.0450448 0.0427928 0 0
Year 25 Pred =  0.363689 0.278141 0.109853 0.0849917 0.0549826 0.0734611 0.0313854 0.00232153 0.00117478
Year 26 Obs  =  0.0110974 0.764488 0.162762 0.0345253 0.0197287 0 0.00493225 0.00246605 0
Year 26 Pred =  0.0781364 0.59143 0.20427 0.0550414 0.0316917 0.0186662 0.0148841 0.00524611 0.000634005
Year 27 Obs  =  0.219298 0.249123 0.352632 0.150877 0.0157895 0.00175435 0.00350883 0.00175435 0.00526318
Year 27 Pred =  0.140386 0.161464 0.534543 0.120628 0.0232093 0.0119431 0.00415991 0.00292019 0.000746456
Year 28 Obs  =  0.00395652 0.51731 0.212661 0.18002 0.083086 0.00296739 0 0 0
Year 28 Pred =  0.0548108 0.34729 0.16949 0.356973 0.0568782 0.00972831 0.00308377 0.000979606 0.000767143
Year 29 Obs  =  0.0311493 0.123523 0.469388 0.16971 0.13319 0.0472609 0.0204082 0.00537054 0
Year 29 Pred =  0.0751391 0.160732 0.424078 0.127561 0.182896 0.0254821 0.00261971 0.000796867 0.000695175
Year 30 Obs  =  0.363234 0.084164 0.145072 0.233666 0.0996677 0.0454042 0.0287929 0 0
Year 30 Pred =  0.203188 0.183674 0.171752 0.293383 0.0619126 0.0787182 0.00629175 0.000579705 0.000500249
Year 31 Obs  =  0.0265252 0.736074 0.122016 0.0570292 0.0384615 0.0159151 0.00397886 0 0
Year 31 Pred =  0.109102 0.430195 0.172506 0.107591 0.134064 0.0255278 0.0193757 0.00132074 0.000318465
Year 32 Obs  =  0.0327868 0.256148 0.342213 0.204918 0.102459 0.034836 0.0266393 0 0
Year 32 Pred =  0.136798 0.238552 0.408739 0.106313 0.0470917 0.0523123 0.00591269 0.00399228 0.000288296
Year 33 Obs  =  0.099526 0.388626 0.2109 0.199052 0.078199 0.0165877 0.00710899 0 0
Year 33 Pred =  0.1241 0.309742 0.231839 0.254853 0.0468536 0.0184604 0.0123742 0.00126238 0.000516226
Year 34 Obs  =  0.0132497 0.417966 0.225209 0.187863 0.12687 0.0254956 0.00334697 0 0
Year 34 Pred =  0.0427988 0.311952 0.334566 0.159884 0.122859 0.0199926 0.00465224 0.00284283 0.000452208
Year 35 Obs  =  0.00592527 0.142545 0.383941 0.215353 0.184199 0.0591923 0.00884417 0 0
Year 35 Pred =  0.0391637 0.125739 0.396047 0.274275 0.0929693 0.0636488 0.00620356 0.00129149 0.00066197
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Year 36 Obs  =  0.0337332 0.187382 0.158354 0.233831 0.266371 0.102963 0.0173653 0 0
Year 36 Pred =  0.0491163 0.13789 0.186441 0.369372 0.178455 0.0534815 0.0224279 0.00202923 0.000787628
Year 37 Obs  =  0.401408 0.0388331 0.0235413 0.0522133 0.169618 0.266398 0.047988 0 0
Year 37 Pred =  0.13748 0.16884 0.19581 0.162227 0.218633 0.0923252 0.016869 0.00683703 0.000978155
Year 38 Obs  =  0.194677 0.427054 0.0769113 0.0616409 0.0523264 0.118213 0.0643685 0.00480818 0
Year 38 Pred =  0.0830409 0.379983 0.195077 0.140024 0.0792079 0.09347 0.0236608 0.00412345 0.00141333
Year 39 Obs  =  0.657835 0.145684 0.0128271 0.0917297 0.0331728 0.0237318 0.0278497 0.00660377 0.000566287
Year 39 Pred =  0.191107 0.182957 0.374194 0.127072 0.0647068 0.0326295 0.0214915 0.00473991 0.00110055
Year 40 Obs  =  0.840647 0.0566066 0.0250615 0.0400243 0.0101157 0.00970434 0.00771655 0.00588063 0.00424303
Year 40 Pred =  0.30691 0.288981 0.130777 0.190527 0.0491876 0.023035 0.00654294 0.00336038 0.000679142
Year 41 Obs  =  0.0137492 0.69875 0.179811 0.0656796 0.0209859 0.0182135 0.00281098 0 0
Year 41 Pred =  0.100998 0.495997 0.223122 0.0727456 0.0811705 0.0193379 0.00505471 0.00110254 0.000472179
Year 42 Obs  =  0.318667 0.681333 0 0 0 0 0 0 0
Year 42 Pred =  0.279183 0.535358 0.152773 0.0207564 0.00319376 0.00658595 0.00188521 7.65984e-05 0.00018752
Year 43 Obs  =  0 0.918346 0.0721092 0.00318711 0.00381488 0.00254325 0 0 0
Year 43 Pred =  0.0752309 0.743233 0.0920483 0.067562 0.0105437 0.0049304 0.00611677 0.000124611 0.000210686
Year 44 Obs  =  0.615382 0.0919161 0.136717 0.148312 0.00432343 0.00334868 0 0 0
Year 44 Pred =  0.44307 0.262596 0.167679 0.0533954 0.0450155 0.0213481 0.00600598 0.000530377 0.000358975
Year 45 Obs  =  0.050081 0.546991 0.153253 0.0329207 0.0749215 0.0883818 0.049331 0.00206004 0.00206004
Year 45 Pred =  0.164863 0.695985 0.0265252 0.0435437 0.015923 0.0408228 0.011651 0.000232955 0.000452674
Year 46 Obs  =  0.669105 0.23874 0.0758828 0.0122035 0.00406887 0 0 0 0
Year 46 Pred =  0.688077 0.20862 0.0570363 0.00555849 0.0104724 0.0116389 0.0179702 0.000364864 0.000262337
Year 47 Obs  =  0.0195705 0.955894 0.0135269 0.00990975 0.000285205 0.000541739 0.000271624 0 0
Year 47 Pred =  0.0748977 0.880615 0.0172685 0.0120986 0.00135361 0.00775097 0.00518598 0.000569657 0.000259612
Year 48 Obs  =  0.875994 0.010291 0.11054 4.70167e-05 0.00144059 0 0.00168696 0 0
Year 48 Pred =  0.88207 0.0626573 0.0476883 0.00239883 0.00192981 0.000656088 0.00226115 0.000107683 0.000231118
Year 49 Obs  =  0.229832 0.762596 0.00161824 0.00595355 0 0 0 0 0
Year 49 Pred =  0.172734 0.814403 0.00373799 0.00731206 0.000422441 0.00103281 0.000211273 5.18197e-05 9.44242e-05
Year 50 Obs  =  0.596692 0.152357 0.231306 0.00942713 0.00813682 0.00208085 0 0 0
Year 50 Pred =  0.62521 0.166492 0.18406 0.00428109 0.0162653 0.00147011 0.00132853 0.000192192 0.000701547
Year 51 Obs  =  0.000203985 0.767831 0.111662 0.113603 0.0016599 0.00504044 0 0 0
Year 51 Pred =  0.0729913 0.687785 0.0886097 0.134904 0.00306872 0.0107166 0.000695152 0.000730366 0.00049975
Year 52 Obs  =  0.397376 0.0209664 0.481455 0.0510616 0.0458306 0.00252993 0.000779936 0 0
Year 52 Pred =  0.353186 0.0843165 0.384429 0.0681795 0.10146 0.00212063 0.00531864 0.000401266 0.000588594
Year 53 Obs  =  0.12455 0.29922 0.0716614 0.451951 0.0312945 0.0200249 0.000493155 0.000804903 0
Year 53 Pred =  0.345226 0.304842 0.0351718 0.220789 0.0382451 0.0522566 0.000784458 0.00229068 0.000394272
Year 54 Obs  =  0.124414 0.279434 0.25634 0.0765293 0.239475 0.0178835 0.00592472 0 0
Year 54 Pred =  0.113403 0.43367 0.184879 0.0293886 0.180227 0.0286641 0.0281024 0.000491266 0.00117599
Year 55 Obs  =  0.0248154 0.0245617 0.387195 0.350854 0.0551877 0.155191 0.00219528 0 0
Year 55 Pred =  0.0789352 0.17405 0.32199 0.188892 0.0293247 0.165136 0.0188774 0.0215418 0.00125311
Year 56 Obs  =  0.0282877 0.00524412 0.0943585 0.481844 0.248019 0.0617107 0.0785911 0.0019442 0
Year 56 Pred =  0.165181 0.109094 0.116166 0.295659 0.169058 0.024061 0.0974815 0.012999 0.0102997
Year 57 Obs  =  0.0308318 0.165781 0.0492178 0.154192 0.475344 0.101534 0.0131711 0.00992887 0
Year 57 Pred =  0.228093 0.195013 0.0620421 0.0909187 0.225167 0.11785 0.0120689 0.057166 0.011681
Year 58 Obs  =  0.138839 0.327844 0.169457 0.0388448 0.0662747 0.188477 0.0547372 0.00753582 0.0079909
Year 58 Pred =  0.250392 0.269633 0.11102 0.0485437 0.0690438 0.156234 0.0589939 0.0070783 0.0290612
Year 59 Obs  =  0.127165 0.506432 0.230247 0.0375036 0.0201527 0.0247659 0.0332249 0.0145325 0.00597554
Year 59 Pred =  0.158839 0.330538 0.170538 0.0966008 0.0408746 0.0529674 0.0864449 0.0384045 0.0247921
Year 60 Obs  =  0.570154 0.0823816 0.196302 0.0713299 0.0154715 0.0105521 0.0139787 0.0225674 0.0172625
Year 60 Pred =  0.469972 0.13914 0.138519 0.098299 0.0537895 0.0207068 0.0193697 0.0372648 0.0229387
Year 61 Obs  =  0.10365 0.76615 0.0397887 0.0318993 0.0214395 0.0129103 0.0120773 0.00411792 0.00796741
Year 61 Pred =  0.163142 0.515182 0.0728391 0.0996988 0.0681905 0.0338849 0.00942832 0.0104223 0.0272124
Year 62 Obs  =  0.180593 0.118733 0.264447 0.0731527 0.103116 0.119672 0.0502753 0.0399953 0.0500162
Year 62 Pred =  0.30197 0.191221 0.288453 0.0558311 0.0731231 0.0451933 0.0163635 0.00541125 0.0224337
Year 63 Obs  =  0.138341 0.467133 0.111522 0.110364 0.0529952 0.0474732 0.0341453 0.0153868 0.0226398
Year 63 Pred =  0.251516 0.326119 0.0970396 0.201108 0.036922 0.043321 0.0194738 0.00848951 0.0160106
Year 64 Obs  =  0.121609 0.329654 0.134973 0.107747 0.116311 0.0885753 0.0611695 0.0287533 0.0112088
Year 64 Pred =  0.229798 0.2991 0.180514 0.074317 0.146623 0.0241396 0.0203854 0.0110389 0.0140841
Year 65 Obs  =  0.568585 0.102906 0.117101 0.0377232 0.0369103 0.0553067 0.0316353 0.0317291 0.0181029
Year 65 Pred =  0.435952 0.199289 0.122633 0.1022 0.0404891 0.0723481 0.00856464 0.008589 0.00993472
Year 66 Obs  =  0.281886 0.418543 0.109505 0.0498703 0.0633214 0.0332717 0.020579 0.016348 0.006675
Year 66 Pred =  0.305996 0.407281 0.0890681 0.0753307 0.0605698 0.0218123 0.0281735 0.00393562 0.00783323
Year 67 Obs  =  0.597211 0.275366 0.0682615 0.0127006 0.00713895 0.0183222 0.00981228 0.00684189 0.00434565
Year 67 Pred =  0.37183 0.287363 0.181413 0.054881 0.0449376 0.0328781 0.00847617 0.0129233 0.00529692
Year 68 Obs  =  0.286794 0.435129 0.124389 0.0595121 0.0370643 0.0254399 0.0135528 0.0106332 0.00748687
Year 68 Pred =  0.231455 0.398044 0.148585 0.128737 0.0378067 0.0283016 0.0149658 0.00451493 0.00759012
Year 69 Obs  =  0.160104 0.328173 0.216088 0.0853181 0.0553272 0.0501796 0.0322665 0.0274253 0.0451183
Year 69 Pred =  0.135703 0.308681 0.255476 0.130102 0.10794 0.0286917 0.0157178 0.00984609 0.00784235
Year 70 Obs  =  0.0907195 0.132568 0.258606 0.158071 0.103525 0.0889858 0.0711439 0.0431607 0.0532205
Year 70 Pred =  0.125739 0.1955 0.20993 0.235833 0.112032 0.0823767 0.016267 0.0108576 0.0114651
Year 71 Obs  =  0.313482 0.077059 0.0700383 0.159918 0.15245 0.116195 0.0508593 0.0347571 0.0252423
Year 71 Pred =  0.263959 0.158443 0.109136 0.164582 0.172659 0.0720026 0.0375944 0.00925011 0.0123728
Year 72 Obs  =  0.366854 0.191166 0.0644712 0.109169 0.128236 0.0826361 0.0354184 0.0142007 0.00784852
Year 72 Pred =  0.357997 0.25442 0.0731106 0.0684691 0.09783 0.0921431 0.0283427 0.0177145 0.00997333
Year 73 Obs  =  0.305678 0.439405 0.0756729 0.0419842 0.0518005 0.0459145 0.0211745 0.0119458 0.00642483
Year 73 Pred =  0.41718 0.310299 0.100568 0.0401636 0.0354203 0.0448957 0.0303637 0.0114355 0.00967429
Year 74 Obs  =  0.110228 0.780057 0.0787162 0.0181348 0.0034718 0.00554983 0.00384275 0 0
Year 74 Pred =  0.210708 0.460218 0.161746 0.0719437 0.0273407 0.0216673 0.0199822 0.0161969 0.0101978
Year 75 Obs  =  0.527677 0.296787 0.102162 0.0375274 0.0131551 0.0129358 0.00656773 0.00189719 0.00129092
Year 75 Pred =  0.388054 0.208582 0.212671 0.103275 0.0437437 0.0149173 0.00852312 0.00945646 0.0107779
Year 76 Obs  =  0.79319 0.120929 0.039149 0.0283708 0.0120824 0.00242117 0.00161412 0.000629423 0.00161412
Year 76 Pred =  0.521106 0.253221 0.0642355 0.0904554 0.0422152 0.0161755 0.00396712 0.00269619 0.00592815
Year 77 Obs  =  0.815607 0.112104 0.0574635 0.00831505 0.00325068 0.00198288 0.00102078 0.000256591 0
Year 77 Pred =  0.549042 0.301727 0.069955 0.0244427 0.0332519 0.0141132 0.00389627 0.0011275 0.00244397
Year 78 Obs  =  0.696374 0.230338 0.0457493 0.018179 0.00532952 0.00194578 0.00161627 0.000468371 0
Year 78 Pred =  0.516518 0.338745 0.0888929 0.0284166 0.00961635 0.0119197 0.00363706 0.001182 0.00107223
Year 79 Obs  =  0 0 0 0 0 0 0 0 0
Year 79 Pred =  0.127849 0.58549 0.184142 0.066599 0.020685 0.00639619 0.00569674 0.00203792 0.00110491

Proportions of Discards at age by fleet
 fleet 1
Year 1 Obs  =  0 0 0 0 0 0 0 0 0
Year 1 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 2 Obs  =  0 0 0 0 0 0 0 0 0
Year 2 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
```

```
Year 3 Obs  =  0 0 0 0 0 0 0 0 0
Year 3 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 4 Obs  =  0 0 0 0 0 0 0 0 0
Year 4 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 5 Obs  =  0 0 0 0 0 0 0 0 0
Year 5 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 6 Obs  =  0 0 0 0 0 0 0 0 0
Year 6 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 7 Obs  =  0 0 0 0 0 0 0 0 0
Year 7 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 8 Obs  =  0 0 0 0 0 0 0 0 0
Year 8 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 9 Obs  =  0 0 0 0 0 0 0 0 0
Year 9 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 10 Obs  =  0 0 0 0 0 0 0 0 0
Year 10 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 11 Obs  =  0 0 0 0 0 0 0 0 0
Year 11 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 12 Obs  =  0 0 0 0 0 0 0 0 0
Year 12 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 13 Obs  =  0 0 0 0 0 0 0 0 0
Year 13 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 14 Obs  =  0 0 0 0 0 0 0 0 0
Year 14 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 15 Obs  =  0 0 0 0 0 0 0 0 0
Year 15 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 16 Obs  =  0 0 0 0 0 0 0 0 0
Year 16 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 17 Obs  =  0 0 0 0 0 0 0 0 0
Year 17 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 18 Obs  =  0 0 0 0 0 0 0 0 0
Year 18 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 19 Obs  =  0 0 0 0 0 0 0 0 0
Year 19 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 20 Obs  =  0 0 0 0 0 0 0 0 0
Year 20 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 21 Obs  =  0 0 0 0 0 0 0 0 0
Year 21 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 22 Obs  =  0 0 0 0 0 0 0 0 0
Year 22 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 23 Obs  =  0 0 0 0 0 0 0 0 0
Year 23 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 24 Obs  =  0 0 0 0 0 0 0 0 0
Year 24 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 25 Obs  =  0 0 0 0 0 0 0 0 0
Year 25 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 26 Obs  =  0 0 0 0 0 0 0 0 0
Year 26 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 27 Obs  =  0 0 0 0 0 0 0 0 0
Year 27 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 28 Obs  =  0 0 0 0 0 0 0 0 0
Year 28 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 29 Obs  =  0 0 0 0 0 0 0 0 0
Year 29 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 30 Obs  =  0 0 0 0 0 0 0 0 0
Year 30 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 31 Obs  =  0 0 0 0 0 0 0 0 0
Year 31 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 32 Obs  =  0 0 0 0 0 0 0 0 0
Year 32 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 33 Obs  =  0 0 0 0 0 0 0 0 0
Year 33 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 34 Obs  =  0 0 0 0 0 0 0 0 0
Year 34 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 35 Obs  =  0 0 0 0 0 0 0 0 0
Year 35 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 36 Obs  =  0 0 0 0 0 0 0 0 0
Year 36 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 37 Obs  =  0 0 0 0 0 0 0 0 0
Year 37 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 38 Obs  =  0 0 0 0 0 0 0 0 0
Year 38 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 39 Obs  =  0 0 0 0 0 0 0 0 0
Year 39 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 40 Obs  =  0 0 0 0 0 0 0 0 0
Year 40 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 41 Obs  =  0 0 0 0 0 0 0 0 0
Year 41 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 42 Obs  =  0 0 0 0 0 0 0 0 0
Year 42 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 43 Obs  =  0 0 0 0 0 0 0 0 0
Year 43 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 44 Obs  =  0 0 0 0 0 0 0 0 0
Year 44 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 45 Obs  =  0 0 0 0 0 0 0 0 0
Year 45 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 46 Obs  =  0 0 0 0 0 0 0 0 0
Year 46 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 47 Obs  =  0 0 0 0 0 0 0 0 0
Year 47 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 48 Obs  =  0 0 0 0 0 0 0 0 0
Year 48 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 49 Obs  =  0 0 0 0 0 0 0 0 0
Year 49 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 50 Obs  =  0 0 0 0 0 0 0 0 0
```

```
Year 50 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 51 Obs  =  0 0 0 0 0 0 0 0 0
Year 51 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 52 Obs  =  0 0 0 0 0 0 0 0 0
Year 52 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 53 Obs  =  0 0 0 0 0 0 0 0 0
Year 53 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 54 Obs  =  0 0 0 0 0 0 0 0 0
Year 54 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 55 Obs  =  0 0 0 0 0 0 0 0 0
Year 55 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 56 Obs  =  0 0 0 0 0 0 0 0 0
Year 56 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 57 Obs  =  0 0 0 0 0 0 0 0 0
Year 57 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 58 Obs  =  0 0 0 0 0 0 0 0 0
Year 58 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 59 Obs  =  0 0 0 0 0 0 0 0 0
Year 59 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 60 Obs  =  0 0 0 0 0 0 0 0 0
Year 60 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 61 Obs  =  0 0 0 0 0 0 0 0 0
Year 61 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 62 Obs  =  0 0 0 0 0 0 0 0 0
Year 62 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 63 Obs  =  0 0 0 0 0 0 0 0 0
Year 63 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 64 Obs  =  0 0 0 0 0 0 0 0 0
Year 64 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 65 Obs  =  0 0 0 0 0 0 0 0 0
Year 65 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 66 Obs  =  0 0 0 0 0 0 0 0 0
Year 66 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 67 Obs  =  0 0 0 0 0 0 0 0 0
Year 67 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 68 Obs  =  0 0 0 0 0 0 0 0 0
Year 68 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 69 Obs  =  0 0 0 0 0 0 0 0 0
Year 69 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 70 Obs  =  0 0 0 0 0 0 0 0 0
Year 70 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 71 Obs  =  0 0 0 0 0 0 0 0 0
Year 71 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 72 Obs  =  0 0 0 0 0 0 0 0 0
Year 72 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 73 Obs  =  0 0 0 0 0 0 0 0 0
Year 73 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 74 Obs  =  0 0 0 0 0 0 0 0 0
Year 74 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 75 Obs  =  0 0 0 0 0 0 0 0 0
Year 75 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 76 Obs  =  0 0 0 0 0 0 0 0 0
Year 76 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 77 Obs  =  0 0 0 0 0 0 0 0 0
Year 77 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 78 Obs  =  0 0 0 0 0 0 0 0 0
Year 78 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15
Year 79 Obs  =  0 0 0 0 0 0 0 0 0
Year 79 Pred =  1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15 1e-15

F Reference Points Using Final Year Selectivity Scaled Max=1.0
 refpt           F       slope to plot on SRR
  F0.1     0.561938     13.1564
  Fmax     9.99999     6440.53
  F30%SPR  0.424104     9.64335
  F40%SPR  0.308242     7.2325
  Fmsy     0.123101     4.29711    SSmsy    118603     MSY   20661.9
  Foy      0.0923259     xxxxxx    SSoy    153905     OY   19513.3
  Fcurrent 0.0783117     3.73962

Stock-Recruitment Relationship Parameters
 alpha     = 1.52404e+06
 beta      = 236062
 virgin    = 185424
 steepness = 0.308615
Spawning Stock, Obs Recruits(year+1), Pred Recruits(year+1)
1929  1.16277e+06  2.94343e+06  1.26685e+06
1930  1.06053e+06  2.55425e+06  1.24656e+06
1931  1.02042e+06  2.43421e+06  1.23771e+06
1932  978710  894967  1.22788e+06
1933  883367  583607  1.20265e+06
1934  747106  455935  1.15811e+06
1935  592114  844859  1.08963e+06
1936  451514  716790  1.0008e+06
1937  344994  1.00357e+06  904874
1938  267252  683986  809239
1939  237022  444659  763565
1940  188787  883869  677224
1941  162671  354547  621760
1942  145339  335498  580759
1943  145301  339405  580664
1944  126880  247012  532783
1945  104667  188381  468160
1946  87674.6  550999  412740
1947  68557.4  323971  342998
```

```
1948  59430.2  107598  306518
1949  56177.7  83756.1  292967
1950  49532.7  77089.8  264324
1951  43205.7  210352  235785
1952  35014.5  662508  196857
1953  29896.2  207874  171316
1954  32920  421322  186523
1955  40177.4  151306  221662
1956  46514.6  159643  250870
1957  41765.9  413086  229108
1958  34537.8  246057  194519
1959  35839.6  327459  200884
1960  37545.9  301526  209136
1961  37780.9  95408.9  210264
1962  40440  68648.9  222899
1963  40078.7  55426.6  221197
1964  30919  101160  176498
1965  19681.3  50033.9  117285
1966  14235.1  124302  86675.9
1967  11612.3  324593  71454.9
1968  13447.4  163732  82138.6
1969  20533.4  188980  121957
1970  31397.3  42171.5  178908
1971  41783.9  156853  229192
1972  46056.1  82248.7  248800
1973  49676.8  601704  264959
1974  55446  113283  289878
1975  70293.5  3.52284e+06  349691
1976  95840  1.64842e+06  440080
1977  148673  6.64599e+06  588932
1978  263041  749739  803209
1979  397917  3.33316e+06  956561
1980  472604  3.99148e+06  1.01637e+06
1981  590565  1.10321e+06  1.08881e+06
1982  662372  529493  1.1236e+06
1983  641691  841667  1.11416e+06
1984  623557  1.02532e+06  1.10552e+06
1985  539151  983582  1.05995e+06
1986  459036  481162  1.00646e+06
1987  378397  1.64298e+06  938534
1988  324384  521270  882106
1989  258032  806597  795901
1990  231281  583382  754222
1991  190701  421100  681021
1992  145855  908875  582033
1993  127578  687579  534687
1994  105836  897366  471771
1995  117870  541059  507548
1996  128394  235404  536901
1997  137003  135354  559681
1998  113751  190579  495582
1999  81273.4  255315  390324
2000  64071.2  305743  325345
2001  40163.6  133326  221597
2002  33738.5  233929  190580
2003  39714.3  472241  219475
2004  41169.2  866391  226321
2005  39433  1.34358e+06  218143
2006  56496.3  302694  294308
2007  86777.2       xxxx   409651

average F (ages 4 to 8 unweighted) by year
Projection into Future
Projected NAA
 2 177720 447948 162367 48656.1 12730.1 3600.52 4149.56 3274.45
 2 1.15262 98360.1 250860 89487.8 26358.3 6826.88 1983.86 4200.26
Projected Directed FAA
 0.0511126 0.0915722 0.0797821 0.095757 0.112995 0.123101 0.0960335 0.0865784 0.0484304
 0.0511126 0.0915722 0.0797821 0.095757 0.112995 0.123101 0.0960335 0.0865784 0.0484304
Projected Discard FAA
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
Projected Nondirected FAA
 -0 -0 -0 -0 -0 -0 -0 -0 -0
 -0 -0 -0 -0 -0 -0 -0 -0 -0
Projected Catch at Age
 0.07859 12284.4 27120.7 11714 4110.21 1166.25 260.478 271.798 122.066
 0.07859 0.0796717 5955.14 18098.4 7559.47 2414.78 493.887 129.944 156.579
Projected Discards at Age (in numbers)
 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0
Projected Yield at Age
 0.00903785 2849.99 9790.57 5962.43 2938.8 926.004 220.624 249.511 114.132
 0.00903785 0.0184838 2149.8 9212.06 5405.02 1917.34 418.322 119.288 146.401
Year, Total Yield (in weight), Total Discards (in weight), SSB, proj_what, SS/SSmsy
2008  23052.1  0  127581  0  1.07569
2009  19368.3  0  148058  0  1.24834

M =  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5
mature =  0 0.07 0.25 0.47 0.73 1 1 1 1
 0 0.07 0.25 0.47 0.73 1 1 1 1
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 0 0.07 0.25 0.47 0.73 1 1 1 1
 0 0.07 0.25 0.47 0.73 1 1 1 1
 0 0.07 0.25 0.47 0.73 1 1 1 1
Weight at age
 0.074 0.167 0.297 0.402 0.523 0.615 0.704 0.8 0.83
 0.06 0.139 0.301 0.422 0.511 0.603 0.698 0.8 0.83
 0.077 0.114 0.276 0.399 0.527 0.606 0.701 0.8 0.83
 0.058 0.081 0.277 0.379 0.508 0.604 0.711 0.8 0.83
 0.059 0.083 0.2 0.299 0.493 0.585 0.7 0.8 0.83
 0.065 0.142 0.198 0.233 0.431 0.538 0.683 0.8 0.83
 0.079 0.186 0.217 0.251 0.379 0.472 0.629 0.79 0.83
 0.086 0.193 0.284 0.338 0.393 0.453 0.574 0.75 0.82
 0.119 0.176 0.318 0.429 0.461 0.502 0.575 0.74 0.8
 0.124 0.174 0.31 0.448 0.532 0.582 0.633 0.726 0.79
 0.191 0.246 0.363 0.46 0.583 0.68 0.775 0.795 0.878
 0.18 0.26 0.339 0.442 0.527 0.64 0.729 0.834 0.82
 0.115 0.259 0.343 0.439 0.559 0.65 0.806 0.807 0.85
 0.18 0.236 0.373 0.471 0.546 0.626 0.684 0.909 0.83
 0.165 0.292 0.339 0.474 0.574 0.65 0.629 0.881 1
 0.144 0.271 0.379 0.472 0.587 0.66 0.754 0.735 0.948
 0.121 0.234 0.383 0.494 0.611 0.704 0.745 0.819 0.842
 0.125 0.261 0.384 0.487 0.617 0.679 0.736 0.778 0.812
 0.119 0.291 0.4 0.499 0.622 0.709 0.753 0.788 0.818
 0.107 0.227 0.354 0.506 0.616 0.706 0.764 0.895 0.871
 0.109 0.192 0.319 0.456 0.607 0.725 0.799 0.917 0.917
```

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 0.084 0.249 0.323 0.455 0.564 0.664 0.784 0.799 0.871
 0.162 0.255 0.346 0.429 0.569 0.694 0.827 0.835 0.853
 0.173 0.297 0.386 0.471 0.568 0.719 0.832 0.988 0.85
 0.162 0.296 0.411 0.512 0.603 0.763 0.834 0.85 1.1
 0.084 0.257 0.387 0.505 0.585 0.744 0.701 0.879 0.87
 0.14 0.253 0.357 0.484 0.583 0.744 0.762 0.778 0.878
 0.111 0.248 0.373 0.485 0.598 0.752 0.722 0.91 0.87
 0.179 0.31 0.374 0.509 0.602 0.649 0.65 0.7 1
 0.176 0.292 0.396 0.488 0.617 0.685 0.775 0.75 0.75
 0.132 0.251 0.398 0.51 0.602 0.702 0.754 0.84 0.85
 0.102 0.276 0.391 0.507 0.611 0.699 0.768 0.82 0.87
 0.144 0.252 0.389 0.495 0.584 0.647 0.817 0.83 0.85
 0.276 0.32 0.42 0.54 0.622 0.712 0.782 0.89 0.86
 0.197 0.298 0.434 0.538 0.627 0.73 0.743 0.84 0.93
 0.181 0.3 0.4 0.503 0.612 0.748 0.812 0.82 0.87
 0.109 0.195 0.384 0.501 0.596 0.723 0.735 0.88 0.85
 0.149 0.273 0.419 0.525 0.658 0.79 0.833 0.85 0.93
 0.166 0.235 0.488 0.51 0.599 0.723 0.869 0.917 0.849
 0.138 0.266 0.391 0.562 0.593 0.709 0.902 0.952 1.07
 0.103 0.322 0.428 0.505 0.662 0.746 0.907 1 1.1
 0.099 0.232 0.402 0.584 0.73 0.837 0.85 1 1.2
 0.266 0.282 0.457 0.481 0.74 0.955 0.88 0.9 1.2
 0.147 0.266 0.449 0.508 0.552 0.746 1 0.9 1.1
 0.119 0.329 0.433 0.609 0.606 0.686 0.758 0.803 0.838
 0.107 0.303 0.604 0.74 0.837 0.8 0.8 0.8 1
 0.127 0.361 0.517 0.973 1.053 1.029 1.35 0.9 0.9
 0.17 0.297 0.672 0.864 1.291 1.223 1.531 1.2 1
 0.122 0.322 0.6 0.847 1.063 1.1 1.3 1.5 1.3
 0.062 0.334 0.473 0.705 0.908 1.1 1.2 1.4 1.6
 0.082 0.189 0.44 0.598 0.81 0.969 1.2 1.3 1.5
 0.072 0.176 0.27 0.437 0.598 0.874 1.066 1.3 1.4
 0.083 0.19 0.239 0.391 0.597 0.715 0.953 0.929 1.4
 0.032 0.151 0.237 0.345 0.516 0.773 0.916 1 1.2
 0.049 0.191 0.302 0.39 0.458 0.511 0.688 0.9 1.1
 0.12 0.235 0.351 0.396 0.505 0.614 0.638 0.871 0.91
 0.157 0.285 0.418 0.461 0.484 0.56 0.612 0.697 0.85
 0.148 0.29 0.408 0.508 0.561 0.595 0.63 0.719 0.784
 0.133 0.272 0.414 0.523 0.6 0.691 0.717 0.766 0.826
 0.101 0.301 0.415 0.576 0.666 0.734 0.806 0.815 0.899
 0.104 0.193 0.381 0.542 0.647 0.749 0.757 0.739 0.827
 0.094 0.267 0.377 0.554 0.649 0.68 0.749 0.775 0.803
 0.071 0.217 0.397 0.514 0.591 0.664 0.724 0.766 0.799
 0.087 0.175 0.33 0.459 0.544 0.661 0.691 0.725 0.805
 0.073 0.228 0.294 0.408 0.583 0.607 0.72 0.756 0.832
 0.1 0.156 0.248 0.361 0.493 0.597 0.644 0.733 0.785
 0.081 0.179 0.275 0.431 0.586 0.689 0.74 0.758 0.92
 0.105 0.182 0.318 0.471 0.589 0.649 0.674 0.705 0.751
 0.149 0.239 0.333 0.446 0.572 0.637 0.719 0.718 0.749
 0.139 0.267 0.325 0.419 0.53 0.615 0.631 0.667 0.689
 0.148 0.228 0.399 0.509 0.575 0.633 0.688 0.754 0.768
 0.114 0.266 0.37 0.55 0.59 0.608 0.646 0.712 0.731
 0.103 0.253 0.347 0.534 0.567 0.619 0.617 0.635 0.627
 0.133 0.218 0.303 0.412 0.552 0.687 0.656 0.728 0.65
 0.125 0.284 0.414 0.603 0.679 0.745 0.809 0.794 0.838
 0.159 0.28 0.407 0.596 0.685 0.821 0.926 0.82 0.902
 0.106 0.267 0.38 0.463 0.556 0.665 0.737 0.797 0.84
 0.115 0.232 0.361 0.509 0.715 0.794 0.847 0.918 0.935
 0.115 0.232 0.361 0.509 0.715 0.794 0.847 0.918 0.935
Fecundity
 0 0.01169 0.07425 0.18894 0.38179 0.615 0.704 0.8 0.83
 0 0.00973 0.07525 0.19834 0.37303 0.603 0.698 0.8 0.83
 0 0.00798 0.069 0.18753 0.38471 0.606 0.701 0.8 0.83
 0 0.00567 0.06925 0.17813 0.37084 0.604 0.711 0.8 0.83
 0 0.00581 0.05 0.14053 0.35989 0.585 0.7 0.8 0.83
 0 0.00994 0.0495 0.10951 0.31463 0.538 0.683 0.8 0.83
 0 0.01302 0.05425 0.11797 0.27667 0.472 0.629 0.79 0.83
 0 0.01351 0.071 0.15886 0.28689 0.453 0.574 0.75 0.82
 0 0.01232 0.0795 0.20163 0.33653 0.502 0.575 0.74 0.8
 0 0.01218 0.0775 0.21056 0.38836 0.582 0.633 0.726 0.79
 0 0.01722 0.09075 0.2162 0.42559 0.68 0.775 0.795 0.878
 0 0.0182 0.08475 0.20774 0.38471 0.64 0.729 0.834 0.82
 0 0.01813 0.08575 0.20633 0.40807 0.65 0.806 0.807 0.85
 0 0.01652 0.09325 0.22137 0.39858 0.626 0.684 0.909 0.83
 0 0.02044 0.08475 0.22278 0.41902 0.65 0.629 0.881 1
 0 0.01897 0.09475 0.22184 0.42851 0.66 0.754 0.735 0.948
 0 0.01638 0.09575 0.23218 0.44603 0.704 0.745 0.819 0.842
 0 0.01827 0.096 0.22889 0.45041 0.679 0.736 0.778 0.812
 0 0.02037 0.1 0.23453 0.45406 0.709 0.753 0.788 0.818
 0 0.01589 0.0885 0.23782 0.44968 0.706 0.764 0.895 0.871
 0 0.01344 0.07975 0.21432 0.44311 0.725 0.799 0.917 0.917
 0 0.01743 0.08075 0.21385 0.41172 0.664 0.784 0.799 0.871
 0 0.01785 0.0865 0.20163 0.41537 0.694 0.827 0.835 0.853
 0 0.02079 0.0965 0.22137 0.41464 0.719 0.832 0.988 0.85
 0 0.02072 0.10275 0.24064 0.44019 0.763 0.834 0.85 1.1
 0 0.01799 0.09675 0.23735 0.42705 0.744 0.701 0.879 0.87
 0 0.01771 0.08925 0.22748 0.42559 0.744 0.762 0.778 0.878
 0 0.01736 0.09325 0.22795 0.43654 0.752 0.722 0.91 0.87
 0 0.0217 0.0935 0.23923 0.43946 0.649 0.65 0.7 1
 0 0.02044 0.099 0.22936 0.45041 0.685 0.775 0.75 0.75
 0 0.01757 0.0995 0.2397 0.43946 0.702 0.754 0.84 0.85
 0 0.01932 0.09775 0.23829 0.44603 0.699 0.768 0.82 0.87
 0 0.01764 0.09725 0.23265 0.42632 0.647 0.817 0.83 0.85
 0 0.0224 0.105 0.2538 0.45406 0.712 0.782 0.89 0.86
 0 0.02086 0.1085 0.25286 0.45771 0.73 0.743 0.84 0.93
 0 0.021 0.1 0.23641 0.44676 0.748 0.812 0.82 0.87
```

```
 0 0.01365 0.096 0.23547 0.43508 0.723 0.735 0.88 0.85
 0 0.01911 0.10475 0.24675 0.48034 0.79 0.833 0.85 0.93
 0 0.01645 0.122 0.2397 0.43727 0.723 0.869 0.917 0.849
 0 0.01862 0.09775 0.26414 0.43289 0.709 0.902 0.952 1.07
 0 0.02254 0.107 0.23735 0.48326 0.746 0.907 1 1.1
 0 0.01624 0.1005 0.27448 0.5329 0.837 0.85 1 1.2
 0 0.01974 0.11425 0.22607 0.5402 0.955 0.88 0.9 1.2
 0 0.01862 0.11225 0.23876 0.40296 0.746 1 0.9 1.1
 0 0.02303 0.10825 0.28623 0.44238 0.686 0.758 0.803 0.838
 0 0.02121 0.151 0.3478 0.61101 0.8 0.8 0.8 1
 0 0.02527 0.12925 0.45731 0.76869 1.029 1.35 0.9 0.9
 0 0.02079 0.168 0.40608 0.94243 1.223 1.531 1.2 1
 0 0.02254 0.15 0.39809 0.77599 1.1 1.3 1.5 1.3
 0 0.02338 0.11825 0.33135 0.66284 1.1 1.2 1.4 1.6
 0 0.01323 0.11 0.28106 0.5913 0.969 1.2 1.3 1.5
 0 0.01232 0.0675 0.20539 0.43654 0.874 1.066 1.3 1.4
 0 0.0133 0.05975 0.18377 0.43581 0.715 0.953 0.929 1.4
 0 0.01057 0.05925 0.16215 0.37668 0.773 0.916 1 1.2
 0 0.01337 0.0755 0.1833 0.33434 0.511 0.688 0.9 1.1
 0 0.01645 0.08775 0.18612 0.36865 0.614 0.638 0.871 0.91
 0 0.01995 0.1045 0.21667 0.35332 0.56 0.612 0.697 0.85
 0 0.0203 0.102 0.23876 0.40953 0.595 0.63 0.719 0.784
 0 0.01904 0.1035 0.24581 0.438 0.691 0.717 0.766 0.826
 0 0.02107 0.10375 0.27072 0.48618 0.734 0.806 0.815 0.899
 0 0.01351 0.09525 0.25474 0.47231 0.749 0.757 0.739 0.827
 0 0.01869 0.09425 0.26038 0.47377 0.68 0.749 0.775 0.803
 0 0.01519 0.09925 0.24158 0.43143 0.664 0.724 0.766 0.799
 0 0.01225 0.0825 0.21573 0.39712 0.661 0.691 0.725 0.805
 0 0.01596 0.0735 0.19176 0.42559 0.607 0.72 0.756 0.832
 0 0.01092 0.062 0.16967 0.35989 0.597 0.644 0.733 0.785
 0 0.01253 0.06875 0.20257 0.42778 0.689 0.74 0.758 0.92
 0 0.01274 0.0795 0.22137 0.42997 0.649 0.674 0.705 0.751
 0 0.01673 0.08325 0.20962 0.41756 0.637 0.719 0.718 0.749
 0 0.01869 0.08125 0.19693 0.3869 0.615 0.631 0.667 0.689
 0 0.01596 0.09975 0.23923 0.41975 0.633 0.688 0.754 0.768
 0 0.01862 0.0925 0.2585 0.4307 0.608 0.646 0.712 0.731
 0 0.01771 0.08675 0.25098 0.41391 0.619 0.617 0.635 0.627
 0 0.01526 0.07575 0.19364 0.40296 0.687 0.656 0.728 0.65
 0 0.01988 0.1035 0.28341 0.49567 0.745 0.809 0.794 0.838
 0 0.0196 0.10175 0.28012 0.50005 0.821 0.926 0.82 0.902
 0 0.01869 0.095 0.21761 0.40588 0.665 0.737 0.797 0.84
 0 0.01624 0.09025 0.23923 0.52195 0.794 0.847 0.918 0.935
 0 0.01624 0.09025 0.23923 0.52195 0.794 0.847 0.918 0.935

SSmsy_ratio = 1.05289
Fmsy_ratio =  0.636157
that's all
```

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A FLEXIBLE FORWARD AGE-STRUCTURED ASSESSMENT PROGRAM

Christopher M. Legault[1], *Victor R. Restrepo*[2]

SUMMARY

This paper documents an age-structured assessment program (ASAP) which incorporates various modeling features that have been discussed by the SCRS in recent years, particularly during meetings of the bluefin tuna species group. The software was developed using the commercial package of AD Model Builder, an efficient too for optimization that uses an automatic differentiation algorithm in order to find a solution quickly using derivatives calculated to within machine precision, even when the number of parameters being estimated is rather large. The model is based on forward computations assuming separability of fishing mortality into year and age components. This assumption is relaxed by allowing for fleet-specific computations and by allowing the selectivity at age to change smoothly over time. The software can also allow the catchability associated with each abundance index to vary smoothly with time. The problem's dimensions (number of ages, years, fleets and abundance indices) are defined at input and limited by hardware only. We illustrate an application of ASAP using data for western Atlantic bluefin tuna.

RÉSUMÉ

Le présent travail documente un programme d'évaluation structuré par âge (ASAP) qui comprend plusieurs facettes de modélisation qui ont été abordées par le SCRS ces dernières années, notamment pendant les sessions du groupe d'espèce thon rouge. Le logiciel a été élaboré au moyen du programme commercial AD Model Builder, qui est un outil efficace d'optimisation utilisant un algorithme différentiel automatique pour arriver rapidement à une solution au moyen de dérivatifs calculés avec une précision quasi-mécanique, même lorsque le nombre de paramètres à estimer est assez important. Le modèle se base sur des calculs forward postulant que la mortalité par pêche peut être ventilée par année et par âge. Ce postulat est rendu plus flexible par le fait qu'il prévoit la réalisation de calculs en fonction de la flottille, ainsi que l'évolution progressive dans le temps de la sélectivité par âge. Le logiciel peut aussi tenir compte de la variation graduelle dans le temps de la capturabilité associée à chaque indice de l'abondance. Les dimensions du problème (nombre d'âges, d'années, de flottilles et d'indices d'abondance) sont définies en tant que données d'entrée et ne sont limitées que par le matériel. Une application de l'ASAP à des données sur le thon rouge de l'Atlantique ouest est présentée à titre d'illustration.

RESUMEN

Este papel documenta un programa de evaluación estructurado por edad (ASAP), que incorpora varias características de modelización discutidas por el SCRS en años recientes, particularmente durante las reuniones del Grupo de especies del atún rojo. Se desarrolló el programa utilizando el paquete comercial AD Model Builder, una eficaz herramienta para la optimización, que utiliza un algoritmo de diferenciación automática para hallar una rápida solución empleando derivados calculados con precisión, incluso cuando el número de parámetros que se estima es amplio. El modelo se basa en cálculos "forward" que asumen la capacidad de separación de la mortalidad por pesca en componentes anuales y por edad. Este supuesto se suaviza permitiendo a lo largo del tiempo el cambio progresivo de los cálculos específicos de la flota y la de la selectividad por clases de edad. El programa también permite que la capturabilidad asociada a cada índice de abundancia varíe gradualmente a lo largo del tiempo. Las dimensiones del problema (números de edades, años, flotas e índices de abundancia) se definen en los datos de entrada y sólo están limitados por el hardware. Se ilustra una aplicación de ASAP que utiliza datos para el atún rojo del Atlántico oeste.

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Introduction

Stock assessment algorithms explain observed data through a statistical estimation procedure based on a number of assumptions. The number and severity of these assumptions are determined by the algorithm and reflect not only the user's paradigms but also the amount and quality of the available data. We present an age-structured assessment program (ASAP) which allows easy comparison of results when certain assumptions are made or relaxed. Specifically, ASAP is a flexible forward program that allows the assumption of separability of gear specific fishing mortality into year and age components to be relaxed and change over time. The assumption of constant catchability coefficients for scaling observed indices of abundance can also be relaxed to change over time. The advantage of this flexibility is an increased ability to fit models and less reliance on assumptions that are thought to be too strict. The disadvantage of such an approach is exactly this ability to explain the data in more (and possibly contradictory) ways through different choices in the amount of variability in the changing parameters. Explicit choices for relative weightings amongst the different parts of the objective function must be made. Slight changes in these parameter weightings in a complex model can produce vastly different results, while a simpler model will be more consistent (not necessarily more accurate) relative to changes in the parameter weightings.

Allowing flexibility in selectivity and catchability greatly increases the number of parameters to be estimated. We use the commercial software package AD Model Builder to estimate the relatively large number of parameters. The software package is based on a C++ library of automatic differentiation code (see Greiwank and Corliss 1991) which allows relatively fast convergence by calculating derivatives to machine precision accuracy. These derivatives are used in a quasi-Newton search routine to minimize the objective function. The array sizes for parameters are defined on input and limited only by hardware. Currently, ASAP is compiled to estimate a maximum of 5,000 parameters, but this can be increased by changing one line of code.

The AD Model Builder software package allows many matrix operations to be programmed easily in its template language and allows for the estimation of parameters to occur in phases. The phases work by estimating only some parameters initially and adding more parameters in a stepwise fashion until all parameters are estimated. When new parameters are added by incrementing the phase, the previously estimated parameters are still estimated, not fixed at the previous values. These phases also allow easy switching between simple and complex models by simply turning on or off phases through the input file. For example, index specific catchability coefficients can be allowed to change or have a constant value over time. An additional feature of the AD Model Builder software is easy likelihood profiling of specified variables, although this can be time consuming for models with large numbers of parameters. We first describe ASAP with all the features and then compare two analyses for bluefin tuna using different levels of complexity in the program.

The Model

Population dynamics

The model's population dynamics follow a standard form common to forward-projection methods such as those of Fournier and Archibald (1982), Deriso et al. (1985), Methot (1998), Ianelli and Fornier (1998), and Porch and Turner (In Press). Catches and fishing mortalities can be modeled as being fleet-specific.

Let a = age, 1...A,
y = year, 1...Y
g = fleet 1....G
u = abundance index series, 1....U

Selectivity (S) at age within a year by a fleet can be limited to a range of ages and averages one, as opposed to having a maximum of one,

$$\frac{\sum_{a(g_{start})}^{a(g_{end})} S_{a,y,g}}{a(g_{end})-a(g_{start})+1}=1.0 \tag{1}$$

where $a(g_{start})$ and $a(g_{end})$ denote the starting and ending ages for the gear's selectivity. The output of the program makes the simple conversion from averaging one to having a maximum of one in order to simplify comparisons with other models.

Fishing mortality is modeled as the product of the selectivity at age within a year by a fleet and a year and fleet specific fishing mortality multiplier ($Fmult_{y,g}$)

$$F_{a,y,g}=S_{a,y,g}Fmult_{y,g}\,. \tag{2}$$

Total fishing mortality at age and year is the sum of the fleet specific fishing mortality rates

$$Ftot_{a,y}=\sum_g F_{a,y,g} \tag{3}$$

and adding the natural mortality rate (M) produces the total mortality rate

$$Z_{a,y}=Ftot_{a,y}+M_{a,y}\,. \tag{4}$$

The catch by age, year and fleet is

$$C_{a,y,g}=\frac{N_{a,y}F_{a,y,g}(1-e^{-Z_{a,y}})}{Z_{a,y}} \tag{5}$$

where N denotes population abundance at the start of the year.

The yield by age, year and fleet is

$$Y_{a,y,g}=C_{a,y,g}W_{a,y} \tag{6}$$

where $W_{a,y}$ denotes weight of an individual fish of age a in year y.

The proportion of catch at age within a year for a fleet is

$$P_{a,y,g} = \frac{C_{a,y,g}}{\sum_a C_{a,y,g}}. \qquad (7)$$

The forward projections begin by computing recruitment as deviations from an average value

$$N_{1,y} = \bar{N}_1 e^{\upsilon_y} \qquad (8)$$

where υ_y~N(0,σ_{Ny}^2) and the other numbers at age in the first year as deviations from equilibrium

$$N_{a,1} = N_{1,1} e^{-\sum_{i=1}^{a-1} Z_{i,1}} e^{\psi_a} \qquad for\ a < A$$

$$N_{a,1} = \frac{N_{1,1} e^{-\sum_{i=1}^{a-1} Z_{i,1}}}{1-e^{-Z_{A,1}}} e^{\psi_a} \qquad for\ a = A \qquad (9)$$

where ψ_a~N(0,σ_{Na}^2). The remaining population abundance at age and year is then computed

$$N_{a,y} = N_{a-1,y-1} e^{-Z_{a-1,y-1}} \qquad for\ a < A$$

$$N_{a,y} = N_{a-1,y-1} e^{-Z_{a-1,y-1}} + N_{a,y-1} e^{-Z_{a,y-1}} \qquad for\ a = A. \qquad (10)$$

Predicted indices of abundance ($\hat{I}$) are a measure of the population scaled by catchability coefficients (q) and selectivity at age (S)

$$\hat{I}_{u,y} = q_{u,y} \sum_{a(u_{start})}^{a(u_{end})} S_{u,a,y} N^*_{a,y} \qquad (11)$$

where $a(u_{start})$ and $a(u_{end})$ are the index specific starting and ending ages, respectively, and N^* corresponds to the population abundance in either numbers or weight at a specific time during the year. The abundance index selectivity at age can either be input or linked to a specific fleet. If the latter is chosen, the age range can be smaller than that of the fleet and the annual selectivity patterns are rescaled to equal 1.0 for a specified age (a_{ref})such that the catchability coefficient is linked to this age

$$S_{u,a,y} = \frac{S_{a,y,g}}{S_{a_{ref},y,g}}. \qquad (12)$$

Time-varying parameters

Fleet specific selectivity and catchability patterns are allowed to vary over time in the model. Changes in selectivity occur each τ_g years through a random walk for every age in a given fleet

$$S_{a,y+\tau,g} = S_{a,y,g} e^{\varepsilon_{a,y,g}} \qquad (13)$$

where $\varepsilon_{a,y,g}$~N(0,σ_{Sg}^2) and are then rescaled to average one following equation (1). If τ_g is greater than one, then the selectivity at age for the fleet is the same as previous values until τ_g years elapse. The catchability coefficients also follow a random walk

$$q_{u,y+1} = q_{u,y} e^{\omega_{u,y}}, \qquad (14)$$

as do the fleet specific fishing mortality rate multipliers

$$Fmult_{y+1,g} = Fmult_{y,g} e^{h_{y,g}} \qquad (15)$$

where $\omega_{u,y}$~N(0,σ_{qu}^2) and $\eta_{y,g}$~N(0,σ_{Fg}^2).

Parameter estimation

The number of parameters estimated depends upon the values of τ_g and whether or not changes in selectivity or catchability are considered. When time varying selectivity and catchability are not considered the following parameters are estimated: Y recruits, A-1 population abundance in first year, YG fishing mortality rate multipliers, AG selectivities (if all ages selected by all gears), U catchabilities, and 2 stock recruitment parameters. Inclusion of time varying selectivity and catchability can increase the number of parameters to be estimated by a maximum of (Y-1)AG + (Y-1)U. Sensitivity analyses can be conducted to determine the tradeoffs between number of parameters estimated and goodness of fit caused by changes in the τ_g values.

The likelihood function to be minimized includes the following components (ignoring constants): total catch in weight by fleet (lognormally distributed)

$$L_1 = \lambda_1[\ln(\sum_a Y_{a,y,g}) - \ln(\sum_a \hat{Y}_{a,y,g})]^2; \qquad (16)$$

catch proportions in numbers of fish by fleet (multinomially distributed)

$$L_2 = -\sum_y \sum_g \lambda_{2,y,g} \sum_a P_{a,y,g} \ln(\hat{P}_{a,y,g}) - P_{a,y,g} \ln(P_{a,y,g}); \qquad (17)$$

and indices of abundance (lognormally distributed)

$$L_3 = \sum_g \lambda_{3,g} \sum_y [\ln(I_{y,g}) - \ln(\hat{I}_{y,g})]^2 / 2\sigma^2_{y,g} + \ln(\sigma_{y,g}), \qquad (18)$$

where variables with a hat are estimated by the model and variables without a hat are input as observations. The second term in the catch proportion summation causes the likelihood to equal zero for a perfect fit. The sigmas in equation 18 are input by the user and can optionally be set to all equal 1.0 for equal weighting of all index points. The weights (λ) assigned to each component of the likelihood function correspond to the inverse of the variance assumed to be associated with that component. Note that the year and fleet subscripts for the catch proportion lambdas allow zero weights to be assigned to specific year and fleet combinations such that only the total catch in weight by that fleet and year would be incorporated in the objective function. Priors for the variances of the time varying parameters are also included in the likelihood by setting λ equal to the inverse of the assumed variance for each component

$$L_4 = \sum_g \lambda_{4,g} \sum_a \sum_y \varepsilon^2_{a,y,g} \qquad (selectivity) \tag{19}$$

$$L_5 = \sum_u \lambda_{5,u} \sum_y \omega^2_{u,y} \qquad (catchability) \tag{20}$$

$$L_6 = \sum_g \lambda_{6,g} \sum_y \eta^2_{y,g} \qquad (F\ multipliers) \tag{21}$$

$$L_7 = \lambda_7 \sum_y \upsilon^2_y \qquad (recruitment) \tag{22}$$

$$L_8 = \lambda_8 \sum_y \psi^2_y \qquad (N\ year1). \tag{23}$$

Additionally, there is a prior for fitting a Beverton and Holt type stock-recruitment relationship

$$L_9 = \lambda_9 \sum_y [\ln(N_{1,y}) - \ln\left(\frac{\alpha\, SSB_{y-1}}{\beta + SSB_{y-1}}\right)]^2 \tag{24}$$

where SSB denotes the spawning stock biomass and α and β are parameters to be estimated. Penalties are used to determine the amount of curvature allowed in the fleet selectivity patterns, both at age

$$\rho_1 = \lambda_{\rho 1} \sum_y \sum_g \sum_{a(g_{start})}^{a(g_{end})-2} (S_{a,y,g} - 2S_{a+1,y,g} + S_{a+2,y,g})^2 \tag{25}$$

and over time

$$\rho_2 = \lambda_{\rho 2} \sum_a \sum_g \sum_{y=1}^{Y-2} (S_{a,y,g} - 2S_{a,y+1,g} + S_{a,y+2,g})^2 . \tag{26}$$

The function to be minimized is then the sum of the likelihoods and penalties

$$L = L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8 + L_9 + \rho_1 + \rho_2 . \tag{27}$$

An additional penalty is utilized in early phases of the minimization to keep the average total fishing mortality rate close to the natural morality rate. This penalty ensures the population abundance estimates do not get exceedingly large during early phases of the minimization. The final penalty added to the objective function forces the parameters for fleet selectivities in the first year to average 1.0. This penalty prevents multiple parameter sets from having the same objective function value, which would cause difficulty for the minimization routine. Each component of the objective function is reported in the output file along with the corresponding number of observations, weight assigned to that component, and residual sum of squared deviations (if appropriate).

Additional Features

The model optionally does some additional computations once the likelihood function has been minimized. These "extras" do not impact the solution, they are merely provided for reference. Each fleet can be designated as either directed or nondirected for the projections and F reference point calculations, with the option to modify the nondirected F in the future. The directed fleets are combined to form an overall selectivity pattern that is used to solve for common fishing mortality rate reference points ($F_{0.1}$, F_{max}, $F_{30\%SPR}$, $F_{40\%SPR}$ and F_{msy}) and compared to the terminal year F estimate. The inverse of the SPR for each of these points is also given so replacement lines corresponding to these reference values can be plotted on the spawner-recruit relationship. Projections are computed using either the stock-recruitment relationship or input values to generate future recruitment. The projections for each successive year can be made using either a total catch in weight or the application of a static $F_{X\%SPR}$, where X is input. A reference year is also input that allows comparison of the spawning stock biomass (SSB) in the terminal year and that in the final projection year as SSB_y/SSB_{ref}. Likelihood profiles for these SSB ratios can optionally be generated.

Example: Western Atlantic Bluefin Tuna

Two analyses of western Atlantic bluefin tuna data using ASAP are presented here. The first analysis (simple) did not allow selectivity and catchability to change over time (225 parameters estimated). The second analysis (complex) used the full complexity allowed by the model, with fleet selectivities allowed to change every two years and index catchabilities allowed to change every year (914 parameters estimated). In both analyses the model was structured for years 1970-1995, ages 1-10+, five fleets, and seven tuning indices (each point input with a variance) with all likelihood component weightings equal between the analyses. The natural mortality rate was set at 0.14 for all ages (for data details see Restrepo and Legault In Press). The number of observations associated with, and the weights given to, each part of the likelihood function are shown in Table 1. In this example, the weights assigned to each component were chosen arbitrarily. In an actual assessment, these weights will need to be selected by the assessment working group.

The overall fit of the complex analysis was better than the simple analysis (lower objective function value) as expected due to the greater number of parameters (Table 1). The complex analysis fits the indices better than the simple analysis, especially the US Rod and Reel Large, US Longline Gulf of Mexico, and the Japan Longline Gulf of Mexico indices. (Figure 1). Recruitment estimates from the two analyses are similar to the estimates from the 1996 SCRS assessment, which used virtual population analysis (VPA) with the main differences occurring in the early years of the time series (Figure 2). The estimates of spawning stock biomass (SSB) differ between the analyses, the complex one is similar in magnitude to the SCRS96 results, while the simple analysis estimates larger values (Figure 3). However, standardizing the SSB trends (dividing by the SSB in 1975) produces similar trends for all three analyses (Figure 3). The resulting stock-recruitment relationship is shown in figure 4. The total fishing mortality rates by year and age differ in both magnitude and pattern, with the complex analysis more closely matching the 1996 SCRS assessment (Figure 5). These differences in F are due to the assumptions about selectivity, fixed for the simple analysis and allowed to vary for the complex one (Figure 6). Note in particular the large change in selectivity of the purse seine fleet, mainly young fish in the early years and old fish in recent years. The catchability values also reflect the difference in assumptions, constant for the simple analysis and allowed to vary in the complex analysis (Figure 7). Note the large lambda given to the larval index causes the catchability coefficients to vary only slightly in the complex analysis. The catch at age proportions are fit relatively well in both analyses, the input and effective sample sizes are similar, even though this is the largest part of the total likelihood. The estimated effective sample size can be computed as

$$Effective\,N_g = \frac{\sum_a \sum_y \hat{p}_{a,y,g}(1-\hat{p}_{a,y,g})}{\sum_a \sum_y (p_{a,y,g} - \hat{p}_{a,y,g})^2} \tag{28}$$

(for details see McAllister and Ianelli, 1997 Appendix 2).

Discussion

The flexibility afforded by ASAP is a continuation of the trend in stock assessment programs from the relatively simple structure of Fournier and Archibald (1982) to the more flexible structure found in Methot (1998), Ianelli and Fournier (1998), and Porch and Turner (In Press). In fact, ASAP is based on the same logic as these more flexible programs, but combines the advantages of the AD Model Builder software with the more general input flexibility of stock synthesis and CATCHEM. J. Ianelli (NMFS, Seattle, pers. comm.) also provided guidance in the formulation of certain model components, specifically the logic of linking fleet specific indices with a specific age in the tuning process (see equation 12). The distinguishing feature between this approach and that found in virtual population analysis (VPA) (Gavaris 1988, Powers and Restrepo 1992) is that VPA assumes the catch at age is measured without error, while ASAP assumes the observed catch at age varies about its true value.

The flexibility of ASAP can also cause problems however. Slight changes in the weights assigned to each likelihood component can produce different results, both in magnitude and trend. The large number of parameters, in the complex model especially, required the solutions in each phase to progress towards a satisfactory region in the solution space. If any phase led the solution away from this region, the final result will not be believable (e.g. total F<1e-5). This problem was not found in multiple tests using simulated data that did not contain errors or only small observation errors. Thus, the ability to fit highly complex models depends upon the quality of the data available, especially the consistency between the catch at age and the tuning indices. Nevertheless, the flexible nature of ASAP allows for easy exploration of the data to determine what level of complexity can appropriately be modeled.

Acknowledgments

The conclusions presented here are entirely the authors' and are not necessarily endorsed by NMFS or UM. We are grateful to Jim Ianelli, Clay Porch, Joe Powers, Gerry Scott and Steve Turner for helpful discussions.

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Table 1. Likelihood function components for two ASAP analyses. nobs=number of observations in that component, λ=weight given to that component, RSS=residual sum of squared deviations, L=likelihood value

Component	nobs	λ	Simple RSS	Simple L	Complex RSS	Complex L
Total Catch in Weight						
Rod and Reel	26	100.5	0.0005	0.0479	0.0001	0.0147
Japan Longline	26	100.5	0.0015	0.1558	0.0003	0.0322
Other Longline	26	100.5	0.0001	0.0069	0.0001	0.0070
Purse Seine	26	100.5	0.0002	0.0183	0.0039	0.3913
Other	26	100.5	0.0001	0.0065	0.0000	0.0026
Total	130	100.5	0.0023	0.2353	0.0045	0.4477
Catch at Age Proportions	1300	N/A	N/A	874.40	N/A	396.47
Index Fits						
Larval Index	16	1	5.26	11.95	5.29	11.61
US Rod and Reel Small	15	1	3.95	9.33	2.02	-1.02
Canadian Tended Line	15	1	2.08	3.05	0.64	-5.95
US Rod and Reel Large	13	1	1.76	1.22	0.39	-5.74
US Longline Gulf of Mexico	9	1	6.13	15.26	0.31	-3.79
Japan Longline Gulf of Mexico	8	1	0.74	1.10	0.58	1.05
Japan Longline NW Atlantic	20	1	3.22	9.51	0.58	-9.19
Total	96	7	23.15	51.43	9.80	-13.02
Selectivity Deviations						
Rod and Reel	12	0.1	0	0	2.52	0.25
Japan Longline	12	0.1	0	0	4.42	0.44
Other Longline	12	0.1	0	0	3.56	0.36
Purse Seine	12	0.1	0	0	8.74	0.87
Other	12	0.1	0	0	3.00	0.30
Total	60	0.5	0	0	22.25	2.22
Catchability Deviations						
Larval Index	16	1000	0	0	0.00	0.29
US Rod and Reel Small	15	6.7	0	0	0.51	3.43
Canadian Tended Line	15	6.7	0	0	0.37	2.45
US Rod and Reel Large	13	6.7	0	0	0.18	1.20
US Longline Gulf of Mexico	9	6.7	0	0	0.21	1.39
Japan Longline Gulf of Mexico	8	6.7	0	0	0.00	0.03
Japan Longline NW Atlantic	20	6.7	0	0	0.35	2.35
Total	96	1040.2	0	0	1.62	11.14
Fmult Deviations						
Rod and Reel	25	0.1	5.26	0.53	5.01	0.50
Japan Longline	25	0.1	21.44	2.14	19.67	1.97
Other Longline	25	0.1	24.30	2.43	23.97	2.40
Purse Seine	25	0.1	5.24	0.52	8.07	0.81
Other	25	0.1	5.60	0.56	6.84	0.68
Total	125	0.1	61.84	6.18	63.56	6.36
Recruitment	26	0.01	10.14	0.10	14.51	0.15
N in Year 1	9	1.44	3.34	4.82	3.08	4.43
Stock-Recruit Fit	25	0.001	9.47	0.01	3.94	0.00
Selectivity Curvature over Age	40	1.44	12.03	17.32	17.19	24.76
Selectivity Curvature over Time	1200	1.44	0	0	52.03	74.92
F penalty	260	0.001	3.0E-01	3.0E-4	2.3E-02	2.3E-02
Mean Sel Year 1 Penalty	50	1	4.5E-12	4.5E-12	4.7E-12	4.7E-12
Objective Function Value				954.50		507.87

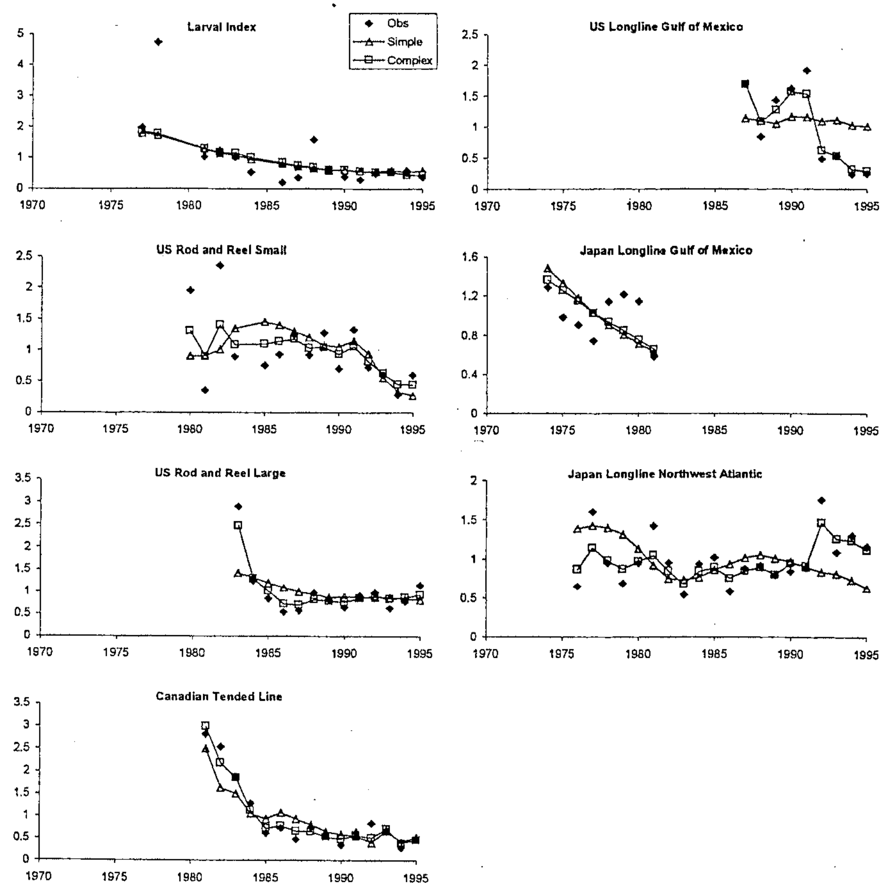

Figure 1. Observed and predicted indices for the simple and complex ASAP analyses.

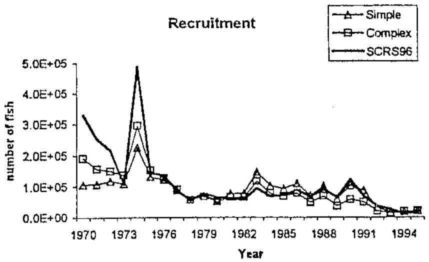

Figure 2. Estimated recruitment from two ASAP analyses and the SCRS 1996 assessment.

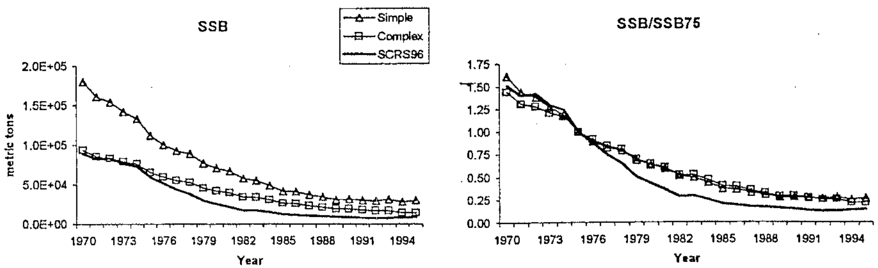

Figure 3. Spawning stock biomass (SSB) from two ASAP analyses and SCRS 1996.

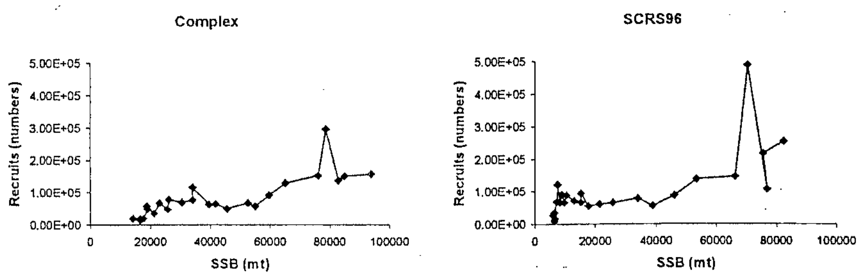

Figure 4. Complex ASAP analysis and SCRS 1996 stock-recruitment relationships.

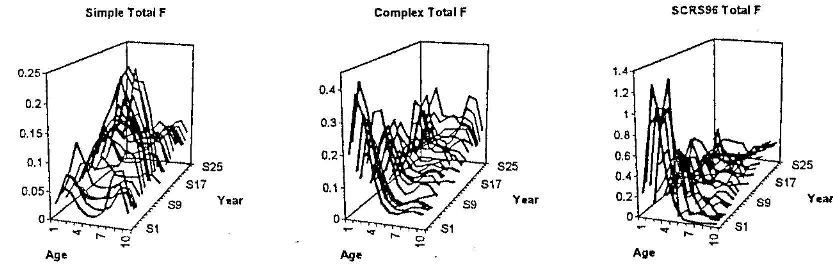

Figure 5. Estimated fishing mortality rates by age and year for two ASAP analyses and SCRS 1996.

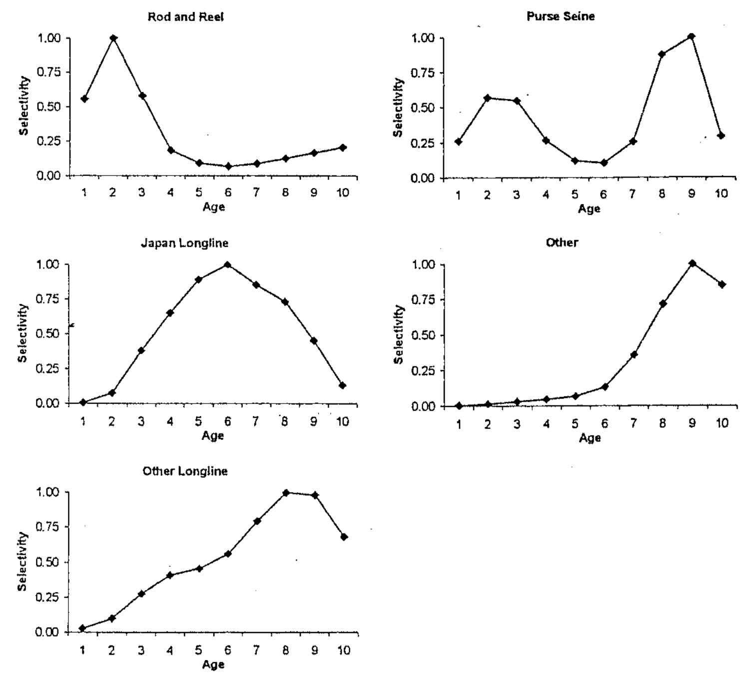

Figure 6a. Selectivity at age for the simple ASAP analysis, constant over all years for each fleet.

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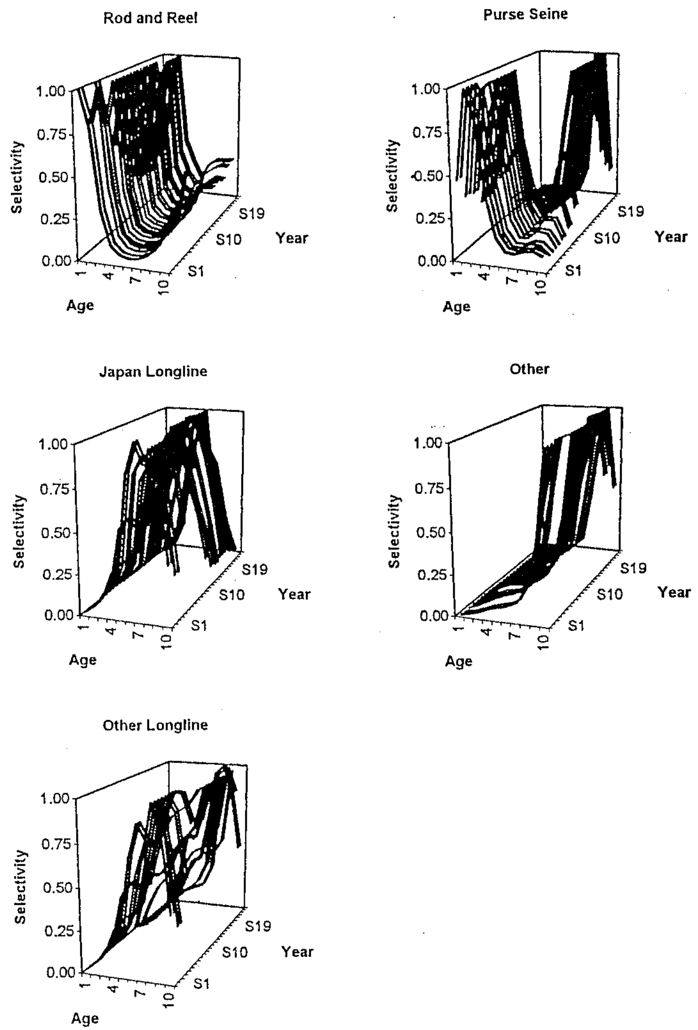

Figure 6b. Selectivity at age for the complex ASAP analysis.

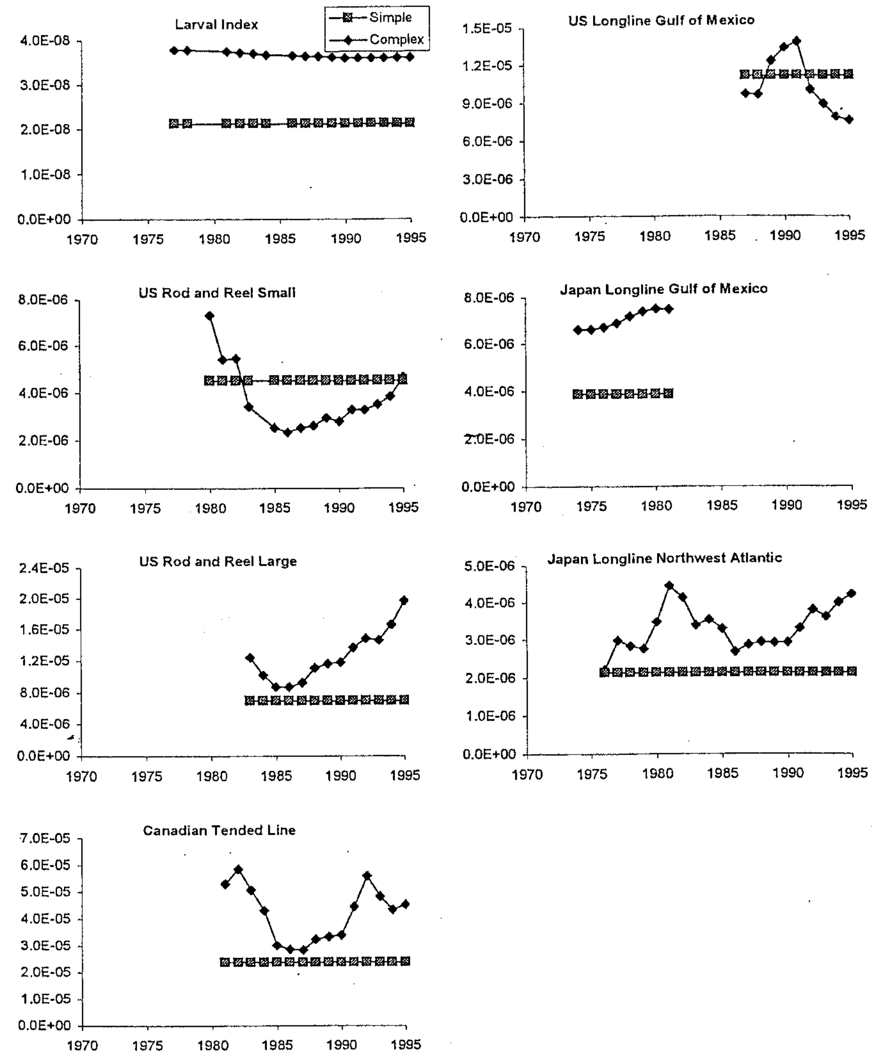

Figure 7. Catchability for each tuning index from the two ASAP analyses.

Agenda Item F.2.b
Attachment 2
June 2007

Pacific Mackerel

STAR Panel Meeting Report

NOAA / Southwest Fisheries Science Center
La Jolla, California
May 1-4, 2007

STAR Panel
Tom Jagielo, Washington Department of Fish of Wildlife (Chair)
André Punt, University of Washington (SSC representative)
Malcolm Haddon, University of Tasmania (CIE)

PFMC
Diane Pleschner-Steele (CPSAS)
Dale Sweetnam, SWFSC (CPSMT)

STAT
Emmanis Dorval, NOAA / SWFSC
Kevin Hill, NOAA / SWFSC
Nancy Lo, NOAA / SWFSC
Jennifer McDaniel, NOAA / SWFSC

1) Overview

The Pacific Mackerel STAR Panel (Panel) met at the Southwest Fisheries Science Center, La Jolla, CA Laboratory from May 1-4, 2007 to review a draft assessment by the Stock Assessment Team (STAT) for Pacific Mackerel. The Panel was originally scheduled to conclude on May 3rd, however, additional time was needed and the Panel also met on the morning of May 4th. Introductions were made (see list of attendees, Appendix 1), and the Panel chair (Tom Jagielo) reviewed the Terms of Reference for CPS assessments with respect to how the STAR Panel would be conducted. Draft assessment documents, model input and output files, and extensive background material (previous assessments, previous STAR Panel reports, SSC statements, etc.) were provided to the Panel in advance of the meeting on an FTP site, which served as a timely and convenient means to distribute the material for review. The Panel chair thanked the STAT for providing the draft assessment approximately one week prior to the meeting, which provided sufficient time for review. A file server was provided at the meeting room to provide common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Emannis Dorval, with assistance from Kevin Hill, led the presentation on assessment methodology. Nancy Lo gave presentations on candidate indices for the stock abundance based on: 1) an aerial spotter program GAM analysis (Appendix I to the draft assessment report), and 2) CalCOFI larval production data (Appendix II to the draft assessment report).

The previous mackerel assessment, used for PFMC management decisions for the period July 1, 2005 to June 30, 2006, used a forward-projection age-structured assessment program (ASAP) model to estimate Pacific mackerel biomass. During the meeting, the Panel reviewed an updated ASAP model, and an alternative model in SS2 provided by the STAT. Initial discussion focused on resolving differences between outputs coming from the two models.

To demonstrate continuity from the previous assessment, the STAT presented revised models in which the ASAP formulation mimicked a comparable SS2 model as closely as possible (see also Section 2 below). The discussion focused on how best to model time changing weight-at-age using SS2, after it was noted that similar estimates of 1+ biomass and recruitment could be obtained from SS2 and ASAP if these two assessment packages were based on the same set of specifications.

Despite the relatively close agreement of many of the outputs from the ASAP and SS2 model runs, detailed scrutiny of the diagnostics and outputs from the SS2 modelling runs revealed that the SS2 model invariably ran up against the harvest rate limit (0.9 and 0.95) in a number of years. Attempts to mitigate this problem were unsuccessful. This was considered to be a critical factor which prevented acceptance of the SS2 implementation. The Panel and the STAT agreed that an updated version of the ASAP model should form the basis for the 2007 assessment.

The Panel commended the STAT for their excellent presentations, well-written and complete documentation, and their willingness to respond to the Panel's requests for additional analyses.

2) Discussion and Requests Made to the STAT during the Meeting

1. The selectivity pattern for the CPFV index is based on fitting the length-frequency data for all recreational modes. The length-frequency data for the CPFV fleet should be compared with the length-frequency data from the other recreational modes to test the assumption that the selectivity pattern for the CPFV fleet is the same as that for the remaining recreational fleets. **Response**. Ultimately, the model chosen as the basecase was framed as an age-structured model obviating the need for this comparison.
2. The CalCOFI indices are based on four methods for estimating the mortality rate and the initial number of larvae (methods "1" – "4"). Methods "3" and "4" are used in cases in which it was impossible to estimate the values for these parameters using weighted non-linear regression. A sensitivity test should be conducted in which the index values based on methods "3 and "4" (which should be the least reliable) are omitted. **Response**: Given the time spent on trying to get the SS2 model to operate successfully, insufficient time remained to attempt this sensitivity analysis.
3. The CalCOFI indices are based on data for the "core" area off southern California, but mackerel spawn from Baja through to northern California. The larval densities for Mexico and the "core" area should be plotted for the years for which data on larval abundance are available for both areas. **Response**. Larval density of mackerel off Mexico is substantially higher than off the "core" area (Fig. 1a). The results of a regression of average larval densities on those for the "core" area (Fig. 1b) indicate that the CALCOFI indices for the "core" area may be able to detect years when larval abundance is high, but the relationship between the larval density for the "core" area and for the region including both Mexico and the "core" area is weak (r^2~0.1) when the two highest larval densities are ignored.
4. The design of the survey used to extend the spotter plane index covers different areas and with different design than the historical (opportunistic) surveys. In addition, estimating the tonnage per block and the proportion positives using models that include a smoothing spline on year leads to temporal correlation among the year-factors. This is inconsistent with the assumptions related to how indices of abundance are included in ASAP and SS2 assessments. Repeat the construction of the spotter plane index using a GLM model in which the survey data (2004 and 2005, years with survey data) and the data for 2003 (low number of trips) are ignored, and in which the smoothing splines on year in the models for the proportion positive and tonnes per block are replaced by a year factor. **Response**. The revised spotter plane index exhibited substantially more inter-annual variability, and the coefficients of variation for the indices were higher. The STAT replaced the original GAM index with the GLM index.
5. Examine the implications of moving from an assessment based on ASAP to one based on SS2. As a first step in this process, apply ASAP and SS2 based on model configurations that are as similar as possible so that the impact of a change in

platform can be examined. This can be achieved using the following specifications for ASAP and SS2:

ASAP configuration:

- Set the weight-at-age in the fishery to the weight-at-age in the population.
- Rescale the catch-at-age data so that the product of catch-at-age and weight-at-age (now based on that for the population) equals the total catch for each year.

SS2 configuration:

- Omit length-based selectivity – assume that selectivity is independent of length.
- Assume age-based selectivity – estimate a selectivity parameter for each age (selectivity option 14).
- Use the catch-at-age data included in the ASAP model (no length data).
- Set weight-at-age to that used in ASAP (not time-varying).
- Have one selectivity pattern only (not time-varying).
- Set selectivity for the spotter and CPFV indices to those used in ASAP.
- Set the recreational catch to 0.0001 for all years.

Response. The STAT conducted the requested analysis, setting the CVs for the ASAP run to the "tuned" values based on the SS2 analyses and setting $\sigma_R = 0.8$. The results from ASAP and SS2 were very similar for the years 1967-2004 but differed slightly for the first years of the assessment period and substantially for the years 2005 onward. The differences between the results for SS2 and ASAP after 2004 were due to the use of the forecast option in SS2, which led to recruitments substantially in excess of those expected under the deterministic stock-recruitment relationship. The Panel agreed that SS2 and ASAP lead to adequately similar results when using the same data, but the SS2 forecast file needs to be corrected for the projections beyond 2004.

6. The recreational catches are included as weights and not numbers in the SS2 assessment. The catches-in-weight are calculated from the catches-in-number under the assumption that each fish weighs 1lb on average. However, SS2 is capable of using catch data entered as catch-in-numbers. Conduct a sensitivity test in which the recreational catches are included in the assessment in the form of catch-in-numbers rather than of catch-in-weight. **Response**. The request became irrelevant once the updated ASAP model was chosen as the assessment platform.
7. The SS2 run presented to the Panel had five time blocks for length-at-age and weight-at-length. Provide the basis for the time-blocking of the growth curves by plotting the annual length-weight relationships for each block. **Response**. The STAT provided the Panel with plots of length versus weight for each year from 1962. There are between-year differences in the length-weight relationship, but it was not possible to identify a preferred time block structure.
8. Run SS2 with pre-specified year-specific growth curves and year-specific length-weight regressions. The CV of length-at-age should be based on the averages over time and the age-specific selectivity pattern for the commercial fishery should be set to three double-normal functions (one for each selectivity epoch). **Response**. The

STAT provided the Panel with several runs in which the CV of length-at-age was set to 0.166 for age 0 animals and 0.05 for age 11 animals (the maximum across years), in which $\sigma_R = 0.8$ (selected by comparing the RMSE for the recruitment residuals and the pre-specified value for σ_R), and in which the CVs assigned to the indices were tuned. The peak abundance is highly sensitive to the value assumed for σ_R. All of the analyses provided to the Panel led to exploitation rates in the 1950s, 1960s, and/or 1990s that exceeded the value permissible value (0.9 and 0.95). After many additional analyses, the Panel and STAT agreed that it would not be possible to base an assessment of Pacific mackerel on SS2 and all additional analyses were based on ASAP.

9. There are concerns with all three potential indices of abundance as they may be in conflict to some extent. Repeat the assessment in which the model is fitted to each index independently. **Response**. The STAT provided results for the ASAP analyses. The different time series are in conflict in some years. For example, the CalCOFI index exhibits an increase in the years 1996 and 1997 whereas the other indices either do not exhibit an increase or show a decline. The stock size exhibits an upturn in the last three or four years of the assessment period. This disappears when the CPFV time series is omitted and only the CalCOFI time series is used (Figure 3).
10. The three indices should be plotted together to provide a visual comparison of where the indices may be in conflict or where each contributes information to the model fit. **Response.** The STAT team produced a graph with an adequate interpretation.
11. Sensitivity runs were requested to examine the impact of varying the natural mortality rate between 0.35 and 0.7yr^{-1}. **Response.** The STAT produced graphs of initial and 1+ biomass which exhibited the expected behaviour; some instability in the model fitting was detected with M between 0.55 and 0.6yr^{-1}. In addition, a table of the likelihood components for the range of M values was produced to aid in the identification of which factors are most influenced by M (Figure 4).

The commercial fleet has failed to take a large proportion of the recommended Harvest Guidelines since 2001. Higher fuel costs that were not matched by comparable increases in price for product were presented as part of the explanation in conjunction with the limited availability of fish close to port. As a result of the increased fuel prices, the area of the fishery has contracted closer to shore, which may have influenced the age composition in recent years by increasing the proportion of 0+ and 1+ fish in the catches. This contraction in area has been exacerbated by spotter plane effort being redirected to higher value fisheries such as tuna.

The results from the 2007 runs based on ASAP are most similar to those from the ADEPT model conducted for assessments prior to 2006 in terms of biomass trends since 1975 (Figure 2). However, there are major differences in biomass trajectories for the years prior to 1950. The results for the 2006 and 2007 ASAP runs differ markedly in terms of biomass in the peak years, in the years prior to 1950 and in recent years. Part of the explanation for this difference is that σ_R has been increased which leads to higher biomass than in the past and because selectivity is estimated for three, rather than one epoch. The increase in biomass in the last three years is a consequence of fitting to the CPFV index; runs without this index lead to markedly less optimistic values.

3) Technical Merits and/or Deficiencies of the Assessment

It was decided to base the 2007 assessment on an ASAP model that includes three selectivity epochs and a higher value for σ_R. Unlike SS2, this model did not lead to diagnostics that were clearly problematical. However, the ASAP is not capable of including more than one fleet so the recreational catches could not be independently modelled. In addition, the ASAP model uses the same weight-at-age for the catch as for the population, which implies that any stock recruitment relationship may be biased. In order to estimate selectivity for a relative abundance index, ASAP requires that the index be associated with a particular fishery. This means there are difficulties estimating the selectivity for the larval abundance and spotter plane indices.

The Panel accepts that the ASAP E1-base model can be used as the basis for management advice and advices that the runs based on all indices included and M=0.35 and M=0.70 be used in order to bracket uncertainty.

4) Areas of Disagreement

There were no major areas of disagreement between the STAT and Panel.

5) Unresolved Problems and Major Uncertainties

Problems unresolved at the end of the meeting form the basis for some of the research recommendations in Section 6. The background to three of the main issues are given here.

1) While the best estimates of the landings off Mexico are included in the assessment, there is a continuing lack of size- and age-composition data from these catches. The 2004 STAR Panel recommended that efforts be made to obtain biological sampling data and especially catch-at-age data from the Mexican fraction of the fishery. The SWFSC began the process of acquiring this information by organizing a US-Mexico workshop in 2007 and obtaining commitments for data provision in time for future assessments. The size and age composition data from the San Pedro fishery are presently assumed to be representative of the whole stock. In addition, two of the indices of relative abundance used in the assessment (the CalCOFI larval survey and the CPFV recreational data) only relate to the Southern Californian Bight. The spawning area is known to extend south to the tip of Baja California. Obtaining data from the Mexican fishery, including the Mexican larval surveys (IMECOCAL) might help remove this important source of uncertainty.
2) There is currently no true fishery-independent index of relative abundance for the whole stock and there are concerns with the three indices used in the present assessment.
    a. The CalCOFI larval surveys are often relatively poor at finding Pacific mackerel larvae. Whether these surveys and the estimates of larval production at hatching constitute representative estimates of the spawning stock size of mackerel is uncertain, especially because the area surveyed is only a fraction of the total spawning region. Obtaining access to the Mexican larval survey data (IMECOCAL) may help solve this problem. In addition, the occurrence of larvae can be limited to one or two size classes in years of relatively low

abundance, which compromises the estimation of the larval production at hatching for those years.

b. The aerial spotter index, up until 2002, provides an opportunistic method for estimating relative abundance. The structure of the index includes an estimate of area based on the number of 10’ x 10’ blocks surveyed, but this number varies from year to year, and includes coastal blocks which are not strictly 10’ x 10’. This acts as a source of uncertainty among years. A further problem with the spotter plane index of abundance is that the design of the sampling changed after 2002. Specifically, a fishery-independent aerial survey was begun in 2004 using a grid search pattern with the added freedom to search for more fish if a school of fish is found. However, the adherence of the pilots to the sampling grid has yet to become stable. The very different sampling strategy used prior to 2003 means that it is questionable whether this new time series can be combined in a meaningful way with the earlier one.

c. The CPFV index is based on the logbook data from the CPFV fleet for California (although limited data do exist for Mexico). Given that it is fishery-dependent data, its use in the assessment as an index of stock abundance is predicated on the assumption that catchability has not changed over time. While this is a concern for all indices of abundance based on fishery-dependent data, the fact that mackerel is not a target species for the CPFV fleet suggests that this assumption may be acceptable in this case.

3) Ageing error rates (see Table 1) indicate substantial imprecision and /or bias, particularly for the younger age-classes (0 and 1), which currently constitute a large fraction of the catch. The impact of this error rate will only become apparent once an ageing error matrix is included in the assessment.

6) Research Recommendations

A. One of the major uncertainties associated with the assessment is that no account is taken of ageing error. SS2 can include an age-reading error matrix. The data from age-reading studies should be used to construct an age-reading error matrix for inclusion in future (SS2) assessments. However, there are currently very few otoliths that have been read multiple times so additional readings need to be made. In the longer-term, an age validation study should be conducted for Pacific mackerel. Such a study should compare age readings based on whole and sectioned otoliths and consider a marginal increment analysis.

B. The next assessment should continue to examine the possibility of using SS2 as the assessment platform. The analyses presented to the Panel suggested that ASAP and SS2 lead to similar outcomes when configured in a similar manner. However, SS2 deals better with indices that are not tied directly to a fishery, can include age-reading error, and allows weight-at-age in the catch to differ from weight-at-age in the population. In principle, it should be easier to represent uncertainty using the MCMC algorithm for assessments based on SS2.

C. The construction of the spotter plane index is based on the assumption that blocks are random within region (the data for each region is a “visit” by a spotter plane to a block in that region). The distribution of density-per-block should be plotted or a random effects model fitted in which block is nested within region to evaluate this assumption (e.g. examine whether certain blocks are consistently better or worse than the average).

D. The data on catches come from several sources. The catch history from 1926-27 to 2006-07 should be documented in a single report.
E. Conduct a study to update the information used to determine maturity-at-length (and maturity-at-age).
F. A large fraction of the catch is taken off Mexico. In particular, catches of mackerel have been as large as those off California in recent years. Efforts should continue to be made to obtain length, age and biological data from the Mexican fisheries for inclusion in stock assessments. Survey data (IMECOCAL program) should be obtained and analyses conducted to determine whether these data could be combined with the CalCOFI data to construct a coastwide index of larval abundance.
G. The SS2 assessment is based on fitting to age-composition data for the commercial fishery. Future SS2 assessments should consider fitting to the length composition and the conditional age-at-length information. This will require estimating time-varying growth curves and may require multiple time-steps within each year.
H. The CalCOFI data should be reviewed further to examine the extent to which CalCOFI indices for the "core" area can be used to provide information on the abundance of the coastwide stock.
I. There are uncertainties regarding the early biological and fishery data. The Panel reiterates the recommendation of the 2004 STAR Panel that consideration should be given to initiating the assessment model in a more recent year (e.g. 1978).
J. The concern of the 2004 STAR Panel that fishery-based weights are used to estimate population parameters has still not been addressed. Future assessments should attempt to estimate a population growth curve in order, for example, to estimate the time-trajectories of 1+ and spawning biomass.

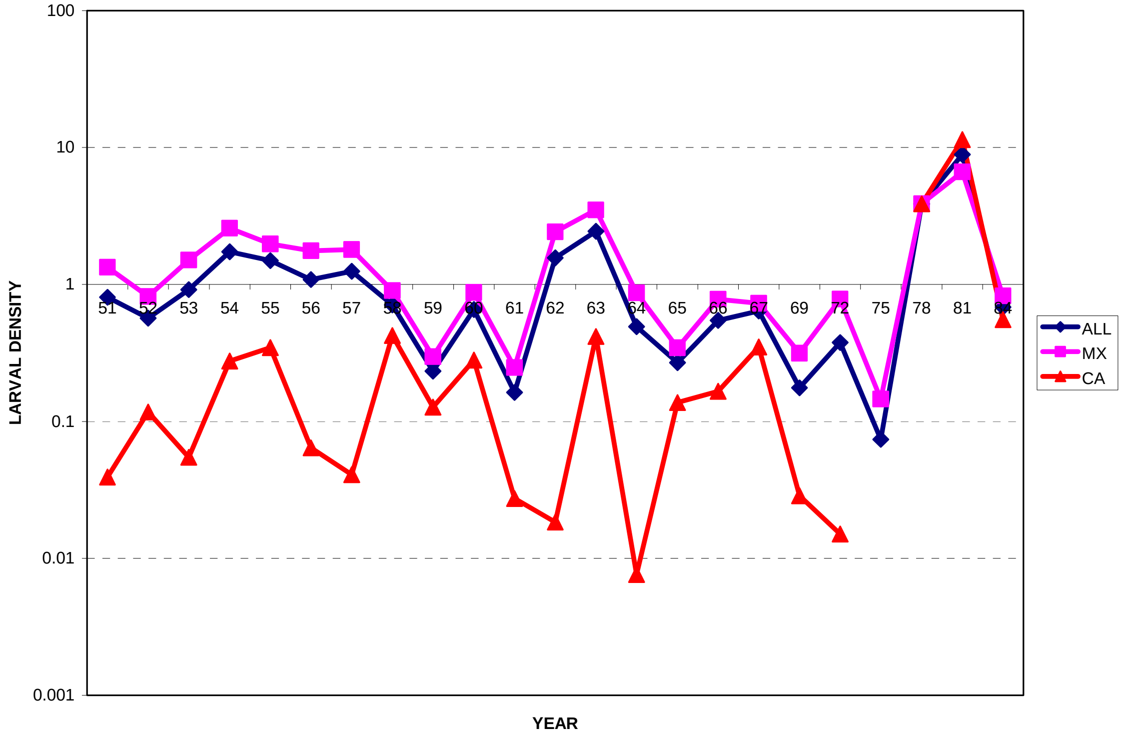

Figure 1a. Coastwide larval densities (diamonds), larval densities off Mexico (squares), and larval densities for the "core" area (results based on CalCOFI surveys that covered Mexico and the "core" area (1951-1984)).

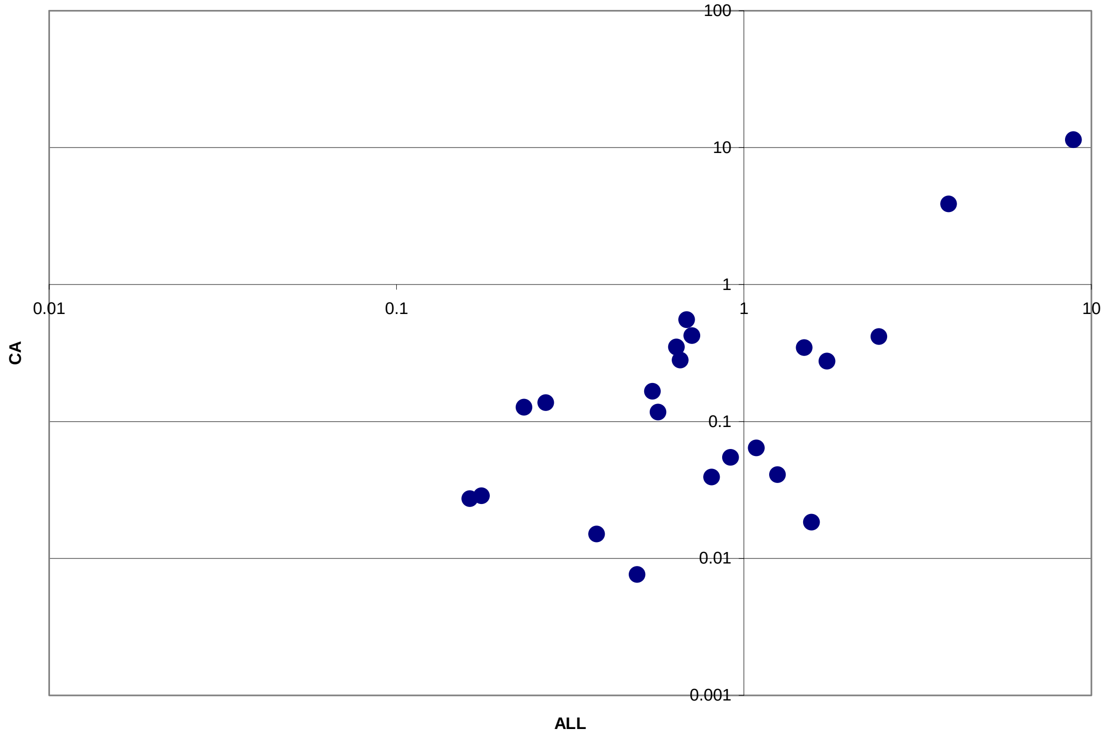

Figure 1b. Average larval densities (Mexico and the “core” area) versus larval densities for the “core” area based on CalCOFI surveys that covered Mexico and the “core” area (1951-1984).

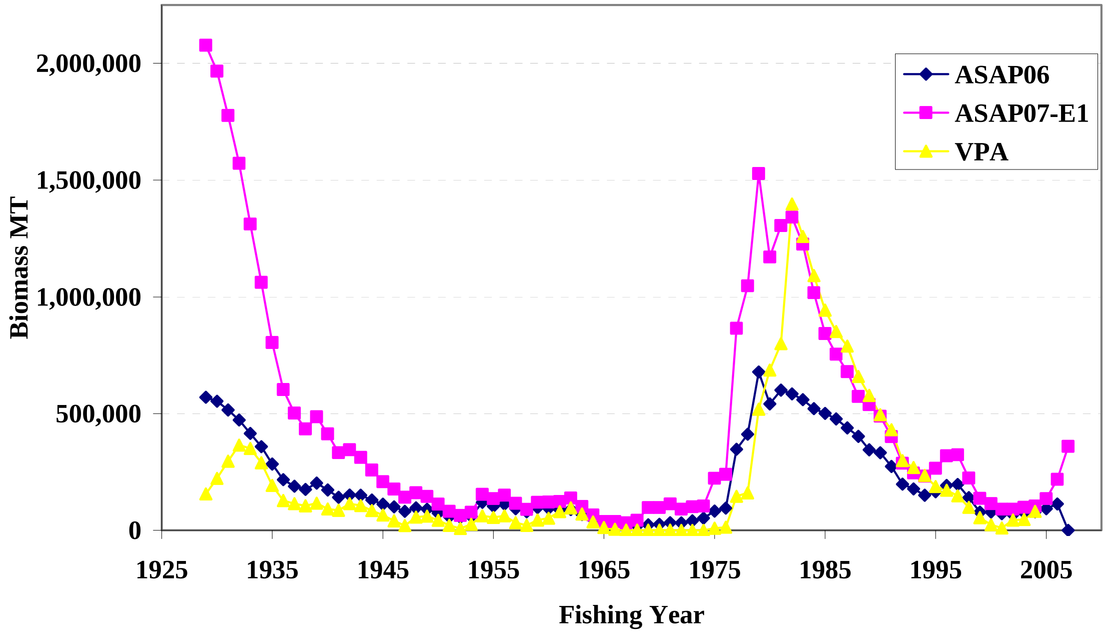

Figure 2. Estimated biomass (age 1+ fish, B in mt) of Pacific mackerel generated from the VPA (2006 assessment), and the ASAP-BaseCase model for the 2007 assessment.

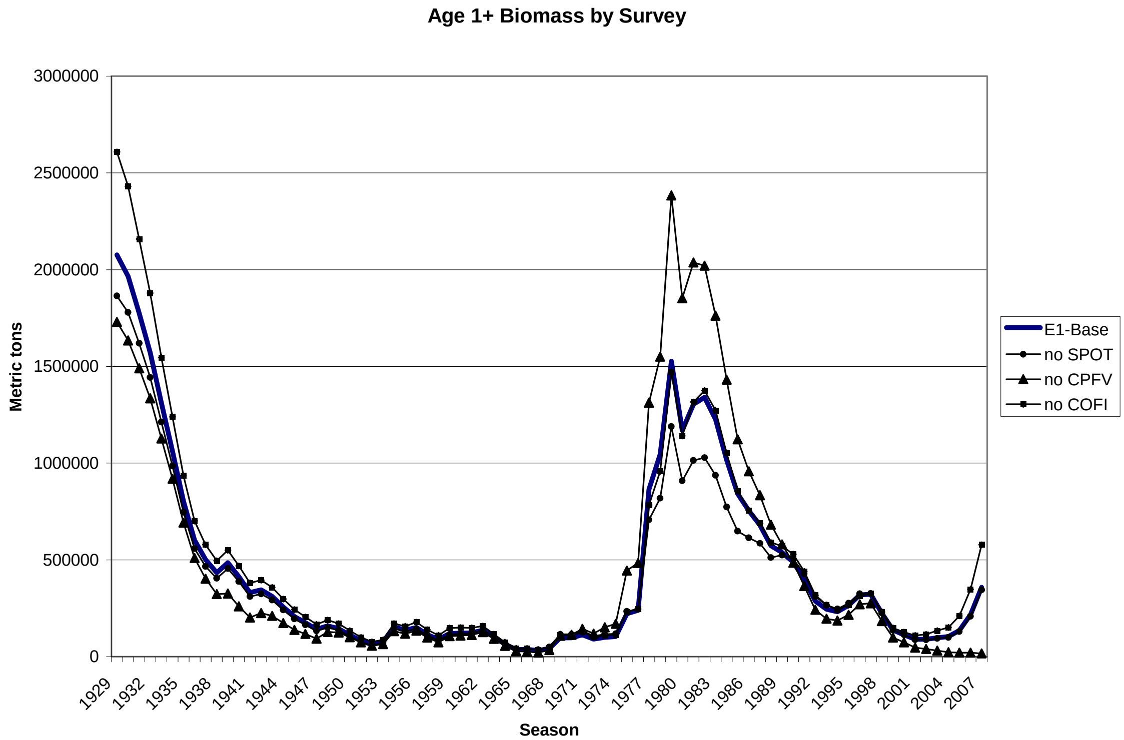

Figure 3. Sensitivity of Base-Case ASAP Model to Indices of Abundance.

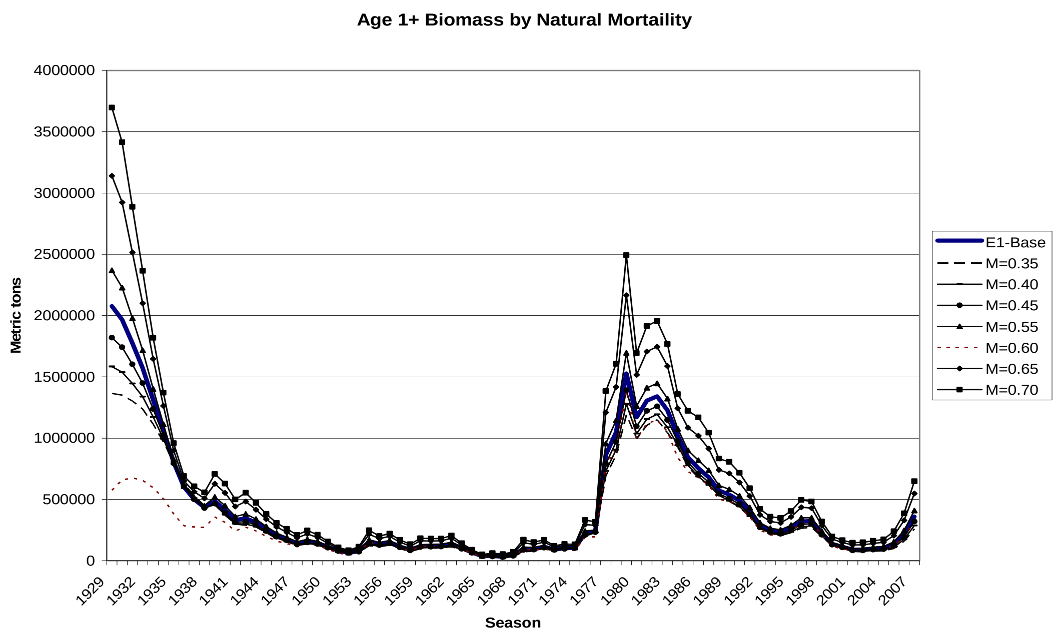

Figure 4. Sensitivity of Base-Case ASAP Model to Natural Mortality.

Table 1
Measures of age-reading error

	Age							
	0	1	2	3	4	5	6	7+
APE	0.298	0.276	0.158	0.150	0.139	0.112	0.111	0.096
CV	0.888	0.758	0.447	0.423	0.408	0.338	0.343	0.286

Appendix 1

STAR Panel Members in Attendance

Mr. Tom Jagielo (Chair), SSC - Washington Department of Fish and Wildlife
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Dr. Malcolm Haddon, CIE - University of Tasmania
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Ms. Jennifer McDaniel, NMFS, SWFSC

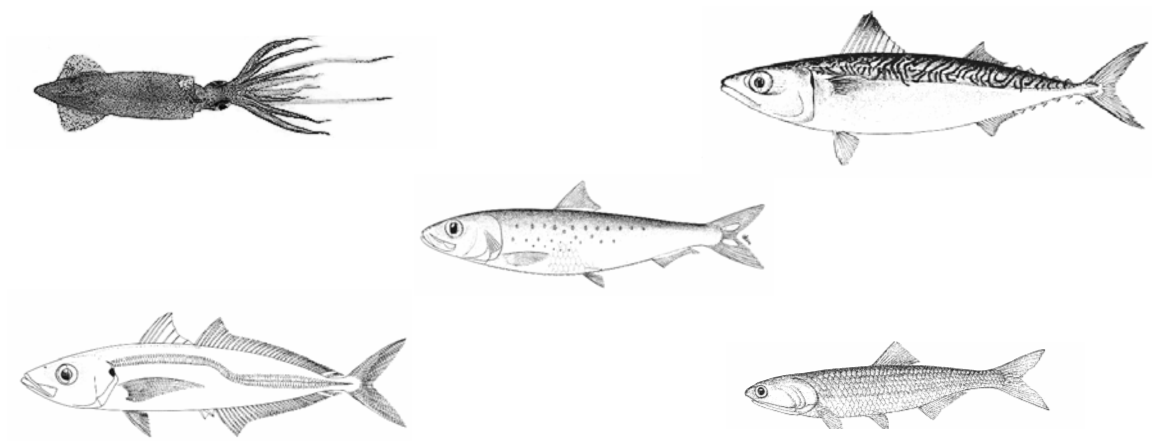
Others in Attendance

Mr. Mike Burner, Pacific Fishery Management Council
Dr. Ray Conser, NMFS, SWFSC
Dr. Paul Crone, NMFS, SWFSC
Dr. Sam Herrick, NMFS, SWFSC
Mr. Jason Larese, NMFS, SWFSC
Dr. Mark Maunder, Inter-American Tropical Tuna Commission (IATTC)
Dr. Kevin Piner, NMFS, SWFSC
Mr. Alexandre Silva, IATTC

Agenda Item F.2.b
Attachment 3
June 2007

STATUS OF THE PACIFIC COAST COASTAL PELAGIC SPECIES FISHERY AND RECOMMENDED ACCEPTABLE BIOLOGICAL CATCHES

STOCK ASSESSMENT AND FISHERY EVALUATION 2007



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BRIEFING BOOK DRAFT
JUNE 2007

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LIST OF ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CANSAR-TAM	Catch-at-age Analysis for Sardine - Two Area Model
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
Commission	California Fish and Game Commission
Council	Pacific Fishery Management Council
CPFV	commercial passenger fishing vessel
CPS	coastal pelagic species
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CPSPDT	Coastal Pelagic Species Plan Development Team
CPUE	catch per unit effort
CUFES	Continuous Underway Fish Egg Sampler
CV	coefficient of variation
DEPM	daily egg production method
EEZ	exclusive economic zone
EFH	essential fish habitat
ENSO	El Niño southern oscillation
FMP	fishery management plan
GIS	Geographic Information System
GT	gross tonnage
HG	harvest guideline
LE	limited entry
LIDAR	light detection and ranging
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MAXCAT	maximum harvest level parameter
MSY	maximum sustainable yield
mt	metric ton
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
OY	optimum yield
PacFIN	Pacific Coast Fisheries Information Network
PFAU	Pelagic Fisheries Assessment Unit
RecFIN	Recreational Fishery Information Network
RFA	Regulatory Flexibility Act
RIR	regulatory impact review
ROV	remotely operated vehicle
SAFE	stock assessment and fishery evaluation
Secretary	U.S. Secretary of Commerce
SSC	Scientific and Statistical Committee
SST	sea surface temperature
STAR	Stock Assessment Review (Panel)
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center (NMFS)
VPA	virtual population analysis
WDFW	Washington Department of Fish and Wildlife

1.0 INTRODUCTION

The Guidelines for Fishery Management Plans (FMPs) published by the National Marine Fisheries Service (NMFS) require that a stock assessment and fishery evaluation (SAFE) report be prepared and reviewed annually for each FMP. SAFE reports are intended to summarize the best available scientific information concerning the past, present, and possible future condition of the stocks, marine ecosystems, and fisheries being managed under federal regulation. Regional Fishery Management Councils use this information to determine annual harvest levels for each stock; document significant trends or changes in the resources, marine ecosystems, and fishery over time; and assess the relative success of existing state and federal fishery management programs.

This is the eight *Status of the Pacific Coast Coastal Pelagic Species Fishery* SAFE document prepared for the Pacific Fishery Management Council (Council). Following NMFS guidelines, the purpose of this report is to briefly summarize aspects of the coastal pelagic species (CPS) FMP and to describe the history of the fishery and its management. Species managed under this FMP include: Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), and market squid (*Loligo opalescens*).

The SAFE report for Pacific Coast CPS fisheries was developed by the Council's Coastal Pelagic Species Management Team (CPSMT) from information contributed by scientists at NMFS, Southwest Fisheries Science Center (SWFSC), California Department of Fish and Game (CDFG), Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). Included in this report are descriptions of landings, fishing patterns, estimates of the status of stocks (including stock assessments for Pacific sardine and Pacific mackerel, Appendix 1 and Appendix 2), and acceptable biological catches (ABCs).

The ABC recommendations, together with social and economic factors, are considered by the Council in determining annual harvest guidelines and other measures for actively managed fisheries (i.e., Pacific mackerel and Pacific sardine).

2.0 THE CPS FISHERY

2.1 Management History

The CPS FMP is an outgrowth of the *Northern Anchovy Fishery Management Plan*, which was implemented in September 1978. The Council began to consider expanding the scope of the northern anchovy FMP in 1990, with development of the seventh amendment to the FMP. The intent was to develop a greatly modified FMP, which included a wider range of coastal pelagic finfish and market squid. A complete draft was finished in November of 1993, but the Council suspended further work because NMFS withdrew support due to budget constraints. In July 1994, the Council decided to proceed with public review of the draft FMP. NMFS agreed with the decision on the condition the Council also consider the options of dropping or amending the northern anchovy FMP. Four principal options were considered for managing CPS fisheries:

1. Drop the anchovy FMP (results in no Federal or Council involvement in CPS).
2. Continue with the existing FMP for anchovy (status quo).
3. Amend the FMP for northern anchovy.
4. Implement an FMP for the entire CPS fishery.

In March 1995, after considering the four options, the Council decided to proceed with option four, developing an FMP for the entire CPS fishery. Final action was postponed until June 1995 when the Council adopted a draft plan that had been revised to address comments provided by NMFS and the Council's Scientific and Statistical Committee (SSC). Amendment 7 was submitted to the U.S. Secretary of Commerce (Secretary), but rejected by NMFS Southwest Region as being inconsistent with National Standard 7. NMFS announced its intention to drop the FMP for northern anchovy in a proposed rule published in the *Federal Register* on March 26, 1996 (61*FR*13148). The proposed rule was withdrawn on November 26, 1996 (61*FR*60254). Upon implementation of Amendment 8 (see below), the northern anchovy FMP was renamed the Coastal Pelagic Species Fishery Management Plan.

2.2 Recent Management

For a complete listing of formal Council actions and NMFS regulatory actions since implementation of the CPS FMP see Tables 1 and 2, respectively.

2.2.1 Amendment 8

Development of Amendment 8 to the northern anchovy FMP began during June 1997 when the Council directed the Coastal Pelagic Species Plan Development Team to amend the FMP for northern anchovy to conform to the recently revised Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and to expand the scope of the FMP to include other species harvested by the CPS fishery.

In June 1999, NMFS partially approved the CPS FMP. Approved FMP elements included the management unit species; CPS fishery management areas, consisting of a limited entry (LE) zone and two subareas; a procedure for setting annual specifications including harvest guidelines, quotas, and allocations; provisions for closing directed fisheries when the directed portion of a harvest guideline or quota is taken; fishing seasons for Pacific sardine and Pacific mackerel; catch restrictions in the LE zone and, when the directed fishery for a CPS is closed, limited harvest of that species to an incidental limit; a LE program; authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited; and a framework process to make management decisions without amending the FMP.

At that time, NMFS disapproved the optimum yield (OY) designation for market squid, because there was no estimate of maximum sustainable yield (MSY). Bycatch provisions were disapproved for lack of standardized reporting methodology to assess the amount and type of bycatch and because there was no explanation of whether additional management measures to minimize bycatch and the mortality of unavoidable bycatch were practicable.

On December 15, 1999, final regulations implementing the CPS FMP were published in the *Federal Register* (64*FR*69888). Provisions pertaining to issuance of LE permits were effective immediately. Other provisions, such as harvest guidelines, were effective January 1, 2000.

2.2.2 Amendment 9

During 1999 and 2000, the CPSMT developed Amendment 9 to the CPS FMP. Originally, Amendment 9 addressed both disapproved provisions of the FMP – bycatch and market squid MSY. The amendment also included provisions to ensure treaty Indian fishing rights are implemented according to treaties between the U.S. and specific Pacific Northwest tribes.

The Council distributed Amendment 9 for public review on July 27, 2000. At its September 2000 meeting, the Council reviewed written public comments, received comments from its advisory bodies, and heard public comments. Based on advice about market squid MSY determination, the Council decided to include in Amendment 9 only the provisions for bycatch and treaty Indian fishing rights. The Council decided to conduct further analysis of the squid resource and prepare a separate amendment to address OY and MSY for squid. The Secretary approved Amendment 9 on March 22, 2001, and the final rule implementing Amendment 9 was published August 27, 2001 (66*FR*44986).

2.2.3 Amendment 10

In April 2001, the Council adopted a capacity goal for the CPS LE finfish fishery and asked the CPSMT to begin work on a 10th amendment to the FMP. Amendment 10 included the capacity goal, provisions for permit transferability, a process for monitoring fleet capacity relative to the goal, and a framework for modifying transferability provisions as warranted by increases or decreases in fleet capacity. The amendment also addressed determination of OY and MSY for market squid.

In June 2002, the Council adopted Amendment 10 to the CPS FMP. Relative to the LE fishery, the amendment established a capacity goal, provided for LE permit transferability to achieve and maintain the capacity goal, and established a process for considering new LE permits. The purpose of this action was to ensure fishing capacity in the CPS LE fishery is in balance with resource availability. Relative to market squid, Amendment 10 established an MSY (or proxy) for market squid to bring the FMP into compliance with the Magnuson-Stevens Act. The purpose of this action was to minimize the likelihood of overfishing the market squid resource. On December 30, 2002, the Secretary approved Amendment 10. On January 27, 2003, NMFS issued the final rule and regulations implementing Amendment 10 (68*FR*3819).

2.2.4 Sardine Allocation Regulatory Amendment

In September 2002, the Coastal Pelagic Species Advisory Subpanel (CPSAS) recommended the Council initiate a regulatory or FMP amendment and direct the CPSMT to prepare management alternatives for revising the sardine allocation framework. The Council directed the CPSMT to review CPSAS recommendations for revising the allocation framework. At the March 2003 Council meeting, the SSC and CPSAS reviewed analyses of the proposed management alternatives for sardine allocation. Based on the advisory body recommendations and public comment, the Council adopted five allocation management alternatives for public review. In April 2003, the Council took final action on the regulatory amendment. This change was implemented by NMFS on September 4, 2003 (68*FR*52523); the new allocation system: (1) changed the definition of Subarea A and Subarea B by moving the geographic boundary between the two areas from 35°40' N latitude (Point Piedras Blancas, California) to 39° N latitude (Point Arena, California), (2) moved the date when Pacific sardine that remains unharvested is reallocated to Subarea A and Subarea B from October 1 to September 1, (3) changed the percentage of the unharvested sardine that is reallocated to Subarea A and Subarea B from 50% to both subareas, to 20% to Subarea A and 80% to Subarea B, and (4) provided for coastwide reallocation of all unharvested sardine that remains on December 1. This revised allocation framework was in place for the 2003 and 2004 fishing seasons. It was also used in 2005 because the 2005 harvest guideline is at least 90% of the 2003 harvest guideline.

2.2.5 Amendment 11

The Council began developing options for a new allocation framework for the coastwide Pacific sardine fishery in 2003 while the fishery operated under the regulatory amendment described in the previous section. This revision to the sardine allocation framework will occur through Amendment 11 to the CPS FMP in 2006. The FMP amendment is intended to achieve optimal utilization of the resource and equitable allocation of harvest opportunity.

The Council tasked the CPSAS with initial development of a range of allocation alternatives. At the November 2004 meeting, the CPSAS presented several program objectives and a suite of alternative allocation formulae. The Council adopted for preliminary analysis a range of alternatives, including the CPSAS recommendations, as well as the following program objectives:

- Strive for simplicity and flexibility in developing an allocation scheme.
- Transfer quota as needed.
- Utilize OY.
- Implement a plan that balances maximizing value and historic dependence on sardine.
- Implement a plan that shares the pain equally at reduced harvest guideline (HG) levels.
- Implement a plan that produces a high probability of predictability and stability in the fishery.

For the analysis of the alternatives, the Council gave specific direction to the CPSMT, including:

- Analyze each alternative in a consistent manner.
- Review differential impacts on northern and southern sectors for each alternative.
- Review effects of high and low catch years by sector for each alternative.
- Review resulting effects at various HG levels ranging from 25,000 mt to 200,000 mt (at appropriate intervals) for each alternative.
- At the discretion of the CPSMT, combine aspects of the various alternatives to create new alternatives that meet program objectives.

At the April 2004 Council meeting, the CPSMT presented preliminary economic analyses of these alternatives to the Council and its advisory bodies. The economic analysis of alternative allocation schemes included five-year projections of the incremental change in producer surplus and landings projections for each fishing sector and subarea. Monthly landings projections were based on 2004 landings and were inflated by 10% annually to account for expected growth in the regional fishery sectors over the next five years. These projections identified months in which there would be a shortfall in landings and months which would start out with no available allocation. These landings projections were conducted under three HG scenarios: (1) low HG = 72,000 mt; (2) Base case HG = 136,000 mt; and, (3) high HG = 200,000 mt.

The Council reviewed the preliminary results and public testimony before following the advice of both the CPSAS and the CPSMT when adopting the remaining range of alternatives for further analysis and public review. The Council directed the CPSMT to take into account the advice of the SSC as they proceed with the analysis. Specifically, the Council requested a sensitivity analysis of the effects of future fishery growth where varying growth assumptions by subarea are applied rather than the previously assumed 10% growth of the fishery coastwide. The Council also recommended that two different provisions for the review of a sardine allocation framework be included in the documentation for public review. The first based on time, where sardine allocation would be reviewed after three, five, or seven years of implementation; the second based on the size of the HG, where sardine allocation would be revisited if the HG falls below 75,000 mt or 100,000 mt.

In June 2005, the Council adopted a long-term allocation framework to apportion the annual Pacific sardine harvest guideline among the various non-tribal sectors of the sardine fishery. The Council followed the unanimous opinion of the CPSAS when adopting a seasonal allocation scheme which provides the following allocation formula for the non-tribal share of the harvest guideline:

(1) January 1, 35% of the harvest guideline to be allocated coastwide;
(2) July 1, 40% of the harvest guideline, plus any portion not harvested from the initial allocation, to be reallocated coastwide; and
(3) September 15, the remaining 25% of the harvest guideline, plus any portion not harvested from earlier allocations, to be reallocated coastwide.

The Council also heeded the advice of the CPSAS, the CPSMT, and the SSC regarding the dynamic nature of the Pacific sardine resource and uncertainties inherent in long-term projections and scheduled a formal review of the allocation formula in 2008. This review will provide a comparison of the performance of the fishery in the first two years to the projections used to evaluate the adopted allocation scheme and will include any new information from Pacific sardine research. The Council recommended NMFS continue to pursue coastwide research on the Pacific sardine stock and requested a report from the Southwest Fisheries Science Center at the September 2005 Council meeting regarding CPS research plans. The Council further recommended that NMFS work closely with the governments of Mexico and Canada to facilitate fishery data exchange and strong international resource stewardship of trans-boundary fish resources.

2.2.6 Amendment 12

At the November 2004 meeting, the Council, initiated development of a formal prohibition on directed fisheries for krill and directed staff to begin development of management measures to regulate directed fisheries for krill within Council-managed waters. The proposal for a krill ban was first proposed for West Coast National Marine Sanctuary waters by the National Marine Sanctuary Program. These measures are recommended to be incorporated into an amendment to the CPS FMP. The Council also included a specific alternative for analysis that would prohibit directed krill fisheries within waters of West Coast National Marine Sanctuaries.

This proposed action is in recognition of the importance of krill as a fundamental food source for much of the marine life along the West Coast. Moreover, state laws prohibit krill landings by state-licensed fishing vessels into California, Oregon, and Washington, respectively. Thus, the action could provide for consistent Federal and state management. There are currently no directed krill fisheries in Council-managed waters.

The NMFS took the lead on this proposed krill amendment and briefed the Council and advisory bodies on progress at the March and April 2005 Council meetings. The Council anticipates an update by NMFS at the September 2005 meeting including a review of draft regulatory and environmental compliance documents. Council final action and regulatory implementation are tentatively scheduled for spring and summer 2006 respectively.

At the November 2005 Council meeting, the Council recommended that all species of krill be included in the CPS FMP as prohibited species and approved a range of krill fishing alternatives for public review and additional analysis over the winter. The Council narrowed the range of alternatives to; 1) status quo, 2) a prohibition on krill fishing in all Council-managed waters, and 3) an initial prohibition combined with the establishment of a process for considering future krill fishing opportunities. Of these alternatives, the Council adopted the second, a complete ban on krill fishing as a preliminary preferred alternative. There are currently no directed krill fisheries on the U.S. West Coast and state laws prohibit krill landings by state-licensed fishing vessels into California, Oregon, and Washington.

In March 2006, the Council adopted a complete ban on commercial fishing for all species of krill in West Coast Federal waters and made no provisions for future fisheries. They also specified essential fish habitat (EFH) for krill, making it easier to work with other Federal agencies to protect krill. This broad prohibition will apply to all vessels in Council managed waters and will take form as Amendment 12 when fully implemented in 2007.

2.3 The CPS Fleet

During the 1940s and 1950s, approximately 200 vessels participated in the Pacific sardine fishery. Some present day CPS vessels are remnants of that fleet. 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). In addition to fishing for CPS finfish, many of these vessels fish for market squid, Pacific bonito, bluefin tuna, and Pacific herring.

A fishery for Pacific sardine has operated off Oregon and Washington since 1999. This fishery targets larger sardine, which are typically sold as bait for Asian longline tuna fisheries.

Along the West Coast, other vessels target CPS finfish in small quantities, typically selling their catch to specialty markets for relatively high prices. In recent years, these included:

- Approximately 18 live bait vessels in southern California and two vessels in Oregon and Washington that landed about 2,000 mt per year of CPS finfish (mostly northern anchovy and Pacific sardine) for sale to recreational anglers. Oregon's landings for live bait in 2005 totaled 2.6 mt of sardines by one vessel.

- Roundhaul vessels that take a maximum of 1,000 mt to 3,000 mt per year of northern anchovy that are sold as dead bait to recreational anglers.

- 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.

2.3.1 Limited Entry Fishery

The CPS LE fleet currently consists of 63 permits and 61 vessels (Table 3). The LE vessels range in age from 4 to 68 years, with an average age of 33 years (Table 4). Average vessel age has decreased by approximately four years since the initial fleet was established.

The capacity goal and transferability provisions established under Amendment 10 are based on calculated gross tonnage (GT) of individual vessels. Calculated GT serves as a proxy for each vessel's physical capacity and is used to track total fleet capacity. Calculated GT incorporates a vessel's length, breadth, and depth, which are consistent measures across vessel registration and U.S. Coast Guard documentation lists. As described at 46 CFR § 69.209, GT is defined as:

$$GT=0.67(length*breadth*depth)/100.$$

Vessel dimension data were obtained from the U.S. Coast Guard database, and each vessel's calculated GT was attached to the permit under Amendment 10. Original GT endorsements (specified in Table 3) remain with the permit, regardless of whether the permit is transferred to a smaller or larger vessel.

GT values for the current fleet range from 23.8 GT to 340.2 GT, with an average of 88.7 GT (Tables 3 and 4). Total fleet GT decreased from 5,462.9 GT to 5,408.4 GT during 2004. This decrease was due to the loss of the "Connie Marie" (permit 64; sank in 2002), which has yet to be replaced by the owner. The fleet capacity goal established through Amendment 10 is 5,650.9 GT, and the trigger for restricting transferability is 5,933.5 GT (Goal + 5%). The current LE fleet is 5,408.4 GT, well within the bounds of the capacity goal.

2.3.2 Northern Fisheries

2.3.2.1 Oregon

Pacific sardine was managed as a developmental fishery from 1999 to 2005. In 2004, the sardine industry asked the Department of Fish and Wildlife to remove Pacific sardines form the developmental species list and create a limited entry system for the fishery. The Department began work with the Developmental Fisheries Bard and the industry to develop alternatives for the fishery. In December 2005, the Oregon Fish and Wildlife Commission (Commission) moved the Pacific sardine fishery from a developing fishery into a state run limited entry fishery system. Twenty Oregon permits were established and made available to qualifying participants for the 2006 fishery. At that point, the Commission directed the Department to create minimum landing requirements for permit renewal. In April, the Commission established permit renewal requirements that included annual minimum landing requirements of at least 10 landings of at least 5 metric tons (mt) each, or landings totaling at least $40,000, based on ex-vessel price, of sardines into Oregon. The industry expressed concern over the lack of markets and the possibility of not being able to meet the minimum landing requirements. Therefore, rules also allow a waiver of landing requirements due to illness, injury, or circumstances beyond the control of the permit holder and authorize the Commission to waive the landing requirements for the industry as a whole for any particular year due to unusual market conditions. In May and August of 2006, the Commission heard petitions to amend limited entry permit eligibility rules to include all 2005 developmental fishery permit holders who did not meet eligibility requirements chosen by the Commission in December. The Commission amended a rule which resulted in an immediate addition of 6 permits for a total of 26 limited entry permits in 2006.

Although 26 permits were issued, only 18 permits were actively utilized in the fishery. Two of those 18 permits were transferred to vessels with the intention of qualify them under the new renewal requirements. A total of eight (of 26) permit holders did not meet the minimum landing requirements for renewal of their limited entry permit. In September, the Commission received letters from eight processors and one fisherman requesting an industry-wide waiver of the minimum landing requirements due to unusual market conditions. The Commission granted a waiver for all 2006 limited entry permit holders in January 2007. The Commission also directed ODFW staff to work with the Oregon sardine industry to establish a minimum number of permits for the fishery and create a regulatory system to reissue permits that are not renewed.

During the winter of 2007, ODFW hosted discussions with Washington and the Pacific Northwest (PNW) sardine industry to focus on current state rules that prevent a directed reduction fishery. Attendees discussed difficulties of minimizing reduction of fish and finding alternative markets for small and unwanted sardines. The two states will continue to work together with the PNW sardine industry to consider the resource, economics and harvesting capabilities to conserve the resource, yet uphold the value of the fishery.

2.3.2.2 Washington

In Washington, sardines are managed under the Emerging Commercial Fishery provisions, which provide for the harvest of a newly classified species or harvest of a previously classified species in a new area or by new means. From 2000 through 2002, WDFW had trial purse seine fisheries for Pacific sardines, under which the number of participants, by law, cannot be limited. Since participation could not be limited, the Washington fishery was managed to a state HG of 15,000 mt. Following an extensive public process, which included establishing and meeting with a formal Sardine Advisory Board, the Director of WDFW decided to advance the sardine fishery from a trial to an experimental fishery in 2003. Experimental fisheries, under the Emerging Commercial Fisheries legislation, require participation to be limited. In collaboration with the Sardine Advisory Board, WDFW developed and implemented an effort limitation program in 2003. The experimental fishery and LE program has continued through 2006. WDFW also conducted a 5-year observer program from 2000 through 2004 to document bycatch levels in the fishery. Overall observer coverage in this program was in excess of 25% and was financially supported by fishery participants as part of their permit conditions. A mandatory logbook program has also been in place since the fishery began in 2000. All logbook records must be submitted, and any outstanding observer or permit fees owed to must be paid prior to receiving a permit for the current season.

In 2006, limited experimental fishery permits were issued to fourteen fishers meeting the necessary permit criteria of previously holding such a permit and also landing at least 40 mt of sardines into Washington over the previous two years. Additionally, the Director of WDFW may issue replacement permits if the total number of experimental permits falls below 20. To qualify for a replacement permit in 2006, a fisher mush have had at least 50% ownership in vessel that was designated on an experimental sardine fishery permit in 2004 or 2005, and that vessel must have landed a minimum of 40 mt of sardine into Washington over the period of 2004 and 2005. Four such replacement permits were issued in 2006, bringing the total number of Washington permits up to 18. Of these, only 7 permits participated in the 2006 fishery. In addition to limiting participation in the fishery, WDFW also restricts the cumulative seasonal total of sardines that can go toward reduction, at both the individual vessel and processor level, to 15 percent.

2.3.3 California's Market Squid Fishery

In 2001, legislation transferred the authority for management of the market squid fishery to the California Fish and Game Commission (Commission). Legislation required that the Commission adopt a market squid fishery management plan and regulations to protect and manage the squid resource. In August and December of 2004, the Commission adopted the Market Squid Fishery Management Plan (MSFMP), the environmental documentation, and the implementing regulations, which went into effect on March 28, 2005, just prior to the start of the 2005/2006 fishing season which started April 1st.

The goals of the MSFMP are to provide a framework that will be responsive to environmental and socioeconomic changes and to ensure long term resource conservation and sustainability. The tools implemented to accomplish these goals include: (1) setting a seasonal catch limit of 107,047 mt (118,000 short tons) to prevent the fishery from over-expanding; (2) maintaining monitoring programs designed to evaluate the impact of the fishery on the resource; (3) continuing weekend closures that provide for periods of uninterrupted spawning; (4) continuing gear regulations regarding light shields and wattage used to attract squid; (5) establishing a restricted access program that includes provisions for initial entry into the fleet, permit types, permit fees, and permit transferability that produces a moderately productive and specialized fleet; and (6) creating a seabird closure restricting the use of attracting lights for commercial purposes in any waters of the Gulf of the Farallones National Marine Sanctuary. Under this framework, the MSFMP provides the Commission specific guidelines for making management decisions. The Commission has the ability to react quickly to changes in the market squid population off California and implement management strategies without the need for a full plan amendment. The MSFMP framework structure was also designed achieve the goals and objectives of the Marine Life Management Act and to be consistent with the management outlined in CPS FMP Amendment 10.

Under the restricted access program in the MSFMP a permit is needed to participate in the fishery. Qualification for different types of permits and transferability options was based on historical participation in the fishery. In 2006 a total of 163 permits were issued under seven permit categories. Market squid vessel permits allow a vessel to attract squid with lights and use large purse seines to capture squid; a total of 73 transferable and 12 non-transferable vessel permits were issued for the 2006-2007 fishing season. Brail permits allow a vessel to attract squid with lights and use brail gear to capture squid; a total of 16 transferable brail permits were issued for the 2006-2007 season. Light boat permits only allow a vessel to attract squid with lights (30,000 watts, maximum); a total of 59 transferable light boat permits were issued. Three experimental non-transferable market squid permits were issued in 2006 which allow these vessels to fish in areas not historically targeted by the market squid fishery (namely north of San Francisco). Landings of two short tons or less are considered incidental and no permit is required.

2.3.4 Treaty Tribe Fisheries

Tribal fisheries on sardine may evolve in waters north of Point Chehalis, Washington. The CPS FMP recognizes the rights of treaty Indian tribes to harvest Pacific sardine and provides a framework for the development of a tribal allocation. The Makah Tribe informed the Council of their intent to enter the sardine fishery in 2006. In response, the Council created the Ad Hoc Sardine Tribal Allocation Committee made up of state, Federal, and tribal representatives, to immediately begin to work on this issue. If a tribal allocation is established, the non-tribal allocation formula will likely be applied to the remainder of the harvest guideline after accommodation of the tribal fishery.

3.0 STOCK ASSESSMENT MODELS

3.1 Pacific Sardine

The Pacific sardine (*Sardinops sagax caerulea*) resource is assessed each fall in support of the Council process that, in part, sets an annual HG (quota) for the U.S. commercial fishery. This process is centered on an environmentally-based control rule that establishes a U.S. coastwide HG for an annual (Jan. 1 to Dec. 31) management cycle. The primary purpose of the assessment is to provide an estimate of current biomass, which is used to calculate annual HGs. A general overview of the harvest control rule is provided in Sections 4.3.2 and 9.1.1.1 of this SAFE report. For background analyses regarding the harvest control rule, see Amendment 8 of the CPS FMP (PFMC 1998).

The Pacific sardine stock assessment used for 2007 management (Hill *et al*. 2006; see Appendix 1) was conducted using a likelihood-based, age-structured model (Age-structured Assessment Program-ASAP, see Legault and Restrepo 1999). The general estimation approach used in the ASAP model is a flexible, 'forward-simulation' that allows for the efficient and reliable estimation of a large number of parameters. The population dynamics and estimator theory that serves as the basis of forward-estimation, age-structured models such as ASAP, is described in Fournier and Archibald (1982), Deriso et al. (1985), Megrey (1989), and Methot (1990, 1998).

The final ASAP model (1982-2006) was based on fishery-dependent data from three fisheries (Ensenada, Mexico; U.S. California; and U.S. Pacific northwest) and fishery-independent data from two research surveys: an index of spawning biomass based on the Daily Egg Production Method survey data, see Lo et al. (1996, 2005, 2006); and an index of pre-adult biomass from aerial spotter plane survey data (Lo *et al.* 1992). Finally, an environmental index (i.e., a time series of sea-surface temperatures recorded at Scripps Pier, La Jolla, California) is used to develop a fishing mortality-based proxy for MSY, which is an additional parameter used in the harvest control rule for determination of annual HGs (see Section 9.1.1.1). For details regarding the current assessment model, readers should consult Hill et al. (2006; see Appendix 1). See Deriso et al. (1996) and Hill et al. (1999) for descriptions of input data and modeling methods used in previous (CANSAR and CANSAR-TAM) assessments of Pacific sardine.

3.2 Pacific Mackerel

A Pacific mackerel (*Scomber japonicus*) stock assessment is conducted each spring in support of the Council process that ultimately establishes a HG for the U.S. management season opening July 1 and ending June 30 of the following year. The primary purpose of the assessment is to provide an estimate of current biomass, which is used in a harvest control rule to calculate the HG. A general overview of the harvest control rule is provided in Section 4.3.3 of this SAFE Report. For background and analyses regarding this species' harvest control rule, see Amendment 8 of the CPS FMP (PFMC 1998).

Full assessments for Pacific mackerel typically occur every third year, necessitating a three-year cycle for the CPS Stock Assessment Review (STAR) process. The National Marine Fisheries Services, Southwest Fisheries Science Center, took the lead in developing a new full assessment of Pacific mackerel for the 2007-2008 fishing season. The full assessment was reviewed during a May 1-4, 2007 STAR Panel meeting in La Jolla, California. The STAR Panel and the assessment team agreed on an assessment for use in managing the upcoming Pacific mackerel season and recommended additional analyses for review at the next CPS STAR Panel meeting schedule for September 18-21, 2007. The Council and the full SSC are scheduled to review the assessment at the June 11-15 Council meeting in Foster City, California. The draft stock assessment, STAR Panel Reports, and statements from the CPSAS and CPSMT are posted at the Council web page in the June 2007 Briefing Book under Agenda Item F.2. This section will be updated and the final assessment documents will be appended to this document following Council final action in June.

3.3 Section References:

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Lo, N.C.H., Y.A. Green Ruiz, M.J. Cervantes, H.G. Moser, and R.J. Lynn. 1996. Egg production and spawning biomass of Pacific sardine (Sardinops sagax) in 1994, determined by the daily egg production method. Calif. Coop. Oceanic Fish. Invest. Rep. 37:160-174.

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4.0 OPTIMUM YIELD, MAXIMUM SUSTAINABLE YIELD, AND MAXIMUM SUSTAINABLE YIELD CONTROL RULES

Information in this section is excerpted from: Amendment 8 (To the Northern Anchovy Fishery Management Plan) incorporating a name change to the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council. Portland, Oregon. 1998.

4.1 Optimum Yield

The Magnuson-Stevens Act defines the term "optimum," with respect to the yield from a fishery, as the amount of fish which:

- Will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.
- Is prescribed on the basis of the MSY from the fishery, as reduced by any relevant social, economic, or ecological factor.
- In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery [50 C*FR* §600.310(f)(1)(i)].

Optimum yield for a CPS stock is defined to be the level of harvest which is less than or equal to ABC estimated using a MSY control rule, consistent with the goals and objectives of this FMP, and used by the Council to manage the stock. The ABC is a prudent harvest level calculated based on an MSY control rule. In practice, OY will be determined with reference to ABC. In particular, OY will be set less than ABC to the degree required to prevent overfishing.

4.2 Maximum Sustainable Yield, MSY Control Rules, and Acceptable Biological Catch

For CPS, an MSY control rule is defined to be a harvest strategy that provides biomass levels at least as high as the F_{MSY} (fishing mortality rate that maximizes catch biomass in the long term) approach while also providing relatively high and consistent levels of catch. According to Federal regulations (50 CFR §600.310(b)(1)(ii)), an MSY control rule is "a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY." Similarly, MSY stock size "means the long-term average size of the stock or stock complex, measured in terms of spawning biomass or other appropriate units that would be achieved under an MSY control rule in which the fishing mortality rate is constant." The definition of an MSY control rule for CPS is more general, because it includes the definition in National Standard 1. It is also more conservative, because the focus for CPS is oriented primarily towards stock biomass levels at least as high as the MSY stock size. The primary focus is on biomass, rather than catch, because most CPS (Pacific sardine, northern anchovy, and market squid) are very important to the ecosystem as forage.

The MSY control rules in the CPS fishery may vary depending on the nature of the fishery, management goals, assessment and monitoring capabilities, and available information. Under the framework management approach used for CPS, it is not necessary to amend the CPS FMP in order to develop or modify MSY control rules or definitions of overfishing.

The use of an MSY control rule for actively managed stocks provides managers with a tool for setting and adjusting harvest levels on a periodic basis while preventing overfishing and overfished stock conditions. All actively managed stocks must have stock-specific MSY control rules, a definition of overfishing, and a definition of an overfished stock. Definitions of overfishing and overfished are detailed below in Section 5.

The main use of an MSY control rule for a monitored stock is to help gauge the need for active management. MSY control rules and harvest policies for monitored CPS stocks may be more generic and simpler than those used for actively managed stocks. Under the FMP, any stock supporting catches approaching the ABC or MSY levels should be actively managed unless there is too little information or other practical problems.

4.3 MSY Control Rules for CPS

The Council may use the default MSY control rule for monitored species unless a better species-specific rule is available, e.g., the MSY-proxy approach adopted for market squid (see Section 4.3.4). The default MSY control rule can be modified under framework management procedures. The default MSY control rule sets ABC for the entire stock (U.S., Mexico, Canada, and international fisheries) equal to 25% of the best estimate of the MSY catch level. Overfishing occurs whenever total catch (U.S., Mexico, Canada, and international fisheries) exceeds ABC or whenever fishing occurs at a rate that is high enough to jeopardize the capacity of the stock to produce MSY. Overfishing of a monitored CPS stock is "approached" whenever projections or estimates indicate the overfishing will occur within two years.

In making decisions about active management, the Council may choose to consider ABC and catches in U.S. waters only. ABC in U.S. waters is the ABC for the entire stock prorated by an estimate of the fraction of the stock in U.S. waters. Active management may not be effective if U.S. catches are small, and overfishing is occurring in Mexico, Canada, or in international waters outside the jurisdiction of Federal authorities.

4.3.1 General MSY Control Rule for Actively Managed Species

The general form of the MSY control rule used for actively managed CPS fisheries was designed to continuously reduce the exploitation rate as biomass declines. The general formula used is:

$$H = (\text{BIOMASS-CUTOFF}) \times \text{FRACTION}$$

H is the harvest target level, CUTOFF is the lowest level of estimated biomass at which directed harvest is allowed, and FRACTION is the fraction of the biomass above CUTOFF that can be taken by the fishery. BIOMASS is generally the estimated biomass of fish age 1+ at the beginning the season. The purpose of CUTOFF is to protect the stock when biomass is low. The purpose of FRACTION is to specify how much of the stock is available to the fishery when BIOMASS exceeds CUTOFF. It may be useful to define any of the parameters in this general MSY control rule, so they depend on environmental conditions or stock biomass. Thus, the MSY control rule could depend explicitly on the condition of the stock or environment.

The formula generally uses the estimated biomass for the whole stock in one year (BIOMASS) to set harvest for the whole stock in the following year (H) although projections or estimates of BIOMASS, abundance index values or other data might be used instead. BIOMASS is an estimate only; it is never assumed that BIOMASS is a perfect measure of abundance. Efforts to develop a harvest formula must consider probable levels of measurement error in BIOMASS which typically have coefficient of variations of about 50% for CPS.

The general MSY control rule for CPS (depending on parameter values) is compatible with the Magnuson-Stevens Act and useful for CPS that are important as forage. If the CUTOFF is greater than zero, then the harvest rate (H/BIOMASS) declines as biomass declines. By the time BIOMASS falls as low as CUTOFF, the harvest rate is reduced to zero. The CUTOFF provides a buffer of spawning stock that is protected from fishing and available for use in rebuilding if a stock becomes overfished. The combination of a spawning biomass buffer equal to CUTOFF and reduced harvest rates at low biomass levels means that a rebuilding program for overfished stocks may be defined implicitly. Moreover, the harvest rate never increases above FRACTION. If FRACTION is approximately equal to F_{MSY}, then the MSY control rule harvest rate will not exceed F_{MSY}. In addition to the CUTOFF and FRACTION parameters, it may be advisable to define a maximum harvest level parameter (MAXCAT) so that total harvest specified by the harvest formula never exceeds MAXCAT. The MAXCAT is used to guard against extremely high catch levels due to errors in estimating biomass, to reduce year-to-year variation in catch levels, and to avoid overcapitalization during short periods of high biomass and high harvest. MAXCAT also prevents the catch from exceeding MSY at high stock levels and spreads the catch from strong year classes over a wider range of fishing seasons.

Other general types of control rules may be useful for CPS and this FMP does not preclude their use as long as they are compatible with National Standards and the Magnuson-Stevens Act.

4.3.2 MSY Control Rule for Pacific Sardine

The MSY Control Rule for Pacific sardine sets ABC for the entire sardine stock based on an estimate of biomass for the whole sardine stock, a CUTOFF equal to 150,000 mt, a FRACTION between 5% and 15% (depending on oceanographic conditions as described below), and MAXCAT of 200,000 mt. The U.S. ABC is calculated from the target harvest for the whole stock by prorating the total ABC based on 87% proportion of total biomass in U.S. waters.

FRACTION in the MSY control rule for Pacific sardine is a proxy for F_{MSY} (i.e., the fishing mortality rate for deterministic equilibrium MSY). FRACTION depends on recent ocean temperatures, because F_{MSY} and sardine stock productivity are higher under ocean conditions associated with warm water temperatures. An estimate of the relationship between F_{MSY} for sardine and ocean temperatures is:

$$FMSY = 0.248649805\ T^2 - 8.190043975\ T + 67.4558326$$

where T is the average three-season sea surface temperature (SST) at Scripps Pier (La Jolla, California) during the three preceding seasons. Thus, the MSY control rule for Pacific sardine sets the control rule parameter FRACTION equal to F_{MSY}, except that FRACTION is never allowed to be higher than 15% or lower than 5%, which depends on recent average sea surface temperature.

Although F_{MSY} may be greater or lesser, FRACTION can never be greater than 15% or less than 5% unless the MSY control rule for sardine is revised, because 5% and 15% are policy decisions based on social, economic, and biological criteria. In contrast, relationships between FRACTION, F_{MSY} and environmental conditions are technical questions and estimates or approaches may be revised by technical teams (e.g. the CPSMT) to accommodate new ideas and data.

4.3.3 MSY Control Rule for Pacific Mackerel

The MSY control rule for Pacific mackerel sets the CUTOFF and the definition of an overfished stock at 18,200 mt and the FRACTION at 30%. Overfishing is defined as any fishing in excess of ABC calculated using the MSY control rule. No MAXCAT is defined because the U.S. fishery appears to be limited by markets and resource availability to about 40,000 mt per year. The target harvest level is defined for the entire stock in Mexico, Canada, and U.S. waters (not just the U.S. portion), and the U.S. target harvest level is prorated based on 70% relative abundance in U.S. waters.

4.3.4 MSY Control Rule for Market Squid

Although market squid is only a monitored species, a potential MSY Control Rule for market squid has been reviewed formally through a stock assessment review (STAR) conducted in 2001, as well as presented within the Council forum in 2002. The proposed MSY Control Rule is generally based on the Egg Escapement method, which currently serves as an informal assessment tool for this species (see

Appendix 3 in PFMC (2002) for further discussion concerning specific details involved in this assessment approach, as well as review-related discussion). It is important to note that the main objective of a MSY Control Rule for a "monitored" stock (e.g., market squid) is to help assess the need for "active" management. That is, the MSY Control Rules and harvest policies for monitored CPS stocks may be based on broader concepts and constraints than those used for stocks with significant fisheries that fall under active management. Any fishery whereby catches approach an ABC or MSY level warrant consideration within active management processes, given catch statistics are scientifically based and management operations can be practically implemented. Overfishing of a monitored CPS stock is considered whenever current estimates or projections indicate that a minimum stock threshold will be realized within two years. In practical terms, the market squid fishery is monitored through a state-based management plan that includes an annual landings cap (CDFG 2005) and various spatial/temporal constraints. Whereas, within a research context only, population dynamics and biological reference point (say MSY-related) evaluations regarding this species are addressed through the Egg Escapement method and simulation analysis. Given the "monitored" status of this population, the above management/research approach appears reasonable; however, "active" management may need to be considered in the future if fishery operations change substantially (e.g., spatially expand, harvest high amounts of immature squid, etc.) and/or ongoing modeling efforts identify areas (spatial or temporal) of concern regarding egg escapement levels associated with commercial fishery sample data. A brief description of the Egg Escapement method follows, with further discussion presented in section 9.2.3.

The Egg Escapement method is founded on conventional spawning biomass "per-recruit" theory. In general, the proposed MSY Control Rule for market squid is based on evaluating (throughout a fishing season) levels of egg escapement associated with the exploited population(s). The estimates of egg escapement are evaluated in the context of a "threshold" that is hypothesized to represent (generally) a biological reference point that, if not exceeded (and over the long-term and given favorable oceanographic conditions), will support sustainable abundance levels and some degree of surplus for fishery-related purposes. It is important to note that the threshold proposed currently (i.e., 30%) represents a strictly preliminary statistic and intended as a precautionary reference point, which ultimately, is expected to be revised (to some degree) as more sample data (spatially and temporally) are examined through egg escapement and simulation research. In this context, in fall 2006, the CPSMT reviewed results from ongoing research addressing egg escapement modeling efforts over the last two years. A working paper summarizing the results of this research will be distributed (via CPSMT discussions) in fall 2007.

4.4 Section References:

California Department of Fish and Game (CDFG). 2005. Final market squid fishery management plan. Document can be obtained from State of California Resources Agency, Department of Fish and Game, Marine Region, 4665 Lampson Avenue (Suite C), Los Alamitos, CA 90720. 124 p.

Pacific Fishery Management Council (PFMC). 1998. Amendment 8 (To the northern anchovy fishery management plan) incorporating a name change to: the coastal pelagic species fishery management plan. Document can be obtained from Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220.

Pacific Fishery Management Council (PFMC). 2002. Status of the Pacific coast coastal pelagic species fishery and recommended acceptable biological catches: stock assessment and fishery evaluation (2002). Appendix 3: market squid MSY. Document can be obtained from Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220.

5.0 OVERFISHING CONSIDERATIONS

Information in this section is excerpted from: Amendment 8 (To the Northern anchovy fishery management plan) incorporating a name change to: the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council. Portland, Oregon. 1998.

5.1 Definition of Overfishing

By definition, overfishing occurs in a fishery whenever fishing occurs over a period of one year or more at a rate that is high enough to jeopardize the capacity of the stock to produce MSY on a continuing basis if applied in the long term. Overfishing in the CPS fishery is "approached" whenever projections indicate overfishing will occur within two years. The definition of overfishing is in terms of a fishing mortality or exploitation rate. Depending on the exploitation rate, overfishing can occur when CPS stocks are at either high or low abundance levels. The Council must take action to eliminate overfishing when it occurs and to avoid overfishing when exploitation rates approach the overfishing level.

In operational terms, overfishing occurs in the CPS fishery whenever catch exceeds ABC, and overfishing is approached whenever projections indicate that fishing mortality or exploitation rates will exceed the ABC level within two years. The definition of an overfished stock is an explicit part of the MSY control rule for CPS stocks.

5.2 Definition of an Overfished Stock

By definition, an overfished stock in the CPS fishery is a stock at a biomass level low enough to jeopardize the capacity of the stock to produce MSY on a continuing basis. An overfished condition is approached when projections indicate that stock biomass will fall below the overfished level within two years. The Council must take action to rebuild overfished stocks and to avoid overfished conditions in stocks with biomass levels approaching an overfished condition.

5.3 Rebuilding Programs

Management of overfished CPS stocks must include a rebuilding program that can, on average, be expected to result in recovery of the stock to MSY levels in ten years. It is impossible to develop a rebuilding program that would be guaranteed to restore a stock to the MSY level in ten years, because CPS stocks may remain at low biomass levels for more than ten years even with no fishing. The focus for CPS is, therefore, on the average or expected time to recovery based on realistic projections. If the expected time to stock recovery is associated with unfavorable ecosystem conditions and is greater than ten years, then the Council and the Secretary may consider extending the time period as described at 50 CFR § 600.310(e).

Rebuilding programs for CPS may be an integral part of the MSY control rule or may be developed or refined further in the event that biomass of a CPS stock reaches the overfished level.

6.0 BYCATCH AND DISCARD MORTALITY

Fishery management plans prepared by a fishery management council or by the Secretary must, among other things, establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and include conservation and management measures that, to the extent are practicable and in the following priority:

1. Minimize Bycatch.
2. Minimize the mortality of bycatch that cannot be avoided.

The Magnuson-Stevens Act defines bycatch as “fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program” (16USC1802).

CPS vessels fish with roundhaul gear (purse seine or lampara nets of approximately one-half mile in total length). These are encircling type nets, which are deployed around a school of fish or part of a school. When the school is surrounded, the bottom of the net may be closed, then the net drawn next to the boat. The area including the free-swimming fish is diminished by bringing one end of the net aboard the vessel. When the fish are crowded near the fishing vessel, pumps are lowered into the water to pump fish and water into the ship’s hold. Another technique is to lift the fish out of the net with netted scoops (e.g., brails). Roundhaul fishing results in little unintentionally caught fish, primarily because the fishers target a specific school, which usually consists of pure schools of one species. The tendency is for fish to school by size, so if another species is present in the school, it is typically similar in size. The most common incidental catch in the CPS fishery is another CPS species (e.g., Pacific mackerel incidental to the Pacific sardine fishery). If larger fish are in the net, they can be released alive before pumping or brailing by lowering a section of the cork-line or by using a dip-net. The load is pumped out of the hold at the dock, where the catch is weighed and incidentally-caught fish can be observed and sorted. Because pumping at sea is so common, any incidental catch of small fish would not be sorted at sea. Grates can be used to sort larger non-CPS from the catch. Grates are mandatory in Oregon to sort larger non-CPS from the catch. At-sea observers have record discard at one time or another since the year 2000 off the states of Oregon, Washington, and California. Incidental harvest of non-prohibited larger fish are often taken home for personal use or processed.

Historically, market squid have been fished at night with the use of powerful lights, which cause squid to aggregate, which enables fishermen to pump squid directly from the sea or to encircle them with a net. California actively manages the market squid fishery in waters off California and has developed an FMP for the state-managed fishery. California’s market squid FMP established a management program for California’s market squid resource with goals that are aimed at ensuring sustainability of the resource and reducing the potential for overfishing. The tools to accomplish these goals include:

- Establishing fishery control rules, including a seasonal catch limitation to prevent the fishery from over-expanding; continuing weekend closures, which provide for periods of uninterrupted spawning; continuing gear regulations regarding light shields and wattage used to attract squid; and maintaining monitoring programs designed to evaluate the impact of the fishery on the resource.

- Instituting a restricted access program, including provisions for initial entry into the fleet, types of permits, permit fees, and permit transferability.

- Establishing a general habitat closure area in northern California rarely used by the squid fishery to eliminate the potential of future negative interactions with seabirds, marine mammals, and important commercial and sport fishes; and adding limitations on using lights to attract squid around several of the Channel Islands, an effort intended to protect nesting seabirds.

In addition to the reasons discussed above, several circumstances in the fishery tend to reduce bycatch:

1. Most of what would be called bycatch under the Magnuson-Stevens Act is caught when roundhaul nets fish in shallow water over rocky bottom. Fishers try to avoid this to protect gear. Also, they may be specifically prohibited to fish these areas because of closures.

2. South of Pt. Buchon, California, many areas are closed to roundhaul nets under California law and the FMP, which reduces the chance for bycatch.

3. In California, a portion of the sardine caught incidentally by squid or anchovy fishers can be sold for reduction, which reduces discard.

4. The five tons or less allowable landing by vessels without LE permits under the FMP should reduce any regulatory discard, because those fish can be landed.

5. From 1996 to 2003, bycatch from the live bait logs was reported with an incidence of 10%. The primary species taken as incidental catch was barracuda. Virtually all fish caught incidentally in this fishery are either used for bait, for personal use, or released alive. See Tables 13, 14, and 15.

6. CDFG has implemented a logbook program for the squid fishery. The data to be collected includes bycatch.

Generally, fisheries for CPS can be divided into two areas: north and south of Pigeon Point, California (approximately 37°10' N latitude). In recent history, virtually the entire commercial fishery for CPS finfish and market squid has taken place south of Pigeon Point. The potential for taking salmon exists in this area, but diminishes south of Monterey, California (37° N latitude). Starting in 1999, CPS fisheries (notably, targeting Pacific sardine) increased in waters off Oregon and Washington. Oregon and Washington actively manage these northern fisheries, in part, because of the heightened potential for salmon bycatch. Section 6.1 through 6.2 describes the California fishery; section 6.3 provides information on Oregon and Washington fisheries.

See Amendment 9 to the CPS FMP (Environmental Assessment/Regulatory Impact Review, March 2001) for a complete description of bycatch-related issues and monitoring and reporting requirements. Amendment 9 is available from the Council office.

6.1 Federal Protection Measures

National Marine Fisheries Service (NMFS) regularly conducts Endangered Species Act (ESA) section 7 consultations to insure that federally threatened or endangered species are not adversely affected by federally managed fisheries. Since 1999 NMFS, Sustainable Fisheries Division (SFD), Southwest Region (SWR) has conducted eight consultations with other federal agencies, including NMFS Protected Resource Division (PRD) and U.S. Fish and Wildlife Service, regarding the CPS fishery.

Most recently, NMFS, SFD, SWR, initiated a formal section 7 consultation with NMFS, PRD, SWR, for the implementation of Amendment 11 to the CPS FMP. PRD completed a formal section 7 consultation on this action and in a Biological Opinion dated March 10, 2006, determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species. Specifically, the current status of the Lower Columbia River Chinook, Snake River Fall Chinook, Upper Willamette Chinook, Puget Sound Chinook, and Lower Columbia River coho were deemed not likely to be jeopardized by the Pacific sardine fishery.

6.1.1 California Coastal Pelagic Species Pilot Observer Program

NMFS SWR initiated a pilot observer program for California-based commercial purse seine fishing vessels targeting CPS in July 2004 with hopes of augmenting and confirming bycatch rates derived from CDFG dockside sampling. SWR personnel trained the first group of CPS observers in mid-July in Long Beach, California. Frank Orth and Associates (FOA), a private contractor, hired and provided observers for training and subsequent deployment. Six observers who had previous experience in other SWR-observed fisheries attended and completed the course. The training course emphasized a review of ongoing observer programs (drift gillnet, pelagic longline) and introduction to the soon-to-be observed fisheries (purse seine, albacore hook-and-line). The training curriculum included vessel safety, fishing operations, species identification, and data collection.

In late July 2004, observers began going to sea aboard CPS vessels. Observers used the ODFW's Sardine Bycatch Observations' form to record data on fishing gear characteristics, fishing operations, and target/non-target species catch and disposition. Observers also recorded data on trip specifics and protected species sightings/interactions. Observers had access to data field definitions in their SWR observer program Field Manuals. Most data detailing length, volume, or weight are obtained verbally from the vessel operator. Position and time data are recorded by the observer directly from hand-held or on-board electronics.

Data from this ongoing program has been compiled though January 2006. A total of 107 trips by vessels targeting CPS (228 sets) were observed from July 2004 to January 2006. Tables 5-8 show incidental catch and bycatch data collected during this time and are categorized by target species of the trip (i.e., Pacific sardine, Pacific mackerel, market squid or anchovy).

Future needs of the CPS observer program include: standardization of data fields, development of a fishery-specific Observer Field Manual, construction of a relational database for the observer data, and creation of a statistically reliable sampling plan. A review of the protocol and catch data by NMFS Southwest Science Center staff, the CPS Management team and other CPS interested parties is planned in the future to help address some of these needs.

NMFS also initiated an ESA section 7 consultation with USFWS regarding the possible effects of implementing Amendment 11 to the CPS FMP. USFWS concurred with NMFS and determined that implementing Amendment 11 may affect, but was not likely to adversely affect (NLAA): the endangered tidewater goby, the threatened western snowy plover, the Santa Ana sucker, the endangered short tailed albatross, the endangered California brown pelican, the endangered California least-tern, the threatened marbled murrelet, the threatened bald eagle, the threatened bull trout, and the candidate Xantus's murrelet. Formal consultation however was deemed necessary on the possible effects to the southern sea otter. The resulting biological opinion signed June 16, 2006, concluded that fishing activities conducted under Amendment 11 and its implementing regulations were not likely to jeopardize the continued existence of the otter. As a result of this BO new reporting requirements and conservation measures were implemented within the CPS FMP to provide further protection for southern sea otters.

6.2 Fishery South of Pigeon Point

Information from at-sea observations of the CDFG and conversations with CPS fishers suggest that bycatch is not significant in these fisheries. However, some individuals have expressed concern that game fish and salmon might constitute significant bycatch in this fishery. This is a reasonable concern, because anchovy and sardine are forage for virtually all predators, but there are no data to confirm significant bycatch of these species. CDFG port samples indicate minimal bycatch in the California fishery (Tables 9,10, and 11). The behavior of predators, which tend to dart through a school of prey rather than linger in it, and can more easily avoid encirclement with a purse seine, may help to minimize bycatch. Large predators such as blue sharks have been observed on occasion, but are by no means a common occurrence.

CDFG port samples collect information from CPS landings in Monterey and ports to the south. Biological samples are taken to monitor the fish stocks, and port samplers report incidentally caught fish. Reports of incidental catch by CDFG port samplers confirm small and insignificant landings of bycatch at California off-loading sites (Tables 9,10, and 11). These data are likely representatives of actual bycatch, because (as noted) fish are pumped from the sea directly into fish holds aboard the vessel. Fishers do not sort catch at sea or what passes through the pump, however, large fishes and other animals that cannot pass through the pump are not observed by the port sampler. Unloading of fish also occurs with pumps. The fish is either pumped into ice bins and trucked to processing facilities in another location or to a conveyor belt in a processing facility, where fish are sorted, boxed and frozen.

From 1985 through 1999, there were 5,306 CDFG port samples taken from the sardine and mackerel landings. From 1992 to 1999, incidental catch was reported on only 179 occasions, representing a 3.4% occurrence. Up to 1999 reports of incidental catch were sparse, and prior to 1992 none were reported. Earlier incidents of bycatch may not have been noted, because the harvest of anchovy and sardine was small, and only in recent years has the harvest of sardine increased. The incidental catch reported are primarily those species that are marketable and do not meet the definition of bycatch in the Magnuson-Stevens Act. During this period, unless an incidental species represented a significant portion of the load (at least a whole percentage point) the amount of the incidental catch was not recorded. Of the incidental catch reported from 1992 to 1999, the two most prevalent species were market squid at 79%, and northern anchovy at 12% incidence within samples (not by load composition). CDFG port sample information provides a useful database for determining the significance of bycatch in the CPS fishery off California (south of Pigeon Point).

In 2001, California wetfish port samplers began tallying undocumented incidental catch observed during landings in greater detail, and listed the occurrence of species in each sampled landing. The port sampling program records bycatch observed (i.e., presence or absence evaluations), but actual amounts of incidental catch have not been quantified to date. These observations are summarized for all areas in Table 9 for the last five years (2002 – 2006). The most commonly occurring animals in wetfish landings during 2006 were kelp, Pacific butterfish, white croaker, market squid, California scorpionfish, queenfish,,bat ray, hornyhead turbot, northern anchovy, California halibut, Pacific bonito, cusk eel, and California lizardfish, and specklefin midshipman. Forty-eight incidental species were observed in total.

In the Monterey area, incidental catch in wetfish landings was enumerated for the fourth year. In contrast to 2005 when only six incidental species were observed, there were thirty-two species observed incidental to finfish landings. The most commonly occurring species were northern anchovy, kelp, unspecified sanddabs, Pacific butterfish, white croaker, jacksmelt, marine algae (red, usually Turkish towel), eelgrass, American shad, sea stars, Pacific electric ray, starry flounder, sand sole, pink surfperch, big skate, plainfin midshipman, C-O sole, and bat ray. Because of staff shortages, the port complex of Santa Barbara/Ventura/Port Hueneme did not collect any CPS finfish samples in 2006.

Kelp (specifically holdfasts), crustaceans, flatfish, California scorpionfish, and elasmobranchs can serve as an indication of shallow set depth. Larger fish and animals are typically sorted for either market, personal consumption, or nutrient recycling in the harbor. To document bycatch more fully at sea, including marine mammal and bird interactions which port samplers are not privy to, NOAA Fisheries has placed observers on a number of California purse seine vessels beginning in the summer of 2004 (see Sec. 11.6).

6.2.1 Incidental Catch Associated with the Market Squid Fishery

Because squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur intermittently. In 2006, about eight percent of round haul squid landings included reported incidental catch of CPS species (Table 12a). Squid also occurs as incidental catch in trawl fisheries for sea cucumber and ridgeback prawn, and in various other gears.

Although non-target catch in market squid landings is considered minimal, the presence of incidental catch (i.e., species that are landed along with squid that are not recorded through landing receipt processes [i.e., not sold] as is typically done for incidentally-caught species) has been documented through CDFG's port sampling program. The port sampling program records bycatch observed (i.e., presence or absence evaluations), but actual amounts of incidental catch have not been quantified to date. During 2006, incidental catch consisted of twenty-nine species (Table 12b). Similar to previous years, most of this catch was other pelagic species, including Pacific sardine, Pacific mackerel, jack mackerel, squid egg cases, and northern anchovy. However, kelp and butterfish were also observed frequently.

Finally, the extent that squid egg beds and bottom substrate are damaged by recent purse seine operations and subsequently, contribute to significant mortality of early life stages is not definitively known at this time. However, information regarding the frequency of occurrence of squid eggs in squid landings port-side generally indicates that egg bed-related impacts have increased over the last several years. For example, from October 1998 through September 2001, bycatch of squid eggs had a 1.8% frequency of occurrence. In 2004, squid egg capsule bycatch was 5.1% statewide, a 0.2% increase over 2003 (4.9%). If bycatch of squid egg capsules continues to increase, some gear regulations may need to be implemented in the future (e.g., restrictions to the depth at which nets could be set, spatio-temporal closures of some shallow water habitats). In this context, further investigations regarding potential damage to squid spawning beds from fishery-related operations would likely benefit status-based analyses concerning the overall squid population off California, given eggs-per-recruit theory underlies the recently adopted squid assessment method. In 2006, CDFG will begin retaining egg capsules in order to determine first, if capsule age can be quickly determined in the laboratory, and second whether a measure of egg bed disturbance can be produced.

6.3 Fishery North of Point Arena

Since 2000, limited fisheries for Pacific sardines have occurred off the Pacific Northwest. Oregon and Washington closely monitor these fisheries and collect information about landings. Information on bycatch from Oregon and Washington is summarized in Tables 13 through 15.

6.3.1 Oregon

Oregon's directed fishery started approximately a month later than past years due to the late arrival of fish into northern Oregon waters. Spotter planes hired by the industry were used to locate fish and the first limited entry permitted landing into Oregon was made at the end of June. However, because of the small fish size and low oil content, major harvest activities did not start in earnest until early August. Approximately 3,000 mt per week were landed during the peak of the fishery from August to September, with an average of 43 mt per landing. The last landing occurred on October 18th and the 2006 Oregon sardine fishery saw the second-highest harvest on record since the current Oregon fishery began in 1999. Eighteen of the 26 permitted vessels landed a total of 35,648 mt of sardines. This a 21% decrease from the 45,110 mt landed in 2005. A total of 766 landings were made at seven different processors throughout Warrenton and Astoria. As in 2005, due to large amounts of small fish in the area, the majority of 2006 fishing activity took place off Washington rather than Oregon. Based on logbook data, 36% of sardine pounds landed were taken off Oregon and 64% off Washington. This is a similar ratio as in 2005. The exvessel value of sardine in the 2006 sardine fishery is roughly $3.54 million with an average price per pound of $0.05. Sardine value varied from $0.02 to $0.09 per pound. Roughly 4,938 mt of sardines were valued at less than $0.02/lb.

Oregon's permit stipulations include allowing observers when requested and requiring a grate over the hold opening to sort out larger species of fish. Oregon did not have personnel dedicated to ride along on sardine vessels and observe bycatch of non-target species. Available staff was able to observe 14 of 766 trips (1.8%). Vessel skippers were also required to record all species caught in a logbook. We received 97% of the logbooks for trips in 2006 which accounted for 98% of the landings. A total of 1041 sets were made with 88% (913) of them successful for sardines. Positive sets averaged 56 mt.

Based on state fish tickets, observer and logbook data bycatch continues to be low. Various bycatch included mackerel, northern anchovy, sharks and salmon (Table 14a & 14b). The estimated total catch of salmon for the fishery, based on log data, is 257 salmon and is the second lowest salmon incidental rate since 2000. An estimated 55% of all salmon were released alive. Based on log data, the incidental catch rates are 0.13 salmon caught per trip and 0.007 salmon per mt of sardine landed. The incidental catches of salmon during 14 observed trips with a total catch of 6 salmon in 2006 is 0.43 salmon per observed trip (two of the 14 trips did not catch fish). This does do not reflect the logbook estimates of 0.13 salmon per trip but the observed rate may be high due to a low number observational trips. The observed salmon per mt of sardine caught during the observed trips (0.010) is similar to the salmon per mt rate calculated from logbooks (0.007). Therefore, the logbooks may reflect the overall fishery incidental rate.

Incidental catch recorded on fishtickets consisted of 665 mt of Pacific mackerel, 1.4 mt of jack mackerel, 8.6 mt of northern anchovy, 1.2 mt of Pacific herring, 0.44 mt of American shad, 0.16 mt of thresher shark and 0.01 mt of sablefish for a total of 2% of the total catch (Table 14b). The 2006 Pacific mackerel exvessel value in the sardine fishery was roughly $35,000.

6.3.2 Washington

The Washington fishery opened by rule on April 1, 2006; however, the first landing into Washington did not occur until July 7. The Department issued a total of 18 permits and 7 of the permit holders participated in the fishery. Three primary vessels accounted for 75% of the harvest. A total of 4,363.1 mt of sardines were landed into Washington. A total of 108 landings were made, of which, 79 occurred within the months of August and September. A total of 127 sets were made; with 95% (121) of them successful. The average catch per successful set was 43.7 mt. Fishers and processors reported that sardines too small for available market demands constrained the 2006 fishery.

As part of the trial fishery and the experimental LE fishery regulations from 2000 through 2004, WDFW required fishers to carry at-sea observers, as well as provide financial support for this observer effort. Bycatch information was collected in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether alive, dead, or in poor condition. During the five-year period of the program, overall observer coverage averaged over 25% of both total landed catch and number of landings made. Based on observer data, the bycatch of non-targeted species in the Washington sardine fishery has been relatively low. Due to low bycatch levels, as well as a WDFW commitment to industry that an observer fee would only be assessed until bycatch in the sardine fishery could be characterized, the mandatory observer program was suspended at the conclusion of the 2004 season. Since a comparison of logbooks to observer data from 2000 to 2004 indicates that logbook data, in general, tends to be under-reported by 20% to 80% (Culver and Henry, 2006) salmon bycatch in the Washington sardine fishery for subsequent fishing years (2005 & 2006) has been calculated using the 5-year average bycatch rates from the observer program applied to total sardine catch. Bycatch and mortality estimates of incidentally captured salmon for the past seven years, by species, based upon 2000 –2004 observer information is shown in Table 12.

6.4 Section References

Culver, M., and C. Henry, 2006. Summary Report of the 2005 Experimental Purse Seine Fishery for Pacific Sardine (Sardinops sagax). Washington Department of Fish and Wildlife, Montesano, Washington. 11 pp.

Hill, K. T., and P. R. Crone. 2004. Stock assessment of Pacific mackerel (Scomber japonicus) in 2004. Paper can be obtained from Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220. 44 p. and Appendices.

McCrae, J., 2006. Oregon's Sardine Fishery, 2005 Summary. Oregon Department of Fish and Wildlife. Newport, Oregon. 12 pp.

NMFS. 2005. Endangered Species Act Section 7 Consultation Biological Opinion. Implementation of the 2005 Harvest Guideline for Pacific sardine fishery under the Coastal Pelagic Species Fishery Management Plan. 501 Ocean Blvd. Long Beach, CA 90802. 40 pp.

7.0 CALIFORNIA LIVE BAIT FISHERY

7.1 Introduction

Through much of the 20th century, CDFG monitored the harvest of CPS finfish in the California live bait fisheries by requiring live bait logs. Northern anchovy and Pacific sardine are the main species in this fishery, with a variety of other nearshore or CPS taken incidentally. An estimated 20% of this harvest is sold to private fishing vessels, with the remainder to the CPFV fleet, where payment to the bait haulers is on a percentage basis of the CPFV revenues (Thomson *et al.* 1994). An example of the first Live Bait Log from 1939, termed a "Daily Bait Record" as printed for the State of California, Department of Natural Resources, and Division of Fish and Game can be found in Aplin (1942). The nature of the data collected were self-reported daily estimates of the number of "scoops" taken and sold by the fishermen, by species. Although this variety of data does not lend itself readily to rigorous scientific analysis, there are at least 63 years of data available, collected in a reasonably uniform manner that can serve as an index to this low volume, high value fishery.

Studies conducted by CDFG, NMFS, and others have examined this fishery, generally with a focus on the dominant species taken over a given period. As in the directed commercial CPS fisheries, the local availability of each CPS to the bait fleet changes periodically. Problems with the live bait data such as conversion factors for scoops of live fish to weight, the economics of the fishery, the character of the fleet, and compliance rates in submitting logs have been addressed in various agency reports (Maxwell 1974; and Thomson *et al.* 1991, 1992, 1994).

7.2 Legislative History

Alpin (1942) describes the earliest implementation of the live bait log program in 1939, which followed a pilot program of verbal interaction with the fishermen that established four categories describing the variation in abundance or availability of CPS to the recreational industry.

Live bait logs have been at different times mandated by state law, or submitted to the CDFG on a voluntary basis. In the early 1990s sardine became more prevalent in the bait fishery, and quotas were imposed on their annual take pursuant to management efforts to recover the sardine population off California. In 1995, CDFG lifted quotas restricting the quantity of sardines that the live bait industry could harvest. The sardine population along the California Coast was increasing toward a "recovered" level, as anchovy showed a decline, and sardines became the preferred live bait over anchovy. With the sardine quota lifted, the level of scrutiny on the harvest of the live bait industry lessened.

7.3 Logbook Information

The CDFG Live Bait Log (Title 14, Section 158, California Code of Regulations: DFG 158, October 1989) requires only the estimated scoops taken daily of either anchovy or sardine be reported, and a check mark be made if other particular species were taken, with space for comments related to fishing. Other species noted, but not consistently enumerated in the live bait harvest, include white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), Pacific and jack mackerels (*Scomber japonicus and Trachurus symmetricus*), and various small fishes collectively known as "brown bait" that can include juvenile barracuda (*Sphyraena argentea*), Osmerids, Atherinids, and market squid (Table 16). Estimates of ancillary catch data has been documented in earlier reports, and in CPS FMP Amendment 9.

The CDFG Pelagic Fisheries Assessment Unit at the SWFSC in La Jolla presently archives the CDFG live bait logs. Preliminary estimates of the reported total live bait harvest in California through 2005 have been appended to previously reported estimates from Thomson *et al.* (1991, 1992, 1994) (Table 17). The CDFG is in the process of an evaluation of the current logbook structure, reporting requirements, and the information obtained in order to correct the data problems identified above, increase reporting compliance rates, and to better estimate the economics of the fishery.

7.4 Species Composition

The ratio of anchovy to sardine in the southern California live bait harvests shifts significantly as the populations of these two fish expand and contract over periods of years or decades. Much of the early reported harvest consisted of anchovy, following the collapse of the sardine fishery in the 1940s (Table 17).

Through the years 1994 to 2006 the proportion of anchovy in the total reported harvest ranged from a high of 58% in 1994 to a new low in 2004 of 5%. The proportion of sardine ranged from a low of 42% in 1994, to a new high of 95% in 2004 (Table 18).

7.5 References:

Alpin, J. A. 1942. Bait records in The commercial fish catch of California for the year 1940. Calif. Dept. Fish and Game Fish Bull. 58: 20-23.

Maxwell, W. D. 1974. A History of the California Live-Bait Fishing Industry. Calif. Dept. Fish and Game Marine Resources Technical Report 27. 24 p.

Thomson, C. J., T. Dickerson, G. Walls, and J. Morgan. 1991. Status of the California coastal pelagic fisheries in 1990. NMFS, SWFSC Admin. Rep. LJ-91-22: 27 p.

Thomson, C. J., T. Dickerson, G. Walls, and J. Morgan. 1992. Status of the California coastal pelagic fisheries in 1991. NMFS, SWFSC Admin. Rep. LJ-92-95:46 p.

Thomson, C. J., T. Bishop, and J. Morgan. 1994. Status of the California coastal pelagic fisheries in 1993. NMFS, SWFSC Admin. Rep. LJ-94-14.

Title 14, California Code of Regulations.

California Fish and Game Code. 2000. Lexis Law Publishing, Charlottesville, VA. 553 p.

California Fish and Game Code. 2001. Gould publications, Altamonte Springs, FL. 568 p.

8.0 VESSEL SAFETY CONSIDERATIONS

In implementing any form of management, it is imperative to evaluate whether the strategy will impact the safety of fishing activities. Roundhaul fisheries operating off the Pacific Coast are often limited by environmental conditions, most notably inclement weather. Given that the average age of permitted CPS vessels in the LE fishery is 32 years and many older vessels are constructed of wood, concern has been raised regarding their safety and seaworthiness. Implementing time/area closures or restricting transferability could impact safety by restricting the ability of an older vessel to be replaced with a newer, safer vessel or by promoting fishing activity during potentially hazardous weather conditions.

In January 2003, NMFS published final regulations to implement Amendment 10 to the CPS FMP, which allows LE permits to be transferred to another vessel and/or individual.

As discussed in Section 2.2, the Council recently implemented a long term allocation strategy for sardines under Amendment 11 to the CPS FMP. This action is not expected to have a substantial adverse impact on public health or safety. However, for Pacific Northwest fisheries, the action is anticipated to enhance safety at sea by advancing the reallocation date from October 1 to September 15. Waiting until October 1 to reallocate has the potential of inducing fishermen to fish in unsafe weather conditions. Ocean conditions off Oregon and Washington become increasingly rough in October. Also, crossing the Columbia River bar, always a hazardous exercise, becomes very dangerous in this time of year.

9.0 SUMMARY OF STOCK STATUS AND MANAGEMENT RECOMMENDATIONS

The CPS FMP distinguishes between "actively managed" and "monitored" species. Actively managed species (Pacific sardine and Pacific mackerel) are assessed annually. Harvest guidelines (HGs), fishing seasons, and other management controls are used. Other CPS species (northern anchovy, jack mackerel, and market squid) are monitored to ensure their stocks are stable, but annual stock assessments and federal fishery controls are not used.

While this document focuses on U.S. fisheries, many CPS stocks are distributed coastwide, hence, catch information from Mexican fisheries is of interest. See Table 18 for information on commercial harvest of CPS finfish landed into Ensenada, Mexico (1978-2001) (Table 15, García and Sanchéz 2003).

9.1 Actively Managed Species

9.1.1 Pacific Sardine

Hill *et al.* (2006; see Appendix 1) summarized the status of the Pacific sardine resource off the U.S. Pacific Coast and northern Baja California, Mexico. Pacific sardine landings for the fisheries off the Pacific Northwest (Oregon-Washington-Canada), California, and Ensenada (Mexico) totaled 152,852 mt in 2005-06 (July-June 'biological year'). In calendar year 2006, landings in California (51,029 mt) increased considerably from the previous year (38,193 mt in 2005; Table 20). Pacific Northwest landings were lower in 2006 (35,665 mt) than in 2005 (51,831 mt; Table 20). The U.S. fisheries (California-Oregon-Washington) are regulated using a quota-based ('Harvest Guideline' or HG) management scheme. Since the mid-1990s, actual landings from the U.S.-based fisheries have been less than the recommended HGs (Table 20). For example, the 2006 U.S. landings of sardine comprised ~73% of the HG established for that year (86,694 mt out of 118,937 mt). Total annual harvest of Pacific sardine by the Mexico fishery is not regulated, but there is a minimum legal size limit of 165 mm (García and Sánchez 2003). The Ensenada fishery landed 41,441 mt in 2006. See Tables 21 and 22 for a retrospective of West Coast Pacific sardine landings, 1981-2006.

Estimated stock biomass (ages 1+) from the assessment conducted in 2006 (Hill et al. 2006; see Appendix 1) indicated the sardine population has remained at a relatively high abundance level, with an estimate of roughly 1.32 million mt as of July 2006. Estimated recruitment (age-0 fish) in 2006 (4.9 billion fish) declined markedly from the peak estimate in 2003 (>14 billion). Further, given the inherent uncertainty surrounding estimated recruitment in recent years, definitive determinations regarding the apparent 'plateau' reached by the sardine population should be interpreted accordingly. See Table 19 for biomass and recruitment time series (1982-2006) from the most recent assessment.

Finally, estimates of Pacific sardine biomass from the 1930s (Murphy 1966 and MacCall 1979) indicate that the sardine population may have been more than three times its current size before the stock decline and eventual collapse observed in the 1960s. Considering the historical perspective, it would appear that the sardine population, under favorable oceanographic conditions, may still have growth potential beyond its current size. However, per capita recruitment estimates show a downward trend in recruits per spawner in recent years, which may be indicative of a stock that has reached a threshold under current environmental conditions.

9.1.1.1 Harvest Guideline for 2007

The Pacific sardine harvest guideline (HG) established for the U.S. fishery in calendar year 2007 was 152,564 mt. The maximum sustainable yield (MSY) control rule defined in Amendment 8 of the Coastal Pelagic Species-Fishery Management Plan (Option J, Table 4.2.5-1, PFMC 1998) was used to calculate the HG. The formula, intended to prevent overfishing and maintain relatively high and consistent catch levels over a long-term horizon, is as follows:

$$HG_{2007} = (BIOMASS_{2006} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where: HG_{2007} is the total U.S. HG in calendar year 2007, $BIOMASS_{2006}$ is the estimated July 1, 2006 stock biomass (ages 1+) from the current assessment (1,319,072 mt), CUTOFF is the lowest level of estimated biomass at which harvest is allowed (150,000 mt), FRACTION is an environment-based percentage of biomass above the CUTOFF that can be harvested by the fisheries (see below), and DISTRIBUTION (87%) is the percentage of $BIOMASS_{2006}$ assumed in U.S. waters. The value for FRACTION in the MSY control rule for Pacific sardine is a proxy for F_{msy} (i.e., the fishing mortality rate that achieves equilibrium MSY). Given F_{msy} and the productivity of the sardine stock have been shown to increase when relatively warm-ocean conditions persist, the following formula has been used to determine an appropriate (sustainable) FRACTION value:

$$\text{FRACTION or } F_{msy} = 0.248649805(T^2) - 8.190043975(T) + 67.4558326,$$

where T is the running average sea-surface temperature at Scripps Pier, La Jolla, California during the three preceding seasons (July-June). Ultimately, under Option J (PFMC 1998), F_{msy} is constrained and ranges between 5% and 15%. Based on the T values observed throughout the period covered by this stock assessment, the appropriate F_{msy} exploitation fraction has consistently been 15% since implementation of this control rule. This remains the case under current oceanic conditions (T_{2006} = 18.11 °C). The 2007 USA harvest guideline (152,564 mt) is 28% higher than the 2006 harvest guideline (118,937 mt), and 51,197 mt greater than the largest recent harvest by the U.S. fisheries (101,367 mt in 2002; Table 20).

9.1.2 Pacific Mackerel

The Pacific mackerel population that inhabits waters off California and northern Baja California (Ensenada, Mexico) has continually declined in abundance since the late 1970s. The coastwide harvest of this species was characterized by a generally similar decreasing pattern over this time frame, although the decline was not as consistent year-to-year or as precipitous as that observed for population biomass. In particular, during the 1990s, the directed fisheries off California had average annual landings of roughly 37,000 mt, whereas since 2002, average yearly landings have decreased nearly 90 percent (5,000 mt per year). This pattern of declining yields generally characterized all of the fisheries, including U.S. commercial and recreational fleets, as well as the commercial fishery of Mexico. Total annual harvest of Pacific mackerel by the Mexico fishery is not regulated, but there is a minimum legal size limit of 255 mm.

Determination of the status of the Pacific mackerel population (1929-2006) for the 2006 fishing/management year (i.e., a fishing season that spans from July 2006 through June 2007) was based on the ‘forward estimation’ assessment model ASAP (see sections 3.1 and 3.2 above, Hill and Crone 2005, and Crone *et al*. 2006).

Pacific mackerel biomass peaked in the late 1970s at approximately 680,000 mt, declining steadily to 67,000 mt in 2002. Presently, the biomass (ages $\geq$ 1 year old fish) is forecasted to be 112,700 mt as of July 1, 2006 (Crone et al. 2006; Appendix 1 of this document). The peak biomass observed during this time largely resulted from historically high levels of recruitment from the mid to late 1970s. These recruitment pulses occurred after a decade of extremely low biomass observed from the early-1960s to early-1970s. The decline in biomass since the early 1980s has resulted from a steady decline in year class strength and relatively low reproductive success (recruits-per-spawning stock biomass) since that time.

9.1.2.1 Harvest Guideline for 2007-2008

In Amendment 8 to the CPS FMP (PFMC 1998), the recommended MSY-based harvest control rule for Pacific mackerel is:

$$HG_{2007} = (\text{TOTAL STOCK BIOMASS}_{2007} - \text{CUTOFF}) \bullet \text{FRACTION} \bullet \text{STOCK DISTRIBUTION},$$

where HG_{2007} is the total U.S. (California) HG recommended for the 2007 fishing year (July 2007 - June 2007), TOTAL STOCK $BIOMASS_{2007}$ is the estimated stock biomass in 2007 (i.e., 112,700 mt; ages $\geq$1), CUTOFF is the lowest level of estimated biomass at which harvest is allowed, FRACTION is an environment-based percentage of biomass above the CUTOFF that can be harvested by the fisheries, and STOCK DISTRIBUTION is the percentage of TOTAL STOCK $BIOMASS_{2007}$ in U.S. waters. CUTOFF (18,200 mt), FRACTION (30%), and STOCK DISTRIBUTION (70%) are currently 'fixed' terms in the harvest control rule. See section 4.0 (PFMC 1998) and MacCall *et al.* 1985 for analyses applicable to parameters included in the harvest control rule.

Adoption of the harvest guideline and management measures for the 2007 Pacific mackerel fishery is scheduled to occur at the June 11-15, 2007 Council meeting in Foster City, California. The draft stock assessment, STAR Panel Reports, and statements from the CPSAS and CPSMT are posted at the Council web page in the June 2007 Briefing Book under Agenda Item F.2. This section will be updated and the final assessment documents will be appended to this document following Council final action in June.

9.2 Monitored Species

The monitored species category of the CPS FMP includes northern anchovy, jack mackerel, and market squid. Figure 1 illustrates distribution of northern anchovy and jack mackerel eggs for areas surveyed off southern California, April 2005.

9.2.1 Northern Anchovy

The most recent complete assessment for northern anchovy was described in Jacobson *et al.* (1995). California landings of northern anchovy began to increase in 1964, peaking in 1975 at 143,799 mt. After 1975, landings declined. From 1983 to 1999, landings did not exceed 6,000 mt per year until 2000. California landings of northern anchovy reported by Pacific Coast Fisheries Information Network (PacFIN) totaled 11,752 mt in 2000; 9,187 mt in 2001; 4,650 mt in 2002; 1,676 mt in 2003; 6,877 mt in 2004; 68 mt in 2005; and increased to 12,788 mt in 2006 (mostly caught in the Monterey area). There are no reported landings of northern anchovy in Oregon from 1981 through 2001, with 3.1 mt reported in 2002; 39 mt in 2003; 13 mt in 2004; 170 mt in 2005, and only 9 mt in 2006. Washington reported about 42 mt in 1988, but didn't land more until 2003 when 214 mt was landed; no landings occurred from 2004 through 2006. Through the 1970s and early 1980s, Mexican landings increased, peaking at 258,700 mt in 1981 (Table 19). Mexican landings decreased to less than 2,324 mt per year during the early 1990s, with a spike of 17,772 mt in 1995, primarily during the months of September through November. Catches in Ensenada decreased to 4,168 mt in 1996; and remained at less than 3500 mt through 2003. Anchovy landings in Ensenada increased to 5,604 in 1995; however, no landings were reported (or were not available) for 2002, 2004 or 2006.

Jacobson *et al.* (1995, 1997) summarized the disposition of northern anchovy landed in California. Beginning in 1965, when a reduction quota was first established separately from non-reduction uses, statistics for each use became available. All non-reduction uses are combined and include fresh, frozen, processed for human consumption, and dead bait. Mexican landings data first appear for 1962.

Total age 1+ biomass of northern anchovy rose in the early 1970s to a maximum estimate of 1,598,000 mt in 1973, and decreased to 392,000 mt in 1994. Further estimates of spawning biomass (age 1+) peaked in

1975 at 1,069,000 mt, and declined to 388,000 mt in 1994. Fishing mortality estimates in 1990 to 1994 did not exceed 0.03%, and declined to zero in 1993 and 1994.

9.2.2 Jack Mackerel

Until 1999, jack mackerel were managed under the Council's Pacific Coast groundfish FMP. Jack mackerel are now a monitored species under the CPS FMP. There is no evidence of significant exploitation of this species on the Pacific Coast of North America, and accordingly, there have not been regular stock assessments or efforts to collect biological information. Management efforts to collect fishery-dependent age composition data, such as the CDFG Port Sampling Program, are in place for the two actively managed CPS (Pacific sardine and Pacific mackerel), but not for jack mackerel, aside from samples taken prior to 1995. Previous discussions of jack mackerel, such as in the groundfish FMP, were brief:

> Available data indicate that the current, nearly un-used spawning biomass is about 1 million mt, the natural mortality rate is in the range of 0.1 to 0.2, a fishery located north of 39° N latitude would harvest fish that are mostly older than age 16, and the long-term potential yield for this age range is 19,000 mt. The [Council's Groundfish Management Team] recommends continuation of the 52,600 mt ABC on the basis of a constant exploitation rate (equal to natural mortality) applied to estimates of current biomass of ages 16 and over. Biomass and short-term yield are expected to slowly decline under this level of exploitation. If this level of exploitation reduces long-term biomass to approximately 30% to 50% of the current biomass, the long-term average yields for this age range would be near 19,000 mt. The GMT recommended close tracking of this fishery and the age composition of the harvested fish, particularly if catches are begun outside the exclusive economic zone. (PFMC, 1998.)

Currently, most landings of jack mackerel are incidental to Pacific sardine and Pacific mackerel in California; however, pure landings do occur sporadically. In California, CDFG landing receipts for jack mackerel totaled 1,269 mt in 2000; 3,624 mt in 2001(these may be somewhat over-reported – the jump in jack mackerel landings in 2001 coincided with an early closure of the Pacific mackerel HG); 1,006 mt in 2002; dropped to only 189 mt in 2003; 1,199 mt in 2004; and dropped back to 253 mt in 2005. Landings of jack mackerel in the California Pelagic Wetfish fishery through the decade of the 1990s reached a maximum of 5,878 mt in 1992, and averaged under 1,900 mt over 1990-2000. During the previous decade, California landings ranged from a high of 25,984 mt in 1982 to a low of 9,210 mt in 1985.

Oregon reported 161 mt in 2000, 183 mt in 2001, 9 mt in 2002, 74 mt in 2003, and 126 mt in 2004, 70 mt in 2005, and 5 mt in 2006. Washington reported 11.5 mt in 2002, 1.8 mt in 2003, none in 2004, 2005, or 2006.

Mason (2001) concluded that spawning biomass estimates of the past were inadequate. Anecdotal evidence suggests that the spawning biomass may be large in California waters, but test fishing found the adult fish too scattered for economical harvest. Most of the contemporary catch is in small aggregations of young fish along rocky shores, or schooling with Pacific sardines or Pacific mackerel.

9.2.3 Market Squid

The CDFG is currently monitoring the market squid fishery through a state-based management plan including an annual landings cap and various spatial/temporal constraints, such as a weekend closures and the establishment of marine protected areas (CDFG 2005). In addition, the Egg Escapement method and simulation modeling currently serve as informal assessment tools (see Appendix 3 in PFMC (2002) and section 4.3.4), within a research context only, to evaluate population dynamics and biological reference points (say MSY-related) regarding this species. However, "active" management may need to be considered in the future if fishery operations change substantially (e.g., spatially expand, harvest high amounts of immature squid, etc.) and/or ongoing modeling efforts identifying areas of concern regarding egg escapement levels associated with commercial fishery sample data.

Currently, limited information is available on market squid population dynamics, and data on its historical and current levels of absolute biomass are unavailable. A STAR Panel was convened in May 2001 to evaluate assessment methods for use in the management of the squid fishery and to assess the appropriateness of defining MSY for this species. Preliminary attempts to estimate biological reference points (e.g., MSY, F_{MSY}, and B_{MSY}) from surplus production models were unsuccessful. In view of the difficulties in determining traditional estimates of MSY for market squid, and given new, albeit limited, information on reproductive biology was available, the STAR Panel focused attention on reference points based on "egg escapement" and its related proxies, such as F. Egg escapement is defined here as the proportion of a female squid's potential lifetime fecundity is spawned, on average, before being harvested in the fishery. An Egg Escapement method (see Appendix 3 in PFMC (2002)) based on conventional yield and spawning biomass "per recruit" theories was fully developed by the Stock Assessment Team and the STAR Panel and subsequently, supported by the SSC, the CPSMT, and the CPSAS.

In practical terms, the Egg Escapement approach can be used to evaluate the effects of fishing mortality (F) on the spawning potential of the stock, and in particular to examine the relation between the stock's reproductive output and potential levels of fishing mortality that results in MSY (F_{MSY}). However, it is important to note that this approach does not provide estimates of historical or current total biomass and thus, a definitive yield (i.e., quota or ABC) cannot be determined at this time. Ultimately, the Egg Escapement method can be used to assess whether the fleet is fishing above or below an a priori-determined sustainable level of exploitation, and in this context can be used as an effective management tool.

The STAR Panel provided general recommendations regarding analytical methods (i.e., the Egg Escapement method) and left determination of specific model configurations and other management-related parameters to the CPSMT. In this context, the CPSMT provided guidance concerning four critical areas of the Egg Escapement method, which were necessary to develop a pragmatic framework for monitoring/managing this species in the future, (1) selection of a "preferred" model scenario; (2) selection of a "threshold" level of egg escapement that can be considered a warning flag when tracking the status of the population; (3) fishery operations in (and after) El Niño/Southern Oscillation (ENSO) events; and finally, (4) important management-related constraints. Readers interested in details regarding assessment methods, STAR-related discussion and conclusions, and CPSMT decisions should refer to papers presented in Appendix 3 of the PFMC (2002).

Data collection programs and subsequent laboratory analysis has continued to the present in attempts to complement baseline information that served as the foundation for developing the Egg Escapement method described above. That is, as generally discussed in previous CPS-related documents [e.g.,, Appendix 3 of the PFMC (2002)] further work surrounding the Egg Escapement assessment approach has addressed the following: (1) collecting much needed samples from the fisheries to bolster the original source of reproductive data that was relied upon initially when developing the overall Egg Escapement method: additional sample data now span from 1999 to 2005; (2) critically evaluating spatial/temporal patterns of the overall fishery through stratified sampling (spatially and temporally) and subsequent analysis including data from 1999 to 2005; (3) in concert with the CPSMT, preparing preliminary analysis-related schedules that could be accommodated within the Council forum and meet the stipulations required for 'monitored' species (also see Section 6.1.1); and (4) conducting simulation modeling to further examine the relationship between critical biological reference points (i.e., 'threshold' levels) and absolute levels of squid population abundance off southern California–results from this research were presented in a working paper distributed (via CPSMT discussions) in the fall of 2006.

To date, preliminary analyses, including estimates of fishing mortality, egg escapement, and abundance estimates have been conducted on a regional/quarterly basis for data from 1999-2006. Furthermore, sensitivity analyses based on varying levels of influential (assumed) parameters, namely natural mortality and egg-laying rates, have also been completed for the same time period. Finally, simulation modeling has been performed to examine levels of fishing mortality and proportional egg escapement (eggs-per-recruit, relative to a maximum value, profiled across levels of fishing mortality) that are most likely to be sustainable, i.e., produce levels of recruitment that sustain long-term population abundance. Preliminary results from these analyses, were presented to the CPSMT in fall 2006, and a working paper will be submitted to the CPSMT for review in fall 2007 (see Section 4.3.4).

9.2.3.1 California's Market Squid Fishery

In 2001, legislation transferred the authority for management of the market squid fishery to the California Fish and Game Commission (Commission). Legislation required that the Commission adopt a market squid fishery management plan and regulations to protect and manage the squid resource. In August and December of 2004, the Commission adopted the Market Squid Fishery Management Plan (MSFMP), the environmental documentation, and the implementing regulations, which went into effect on March 28, 2005, just prior to the start of the 2005/2006 fishing season which started April 1st.

The goals of the MSFMP are to provide a framework that will be responsive to environmental and socioeconomic changes and to ensure long term resource conservation and sustainability. The tools implemented to accomplish these goals include: (1) setting a seasonal catch limit of 107,047 mt (118,000 short tons) to prevent the fishery from over-expanding; (2) maintaining monitoring programs designed to evaluate the impact of the fishery on the resource; (3) continuing weekend closures that provide for periods of uninterrupted spawning; (4) continuing gear regulations regarding light shields and wattage used to attract squid; (5) establishing a restricted access program that includes provisions for initial entry into the fleet, permit types, permit fees, and permit transferability that produces a moderately productive and specialized fleet; and (6) creating a seabird closure restricting the use of attracting lights for commercial purposes in any waters of the Gulf of the Farallones National Marine Sanctuary. Under this framework, the MSFMP provides the Commission specific guidelines for making management decisions. The Commission has the ability to react quickly to changes in the market squid population off California and implement management strategies without the need for a full plan amendment. The MSFMP framework structure was also designed achieve the goals and objectives of the Marine Life Management Act and to be consistent with the management outlined in CPS FMP Amendment 10.

In 2006, the market squid fishery was the largest fishery in the state, with landings estimated at 49,145 mt. This is 12% less than in 2005 (55,606 mt) and 59% less than the record high set in 2000 (118,827 mt). The ex-vessel price ranged from \$88-\$1,102/mt, with an average of \$569/mt. The 2006 ex-vessel value was approximately \$27.2 million, a 14% decrease from 2005 (\$31.6 million).

The fishing permit season for market squid runs from April 1st through March 31st the following year. During the 2006/2007 season (as opposed to the 2006 calendar year), 31,786 mt were landed, 55% less than the 2005/2006 season (70,972 mt). The northern fishery continued to experience a decline in catch levels during the 2006/2007 season. Only 628 mt was landed, a 70% decrease from the 2005/2006 season and a 96% decrease from the 2003/2004 season (17,399 mt). The southern fishery once again surpassed the northern fishery with 31,158 mt landed (98% of the catch) during the 2006/2007 season. However, this was a 55% decrease from the 2005/2006 season (68,925 mt). The southern fishery was centered mainly around the northern Channel Islands (Santa Cruz, Santa Rosa) which is in stark contrast to the 2005/2006 season which was predominantly centered farther south around Santa Catalina Island.

Market squid remains an important international commodity. Squid is used domestically for food and bait and are packed and processed for export. In 2006, approximately 22,562 mt of market squid were exported for a value of $28.8 million. Asian countries were the main export market with China and Japan taking about 49% of the trade.

9.3 References

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10.0 EMERGING ISSUES

This section describes current and future issues that may need to be addressed relative to FMP species and management in general.

10.1 Pacific Sardine

In April 2003, the Council adopted an interim (through 2005 fishing season) allocation framework that seeks optimal use of the annual Pacific sardine HG with minimal impacts on all sectors of the West Coast sardine fishing industry and communities. The CPSMT generally agreed that the impacts of the interim allocation scheme used to partition the Pacific sardine HG were primarily socioeconomic. However, the development of a long-term allocation framework would require that the biological-based implications of different allocation schemes be further evaluated to provide management guidance regarding how the operations of the sectoral fisheries might affect the dynamics of the sardine population at large. Thus, a comprehensive analysis was conducted regarding alternative allocation frameworks, particularly in terms of long-term socioeconomic impacts; results from this analysis were presented to the Council over a series of meetings from 2004-2005.

Further, although this allocation issue primarily influenced socioeconomic factors associated with the fishery, broad biological questions arise, given the relation between this species' biology and how quotas are implemented spatially and temporally across the state-based fishery sectors of southern California, Northern California, and Pacific Northwest (PNW):

- What are impacts to the coastwide sardine resource from a fishery that targets older, mature fish vs. a fishery that targets younger, immature fish?;
- Are there indications of changes in sardine maturity rates (i.e., delayed maturity) in the southern fisheries resulting from density-dependent factors?; and
- Are there potential refinements to the sardine assessment and/or harvest control rule in response to new biological information?

To address these questions, biological information has been collected from NMFS research surveys off the PNW. That is, the PNW research surveys have occurred in July 2003, March and July 2004, and the first coastwide survey occurred in April 2006. These Southwest Fisheries Science Center-based surveys included sardine acoustic trawl and Continuous Underway Fish Egg Sampler surveys off the coast of Oregon and Washington. The surveys are designed to fill major gaps in knowledge of sardine populations, by measuring the age structure and reproductive rates, and assessing the extent the fishery is dependent on migration and on local production of sardine. The primary objective of the surveys is to accumulate additional biological data regarding the northern expansion of the population into waters off the PNW and ultimately, to include data directly (or indirectly) in ongoing stock assessments of both Pacific sardine and Pacific mackerel.

Finally, many review bodies (CPSMT, CPSAS, SSC, and STAR-related) encourage the continuance of synoptic research surveys on an annual basis to ensure survey results are representative of the entire range of this species (as well as other coastal pelagic species of concern). That is, developing and conducting such a survey will necessarily require considerable additions to current budgets, staff, and equipment (see Section 11).

10.2 Pacific Mackerel

At this time, emerging issues for Pacific mackerel are similar to those described for Pacific sardine.

As the Pacific mackerel abundance estimate has decreased over the past several years, the CPSMT discussed overfishing concerns related to this fishery. Based on the current modeling approach and the harvest control rules in the FMP, there is, currently, not a concern related to overfishing of Pacific mackerel. Historically, intermittent periods of high recruitment have supported relatively high amounts of fishing pressure. However, more recently, protracted periods of generally lower recruitment have contributed to lower levels of spawning stock and total biomass. Fishing pressure is largely influenced by availability of the resource to the fishery, as well as market factors. The U.S. West Coast Pacific mackerel fishery targets the mackerel in the northern parts of its overall range and in inshore waters. It is possible that mackerel abundance could be strong south of the U.S. border and/or in offshore waters beyond the range of the U.S. West Coast CPS fleet. Also, as in other CPS fisheries, market dynamics greatly influence total harvest. While mackerel is desirable it is not as important to the CPS fishery as Pacific sardine and market squid. In addition, most commercial harvest of Pacific mackerel occurs within the area under LE as defined by the CPS FMP. Under the LE system, overall effort on Pacific mackerel is constrained by a cap on harvest capacity. Thus, given the reasons above, the level of fishing effort relative to mackerel abundance should not give rise to immediate concern. However, model estimates of the spawning stock and recruitment relationship indicate little to no reproductive-related compensation at low levels of spawning stock biomass. Thus, issues surrounding recruitment-based overfishing should be monitored closely.

Overfishing for Pacific mackerel is defined in the CPS FMP as harvest exceeding ABC for two concurrent years. Recent landings have been well below ABC. Also, the cutoff value in the harvest control rule serves as a proxy for determining if mackerel is overfished. The cutoff value equates to a biomass estimate of 18,200 mt. The current biomass estimate of 112,700 mt is well above the cut off value.

10.3 Market Squid

It has been observed that the northern fishery (Monterey Bay) that exploits the squid resource off California may not operate in a similar manner as observed in the southern fishery, e.g., patterns of fishing in the day vs. the night (see Sections 6.1.1 and 9.2.3) and gear-related impacts to squid egg beds on or near the ocean floor. The differences between the two fisheries may have considerable influence to the state-wide monitoring programs currently in place, as well as results generated from the assessment method recently adopted for this marine resource. This issue should not be considered a trivial one, given that due to limited amounts of sample information, the population analysis recently developed for this species (i.e., the Egg Escapement method, see Section 9.2.3) was strictly based on rather broad stock distribution assumptions. That is, the recent observations regarding differences in fishery operations north and south of Point Conception necessarily dictate more detailed data collection programs and subsequent analysis to ensure that spatio-temporal patterns related to the squid population(s) are considered when assessing the overall status of the exploited resource. In this context, over the next year, the CPSMT will discuss, develop, and bring forth to the Council a workable monitoring/analysis schedule that is based on more detailed (stratified spatially and temporally) analysis of the accumulated data to date. Since fall 2003, the SWFSC and CDFG have coordinated research efforts that involve simulation modeling that generally focus on important biological reference points included in the Egg Escapement method, such as the relationship between reproductive-based thresholds and absolute population abundance levels for this species (see also Section 4.3.4). Results from this research were presented to the CPSMT in fall 2006, and will be summarized in working paper (to be reviewed by the CPSMT) in fall 2007.

10.4 Management Issues

Emerging management issues include market squid overfishing definition; international CPS fisheries; and standardized bycatch reporting, including at-sea observers in California-based CPS fisheries.

10.4.1 Bycatch Reporting and Observer Programs

The States of Oregon and Washington have had observers on vessels indicating there has not been a bycatch problem to the north (see Section 6.3). While CDFG port sampling suggests there is not a bycatch problem, port sampling alone is insufficient to demonstrate with assurance that there is not a bycatch problem. Therefore, NMFS has placed observers on some California-based CPS vessels in a pilot project intended to provide better information on the extent to which there is bycatch in this fishery (see Section 6.1.1 and Section 11.6). NMFS will work with the CPSMT to consider the need for additional field observations including possible expansion of observer coverage to Oregon and Washington since state observer programs there have been discontinued, and possibly consider alternative ways to address any bycatch issues identified, as required by the Magnuson-Stevens Act.

10.4.2 Market Squid Overfishing Definition

With respect to market squid, it appears that there is a need to address further the prospective use of the egg escapement value as a proxy for MSY and as a value for determining if the stock is overfished or is subject to overfishing (i.e., minimum stock size and maximum fishing mortality thresholds). Based on the most recent review for the annual NMFS Report to Congress on the status of fish stocks, NMFS notified the Council that the current FMP language is ambiguous (see Section 4.3.4). NMFS is currently working ot revise National Standard 1 Guidelines to meet the new provisions of the reauthorized MSA. The Council may direct the CPSMT to consider this issue and advise the Council as to possible revisions once any changes to the Guidelines have been proposed.

10.4.3 International CPS Fisheries

There has been interest in coastwide management for the Pacific sardine fishery which would entail a more consistent forum for discussion between the U.S. and Mexico. Recent U.S.-Mexico bilateral meetings indicated a willingness from Mexico to continue scientific data exchange and cooperation on research, and engage in discussions of coordinated management. Mexico suggested that the Trinational Sardine Forum would be a good venue for starting that discussion. Canada will host the next Trinational Sardine Forum in October of 2006. Mexico also agreed to host a Mexico-U.S. scientific meeting to discuss CPS. The meeting is slated to take place in La Paz, Mexico in June of 2006.

11.0 RESEARCH AND DATA NEEDS

Several recent developments highlight the need to enhance current assessment procedures in order to meet the requirements of the FMP. These include (1) the development of a high-volume fishery for Pacific sardine in Oregon and Washington; (2) increasing recognition of the importance of CPS as principal forage for many salmon and groundfish stocks that are currently at low abundance levels; (3) the importance of CPS biomass estimates to the Council's annual determination of allowable coastal pelagic harvests; and (4) the need to monitor status of the market squid stock using data-intensive techniques. A pressing need exists for stock assessments that accurately reflect the reproductive characteristics of CPS stocks throughout their geographic range and for additional stock assessment personnel in NMFS and the three Pacific Coast states to carry out these assessments.

In addition to research and data needs presented in this chapter, in December 2006, the Council adopted its comprehensive research and data needs document for 2007-2008. The document includes a chapter dedicated to CPS matter and can obtained by contacting the Council office or by visiting the Council web page.

The highest priority research and data needs for CPS are:

- Gain more information about the status of CPS resources in the north using egg pumps, trawl and sonar surveys, and spotter planes.

- Develop a coastwide (Mexico to British Columbia) synoptic survey of sardine and Pacific mackerel biomass; i.e., coordinate a coastwide sampling effort (during a specified time period) to reduce "double-counting" caused by migration.

- There is a need to develop a formal review process for the harvest control rules for Pacific sardine and Pacific mackerel. Currently this review is not part of the stock assessment process.

- Increase fishery sampling for age structure (Pacific sardine and Pacific mackerel) in the northern and southern end of the range. Establish a program of port sample data exchange with Mexican scientists.

- Evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS and define predatory-prey relationships.

- Routinely, collect detailed cost-earnings data to facilitate analyses for long-term changes to the sardine allocation structure.

11.1 Pacific Sardine

The Trinational Sardine Forum (Mexico, U.S., and Canada) met again in 2005 in Ensenada, Mexico to discuss issues related to the rapidly recovered sardine population and fishery along the West Coast of North America. The Forum has identified several issues for priority work. Issue 1 is developing cooperative relationships with the fishing industry to provide fishing vessel platforms for critical studies of the life history of sardine. Issue 2 is to standardize fishery-dependent data collection among agencies, particularly age and size data, and improve exchange of this data in summarized form to stock assessment scientists. Issue 3 is the need to assemble mutually compatible fishery assessments off of the West Coast of Mexico, U.S., and Canada to form a baseline of stock status and variability of possibly more than one interbreeding stock of sardines, or a temperature-derived phenotype with radically heterogeneous population parameters influencing HGs. Coastwide sea surveys which include egg and adult samples are viewed as a top priority. Otolith microchemistry and DNA analyses are promising tools to improve our knowledge of sardine stock structure.

11.2 Pacific Mackerel

California's Pacific mackerel fishery has been sampled by CDFG for age composition and size-at-age since the late-1920s. The current stock assessment model incorporates a complete time series of landings and age composition data from 1929 onward. Ensenada (Baja California) landings have rivaled California's over the past decade, however, no biological information is readily available from Mexico's fishery. Landings are accounted for in the assessment, but size and age composition are assumed to be similar to the San Pedro, California fishery. Like sardine, there is a need to establish a program of port sample data exchange with Mexican scientists (INP, Ensenada) to fill this major gap in the stock assessment.

Fishery-independent survey data for measuring changes in mackerel recruitment and spawning biomass are generally lacking. The current CalCOFI sampling pattern provides information on mackerel egg distributions in the Southern California Bight, the extreme northern end of the spawning area. Mexican scientists have conducted a number of egg and larval surveys off of Baja California in recent years (e.g., IMECOCAL program). Access to these data would enable us to continue the historical CalCOFI time series, which begins in 1951. This information could be directly incorporated into the assessment model. Night-light surveys for newly recruited Pacific mackerel should be re-instituted in the Southern California Bight. Surveys following protocols employed during CDFG Sea Survey cruises (1950-1988) could allow splining the new recruitment data set to the historical time series. The new time series would represent the only recruitment index in the mackerel stock assessment and would strengthen the ability to accurately forecast age zero and total stock abundance for each coming fishing season.

Pacific mackerel biomass has been declining since the early 1980s, but recent El Niño events have concurrently extended their northern range to British Columbia. Pacific mackerel are caught incidentally in the Pacific whiting and salmon troll fisheries. Pacific mackerel are regularly caught in triennial survey trawls off the Pacific Northwest. A simple reporting system is needed to document incidental take of mackerel in fisheries to the north. Presence-absence information may allow us to detect southward movement or further decreases in biomass.

11.3 Market Squid

Currently, there exists only limited understanding of market squid population dynamics, which has hampered assessing the status (health) of this valuable marine resource found off California. General information concerning important stock- and fishery-related parameters suggests maximum age is less than one year and the average age of squid harvested is roughly six to seven months. However, at this time, there is considerable variability (uncertainty) surrounding many of these estimated parameters. In this context, the CPSMT strongly advises that extensive monitoring programs continue for this species, including tracking fishery landings, collecting reproductive-related data from the fishery, and obtaining fishermen-related logbook information.

Although some information exists on coastwide squid distribution and abundance from fishery-independent midwater and bottom trawl surveys largely aimed at assessing other finfish species, there is no reliable measure of annual recruitment success beyond information obtained from the fishery. Given fishing activity generally occurs only on shallow-water spawning aggregations, it is unclear how fluctuations in landings are related to actual population abundance and/or availability to the fishery itself. That is, the general consensus from the scientific and fishery management communities is that squid do inhabit, to some degree, greater depths than fished by the fleet; however, species' range suppositions remain largely qualitative at this point in time. Better information on the extent and distribution of spawning grounds along the U.S. Pacific Coast is needed, particularly, in deep water and areas north of central California. Additionally, fecundity, egg survival, and paralarvae density estimates are needed from different spawning habitats in nearshore areas and oceanographic conditions associated with the population. Furthermore, information describing mechanisms and patterns of dispersal of adults, as well as paralarvae, along the coast is required to clarify how local impacts might be mitigated by recruitment from other areas inhabited by this short-lived species.

Although some fishery effort information is now being collected with a newly-implement logbook program in the State of California, the continuation of this program is essential to provide estimates of relative abundance (e.g., CPUE time series) in the future. Continuation and/or establishment of annual surveys using midwater trawls, bottom trawls, remotely operated vehicles (ROVs), and satellite and aerial surveys would also provide useful information for developing alternative indices of abundance other than those derived from logbook data.

Potential impacts to EFH-related issues would most likely arise in concert with fishing activity by the purse-seine fleet on spawning aggregations in shallow water when gear potentially makes contact with the sea floor (see Section 6.1.1). In this regard, there are two areas of potential concern that have not been quantified to date: (1) damage to substrate where eggs may be deposited; and (2) damage or mortality to egg masses from contact with the gear itself. The CDFG is currently working on research methods to evaluate egg stage of squid egg capsules collected in fishery landings to determine the how long the egg capsule had been laid before being taken by the fishery.

Currently, market squid fecundity estimates, based on the Egg Escapement method (see Section 9.2.3), are used to assess the status of the stock and evaluate biological reference points, such as MSY. The Egg Escapement method is based on several assumptions, (1) immature squid are not harvested; (2) potential fecundity and standing stock of eggs are accurately measured; (3) life history parameters are accurately estimated (e.g., natural mortality, egg laying rate); and (4) instantaneous fishing mortality (F) translates into meaningful management units. Given the inherent uncertainty associated with these assumptions, it is imperative that each receive further scrutiny in the future, through continuation of rigorous sampling programs in the field that generate representative data for analysis purposes, as well as further histological evaluations in the laboratory and more detailed assessment-related work. For example, data collected through the CDFG port sampling program currently in place will provide information on the age and maturity stages of harvested squid. Also, the CDFG logbook program should be maintained (and bolstered) for purposes of developing alternative tools for assessing the status of the resource. Further, laboratory work concerning general mantle condition, especially the rate of mantle 'thinning,' will likely benefit the current understanding of squid life history and subsequently, help improve the overall assessment of this species. Finally, other biological-related parameters that are currently poorly understood generally surround spawning and senescence, (e.g., life history strategies concerning spawning frequency, the duration of time spent on spawning grounds, and the period of time from maturation to death).

11.4 Live Bait Fishery

Although tonnage of CPS and squid taken in the live bait fishery is minimal compared with volume taken in the commercial fishery, better estimates of live-bait landings and sales of sardine, anchovy and squid is essential as it pertains to estimates of the overall economic value of these fisheries. Outdated estimates have previously shown that the value of the live-bait fishery for sardine has equaled that of the commercial catch. In the case of squid, there is no documentation of the dramatic expansion of live-bait sales in southern California made by commercial light vessels in recent years.

The live bait fishery supplies product for several recreational fisheries along the Pacific Coast, primarily in southern California, but as far north as Eureka. Live bait catch is generally comprised of both Pacific sardine and northern anchovy; the predominant species depends on biomass levels and local availability. Recent landings estimates range between 5,000 mt and 8,000 mt annually statewide, with effort increasing in summer months. However, these estimates are based only on logbooks provided by a limited number of bait haulers, and estimates provided by the CPFV industry. Since the sale of live bait in California is not permitted in a manner similar to that used for the commercial sale of CPS, estimates of tonnage and value are imprecise. Therefore, no estimates of volume or value for the sale of market squid for live bait are available at this time. However, the CDFG will reexamine reporting requirements and data needs to better estimate landings and value.

11.5 Socioeconomic Data

Economic analyses of management actions effecting coastal pelagic fisheries requires detailed, representative cost and earnings data for the sardine harvesters and processors making up each fishery sector. Experience with the long-term allocation of the Pacific HG emphasizes this need, and moreover underscores the necessity to collect these data on a routine basis. Collecting such data as needed to address an issue at hand makes them suspect in a number of regards particularly in terms of strategic bias.

A step in this direction has been taken with the advent of a bycatch observer program for coastal purse seine vessels participating in CPS fisheries. Observers will be collecting economic data on the vessel's fishing operations during observed trips. The key will be designing the program to provide observer coverage that satisfy the requirements in terms of obtaining representative bycatch data as well as vessel economic data. This data collection effort would have to be supplemented with an onshore complement to obtain comprehensive economic data for harvesting vessels.

A parallel effort will need to be taken with regard to processors. To be able to fully evaluate the economic impacts of proposed management actions detailed, representative cost and earnings data for west coast sardine processors will also be needed on a routine basis. This will entail periodic surveys of CPS processors to collect representative economic data on their processing operations.

11.6 Observer Program

Bycatch in the California contingent of the CPS fishery has been qualitatively monitored by the CDFG's dockside monitoring program since the mid-1980s (Sweetnam and Laughlin, Pers. Comm., 2005). CDFG only gives qualitative descriptions of bycatch meaning they do not document the amount or quantity of bycatch but rather only document the species or type of bycatch encountered at the fish processing plant. In order to confirm bycatch rates derived from CDFG's dock-side sampling, NMFS started a pilot observer program in July 2004 on the California purse seine fishing vessels landing CPS in the LE fishery. The pilot observer program's main focus is to gather data on total catch and bycatch, and on interactions between their fishing gear and protected species such as marine mammals, sea turtles, and sea birds. See Section 6.1.1 for additional information and preliminary results from this program.

11.7 References

Sweetnam, D., and L. Laughlin. 2005. Personal Communication, January 11, 2005. California Department of Fish and Game, La Jolla, California. Email address: Dale.Sweetnam@noaa.gov.

12.0 ECONOMIC STATUS OF WASHINGTON, OREGON, AND CALIFORNIA CPS FISHERIES IN 2006

This section summarizes economic data presented in tables 25-35 and figures 2-8. Pacific Coast landings of CPS totaled 156,192 mt in 2006, an 1% decrease from 2005 Market squid landings, all in California, were 49,070 mt in 2006, down 12% from 2005. Pacific sardine landings at 86,452 mt in 2006 were virtually unchanged from 2005 (85,791 mt). The exvessel value of all CPS landings was $38.8 million in 2006, down 14% from 2005 (2005 converted to 2006 dollars). Market squid accounted for 31%, and Pacific sardine 55% of total Pacific coast, CPS landings in 2006. Landings of Pacific mackerel increased 82%, and landings of northern anchovy rose 14% from 2005 to 2006. Real exvessel market squid revenues (2006 $) decreased 17% from 2005. The decrease in market squid landings was accompanied by a 6% decrease in exvessel price from $581 to $548 per mt (2006 $). There was a 5% increase in aggregate CPS finfish landings from 2005; exvessel revenue also fell 5%, with a corresponding overall finfish exvessel price decline of 10% in 2006. In 2006, market squid made up almost 7% of the exvessel value of total Pacific Coast landings, and CPS finfish accounted for almost 3%. California accounted for 74% of coastwide CPS landings in 2006, up from 67% in 2005; Oregon 23% down from 29% and Washington 3% down from 4% in 2005.

California sardine landings were 46,438 mt in 2006 up 34% from 2005, 34,552 mt. Market squid ranked second in exvessel value among California commercial fisheries in 2006, with exvessel revenue of, $26.8 million, $17.8 million less than that for Dungeness crab, the most valuable California fishery in 2006. Landings of Pacific sardine ranked sixth highest in California exvessel value in 2006 at $5.1 million. California Pacific mackerel landings were 5,381 mt in 2006, up 80% from 2005. California landings of Northern anchovy were 12,788 mt in 2006, up 14% from 2005.

Oregon's landings of Pacific sardine decreased 21% in 2006, from 45,110 mt to 36,651 mt. Sardine generated $3.9 million in exvessel revenue for Oregon in 2006, 4% of the state's total exvessel revenue, ranking it seventh behind Dungeness crab in total exvessel value. Washington landings of Pacific sardine decreased 35% from 6,721 mt in 2005 to 4,363 mt in 2006. With exvessel revenue less than 1% of the Washington total in 2006, sardine ranked 19th behind Dungeness crab in exvessel value.

Oregon landings of Pacific mackerel increased from 318 mt in 2005 to 665 mt in 2006. Washington landings of Pacific mackerel increased from 24 mt in 2005 to 41 mt in 2006 while anchovy landings fell from 164 mt to 161 mt.

In 2006, the number of vessels with Pacific Coast landings of CPS finfish was 191, up from 188 in 2005. With the increase in vessels and an increase in total CPS finfish landings, finfish landings per vessel, 561 mt in 2006, increased 4% from 2005. Of the CPS finfish vessels active in 2006, 14% depended on CPS finfish for the largest share of their 2006 exvessel revenues. From 2005 to 2006, the number of vessels with Pacific Coast landings of market squid increased from 173 to 196, with 36% of these vessels dependent on market squid for the largest share of their total 2006 exvessel revenue. Market squid landings were 250 mt per vessel in 2006, down 22% from 2005. Market squid total revenue shares for vessels that depend mainly on market squid have been higher on average than average finfish total revenue shares for vessels that depend primarily on CPS finfish, suggesting that market squid vessels tend to be more specialized than CPS finfish vessels. By far, roundhaul gear accounted for the largest share of total CPS landings and exvessel revenue by gear in 2006, dip net gear was a far distant second.

The major West Coast processors and buyers of CPS finfish are concentrated in the Los Angeles, Santa Barbara-Ventura, Monterey and Oregon-Washington Columbia River port areas. The exvessel markets for market squid are mainly in the Los Angeles, Santa Barbara-Ventura and Monterey port areas.

In 2006, 47,224 mt of market squid were exported through West Coast customs districts with an export value of \$58.5 million; an 8% increase in quantity, and a 5% increase in the real value of West Coast market squid exports from 2005. The primary country of export was China, 56% of the total, which received 26,477 mt, 5% more than the quantity exported to China in 2005. Eighty-three percent of market squid exports went to China and four additional countries: Switzerland (4,201 mt), Japan (3,136 mt), Philippines (3,009 mt) and Spain (2,479 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or for use as bait.

In 2006, 72,201 mt, of sardines were exported through West Coast customs districts up 7% from 2005. Sardine exports were valued at \$48.4 million in 2006, down 14% from 2005. Almost 85% of sardine exports were in the frozen form, the balance were in the preserved form. Australia was the primary export market in 2006, receiving 23,630 mt, up 42% from 2005, representing 33% of total west coast sardine exports in 2006. Japan was second with 20,999 mt, 29% of the total a 32% decrease from 2005. West Coast Pacific sardine exports to Australia are primarily for feed in Australia's bluefin tuna ranching operations. Japanese demand for Pacific sardine is for both human consumption and use as bait in its longline fisheries. Domestic use of Pacific sardine is primarily as canned product for human consumption.

Table 1. History of Council Actions

- The Council initiated development of the FMP for Northern anchovy in January of 1977. The FMP was submitted to the U.S. Secretary of Commerce (Secretary) in June of 1978. Regulations implementing the FMP were published in the Federal Register on September 13, 1978 (43*FR*40868). Subsequently, the Council has considered seven amendments.

- The first amendment changed the method of specifying the domestic annual harvest for Northern anchovy and added a requirement for an estimate of domestic processing capacity and expected annual level of domestic processing. Approval for this amendment was published in the Federal Register on July 18, 1979 (44*FR*41806).

- The second amendment, which became effective on February 5, 1982, was published in the Federal Register on January 6, 1982 (47*FR*629). The purpose of this amendment was to increase the domestic fishing fleet's opportunity to harvest the entire optimum yield (OY) of Northern anchovy from the U.S. EEZ by releasing, inseason, unutilized portions of the Northern quota.

- During the spring of 1982, the Council considered a third amendment that divided the quota for Northern anchovy into two halves and made release of the second half conditional on the results of a mid season review of the status of the stock. The methods proposed for the mid season assessment were considered too complex to implement, and the amendment was not approved.

- The fourth amendment, which had two parts, was published in the Federal Register on August 2, 1983 (48*FR*34963) and became effective on August 13, 1983. The first part abolished the five inch size limit in the commercial fishery and established a minimum mesh size of 5/8 inch for Northern anchovy. The mesh size requirement did not become effective until April 1986 in order to give the fleet additional time to comply without undue economic hardship. The second part established a mid season quota evaluation that was simpler in design than the method proposed in Amendment 3.

- The fifth amendment in 1983 incorporated advances in scientific information concerning the size and potential yield of the central subpopulation of Northern anchovy. In addition, the fifth amendment included changes to a variety of other management measures. Two or more alternative actions were considered in each of seven general categories; (1) OY and harvest quotas; (2) season closures; (3) area closures; (4) quota allocation between areas; (5) the reduction quota reserve; (6) minimum fish size or mesh size; and (7) foreign fishing and joint venture regulations. The alternatives for the fifth amendment were reviewed by the Council during 1983. The final rule was published in the Federal Register on March 14, 1984 (49*FR*9572).

- In 1990, the sixth amendment implemented a definition of overfishing for Northern anchovy consistent with National Standard 7, and addresses vessel safety (56*FR*15299, April 16, 1991).

- The Council began developing the seventh amendment as a new FMP for CPS on a motion from NMFS and California in 1990. A complete draft was available in November of 1993, but the Council suspended further work, because NMFS withdrew support due to budget constraints. In July of 1994, the Council decided to proceed with the plan through the public comment period. NMFS agreed with the decision on the condition that the Council also consider the options of dropping or amending the anchovy FMP.

Thus, four principal options were considered for managing CPS (1) drop the anchovy FMP (no federal or Council involvement in CPS); (2) continue with the existing FMP for anchovy (status quo); (3) amend the FMP for Northern anchovy; and (4) implement an FMP for the entire CPS fishery. In March of 1995, the Council decided to proceed with the FMP for CPS. Final action was postponed until June 1995 when the Council adopted a draft plan that had been revised to address comments provided by NMFS and the SSC. Amendment 7 was submitted to the Secretary, but rejected by NMFS, Southwest Region, as being inconsistent with National Standard 7. NMFS announced its intention to drop the FMP for Northern anchovy (in addition to FMP=s other species) in the Federal Register on March 26, 1996 (61*FR*13148), but the action was never completed.

- Development of Amendment 8 began in June, 1997 when the Council directed the CPSPDT to amend the FMP for Northern anchovy to conform to the recently revised Magnuson-Stevens Fishery Conservation and Management Act and to expand the scope of the FMP to include the entire CPS fishery. Amendment 8 was partially approved by the U.S. Secretary of Commerce on June 10, 1999, and final regulations were published on December 15, 1999 (64*FR*69888). The FMP was implemented on January 1, 2000.

- At its meeting in June 1999, the Council directed its Coastal Pelagic Species Management Team (CPSMT) to recommend appropriate revisions to the FMP and report to the Council the following September. A public meeting of the CPSMT was held in La Jolla, California, on August 3 and 4, 1999, and August 24, 1999, and a meeting was held between the CPSMT and the Coastal Pelagic Species Advisory Subpanel on August 24, 1999. At its September 1999 meeting, the Council gave further direction to the CPSMT regarding MSY for squid. At its March 2000 meeting, the Council asked the CPSMT for a more thorough analysis of the alternatives proposed for establishing MSY for squid and for bycatch. At a public meeting in La Jolla, California, on April 20 and 21, 2000, the CPSMT reviewed comments from the Council, the Council's Scientific and Statistical Committee (SSC) and prepared additional material for establishing MSY for squid based on spawning area.

- The Council distributed Amendment 9 for public review on July 27, 2000. At its September 2000 meeting, the Council reviewed written comments, received comments from its advisory bodies, and heard public comments, and decided to submit only two provisions for Secretarial review. Based on testimony concerning MSY for squid, the Council decided to include in Amendment 9 only the bycatch provision and a provision providing a framework to ensure that Indian fishing rights are implemented according to treaties between the U.S. and the specific tribes. Since implementation of the FMP, the CPS fishery has expanded to Oregon and Washington. As a result, the FMP must discuss Indian fishing rights in these areas. These rights were not included in the FMP; and the Council decided to address this issue in Amendment 9. The Council decided to conduct further analysis of the squid resource and will prepare a separate amendment that addresses OY and MSY for squid.

- The Secretary of Commerce approved Amendment 9 on March 22, 2001.

- In April 2001, the Council adopted the capacity goal and transferability provisions recommended by the CPSMT for inclusion in Amendment 10. The Council directed the CPSMT to develop an amendment to the CPS FMP that will include the capacity goal, provisions for permit transferability, a process for monitoring fleet capacity relative to the goal, and a framework for modifying transferability provisions as warranted by increases or decreases in fleet capacity. The amendment will also address determination of OY and MSY for market squid.

- In November 2001, the Council reviewed the findings of the market squid stock assessment review (STAR) workshop and endorsed the egg escapement approach as a proxy for squid MSY, as recommended by the market squid STAR Panel and CPSMT.

- In March 2002, the Council adopted draft Amendment 10 to the CPS FMP for public review.

- In June 2002, the Council adopted Amendment 10 to the CPS FMP.

- December 30, 2002, the Secretary of Commerce approved Amendment 10. On January 27, 2003 NMFS issued the final rule and regulations for implementing Amendment 10.

- September 2002, the Council requested NMFS take emergency action to reallocate the unharvested portion of the harvest guideline prior to October 1. The Council believed this action would minimize negative economic impacts in the northern fishery without causing market disruptions in the southern fishery. On September 26, 2002, through an emergency rule, NMFS reallocated the remaining Pacific sardine harvest guideline and reopened the northern subarea fishery, which had been closed on September 14, 2002.

- September 2002, the CPSAS recommended the Council initiate a regulatory or FMP amendment and direct the CPSMT to prepare management alternatives for revising the sardine allocation framework. The Council directed the CPSMT to review CPSAS recommendations for revising the allocation framework. A public meeting of the CPSMT was held on October 8, 2002. The CPSMT discussed information needs and prospective analyses for developing allocation management alternatives.

- On October 30, 2002, the Council initiated a regulatory amendment to address allocation problems.

- The CPSMT met January 30-31, 2003 to analyze various alternatives for revising the allocation framework and developed recommendations for Council consideration.

- At the March 2003 Council meeting, the SSC and CPSAS reviewed analyses of the proposed management alternatives for sardine allocation. Based on the advisory body recommendations and public comment, the Council adopted five allocation management alternatives for public review.

- At the April 2003 Council meeting, the CPSAS reviewed the five management alternatives and developed recommendations for the Council. The Council took final action on the regulatory amendment. The proposed action adopted by the Council would (1) change the definition of subarea A and subarea B by moving the geographic boundary between the two areas from 35° 40' N latitude to 39° N latitude, (2) move the date when Pacific sardine that remains unharvested is reallocated to Subarea A and Subarea B from October 1 to September 1, (3) change the percentage of the unharvested sardine that is reallocated to Subarea A and Subarea B from 50 percent to both subareas to 20 percent to Subarea A and 80 percent to Subarea B, and (4) reallocate all unharvested sardine that remains on December 1 coast wide. The Council=s intent is for this interim revision to the allocation framework be in effect for the 2003 and 2004 seasons. The allocation regime could be extended to 2005 if the 2005 harvest guideline were at least 90% of the 2003 harvest guideline.

- The regulatory amendment for allocation of the Pacific sardine harvest guideline was approved on August 29, 2003. The final rule implementing the regulatory amendment was published September 4, 2003 (68*FR*52523).

- At the November 2003 Council meeting, the Council adopted a harvest guideline of 122,747 mt for the 2004 Pacific sardine fishery, within an incidental catch allowance of up to 45%. This harvest guideline is based on a biomass estimate of 1,090,587 mt. Per the revised allocation framework, on January 1, the harvest guideline will be allocated 33% to the northern subarea and 66% to the southern subarea, with a subarea dividing line at Point Arena, CA. . The final rule implementing the harvest guideline was published December 3, 2003 (68*FR*67638).

- At the June 2004 Council meeting, the Council adopted the following management measures for the July 2004-June 2005 Pacific mackerel fishery: 1) Total fishery harvest guideline of 13,268 mt; 2) Directed fishery guideline of 9,100 mt; and 3) Set-aside for incidental catches of 4,168 mt and an incidental catch rate limit of 40% when mackerel are landed with other CPS species, except that up to one mt of Pacific mackerel can be landed without landing any other CPS. The Council also requested NMFS track utilization of the directed fishery guideline and advise the Council at the March 2005 meeting if additional action (e.g. a mop-up fishery) is warranted. Additionally, the Council initiated an amendment to the CPS FMP with the primary purpose of allocating the coastwide Pacific sardine harvest guideline. The Council discussed a schedule that included final Council action on the FMP amendment by June 2005, which would enable implementation by January 2006. To facilitate development of the amendment, the Council directed the CPSAS to draft a range of alternative sardine allocation scenarios. The Council also directed the CPS Management Team to formally review the CPS FMP issues raised by NMFS to identify issues that could be addressed through amendment to the CPS FMP and if they could be addressed in the short-term or would require more extensive time to complete.

- At the September 2004 Council meeting, the Council adopted STAR Panel reports for Pacific mackerel and Pacific sardine. New assessment methodologies will be used for management of the 2005 sardine fishery and the 2005-2006 Pacific mackerel fishery. Relative to the CPS FMP amendment process, the Council requested the CPSAS to narrow the current broad range of Pacific Sardine allocation alternatives for Council consideration at the November 2004 meeting and Secondly, received information from the CPSMT about their consideration of several FMP-related issues raised by NMFS, and directed Council staff to communicate to NMFS the Council plans for further review of CPS EFH.

- At the November 2004 Council meeting, the Council adopted a harvest guideline of 136,179 mt for the 2005 Pacific sardine fishery. This harvest guideline is based on a biomass estimate of 1.2 million mt. Per the FMP allocation framework, on January 1 the harvest guideline will be allocated 33% to the northern subarea and 66% to the southern subarea with a subarea dividing line at Point Arena, California. Additionally, the Council directed the Coastal Pelagic Species (CPS) Management Team and staff to begin development of Amendment 11 to the CPS FMP to include alternatives for sardine allocation, as recommended by the CPSAS as well as two additional alternatives The Council anticipates reviewing the draft analyses and considering formal adoption of allocation alternatives at the April 2005 Council meeting.

- At the March 2005 Council meeting, the Council reviewed a progress update from NMFS Southwest Region on a proposed course of action for management of krill in the West Coast Exclusive Economic Zone and National Marine Sanctuaries under the auspices of the Coastal Pelagic Species FMP. The Council approved a draft outline for an alternatives analysis.

- At the April 2005 Council meeting, the Council approved a range of alternatives for the allocation of Pacific sardine for further analysis and public review. After reviewing preliminary results on the range of alternatives approved for analysis in November 2004 and reports of the Coastal Pelagic Species (CPS) advisory bodies, the Council eliminated two alternatives (Alternatives 2 and 5) from further consideration. The Council recommended that the CPS Management Team follow the advice of the SSC as they complete the analysis of allocation alternatives for public review.

- At the June 2005 Council meeting, the Council addressed three CPS matters, pacific mackerel harvest guideline and management measures, long term Pacific sardine allocation and CPS essential fish habitat (EFH).

  Regarding Pacific mackerel, the Council adopted the new assessment and the following management measures for the July 2005-June 2006 Pacific mackerel fishery: 1) total fishery harvest guideline of 17,419 mt; 2) directed fishery guideline of 13,419 mt; and 3) set-aside for incidental catches of 4,000 mt and an incidental catch rate limit of 40%, when mackerel are landed with other coastal pelagic species, except that up to one mt of Pacific mackerel can be landed without landing any other CPS. The Council requested NMFS track utilization of the directed fishery guideline and advise the Council at the March 2006 meeting if release of the incidental set-aside is warranted.

  Regarding Pacific sardine allocation, the Council took final action on a long-term allocation of the annual Pacific sardine harvest guideline. The Council approved a modified version of Alternative 3, which provides the following allocation formula for the non-tribal share of the harvest guideline:

  1. a seasonal allocation structure with 35% of the harvest guideline to be allocated coastwide on January 1;
  2. 40% of the harvest guideline, plus any portion not harvested from the initial allocation, to be reallocated coastwide on July 1; and
  3. on September 15 the remaining 25% of the harvest guideline, plus any portion not harvested from earlier allocations, to be reallocated coastwide.

  The Council also recommended a review of the allocation formula in 2008.

  The Council adopted the 2005 SAFE document as drafted by the CPSMT including the required review of CPS EFH. The Council recommended no changes to the existing definition of EFH because the CPSMT review identified no new information on which to base EFH modifications. The Council agreed with the research needs identified by the CPSMT in the 2005 SAFE and stressed the importance of coastwide sardine research and harvest policy review.

- At the November 2005 Council meeting, the Council adopted a Pacific sardine harvest guideline of 118,937 mt for the 2006 season to be managed under the terms of the allocation arrangements under Amendment 11.

  The Council also approved a range of krill fishing alternatives for public review and additional analysis, including a preliminary preferred alternative to identify krill as a prohibited species in the Exclusive Economic Zone. The proposed krill management measures will be implemented as Amendment 12 to the CPS FMP. At the June 2005 Council meeting, the Council addressed three CPS matters, pacific mackerel harvest guideline and management measures, long term Pacific sardine allocation and CPS essential fish habitat (EFH).

- At the March 2006 Council meeting, the Council took final action adopting Coastal Pelagic Species Fishery Management Plan Amendment 12 to prohibit harvest of all species of krill in the U.S. Exclusive Economic Zone. Additionally, the Council adopted an essential fish habitat designation for all species of krill that extends the length of the West Coast from the shoreline to the 1,000 fm isobath and to a depth of 400 meters. No habitat areas of particular concern were identified.

- At the June 2006 meeting, the Council adopted the new assessment model and the following management measures for the July 2006-June 2007 Pacific mackerel fishery: a total fishery harvest guideline of 19,845 metric tons (mt), a directed fishery guideline of 13,845 mt; and a set-aside for incidental catches of 6,000 mt and an incidental catch rate limit of 40% when mackerel are landed with other coastal pelagic species, except that up to one mt of Pacific mackerel can be landed without landing any other CPS.

- At the November 2006 meeting, the Council adopted a harvest guideline (HG) of 152,654 metric ton (mt) for the 2007 Pacific sardine fishery. This harvest guideline is based on a biomass estimate of 1.32 million mt. Per the FMP allocation framework adopted under Amendment 11, the Pacific sardine HG is allocated seasonally with 35% of the HG to be allocated coast wide January 1, 40% of the HG plus any portion not harvested from the initial allocation reallocated coast wide July 1; and the remaining 25% of the HG, plus any portion not harvested from earlier allocations, to be reallocated coast wide September 15. The Council also recommended a 45% incidental catch rate be allowed for other coastal pelagic species (CPS) fisheries in the event that a seasonal allocation be taken before the end of an allocation period or the HG is taken before the end of the year.

  Additionally, the Council reviewed the draft Terms of Reference for the CPS stock assessment process scheduled for 2007 and directed Council staff to revise the document as recommended by the CPS Advisory Subpanel, the CPS Management Team, and the SSC and distribute it for public review. The Council is scheduled to approve a final document in March 2007 for use during the review of full assessments for Pacific mackerel and Pacific sardine in May and September, respectively.

Table 2. Regulatory Actions

January 25, 2000. NMFS published harvest guidelines for Pacific sardine and Pacific mackerel for the fishing year beginning January 1, 2000. A harvest guideline of 186,791 mt was established for Pacific sardine, based on a biomass estimate of 1,581,346 mt. The harvest guideline was allocated for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation was 62,264 mt; the southern allocation was 124,527 mt. The sardine harvest guideline was in effect until December 31, 2000, or until it was reached and the fishery closed. A harvest guideline of 42,819 mt was established for Pacific mackerel based on a biomass estimate of 239,286 mt. The harvest guideline for Pacific mackerel was in effect until June 30, 2000, or until it was reached and the fishery closed. (65*FR*3890)

September 11, 2000. NMFS announced the annual harvest guideline for Pacific mackerel in the exclusive economic zone (EEZ) off the Pacific Coast. Based on the estimated biomass of 116,967 mt and the formula in the FMP, a harvest guideline of 20,740 mt was calculated for the fishery beginning on July 1, 2000. This harvest guideline is available for harvest for the fishing season July 1, 2000, through June 30, 2001. (65*FR*54817)

November 1, 2000. NMFS announced the closure of the directed fishery for Pacific mackerel in the EEZ off the Pacific Coast on October 27, 2000. The FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on a formula in the FMP and to close the fishery when the harvest guideline is reached. The harvest guideline of 20,740 mt is projected to be reached before the end of the fishing season on June 30, 2001, which requires closing the directed fishery and setting an incidental harvest limit for Pacific mackerel so that the harvest of other coastal pelagic species will not be further restricted. The intended effect of this action is to ensure conservation of the Pacific mackerel resource. For the reasons stated here and in accordance with the FMP and its implementing regulations at 50 CFR 660.509, the directed fishery for Pacific mackerel will be closed October 27, 2000, after which time no more than 20% by weight of any landing of Pacific sardine may be Pacific mackerel. (65*FR*65272)

November 17, 2000. NMFS published a correction to the Pacific mackerel closure which was published on November 1, 2000. In 65*FR*65272, make the following correction: On page 65272, in the third column, under the heading SUPPLEMENTARY INFORMATION, the last sentence is corrected to read as follows: "For the reasons stated here and in accordance with the FMP and its implementing regulations at 50 CFR 660.509, the directed fishery for Pacific mackerel will be closed October 27, 2000, after which time no more than 20% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid may consist of Pacific mackerel." (65*FR*69483)

December 27, 2000. NMFS announced the annual harvest guideline for Pacific sardine in the EEZ off the Pacific Coast for the January 1, 2001, through December 31, 2001, fishing season. This harvest guideline has been calculated according to the regulations implementing the FMP. The intended effect of this action is to establish allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 1,182,465 mt and the formula in the FMP, a harvest guideline of 134,737 mt was calculated for the fishery beginning January 1, 2001. The harvest guideline is allocated one third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and two thirds for Subarea B, which is south of 35° 40' N latitude to the Mexican border. Any unused resource in either area will be reallocated between areas to help ensure that the optimum yield will be achieved. The northern allocation is 44,912 mt; the southern allocation is 89,825 mt. (65*FR*81766)

February 22, 2001. NMFS announced changes to the restriction on landings of Pacific mackerel for individuals participating in the CPS fishery and for individuals involved in other fisheries who harvest small amounts of Pacific mackerel. The incidental limit on landings of 20% by weight of

Pacific mackerel in landings of Pacific sardine, northern anchovy, jack mackerel, and market squid remains in effect; however, CPS fishermen may land up to 1 mt of Pacific mackerel even if they land no other species from the trip. Non CPS fisherman may land no more than 1 mt of Pacific mackerel per trip. After the harvest guideline of 20,740 mt is reached, all landings of Pacific mackerel will be restricted to 1 mt per trip. This action is authorized by the FMP and is intended to ensure that the fishery achieves, but does not exceed, the harvest guideline while minimizing the economic impact on small businesses. For the reasons stated here, no fishing vessel may land more than 1 mt of Pacific mackerel per fishing trip, except that fishing vessels with other CPS on board may land more than 1 mt of Pacific mackerel in a fishing trip if the total amount of Pacific mackerel on board the vessel does not exceed 20% by weight of the combined weight of all CPS on board the vessel. (66*FR*11119)

March 30, 2001. NMFS announced the closure of the fishery for Pacific mackerel in the EEZ off the Pacific Coast at 12:00 a.m. on March 27, 2001. The FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on a formula in the FMP and to close the fishery when the harvest guideline is reached. The harvest guideline of 20,740 mt has been reached. Following this date no more than 1 mt of Pacific mackerel may be landed from any fishing trip. The effect of this action is to ensure conservation of the Pacific mackerel resource. (66*FR*17373)

July 25, 2001. NMFS announced a harvest guideline of 13,837 mt for Pacific mackerel for the fishing season July 1, 2001 through June 30, 2002. A directed fishery of 6,000 mt was established, which, when attained, would be followed by an incidental allowance of 45% of Pacific mackerel in a landing of any coastal pelagic species. If a significant amount of the harvest guideline remained unused before the end of the fishing season on June 30, 2002, the directed fishery would be reopened. This approach was taken because of concern about the low harvest guideline's potential negative effect on the harvest of Pacific sardine if the fishery for Pacific mackerel had to be closed. The two species occur together often and could present incidental catch problems. (66*FR*38571)

November 27, 2001. NMFS announced the closure of the directed fishery for Pacific mackerel in the EEZ off the Pacific Coast at 12:00 noon on November 21, 2001. For the fishing season beginning July 1, 2001, 6,000 mt of the 13,837 mt harvest guideline was established for a directed fishery. More than 6,000 mt has been landed. Therefore, the directed fishery for Pacific mackerel was closed on November 21, 2001, after which time no more than 45% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid could consist of Pacific mackerel. The intended effect of this action was to ensure that the harvest guideline was achieved, but not exceeded, and to minimize bycatch of Pacific mackerel while other CPS were being harvested. (66*FR*59173)

December 27, 2001. NMFS published the harvest guideline for Pacific sardine for the fishing season beginning January 1, 2002. A harvest guideline of 118,442 mt was established for Pacific sardine based on a biomass estimate of 1,057,599 mt. The harvest guideline is allocated for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation is 39,481 mt; the southern allocation is 78,961mt. The sardine harvest guideline is in effect until December 31, 2002, or until it is reached and the fishery closed. (66*FR*66811)

April 5, 2002. NMFS announced the reopening of the directed fishery for Pacific mackerel in the U.S. EEZ off the Pacific Coast on April 1, 2002. A significant portion of the Pacific mackerel harvest guideline remains unharvested (6,585 mt). Therefore, the incidental catch allowance that has been in effect since November 21, 2001 is removed, and any landing of Pacific mackerel may consist of 100% Pacific mackerel. This action was taken to help ensure that the harvest guideline is attained. If the harvest guideline is projected to be reached before June 30, 2002, the directed fishery will be closed and an appropriate incidental landing restriction imposed. (67*FR*16322)

July 11, 2002. NMFS proposed a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. This action proposes allowable harvest levels for Pacific mackerel off the Pacific Coast. Based on the estimated biomass of 77,516 mt and the formula in the FMP, a harvest guideline of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the harvest guideline is attained and the fishery closed before June 30. (67*FR*45952)

September 18, 2002. NMFS announced the closure of the fishery for Pacific sardine in the U.S. EEZ off the Pacific Coast north of Point Piedras Blancas, California, (35°□ 40' N latitude) at 0001 hrs local time on September 14, 2002. The closure will remain in effect until the reallocation of the remaining portion of the coast wide harvest guideline is required by the CPS FMP. That reallocation is expected to occur on or about October 1, 2002. The purpose of this action is to comply with the allocation procedures mandated by the FMP. (67*FR*58733)

September 26, 2002. Emergency rule. NMFS announced the reallocation of the remaining Pacific sardine harvest guideline in the U.S. EEZ off the Pacific Coast. The CPS FMP requires that NMFS conduct a review of the fishery 9 months after the beginning of the fishing season on January 1, and reallocate any unharvested portion of the harvest guideline, with 50% allocated north and south of Point Piedras Blancas, California. The allocation north of Point Piedras Blancas was reached on September 14, 2002, and the fishery was closed until the scheduled time for reallocation on October 1, 2002. This action reallocates the remainder of the harvest guideline earlier than the date specified in the FMP in order to minimize the negative economic effects on fishing and processing, primarily in the Pacific Northwest, that would result from delaying the reallocation. (67*FR*60601)

October 3, 2002. NMFS issued a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. This action is to conserve Pacific mackerel off the Pacific Coast. Based on the estimated biomass of 77,516 mt and the formula in the FMP, a harvest guideline of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the harvest guideline is attained and the fishery closed before June 30. There will be a directed fishery of at least 9,500 mt, and 3,035 mt of the harvest guideline will be utilized for incidental landings following the closure of the directed fishery. After closure of the directed fishery, no more than 40% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid may consist of Pacific mackerel, except that up to 1 mt of Pacific mackerel may be landed without landing any other CPS. The fishery will be monitored, and if a sufficient amount of the harvest guideline remains before June 30, 2003, the directed fishery will be reopened. The goal is to achieve the harvest guideline and minimize the impact on other coastal pelagic fisheries. 67*FR*61994)

October 30, 2002. NMFS proposed a regulation to implement Amendment 10 to the CPS FMP, which was submitted by the Council for review and approval by the Secretary of Commerce. Amendment 10 addresses the two unrelated subjects of the transferability of limited entry permits and maximum sustainable yield for market squid. Only the provisions regarding limited entry permits require regulatory action. The purpose of this proposed rule is to establish the procedures by which limited entry permits can be transferred to other vessels and/or individuals so that the holders of the permits have maximum flexibility in their fishing operations while the goals of the FMP are achieved. (67*FR*66103)

November 25, 2002. NMFS proposed a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This harvest guideline has been calculated according to the CPS

FMP and establishes allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 999,871 mt and the formula in the FMP, a harvest guideline of 110,908 mt was determined for the fishery beginning January 1, 2003. The harvest guideline is allocated one third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and two thirds for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation is 36,969 mt; the southern allocation is 73,939 mt. (67*FR*70573)

December 31, 2002. NMFS issued a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This harvest guideline has been calculated according to the CPS FMP and establishes allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 999,871 mt and the formula in the FMP, a harvest guideline of 110,908 mt was determined for the fishery beginning January 1, 2003. The harvest guideline is allocated one third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas, California) to the Canadian border, and two thirds for Subarea B, which is south of 35° 40' North latitude to Mexican border. The northern allocation is 36,969 mt; the southern allocation is 73,939 mt. If an allocation or the harvest guideline is reached, up to 45% by weight of Pacific sardine may be landed in any landing of Pacific mackerel, jack mackerel, northern anchovy, or market squid. (67*FR*79889).

January 27, 2003. NMFS issued a regulation to implement Amendment 10 to the CPS FMP, which was submitted by the Council for review and approval by the Secretary of Commerce. Amendment 10 addresses the two unrelated subjects of the transferability of limited entry permits and maximum sustainable yield for market squid. Only the provisions regarding limited entry permits require regulatory action. The primary purpose of this final rule is to establish the procedures by which limited entry permits can be transferred to other vessels and/or individuals so that the holders of the permits have maximum flexibility in their fishing operations while the goals of the FMP are achieved. (68*FR*3819)

June 26, 2003. NMFS proposed a regulatory amendment to the CPS FMP. This amendment was submitted by the Council for review and approval by the Secretary. The proposed amendment would change the management subareas and the allocation process for Pacific sardine. The purpose of this proposed amendment is to establish a more effective and efficient allocation process for Pacific sardine and increase the possibility of achieving OY. (68*FR*37995)

July 29, 2003. NMFS proposed a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. (68*FR*44518)

September 4, 2003. NMFS issued a final rule to implement a regulatory amendment to the CPS FMP that changed the management subareas and the allocation process for Pacific sardine. The purpose of this final rule was to establish a more effective and efficient allocation process for Pacific sardine and increase the possibility of achieving OY. (68*FR*52523)

September 9, 2003. NMFS announced the reallocation of the remaining Pacific sardine harvest guideline in the EEZ off the Pacific Coast. On September 1, 2003, 59,508 mt of the 110,908 mt harvest guideline is expected to remain unharvested. The CPS FMP requires that a review of the fishery be conducted and any uncaught portion of the harvest guideline remaining unharvested in Subarea A (north of Pt. Arena, California) and Subarea B (south of Pt. Arena, California) be added together and reallocated, with 20 percent allocated to Subarea A and 80 percent to Subarea B; therefore, 11,902 mt is allocated to Subarea A and 47,600 mt is allocated to Subarea B. The intended effect of this action is to ensure that a sufficient amount of the resource is available to all harvesters on the Pacific Coast and to achieve OY. (68*FR*53053)

October 3, 2003. NMFS issued a final rule to implement the annual harvest guideline for the July 1, 2003 - June 30, 2004 Pacific mackerel fishery in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. Based on this approach, the biomass for July 1, 2003, is 68,924 mt. Applying the formula in the FMP results in a harvest guideline of 10,652 mt, which is lower than last year but similar to low harvest guidelines of recent years. (68*FR*57379)

October 28, 2003. NMFS announced the closure of the fishery for Pacific sardine in the EEZ off the Pacific Coast north of Pt. Arena, California (39° N latitude) at 12:01 a.m. local time on October 17, 2003. The purpose of this action is to comply with the allocation procedures mandated by the CPS FMP. (68*FR*61373)

December 3, 2003. NMFS proposed a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2004, through December 31, 2004. This harvest guideline was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. (68*FR*67638)

February 25, 2004. NMFS issued a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2004, through December 31, 2004. This action adopts a harvest guideline and initial subarea allocations for Pacific sardine off the Pacific coast that have been calculated according to the regulations implementing the CPS FMP. Based on a biomass estimate of 1,090,587 mt (in U.S. and Mexican waters), using the FMP formula, the harvest guideline for Pacific sardine in U.S. waters for January 1, 2004, through December 31, 2004 is 122,747 mt. The biomass estimate is slightly higher than last year's estimate; however, the difference between this year's biomass is not statistically significant from the biomass estimates of recent years. Under the FMP, the harvest guideline is allocated one third for Subarea A, which is north of 39° N latitude (Pt. Arena, California) to the Canadian border, and two thirds for Subarea B, which is south of 39° N latitude to the Mexican border. Under this final rule, the northern allocation for 2004 would be 40,916 mt and the southern allocation would be 81,831 mt. (69*FR*8572). July 20, 2004. NMFS proposed a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific coast for the fishing season July 1, 2004, through June 30, 2005. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. This action proposes allowable harvest levels for Pacific mackerel off the Pacific coast. (69 *FR* 43383)

September 14, 2004. Information memorandum. NMFS announced the reallocation of the remaining Pacific sardine harvest guideline in the U.S. EEZ off the Pacific Coast. A regulatory amendment (69 *FR* 8572, February 25, 2003) requires that NMFS conduct a review of the fishery 10 months after the beginning of the fishing season on January 1, and reallocate any unharvested portion of the harvest guideline, with 20% allocated north of Point Area, California, and 80% allocated south of Point Arena, California. (69 *FR* 55360)

October 21, 2004. NMFS issued a final rule to implement the annual harvest guideline for the July 1, 2004 - June 30, 2005 Pacific mackerel fishery in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. Based on this approach, the biomass for July 1, 2003, is 81,383 mt. Applying the formula in the FMP results in a harvest guideline of 13,268 mt. (69 *FR* 61768)

December 8, 2004. NMFS proposed a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2005, through December 31, 2005. This harvest guideline was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. (69 *FR* 70973)

June 22, 2005. NMFS issues a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. exclusive economic zone off the Pacific coast for the fishing season January 1, 2005, through December 31, 2005. This harvest guideline was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. Based on a biomass estimate of 1,193,515 metric tons (mt)(in U.S. and Mexican waters) and using the FMP formula, NMFS calculated a harvest guideline of 136,179 mt for Pacific sardine in U.S. waters. Under the FMP, the harvest guideline is allocated one-third for Subarea A, which is north of 39°00′ N. lat. (Pt. Arena, California) to the Canadian border, and two-thirds for Subarea B, which is south of 39° 00′ N. lat. to the Mexican border. Under this final rule, the northern allocation for 2005 would be 45,393 mt, and the southern allocation would be 90,786 mt. (70 *FR* 36053)

August 29, 2005. NMFS proposes a regulation to implement the annual harvest guideline for Pacific mackerel in the U.S. exclusive economic zone (EEZ) off the Pacific coast. For specific regulations, see final rule language from October 21, 2005 below. (70 *FR* 51005)

October 21, 2005. NMFS issues a final rule to implement the annual harvest guideline for Pacific mackerel in the U.S. exclusive economic zone (EEZ) off the Pacific coast. The biomass estimate for July 1, 2005, would be 101,147 metric tons (mt). Applying the formula in the FMP results in a harvest guideline of 17,419 mt, which is 32 percent greater than last year but similar to low harvest guidelines of recent years. For the last three years, the fishing industry has recommended dividing the harvest guideline into a directed fishery and an incidental fishery, reserving a portion of the harvest guideline for incidental harvest in the Pacific sardine fishery so that the Pacific sardine fishery is not hindered by a prohibition on the harvest of Pacific mackerel. At its meeting on June 15, 2005, the Subpanel recommended for the 2005–2006 fishing season that a directed fishery of 13,419 mt and an incidental fishery of 4,000 mt be implemented. An incidental allowance of 40 percent of Pacific mackerel in landings of any CPS would become effective if the 13,419 mt of the directed fishery is harvested. The Subpanel also recommended to allow up to 1 mt of Pacific mackerel to be landed during the incidental fishery without the requirement to land any other CPS. (70 *FR 61235*)

October 28, 2005. NMFS announces that the Pacific Fishery Management Council (Council) has submitted Amendment 11 to the Coastal Pelagic Species Fishery Management Plan (FMP) for Secretarial review. Amendment 11 would change the framework for the annual apportionment of the Pacific sardine harvest guideline along the U.S. Pacific coast. The purpose of Amendment 11 is to achieve optimal utilization of the Pacific sardine resource and equitable allocation of the harvest opportunity for Pacific sardine. The public comment period on Amendment 11 was open through December 27, 2005.. (70 *FR* 62087)

January 17, 2006. NMFS proposes a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. exclusive economic zone off the Pacific coast for the fishing season of January 1, 2006, through December 31, 2006. This harvest guideline has been calculated according to the regulations implementing the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP) and establishes allowable harvest levels for Pacific sardine off the Pacific coast... (71 *FR* 2510)

June 29, 2006. NMFS issues the final rule to implement Amendment 11 to the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), which changes the framework for the annual apportionment of the Pacific sardine harvest guideline along the U.S. Pacific coast. The purpose of this final rule is to achieve optimal utilization of the Pacific sardine resource and equitable allocation of the harvest opportunity for Pacific sardine. (71 *FR* 36999)

July 5, 2006. NMFS issues a final rule to implement the annual harvest guideline for Pacific sardine in the U.S. exclusive economic zone off the Pacific coast for the fishing season of January 1, 2006, through December 31, 2006. This harvest guideline has been calculated according to the regulations implementing the CPS FMP and establishes allowable harvest levels for Pacific sardine off the Pacific coast. Based on the estimated biomass of 1,061,391 mt and the formula in the FMP, a harvest guideline of 118,937 mt was determined for the fishery beginning January 1, 2006. (71 *FR* 38111)

August 21, 2006. This notice retracts the Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) to analyze a range of alternatives for the annual allocation of the Pacific sardine harvest guideline proposed action published on July 19, 2004. Further scoping subsequent to the publication of the NOI revealed additional information indicating that it was unlikely the proposed action would result in significant environmental impacts. An Environmental Assessment (EA) was completed and a subsequent Finding of No Significant Impact (FONSI) was signed. (71 *FR* 48537)

October 20, 2006. NMFS proposes a regulation to implement the annual harvest guideline for Pacific mackerel in the U.S. exclusive economic zone (EEZ) off the Pacific coast. (71 *FR* 61944).

December 7, 2006 NMFS proposes a regulation to implement new reporting and conservation measures under the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP). These reporting requirements and prohibitive measures would require coastal pelagic species (CPS) fishermen/vessel operators to employ avoidance measures when southern sea otters are present in the area they are fishing and to report any interactions that may occur between their vessel and/or fishing gear and sea otters. The purpose of this proposed rule is to comply with the terms and conditions of an incidental take statement from a biological opinion issued by the U.S. Fish and Wildlife Service regarding the implementation of Amendment 11 to the CPS FMP. (71 *FR* 70941).

Table 3. Coastal pelagic species limited entry permit vessel listing, with U.S. Coast Guard registered measurements and calculated gross tonnage (GT) values for each vessel. (Page 1 of 2)

Vessel Name	Coast Guard Number	Year Built	Vessel Age	Registered Measurements (ft)/1			Calculated Vessel GT/2	Permit No.	Permit GT Endorsement	Permit Transfer Allowance
				Length	Breadth	Depth				
Misty Moon	D578511	1976	29	49.60	19.00	10.10	63.8	1	63.8	70.2
Paloma	D280452	1960	45	47.40	16.50	8.30	43.5	2	43.5	47.9
St. George II	D238969	1939	66	71.40	21.20	9.70	98.4	3	98.4	108.2
Barbara H	D643518	1981	24	64.90	24.00	11.60	121.1	4	121.1	133.2
San Antonio	D236947	1937	68	72.10	19.50	8.70	82.0	5	82.0	90.2
Permit No Longer Exists	---	---	---	---	---	---	---	6	---	---
San Pedro Pride	D549506	1973	32	79.60	24.50	12.30	160.7	7	160.7	176.8
Ferrigno Boy	D602455	1978	27	69.60	23.70	12.60	139.3	8	139.3	153.2
King Phillip	D1061827	1997	8	79.00	26.00	11.40	156.9	9	156.9	172.6
Sea Wave	D951443	1989	16	78.00	22.00	18.00	206.9	10	206.9	227.6
Mary Louise	D247128	1944	61	58.30	18.00	8.00	56.2	11	56.2	61.8
Bainbridge	D236505	1937	68	78.60	22.70	9.60	114.8	12	114.8	126.3
Pioneer	D246212	1944	61	77.80	24.30	11.20	141.9	13	141.9	156.1
Maria	D236760	1937	68	70.70	20.50	9.20	89.3	14	89.3	98.2
St. Joseph	D633570	1981	24	62.90	22.00	9.10	84.4	15	84.4	92.8
Permit No Longer Exists	---	---	---	---	---	---	---	16	---	---
Retriever	D582022	1977	28	54.20	19.60	8.70	61.9	17	61.9	68.1
Atlantis	D649333	1982	23	49.60	19.00	10.10	63.8	18	63.8	70.2
G. Nazzareno	D246518	1944	61	78.00	22.70	10.50	124.6	19	124.6	137.1
Sea Queen	D582167	1974	31	68.40	22.00	11.10	111.9	20	111.9	123.1
Pacific Leader	D643138	1981	24	59.50	21.00	9.20	77.0	21	77.0	84.7
Chovie Clipper	D524626	1970	35	51.10	18.00	10.30	63.5	22	63.5	69.9
Pacific Journey/4	OR661ZK	2001	4	64.30	22.01	10.30	97.7	23	97.7	107.5
Ocean Angle I	D584336	1977	28	49.60	19.00	10.10	63.8	24	63.8	70.2
Maria T	D509632	1967	38	57.30	18.10	9.80	68.1	25	68.1	74.9
Manana	D253321	1947	58	40.10	13.20	6.70	23.8	26	23.8	26.2
Miss Juli/5	---	---	---	---	---	---	---	27	55.5	61.1
Mineo Bros.	D939449	1989	16	58.00	21.00	9.00	73.4	28	73.4	80.7
Sea Queen	D583781	1977	28	49.00	16.00	8.00	42.0	29	42.0	46.2
Little Joe II	D531019	1971	34	50.10	16.00	7.60	40.8	30	40.8	44.9
Caitlin Ann	D960836	1990	15	98.00	33.00	15.70	340.2	31	340.2	374.2
Eldorado	D690849	1985	20	56.00	17.00	8.60	54.9	32	54.9	60.4
Kristen Gail	D618791	1980	25	87.00	26.00	12.80	194.0	33	194.0	213.4
Fiore D'Mare	D550564	1973	32	71.50	23.00	11.40	125.6	34	125.6	138.2
Endurance	D613302	1979	26	49.00	16.00	8.00	42.0	35	42.0	46.2
New Sunbeam	D284470	1961	44	50.30	20.00	4.00	27.0	36	27.0	29.7
Calogera A	D984694	1992	13	57.75	21.00	10.50	85.3	37	85.3	93.8
Eileen	D252749	1947	58	79.40	22.10	10.20	119.9	38	119.9	131.9
Pamela Rose	D693271	1985	20	54.00	19.00	9.00	61.9	39	61.9	68.1
New Stella	D598813	1978	27	58.00	22.00	8.40	71.8	40	71.8	79.0
Traveler	D661936	1983	22	56.00	17.00	6.90	44.0	41	44.0	48.4
Lucky Star	D295673	1964	41	49.90	17.00	7.30	41.5	42	41.5	45.7
Ocean Angel II	D622522	1980	25	74.50	28.00	10.70	149.5	43	149.5	164.5
Crystal Sea/7	D1061917	1997	8	66.00	26.00	12.00	138.0	44	138.0	151.8
Trionfo	D625449	1980	25	63.80	19.30	9.60	79.2	45	79.2	87.1
Corva May/6	D615795	1979	26	49.60	19.00	10.10	63.8	46	85.0	93.5
Heavy Duty	D655523	1983	22	58.00	21.30	10.20	84.4	47	84.4	92.8
Aliotti Bros	D685870	1985	20	67.60	26.00	9.10	107.2	48	107.2	117.9
Lady J	D647528	1982	23	50.30	17.00	7.10	40.7	49	40.7	44.8
Anna S	D253402	1947	58	50.80	16.20	9.10	50.2	50	50.2	55.2
Endeavor	D971540	1990	15	57.40	19.00	9.90	72.3	51	72.3	79.5

Table 3. Coastal pelagic species limited entry permit vessel listing, with U.S. Coast Guard registered measurements and calculated gross tonnage (GT) values for each vessel. (Page 2 of 2)

Vessel Name	Coast Guard Number	Year Built	Vessel Age	Registered Measurements (ft)/1			Calculated Vessel GT/2	Permit No.	Permit GT Endorsement	Permit Transfer Allowance
				Length	Breadth	Depth				
Antoinette W	D606156	1978	27	45.40	16.00	7.60	7.0	52	37.0	40.7
Donna B	D648720	1982	23	73.20	25.00	12.90	158.2	53	158.2	174.0
Papa George	D549243	1973	32	72.00	22.80	11.50	126.5	54	126.5	139.2
Mercurio Bros	D650376	1982	23	42.00	16.70	8.60	40.4	55	40.4	44.4
Kathy Jeanne	D507798	1967	38	65.90	22.20	8.80	86.3	56	86.3	94.4
Merva W	D532023	1971	34	56.70	17.90	8.00	54.4	57	54.4	59.8
Santa Maria	D236806	1937	68	79.20	19.50	8.80	91.1	58	91.1	100.2
Buccaneer	D592177	1978	27	62.10	19.90	9.00	74.5	59	74.5	82.0
Midnight Hour	D276920	1958	47	61.10	18.00	8.60	63.4	60	63.4	69.7
Nancy B II	D542513	1972	33	56.40	18.00	8.80	59.9	61	59.9	65.9
Miss Kristina	D580843	1977	28	50.00	16.00	7.40	39.7	62	39.7	43.7
Emerald Sea	D626289	1980	25	62.70	26.00	7.90	86.3	63	86.3	94.9
Connie Marie/8	---	---	---	---	---	---	---	64	54.5	60.0
Theresa Marie	D629721	1980	25	40.90	14.70	6.60	26.4	65	26.4	29.0

/1 Vessel dimension information was obtained from the Coast Guard Website at: http://psix.uscg.mil/
/2 Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100. See 46 CFR 69.209.
/3 Maximum transfer allowance is based on permit GT + 10%.
/4 Pacific Journey was built in Canada and is not currently registered with the U.S. Coast Guard. Measurements by marine surveyor Det Norske Veritas.
/5 Miss Juli sank in 2001 and is pending replacement.
/6 Permit #46 was transferred to Corva May after the Jenny Lynn sank in 2003.
/7 Permit #44 formerly registered as Mellow Boy was sold and the name changed to Crystal Sea. The permit was transferred to new owner on 01/17/2005.
/8 Connie Marie sank in 2002 and is pending replacement.

Table 4. Vessel age and calculated gross tonnage (GT) for the initial and current limited entry fleet.

	Initial Fleet	Current Fleet
Number of Vessels	65	61
Average Vessel Age	35 years	33 years
Range of Ages	12 to 66 years	4 to 68 years
Average GT	71.3	88.7
Range of GT	12.8 to 206.9	23.8 to 340.2
Sum of Fleet GT	4,635.9	5,408.4
Capacity Goal (GT)/1	---	5,650.9
Transferability Trigger	---	5,933.5

/1 Established in Amendment 10 to the CPS FMP.

Table 5. Preliminary catch summary for vessels targeting Pacific sardine from NMFS-SWR coastal pelagic species pilot observer program. Page 1 of 2.

Target species - Pacific sardine					
Species	Target Catch	Incidental Catch	Bycatch Returned		
			Alive	Dead	Unknown
Sardine	1495 mt		80 mt	100 lbs	100 lbs
Anchovy		9 mt	82	1300 lbs	
Bat Ray		1	143	14	1
Bat Star			5		
CA Barracuda		2	1	3	
CA Halibut		9		4	
Giant Sea Bass			2		
Jacksmelt		1			
Jack Mackerel		2 mt			
Midshipman			1	13	1
Moon Jelly		1			
Pacific Bonito		10 lbs			
Pacific Butterfish		3			
Pacific Electric Ray			2		
Pacific Mackerel		1 mt	100 lbs		
Pacific Tomcod		1			
Pompano		167			
Queenfish		49			
Sanddab			25 lbs	10 lbs	
Scorpionfish		1			1
Sculpin				1	3
Shovelnose Guitarfish			1		
Spanish Mackerel		100 lbs			
Squid		1 mt	2 mt		
Starry Flounder			2		
Stingray		2			
Thornback Ray			2		
Unid. Crab			1		1
Unid. Croaker		40			
Unid. Flatfish		78	8	130	12
Unid. Jellyfish		3	3		
Unid. Mackerel		8 mt	12 mt		
Unid. Octopus					2
Unid. Ray					2
Unid. Rockfish		2	1		
Unid. Seastar			41	135	1
Unid. Scorpionfish/Sculpin					1
Unid. Shark				2	
Unid. Skate				3	

Table 5. Preliminary catch summary for vessels targeting Pacific sardine from NMFS-SWR coastal pelagic species pilot observer program. Page 2 of 2.

Target species - Pacific sardine					
Species	Target Catch	Incidental Catch	Bycatch Returned		
			Alive	Dead	Unknown
Unid. Smelt		2			
Unid. Surf Perch		1			
Unid. Turbot				60	
White Croaker		31 lbs	50 lbs		
Yellowfin Croaker		10 lbs			
CA Sea Lion			49		
Harbor Seal			1		
Unid. Gull			3	2	4

Table 6. Preliminary catch summary for vessels targeting market squid from NMFS-SWR coastal pelagic species pilot observer program.

Target species - Squid					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Squid	1274 mt		28 mt	350 lbs	2 mt
Anchovy		100 lbs	120 lbs		
Jack Mackerel		2 mt	18 lbs	2 lbs	
Pacific Mackerel		20 mt	20 mt	180 lbs	1 lb
Sardine		12 mt	13 mt	1077 lbs	3 lbs
Spanish Mackerel		20 lbs			
Bat Ray			53		1
Bat Star			1		
Blue Shark			2		
Common Mola			1		
Pelagic Stingray			60		
Pacific Butterfish		19			1
Sunstar		30	4		
Squid Eggs					505 lbs
Lobster			3		
Brittle Star				3000	
Unid. Batfish				2 lbs	
Unid. Crab		1	1		93
Unid. Croaker		3	2	16 lbs	
Unid. Flatfish		1	1	6	2
Unid. Jellyfish		4			
Unid. Mackerel		2 lbs	102 lbs		
Unid. Octopus		1			
Unid. Rockfish		1	1	4	
Unid. Ray			4		1
Unid. Sanddab		4	3		4
Unid. Seastar		1			
Unid. Seaslug					21
Unid. Scorpionfish		1			
Unid. Surfperch				3	
Unid. Skate		3		1	
Unid. Smelt		49			
Unid. Stingray		9	17		
Unid. Shark					1
Thresher Shark		1			
CA Sea Lion			98		
Harbor Seal			3		
Common Dolphin				1	
Unid. Gull			16	1	

Table 7. Preliminary catch summary for vessels targeting Pacific mackerel from NMFS-SWR coastal pelagic species pilot observer program.

Target species - Pacific mackerel					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Pacific Mackerel	40 mt				
Bat Ray			2		
CA Yellowtail			1		
Midshipman			1		
Sardine		16 mt			
Sea Cucumber		5			
Unid. Crab		1			
Unid. Flatfish			3		
Unid. Jellyfish			3		
Unid. Shark			1		

Table 8. Preliminary catch summary for vessels targeting northern anchovy and northern anchovy/Pacific sardine from NMFS-SWR coastal pelagic species pilot observer program.

Target species - Anchovy and Anchovy/Sardine					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Anchovy	373 mt		2 mt	1 mt	
Sardine		21 mt	2 mt		
Bat Ray			4		
CA Lizardfish			4		
Kelp Bass		1			
Midshipman					5
Pacific Bonito			20 lbs		
Pacific Mackerel		2			
Queenfish		50 lbs	11 lbs		
Round Stingray			1		
Sculpin		2			
Spiny Dogfish			1		
Unid. Croaker		20	45		
Unid. Flatfish		10			
Unid. Hake		4			
Unid. Seastar			1		
Unid. Smelt		2			
Unid. Turbot			1	1	20
White Croaker		50 lbs	35 lbs		
Yellowfin Croaker		50 lbs	10 lbs		
CA Sea Lion			5		
Sea Otter			1		

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2002-2006. (Page 1 of 3).

	All Ports					San Pedro					Monterey			
Common Name	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2003**	**2004**	**2005**	**2006**
Finfish														
Anchovy, northern	3.8	3.7	7.4	6.1	9.2	3.8	4.1	4.2	5.8	3.5	2.1	32.6	18.2	24.0
Barracuda, California	0.6		0.5	0.4	0.4	0.6		0.6	0.4	0.3				0.4
Bass, barred sand	1.5	1.1	1.1	1.1	0.6	1.5	1.4	1.2	1.2	0.9				
Bass, kelp	0.6	1.1		1.1	0.7	0.6	1.4		1.2	1.0				
Blacksmith					0.1					0.2				
Bonito, Pacific	0.3				2.1	0.3				2.9				
Butterfish, Pacific (Pompano)	3.2	2.8	4.7	5.5	6.0	3.2	2.7	5.1	5.2	6.4	3.1	2.3	18.2	4.9
Cabezon					0.1									0.4
Combfish, longspine		0.2			0.7					1.0				
Corbina, California	1.5				0.5	1.5				0.7				
Croaker, white (kingfish)		7.8	6.9	0.2	5.8		7.4	5.7	0.2	6.4	9.4	16.3		4.4
Croaker, yellowfin	0.3					0.3	0.0	0.0	0.0					
Cusk-eel, spotted					0.9					0.9				0.9
Cusk-eel, unspecified	2.6	1.1	1.3	4.7	2.1	2.6	1.4	1.5	4.8	2.9				
Eel, yellow snake	0.3	0.2				0.3	0.3							
Eel, wolf		0.2									1.0			
Fish, unspecified		0.9					1.1							
Flatfish, unspecified	8.5	2.2	1.8	0.2	0.6	8.5	2.7	2.1	0.2	0.7				0.4
Flounder, starry		0.4	0.3		0.5						2.1	2.3		1.8
Flyingfish	0.6	0.4	0.3	0.6		0.6	0.5	0.3	0.6					
Grunion, California			0.3		0.1					0.2		2.3		
Halfmoon					0.1									0.4
Halibut, California	1.8	6.9	4.2	7.6	2.5	1.8	7.1	4.8	7.7	3.3	6.3			0.4
Herring, Pacific		0.4			0.1						2.1			0.4
Jacksmelt	0.9	1.1	0.8	1.5	1.9	0.9	0.3	0.6	1.0	0.9	4.2	2.3	27.3	4.4
Kelpfish, giant					0.1					0.2				
Lizardfish, California	2.6	0.9	2.1	5.7	2.1	2.6	1.1	2.4	5.8	2.9				
Midshipman, plainfin	3.8				1.6	3.8				1.7				1.3
Midshipman, specklefin		0.4	1.3		1.6		0.5	1.5		2.2				
Midshipman, unspecified		3.5	2.1	0.6			4.4	2.4	0.6					
Pipefish, kelp		0.2	1.1	0.6	0.1		0.3	1.2	0.6	0.2				
Poacher, unspecified					0.1					0.2				
Queenfish					3.1					4.3				
Rockfish, chilipepper					0.1									0.4
Sablefish														
Salema					0.1					0.2				
Sanddab, longfin					0.2					0.3				
Sanddab, Pacific		0.2			1.4					1.9	1.0			
Sanddab, speckled					0.1					0.2				
Sanddab, unspecified	0.3	3.0	4.0	2.1	2.6	0.3	2.2	3.9	1.9	1.4	6.3	4.7	9.1	5.8
Scorpionfish, California	7.6	8.0	10.0	8.7	3.4	7.6	9.9	11.3	8.9	4.7	1.0			
Sculpin, pithead		0.2	1.3	0.2	0.1			0.3	0.2	0.2	1.0	9.3		
Sculpin, staghorn		0.4			0.1						2.1			0.4
Sculpin, unspecified					0.2					0.3				
Seabass, giant (black)	0.3				0.1	0.3				0.2				
Senorita	0.3					0.3								
Shad, American					0.9									3.1

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2002-2006. (Page 2 of 3).

	All Ports					San Pedro					Monterey			
Common Name	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2003**	**2004**	**2005**	**2006**
Sheephead, California					0.1					0.2				
Silversides					0.5					0.7				
Smelt, whitebait		0.7									3.1			
Sole, C-O					0.6					0.3				1.3
Sole, curlfin		0.2					0.3							
Sole, English					0.2									0.9
Sole, fantail	0.3	0.0				0.3								
Sole, sand		2.2	0.3		0.5						10.4	2.3		1.8
Sole, slender					0.1					0.2				
Sole, unspecified		0.2			0.2						1.0			0.9
Sturgeon, unsp.		0.2									1.0			
Sunfish, ocean					0.1									0.4
Surfperch, barred					0.1									0.4
Surfperch, black					0.1					0.2				
Surfperch, pink	0.6				1.1	0.6				0.9				
Surfperch, rubberlip					0.1					0.2				1.8
Surfperch, shiner					0.9					1.0				0.4
Surfperch, unspecified	0.3	0.3			0.4	0.3				0.3	2.3			0.4
Surfperch, walleye			0.3									2.3		
Surfperch, white					0.1					0.2				
Tonguefish	0.9	0.9	2.1	1.9	1.4	0.9	1.1	2.4	1.9	1.7				0.4
Topsmelt	0.3					0.3								
Turbot, curlfin	0.3				0.1	0.3				0.2				
Turbot, diamond	0.3				0.2	0.3				0.3				
Turbot, hornyhead	0.9	3.5	4.0	6.1	2.9	0.9	4.4	4.5	6.2	3.6				
Turbot, spotted					0.6									
Turbot, unspecified		0.7		1.1	1.0		0.3		1.2	1.4	2.1			
Whitefish, ocean	0.3					0.3								
Whiting, Pacific					0.1									0.4
Total % Freq. Incidents	**45.3**	**56.0**	**58.0**	**55.9**	**65.2**	**45.3**	**55.1**	**55.7**	**55.5**	**64.6**	**59.4**	**76.7**	**72.7**	**63.6**
Elasmobranchs														
Guitarfish, shovelnose	0.3	2.0		1.5	0.2	0.3	2.5		1.5	0.3				
Ratfish, spotted					0.1					0.2				
Ray, Bat	5.8	7.8	7.4	6.3	3.0	5.8	9.3	7.1	6.4	3.6	2.1	9.3		1.3
Ray, California butterfly	0.3			0.2		0.3			0.2					
Ray, Pacific electric	0.9	0.4	0.3		1.2	0.9		0.3		0.9	2.1			2.2
Ray, Unspecified		0.2					0.3							
Shark, brown smoothhound	0.3	0.0			0.1	0.3				0.2				
Shark, gray smoothhound	0.3	0.2			0.2	0.3				0.3	1.0			
Shark, horn					0.6					0.9				
Shark, Pacific angel	0.3				0.2	0.3				0.3				
Shark, shortfin mako		0.4									2.1			
Shark, spiny dogfish			0.3		0.1							2.3		0.4
Shark, swell														
Shark, Unspecified	0.3					0.3								
Skate, Big		0.4			0.6					0.2	2.1			1.8
Skate, California		0.2			0.5					0.7	1.0			

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2002-2006. (Page 3 of 3).

	All Ports					San Pedro					Monterey			
Common Name	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2003**	**2004**	**2005**	**2006**
Skate, longnose		0.4	0.8				0.5	0.9						
Skate, thornback	1.5	3.7	2.4	3.6	1.6	1.5	3.6	2.7	3.7	1.9	4.2			
Skate, Unspecified	0.6	0.4			0.1	0.6				0.2	2.1			
Stingray, round	0.3	1.1	0.3	1.5	0.2	0.3	1.4	0.3	1.5	0.3				
Total % Freq. Incidents	**10.8**	**17.4**	**11.3**	**13.1**	**9.1**	**10.8**	**17.5**	**11.3**	**13.3**	**10.0**	**16.7**	**11.6**	**0.0**	**5.8**
Invertebrates and Plants														
Algae, marine					1.2									1.2
Bryozoans					0.1									0.1
Crab shells	0.3	0.2	0.8		0.3	0.3	0.3	0.9		0.3				0.4
Crab, box					0.1					0.2				0.1
Crab, decorator		0.2			0.2						1.0			0.2
Crab, Dungeness		1.1			0.1						5.2			0.1
Crab, elbow		0.2					0.3							
Crab, pelagic red	1.8					1.8								
Crab, rock unspecified	0.9	0.9	1.3	0.2	0.2	0.9	0.8	1.5	0.2	0.3	1.0			0.2
Crab, sheep		0.2			0.1		0.3			0.2				0.1
Crab, slender		0.4									2.1			
Crab, swimming					0.3					0.5				0.4
Crab, unspecified					0.5					0.7				0.5
Eelgrass	0.9	0.9	1.1	1.5	2.0	0.9	1.1	1.2	1.5	1.4				2.1
Gorgonians	0.3				0.6	0.3				0.9				0.6
Jellies	0.3	1.1	1.3	2.3	0.2	0.3	0.5	0.3	2.3	0.3	3.1	9.3		0.2
Kelp	19.6	10.4	15.3	15.0	10.4	19.6	12.6	17.3	14.9	10.4	2.1		18.2	11.2
Kelp, feather boa					0.3									0.4
Lobster, California spiny	0.9					0.9								0.9
Octopus, unspecified	0.9				0.8	0.9				1.0				0.1
Pleurobranch	0.3					0.3								0.5
Prawn, spot	0.3				0.1	0.3				0.2				1.7
Salps	5.6	0.7	0.5	0.2		5.6	0.8	0.6	0.2	0.7				0.1
Sea cucumber	0.9	0.9	0.3	0.6	0.5	0.9	1.1	0.3	0.6					0.1
Sea pansies		0.2		0.2			0.3	0.0	0.2	1.2				4.2
Sea star	0.6	2.2	0.3	0.8	1.6	0.6	1.9	0.3	0.8		3.1			
Shrimp, black-spotted bay		0.4		0.2			0.5	0.0	0.2					
Shrimp, unspecified					7.6					0.2				
Snail, Unspecified														
Sponge, unspecified					0.1					0.2				
Squid Egg Cases	0.3	0.2	0.5			0.3		0.6			1.0			
Squid, market	10.2	6.1	9.2	10.2	3.9	10.2	6.8	10.1	10.3	5.9	3.1	2.3	9.1	
Total % Freq. Incidents	**43.9**	**27.1**	**31.9**	**31.3**	**31.3**	**44.7**	**28.2**	**34.5**	**31.1**	**24.5**	**22.9**	**11.6**	**27.3**	**25.7**
Total All Incidents	**342**	**461**	**379**	**528**	**804**	**342**	**365**	**336**	**517**	**579**	**96**	**43**	**11**	**225**
Total Observed Landings	**203**	**200**	**205**	**199**	**266**	**203**	**167**	**180**	**199**	**172**	**27**	**33**	**25**	**94**

Table 10. Market squid incidental catch for 2001 - 2006. Incidental catch includes species landed with market squid and recorded on landing receipts (round haul gear).

	2002		2003		2004		2005		2006	
Species name	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**
Pacific sardine	127	1,601.6	109	1,447.9	122	1,525.7	179	1,076.9	184	534.6
Northern anchovy	19	342.6	8	91.9	17	616.1	31	1,042.9	19	122.3
Pacific mackerel	37	71.2	16	163.2	23	143.1	187	571.5	169	360.3
Jack Mackerel	15	16.5	14	33.6	19	38.8	19	21.0	28	45.6
Jacksmelt			1	1.9			2	0.2		
Yellowtail										
Surfperch			1	0.1						
Kelpfish					1	2.2				
Bonito					1	0.01	1	1.3	3	3.3
Pacific herring							2	34.0		
White seabass							1	>0.1		

Table 11. Percent frequency of incidental in observed loads of California market squid by port, 2002-2006 (Page 1 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
Finfish																				
Anchovy, northern	4.8	4.4	5.8	5.7	5.1	5.9	4.2	4.1	5.9	5.0		5.8	7.4	3.8	7.8	3.8	3.2	5.8	6.5	3.2
Baracuda, California		0.2		0.3	1.3		0.2			0.8					3.9				0.7	
Bass, barred sand		0.2					0.2													
Bass, kelp					0.4					0.8										
Blacksmith		0.5			0.4		0.5			0.8										
Bonito, Pacific		0.2			0.4		0.2								2.0					
Butterfish, Pacific (Pompano)	4.1	3.3	1.6	0.5	2.6	3.9	1.7	2	0.7	4.2		4.2			2.0	5.1	4.1	1.2	0.7	
Cabezon	0.4	0.2				0.7	0.2									0.6				
Combfish, longspine			0.7					0.7												
Croaker, queenfish		0.5					0.5													
Croaker, white (kingfish)	0.7	0.5	0.6			2	0.5											0.6		
Croaker, unspecified			0.7					0.7												
Cusk-eel			0.7					0.7												
Eel, wolf			1.2															1.2		
Fish, unspecified	0.9					2.6														
Flatfish, unspecified			0.7		0.4			0.7												1.6
Flounder, starry			1.2															1.2		
Flyingfish		0.7					0.7													
Greenling, painted		0.2	0.7				0.2	0.7												
Halibut, California		0.9					1										0.9			
Herring, Pacific	0.4	0.9	1.8	0.5												1.3	0.9	1.8	1.3	
Herring, round		0.2	0				0.2	0												
Jack mackerel	5.2	8.1	7.5	6.5	12.4	5.9	10.5	8.2	10.5	15.0		4.2	7.4		2.0	6.4	9.6	7	5.9	15.9
Jacksmelt	2.6	4	7.7	3.1	0.4		0.7	0.7	0.7							7.7	7.3	14.6	7.2	1.6
Lizardfish, California		0.5	0.7				0.5	0.7												
Mackerel, Pacific	8.9	9.9	13.8	21.0	18.8	13.1	10.3	10.9	25.7	17.5	0.1	15.8	25.9	41.3	33.3	1.3	3.7	4.7	5.9	9.5
Midshipman, plainfin	0.2					0.7														
Midshipman, specklefin					0.4					0.8										
Midshipman, unspecified		0.7	1.2	0.5			0.5	0.7						1.3			0.9	1.8	0.7	
Medusa fish		0.5															0.5			
Poacher , unspecified		0.2					0.2													
Pomfret, Pacific																				
Rockfish, blue		0.5		0.3					0.7								0.5			
Rockfish, bocaccio	0.4	0.8	0.7				0.7	0.7								1.3	0.9			

Table 11. Percent frequency of incidental in observed loads of California market squid by port, 2002-2006 (Page 2 of 4).

	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
Common Name	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**
Rockfish, chilipepper			1.8	0.3														1.8	0.7	
Rockfish, olive		0.2					0.2													
Rockfish, shortbelly		0.5															0.5			
Rockfish, unspecified	0.2	0.4					0.2									0.6	0.5			
Roughback Sculpin			0.7					0.7												
Salema		1.4															1.4			
Salmon, chinook	1.3	0.5	0.6		0.4											3.8	0.5	0.6		1.6
Salmon, unspecified		0.5															0.5			
Sanddab, longfin		0.7	0.7				0.7	0.7												
Sanddab, Pacific	0.2	1.3	1.6	2.1	1.3		1.7	2	1.3	0.8				1.3		0.6	0.9	1.2	3.3	3.2
Sanddab, speckled		0.4	0.7				0.2	0.7									0.5			
Sanddab, unspecified	2.2	4.4	3	0.5		0.7	3.7	0.7			0.1	6.7				0.6	2.7	5.3	1.3	
Sardine, Pacific	26	24.2	24.8	21.6	22.2	32.7	18.1	21.1	23.7	26.7	0.3	42.5	44.4	25.0	33.3	12.2	11.9	8.8	17.6	4.8
Saury, Pacific	0.4	0.8					0.2									1.3	1.4			
Scorpionfish, California	0.9	3.2	1.4	0.8		2.6	3.2	1.4	2.0											
Sculpin, staghorn				0.3					0.7											
Sculpin, unspecified		1.4															1.4			
Silversides (jack- or topsmelt)				0.3					0.7											
Smelt, night		0.5															0.5			
Smelt, true		0.2					0.2													
Smelt, unspecified		0.2					0.2													
Sole, bigmouth	0.2	0.2				0.7	0.2													
Sole, curlfin		0.2					0.2													
Sole, English	0.2	0.6					0.2									0.6	0.9			
Sole, fantail		0.5					0.5													
Sole, sand		0.9	0.6														0.9			
Sole, Petrale																				
Sole, unspecified	0.4	0.8	3.7			0.7						0.8	3.7					0.6		
Sunfish, ocean		0.5			0.4										2.0		0.5			
Surfperch, kelp		0.2					0.2													
Surfperch, pink	0.2	0.2			0.4	0.7	0.2													
Surfperch, shiner			2		0.4			2		0.8										
Surfperch, unspecified	0.2	0.4					0.2			0.8						0.7	0.5			
Topsmelt		0.2	3.7	0.3			0.2						3.7	1.3						
Thornyhead, unspecified		0.2					0.2													

Table 11. Percent frequency of incidental in observed loads of California market squid by port, 2002-2006 (Page 3 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
Triggerfish	0.2					0.7														
Turbot, curlfin	0.2	0.6				0.7	0.2										0.9			
Turbot, diamond	0.2	0.2				0.7	0.2													
Turbot, hornyhead	0.2	1	0.7	0.3		0.7	1	0.7											0.7	
Turbot, unspecified	0.2	3.7	0.7	0.3				0.7								0.6	3.7		0.7	
Total Percent Frequency Fish Incidents	**62.0**	**89.3**	**94.0**	**64.9**	**67.9**	**75.7**	**65.8**	**62.2**	**72.4**	**74.2**	**0.5**	**80.0**	**92.5**	**73.8**	**86.3**	**48.5**	**62.6**	**58.2**	**52.9**	**41.3**
Elasmobranchs																				
Guitarfish, shovelnose	0.2					0.7														
Ray, bat	1.5	1.2	1.3	2.1	1.3	2	1.5	1.4	3.3	0.8		0.8		3.8	3.9	1.9	1.4			
Ray, Pacific electric	1.7		6.4	3.9	0.4											5.1		1.2	9.8	1.6
Ray , thornback		0.5					0.5											6.4		
Ray, unspecified	0.2	0.2					0.2									0.6				
Shark, horn	0.4	0.7		0.3		0.7	0.5		0.7			0.8								
Shark, Pacific angel		0.2					0.2													
Shark, spiny dogfish																				
Shark, unspecified					0.4															1.6
Skate, California																				
Skate, thornback																				
Skate, unspecified				0.3															0.7	
Stingray, round	0.4	0.7	3.4			0.7	0.5	3.4				0.8								
Total Percent Frequency Elasmobranch Incidents	**4.4**	**3.5**	**11.1**	**6.5**	**2.1**	**4.1**	**3.4**	**4.8**	**3.9**	**0.8**	**0.0**	**2.4**	**0.0**	**3.8**	**3.9**	**7.6**	**1.4**	**7.6**	**10.5**	**3.2**
Invertebrates and Plants																				3.2
Algae, marine					0.9															
Barnacle	0.2					0.7														
Cnideria (Sea Anenomes)	0.2	3			0.4		0.5									0.6	5.5			1.6
Crab shells		0.7					0.7													
Crab, box		0.2					0.2													
Crab, decorator		0.2					0.2													
Crab, Dungeness	2.2	5	1.2					0.7								6.4	5			
Crab, elbow																		1.8		
Crab, hermit		0.2					0.2													

Table 11. Percent frequency of incidental in observed loads of California market squid by port, 2002-2006 (Page 4 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2002	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**	**2002**	**2003**	**2004**	**2005**	**2006**
Crab, pelagic red	0.2					0.7														
Crab, purple globe		0.5					0.5													
Crab, sheep		0.7		0.3			0.7		0.7											
Crab, rock unspecified	0.4	0.5		0.3		1.3	0.5		0.7											
Eelgrass		1.5	5.4	0.8	0.9		1.5	5.4	2.0	1.7										
Gorgonians			0.7		0.4			0.7		0.8										
Invertebrates, colonial	15.2					0.7										44.2				
Jellies		7.1	15.8	2.6	0.4		0.5							1.3			13.7		5.9	1.6
Kelp	15.4	10.7	8.9	17.4	16.7	21	13.9	13.6	18.4	15.0	0.1	14.2	3.7	13.8	7.8	14.1	4.1	15.8	18.3	27.0
Lobster, California spiny				0.3					0.7											
Mussels	0.2					0.7														
Octopus, unspecified		0.7					0.7											9.4		
Salps		0.2	2.7				0.2	2.7												
Sea cucumber		1.5					1.5													
Sea star	0.9	1.1	1.9	0.5	1.3	2	1	0.7	1.3	0.8		0.8	3.7				1.4			3.2
Squid Egg Cases	8	4.9	5.1	1.6	8.5	3.3	5.4	8.8		5.8		2.5	0		2.0	18.6	6.8	1.2	3.9	19.0
Squid, jumbo		0.2	0.7	4.9	0.4		0.2	0.7		0.8				7.5				6.4	8.5	
Tunicates		0.5					0.5													
Urchin, purple		0.7					0.7													
Total Percent Frequency Invert/Plant Incidents	**42.9**	**40.1**	**42.4**	**28.6**	**29.9**	**30.4**	**29.6**	**33.3**	**23.7**	**25.0**	**0.1**	**17.5**	**7.4**	**22.5**	**9.8**	**83.9**	**36.5**	**34.6**	**36.6**	**52.4**
Total All Incidents	**506**	**802**	**345**	**384**	**234**	**167**	**449**	**147**	**152**	**120**	**120**	**120**	**27**	**79**	**51**	**219**	**233**	**171**	**153**	**63**
Total Observed Landings	**461**	**395**	**160**	**178**	**136**	**153**	**192**	**86**	**100**	**73**	**156**	**117**	**32**	**42**	**37**	**152**	**86**	**42**	**36**	**26**

Table 12. Expanded salmonid bycatch in Pacific sardine fisheries in Oregon and Washington, 2000-2006.

	Chinook (live)	Chinook (dead)	Coho (live)	Coho (dead)	Pink (live)	Unid (live)	Unid (dead)	Total (live)	Total (dead)	Grand Total
2006										
Oregon[1/]								164	93	257
Washington[2/]	31	101	19	116				50	217	267
2005										
Oregon[1/]								411	176	587
Washington[3/]	47	156	29	178				76	334	410
2004										
Oregon[1/]								518	305	823
Washington	35	225	19	105	0	39	0	93	330	423
2003										
Oregon[1/]								315	185	500
Washington	92	262	81	231	0	173	0	346	493	839
2002										
Oregon[1/]								199	81	280
Washington	150	356	61	765	0	200	0	411	1211	1532
2001[2/]										
Oregon	45	45	201	134	22	45	0	313	179	492
Washington	449	170	571	504	0	80	0	1100	674	1774
2000[2/]										
Oregon	43	72	159	43	0	303	43	505	158	663
Washington	38	3	276	116	0	7	0	321	119	440

1/ Oregon salmon bycatch data 2000-2001 are expanded from a bycatch rate of salmon/trip based on vessel observation program.
2/ Oregon salmon bycatch data 2002-2006 are from logbooks.
3/ 2005 Washington totals calculated from observed 2000-2004 observed bycatch rates

Table 13. Reported logbook and observed catches of non-target species caught in Oregon sardine fishery, 2006.

Species	Logbook data (97% coverage)	Observer data (1.8% coverage)
	# Caught	# Caught
Blue shark	3	0
Thresher shark	2	0
unknown shark	1	0
Salmonids	257 (55% alive; 45% dead)	6 (55% alive; 45% dead)
Mackerel	292,150 lb	Approx. 30,000 lbs
Anchovy	1000 lb	½ lb
Squid	150	0
Jelly fish	<100 lb	250 lbs

Table 14. Recorded incidental catch (mt) in Oregon sardine fishery, 2001-2006 (from fish ticket data).

Species	2001		2002		2003		2004		2005		2006	
	mt landed	% of catch	mt landed	% of catch	mt landed	% of catch	mt landed	% of catch	mt landed	% of catch	mt landed	% of catch
Pacific mackerel	52.8	0.4	126.3	0.6	158.3	0.6	161.5	0.5	316.1	0.7	665	1.8
Jack mackerel	1.2	<0.1	0.3	<0.1	3.2	<0.1	24.1	0.1	3.6	<0.1	1.4	<0.1
Pacific herring	-	-	3.3	<0.1	-	-	10.3	<0.1	0.1	<0.1	1.2	<0.1
Northern anchovy	-	-	0.2	<0.1	-	-	1.0	<0.1	68.4	0.2	8.6	<0.1
American shad	-	-	0.3	<0.1	-	-	1.2	<0.1	-	-	0.44	<0.1
Pacific hake	-	-	-	-	0.1	<0.1	-	-	-	-	-	-
thresher shark	-	-	-	-	0.3	<0.1	0.3	<0.1	0.4	<0.1	0.16	<0.1
Squid	-	-	-	-	-	-	13.9	<0.1	-	-	-	-
Jellyfish	-	-	-	-	-	-	5.5	<0.1	-	-	-	-

Table 15. Species noted as encountered on CDFG Live Bait Logs, 1996-2006.

Year	Days Fished	Jack Mackerel	Pacific Mackerel	Barracuda	Herring	Grunion	Smelts	Shiner Surfperch	Jellyfish	Queenfish	Market Squid	Pacific Bonito
2006	940	7	169	3								2
2005	1,045	49	188	27					1		1	6
2004	1,059	87	214	13						1	1	8
2003	1,123	18	140	23							2	
2002	1,105	9	147	1						1		
2001	1,052	11	176	56		1						
2000	488	25	87	34		1						
1999	449	16	77	7	1		1					
1998	809	8	189	69	1			1				
1997	773	46	190	104				3				
1996	522	10	45	27	3		5					

Table 16. Estimates of Pacific sardine and Northern anchovy live bait harvest in California (mt). Data for 1939-1992 from Thomson et al. (1994), and 1993-2006 from CDFG logs.

Year	Anchovy	Sardine	Year	Anchovy	Sardine
1939	1,364	0	1973	5,639	0
1940	1,820	0	1974	5,126	0
1941	1,435	0	1975	5,577	0
1942	234	0	1976	6,202	0
1943	World War II	World War II	1977	6,410	0
1944	World War II	World War II	1978	6,013	107
1945	World War II	World War II	1979	5,364	0
1946	2,493	0	1980	4,921	12
1947	2,589	0	1981	4,698	6
1948	3,379	0	1982	6,978	38
1949	2,542	0	1983	4,187	193
1950	3,469	0	1984	4,397	53
1951	4,665	0	1985	3,775	11
1952	6,178	0	1986	3,956	17
1953	5,798	0	1987	3,572	216
1954	6,066	0	1988	4,189	50
1955	5,557	0	1989	4,594	100
1956	5,744	0	1990	4,842	543
1957	3,729	0	1991	5,039	272
1958	3,843	0	1992	2,572	1,807
1959	4,297	0	1993	669	176
1960	4,225	0	1994	2,076	1,506
1961	5,364	0	1995	1,278	2,055
1962	5,595	0	1996	703	1,801
1963	4,030	0	1997	1,077	2,344
1964	4,709	0	1998	304	2,037
1965	5,645	0	1999	453	2,411
1966	6,144	0	2000	834	1,270
1967	4,898	0	2001	1,238	1,245
1968	6,644	0	2002	965	1,701
1969	4,891	0	2003	1,085	3,028
1970	5,543	0	2004	192	3,900
1971	5,794	0	2005	1,464	2,949
1972	5,307	0	2006	476	3,629

Table 17. Ratio of anchovy to sardine in reported live bait catch in California, 1994-2006. Values are in metric tons with the assumption that 1 scoop =12.5 lbs.

Year	Anchovy	Sardine	Total	Proportion Anchovy	Proportion Sardine
2006	476	3,629	4,105	0.12	0.88
2005	1,464	2,949	4,413	0.33	0.67
2004	192	3,900	4,092	0.05	0.95
2003	1,085	3,028	4,113	0.26	0.74
2002	965	1,701	2,666	0.36	0.64
2001	1,238	1,245	2,483	0.50	0.50
2000	834	1,270	2,104	0.40	0.60
1999	453	2,411	2,864	0.16	0.84
1998	304	2,037	2,341	0.13	0.87
1997	1,077	2,344	3,420	0.31	0.69
1996	703	1,801	2,504	0.28	0.72
1995	1,278	2,055	3,333	0.38	0.62
1994	2,076	1,506	3,582	0.58	0.42

Table 18. Commercial harvest (metric tons) of CPS finfish in Ensenada, Baja California, Mexico, for calendar years 1978-2006[1,2,3,4/]. Market squid are not commercially fished off Ensenada.

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Year	Pacific sardine	Northern anchovy	Pacific mackerel	Jack mackerel
1978	0	135,036	0	n/a
1979	0	192,476	0	n/a
1980	0	242,907	0	n/a
1981	0	258,745	0	n/a
1982	0	174,634	0	n/a
1983	274	87,429	135	n/a
1984	0	102,931	128	n/a
1985	3,722	117,192	2,582	n/a
1986	243	93,547	4,883	n/a
1987	2,432	124,482	2,082	n/a
1988	2,035	79,495	4,484	902
1989	6,224	81,811	13,687	0
1990	11,375	99	35,767	25
1991	31,391	831	17,500	30
1992	34,568	2,324	24,345	n/a
1993	32,045	284	7,741	n/a
1994	20,877	875	13,319	85
1995	35,396	17,772	4,821	0
1996	39,065	4,168	5,604	47
1997	68,439	1,823	12,477	78
1998	47,812	972	50,726	480
1999	58,569	3,482	10,168	781
2000	51,173	1,562	7,182	0
2001	22,246	76	4,078	0
2002	43,437	0	7,962	0
2003	30,540	1,287	2,678	0
2004	44,382	n/a	n/a	n/a
2005	56,715	5,604	2,126	0
2006	41,441	n/a	n/a	n/a

1/ Data for 1978 to 2002 from García and Sánchez (2003).
2/ Data for Jan-Nov 2003 were provided by Dr. Celia Eva-Cotero, CRIP Instituto Nacional de la Pesca, Ensenada (pers. comm.).
3/ 2005 data from Cota et al. (2006).
4/ Sardine landings for 1989 through 2006 provided by Manuel Nevarrez, CRIP-INP Guaymas (pers. comm.).

Table 19. Pacific sardine population numbers at age (millions), spawning stock biomass (SSB, mt), and age 1+ biomass (mt) at the beginning of each biological year, 1982-83 to 2006-07 (July-June) (Hill et al. 2006). 'Model SSB' is based on maturity-at-age and fishery weights-at-age and is used in ASAP to estimate stock-recruitment. 'Population SSB' and 'Age 1+ biomass' were calculated using population weights-at-age. Total landings (Canada+USA+Ensenada) by biological year are also provided. Recruitment is shown as population numbers at age-0. Age 1+ biomass as of July 2006 (bold) served as the basis for setting a harvest guideline for the U.S. fishery in calendar year 2007.

Biological	--- Population Numbers-at-age (millions) ---						Model	Population	Age 1+	Total
Year	0	1	2	3	4	5+	SSB	SSB	Biomass	Landings
1982-83	176	15	9	5	3	2	7,393	5,543	4,680	487
1983-84	328	117	9	5	3	3	15,236	12,826	15,395	372
1984-85	467	219	77	6	3	4	35,590	29,056	36,085	3,571
1985-86	519	303	136	46	4	5	57,736	48,793	60,367	1,838
1986-87	1,261	346	199	86	30	6	88,068	78,108	85,518	2,667
1987-88	1,392	841	227	127	56	23	148,640	124,428	155,124	5,887
1988-89	2,495	927	548	141	81	52	223,080	194,543	222,866	4,795
1989-90	2,481	1,666	612	354	92	88	366,450	286,496	352,707	15,322
1990-91	3,004	1,641	1,080	388	228	119	431,690	387,036	453,436	20,602
1991-92	4,954	1,984	1,058	678	249	228	489,870	492,340	557,239	35,022
1992-93	3,941	3,217	1,230	650	428	312	467,370	613,992	751,102	74,214
1993-94	7,148	2,452	1,791	673	380	470	491,760	702,226	777,950	31,540
1994-95	9,785	4,651	1,523	1,105	426	559	629,310	907,218	1,062,119	66,295
1995-96	6,803	6,276	2,774	901	681	643	778,570	1,158,675	1,437,764	62,677
1996-97	5,641	4,413	3,861	1,695	567	868	1,024,000	1,341,011	1,559,516	65,968
1997-98	6,737	3,673	2,744	2,386	1,075	946	976,910	1,375,343	1,536,719	131,380
1998-99	7,054	4,212	2,056	1,514	1,401	1,292	803,950	1,291,477	1,462,943	113,901
1999-00	5,100	4,366	2,293	1,101	871	1,709	628,580	1,229,013	1,427,391	119,258
2000-01	3,853	3,092	2,242	1,153	607	1,636	752,430	1,090,755	1,238,913	121,295
2001-02	7,487	2,389	1,680	1,177	639	1,383	751,430	977,236	1,048,074	125,612
2002-03	3,371	4,631	1,285	866	637	1,217	729,770	925,604	1,139,043	141,774
2003-04	14,370	2,100	2,528	662	459	1,072	823,690	972,553	969,557	106,550
2004-05	5,100	9,245	1,255	1,424	370	889	836,480	1,177,696	1,599,603	140,985
2005-06	5,468	3,258	5,412	684	766	710	833,470	1,323,892	1,503,871	152,852
2006-07	4,877	3,459	1,862	2,870	361	808	731,210	1,160,075	1,319,072	133,827

Table 20. Annual U.S. Pacific sardine landings and harvest guidelines (metric tons) by state and management subarea, 1981-2007.

	California						Management Subarea[1,2] Landings			Harvest Guidelines by Subarea[1,2]		
Year	So. Calif.	Cen. Calif.	No. of 39°N	California	Oregon	Washington	Southern	Northern	Total	Southern	Northern	Total
1981	34.4	0.0	0.0	34.4	0.0	0.0	34.4	0.0	34.4	n/a	n/a	n/a
1982	1.8	0.0	0.0	1.8	0.0	0.0	1.8	0.0	1.8	n/a	n/a	n/a
1983	0.6	0.0	0.0	0.6	0.0	0.0	0.6	0.0	0.6	n/a	n/a	n/a
1984	0.9	0.3	0.0	1.2	0.0	0.0	0.9	0.3	1.2	n/a	n/a	n/a
1985	3.7	2.2	0.0	5.9	0.0	0.0	3.7	2.2	5.9	n/a	n/a	n/a
1986	304.0	84.4	0.0	388.4	0.0	0.0	304.0	84.4	388.4	n/a	n/a	n/a
1987	391.6	47.8	0.0	439.4	0.0	0.0	391.6	47.8	439.4	n/a	n/a	n/a
1988	1,185.4	3.0	0.0	1,188.4	0.0	0.0	1,185.4	3.0	1,188.4	n/a	n/a	n/a
1989	598.7	238.0	0.0	836.7	0.0	0.0	598.7	238.0	836.7	n/a	n/a	n/a
1990	1,537.1	127.1	0.0	1,664.2	0.0	0.0	1,537.1	127.1	1,664.2	n/a	n/a	n/a
1991	6,601.4	985.9	0.0	7,587.3	0.0	0.0	6,601.4	985.9	7,587.3	n/a	n/a	n/a
1992	14,821.9	3,127.6	0.0	17,949.5	4.0	0.0	14,821.9	3,131.6	17,953.5	n/a	n/a	n/a
1993	14,669.6	675.6	0.0	15,345.2	0.2	0.0	14,669.6	675.8	15,345.4	n/a	n/a	n/a
1994	9,348.5	2,295.0	5.0	11,643.5	0.0	0.0	9,348.5	2,295.0	11,643.5	n/a	n/a	n/a
1995	34,645.7	5,681.2	2.0	40,326.9	0.0	0.0	34,645.7	5,681.2	40,326.9	n/a	n/a	n/a
1996	24,565.0	7,988.1	0.5	32,553.1	0.0	0.0	24,565.0	7,988.1	32,553.1	n/a	n/a	n/a
1997	29,885.4	13,359.7	0.0	43,245.1	0.0	0.0	29,885.4	13,359.7	43,245.1	n/a	n/a	n/a
1998	32,462.1	10,493.3	21.0	42,955.4	1.0	0.0	32,462.1	10,494.3	42,956.4	n/a	n/a	n/a
1999	42,017.2	17,246.3	0.0	59,263.5	775.5	1.0	42,017.2	18,022.8	60,040.0	n/a	n/a	n/a
2000	42,248.0	11,367.5	0.0	53,615.5	9,527.9	4,842.0	42,248.0	25,737.4	67,985.4	124,527.3	62,263.7	186,791.0
2001	44,721.5	7,103.5	0.5	51,825.0	12,780.3	11,127.1	44,721.5	31,010.9	75,732.4	89,824.7	44,912.3	134,737.0
2002	44,464.0	13,881.0	0.0	58,345.0	22,710.8	15,832.4	44,464.0	52,424.2	96,888.2	78,961.3	39,480.7	118,442.0
2003	24,832.0	7,907.5	14.0	32,739.5	25,257.6	11,920.1	32,739.5	37,177.7	69,917.2	73,938.7	36,969.3	110,908.0
2004	32,393.4	15,284.8	23.6	47,701.8	36,110.7	8,934.3	47,678.2	45,068.6	92,746.8	81,831.3	40,915.7	122,747.0
2005	30,252.6	7,940.1	0.0	38,192.7	45,109.7	6,721.1	38,192.7	51,830.8	90,023.5	90,786.0	45,393.0	136,179.0
2006	33,285.8	17,743.1	0.0	51,028.9	35,651.8	4,363.1	51,028.9	35,664.6	86,693.5	n/a	n/a	118,937.0
2007	---	---	---	---	---	---	---	---	---	n/a	n/a	152,564.0

1\ As of 2003, the 'Southern Subarea' comprises fisheries and landings from Pt. Arena, California (39°N latitude) to the Mexican border.
2\ As of 2006, the U.S. sardine harvest guideline is no longer managed by subarea. HG's are now allocated coastwide and released on a seasonal basis.

Table 21. West Coast Pacific sardine landings by country, 1981-2006. Landings made by commercial fisheries based in southern Baja California and the Gulf of California are not included.

Year	Ensenada Mexico	United States	Canada	Total
1981	0.0	34.4	0.0	34.4
1982	0.0	1.8	0.0	1.8
1983	274.0	0.6	0.0	274.6
1984	0.0	1.2	0.0	1.2
1985	3,722.0	5.9	0.0	3,727.9
1986	243.0	388.4	0.0	631.4
1987	2,432.0	439.4	0.0	2,871.4
1988	2,035.0	1,188.4	0.0	3,223.4
1989	6,224.0	836.7	0.0	7,060.7
1990	11,375.0	1,664.2	0.0	13,039.2
1991	31,391.0	7,587.3	0.0	38,978.3
1992	34,568.0	17,953.5	0.0	52,521.5
1993	32,045.0	15,345.4	0.0	47,390.4
1994	20,877.0	11,643.5	0.0	32,520.5
1995	35,396.0	40,326.9	25.0	75,747.9
1996	39,065.0	32,553.1	88.0	71,706.1
1997	68,439.0	43,245.1	34.0	111,718.1
1998	47,812.0	42,956.4	745.0	91,513.4
1999	58,569.0	60,040.0	1,250.0	119,859.0
2000	51,173.0	67,985.4	1,718.0	120,876.4
2001	22,246.0	75,732.4	1,600.0	99,578.4
2002	43,437.0	96,888.2	1,044.0	141,369.2
2003	30,540.0	69,917.2	954.0	101,411.2
2004	44,382.0	92,746.8	4,258.8	141,387.6
2005	56,715.0	90,023.5	3,200.0	149,938.5
2006	41,441.0	86,693.5	1,558.0	129,692.5

Table 22. RecFIN estimated recreational harvest of Pacific (chub) mackerel by state (type A+B1estimate in metric tons), 1980-2006.

Year	California	Oregon	Washington	Total
1980	2,754.44	0.00	0.00	2,754.44
1981	1,394.47	0.00	0.00	1,394.47
1982	1,667.49	0.00	0.00	1,667.49
1983	1,467.35	1.50	0.00	1,468.85
1984	1,445.11	0.24	0.00	1,445.36
1985	1,076.62	0.02	0.00	1,076.64
1986	1,002.60	0.00	0.00	1,002.60
1987	1,271.19	0.00	0.00	1,271.19
1988	800.08	0.00	0.00	800.08
1989	610.57	0.00	0.00	610.57
1990	n/a	n/a	n/a	n/a
1991	n/a	n/a	n/a	n/a
1992	n/a	n/a	n/a	n/a
1993	621.92	2.08	0.00	624.00
1994	947.13	0.21	0.00	947.34
1995	1,026.32	0.12	0.00	1,026.44
1996	693.85	0.10	0.00	693.95
1997	966.96	0.31	0.00	967.27
1998	448.23	0.04	1.00	449.26
1999	196.04	0.21	0.33	196.58
2000	250.00	0.07	0.00	250.07
2001	561.39	0.05	0.00	561.44
2002	279.11	0.11	0.00	279.22
2003	341.35	0.27	0.00	341.61
2004	546.44	0.10	0.00	546.53
2005	411.48	0.07	0.00	411.55
2006	633.81	0.11	0.00	633.92

Table 23. RecFIN estimated recreational harvest of Pacific (chub) mackerel by fishing mode (type A+B1 estimate in metric tons), 1980-2006. Estimates for ‘Man Made Structures’ and ‘Beach/Bank’ were included in ‘Shore Modes’.

Year	Shore Modes	Party/Charter	Private/Rental	Total
1980	424.8	1,320.5	1,009.2	2,754.4
1981	288.1	590.7	515.7	1,394.5
1982	274.7	865.1	527.6	1,667.5
1983	361.9	702.6	404.3	1,468.9
1984	281.9	577.9	585.5	1,445.4
1985	142.0	544.7	389.9	1,076.6
1986	91.6	520.1	390.9	1,002.6
1987	450.8	244.6	575.8	1,271.2
1988	105.5	239.1	455.4	800.1
1989	256.7	134.8	219.1	610.6
1990	n/a	n/a	n/a	n/a
1991	n/a	n/a	n/a	n/a
1992	n/a	n/a	n/a	n/a
1993	88.8	172.5	362.7	624.0
1994	205.9	245.1	496.3	947.3
1995	121.2	373.5	531.8	1,026.4
1996	93.4	319.4	281.1	694.0
1997	148.3	168.6	650.4	967.3
1998	96.7	131.2	221.4	449.3
1999	62.4	60.8	73.4	196.6
2000	51.3	76.8	121.9	250.1
2001	347.0	52.2	162.2	561.4
2002	92.9	25.7	160.6	279.2
2003	208.4	25.4	107.8	341.6
2004	406.3	20.3	119.9	546.5
2005	314.7	19.4	77.4	411.6
2006	586.9	7.5	39.5	633.9

Table 24. Pacific mackerel harvest guidelines and landings (mt) by July-June management season.

Season	**Quota or HG[/a]**	**Landings**
1992-93	34,010	18,307
1993-94	23,147	10,793
1994-95	14,706	9,372
1995-96	9,798	7,615
1996-97	8,709	9,788
1997-98	22,045	23,413
1998-99	30,572	19,578
1999-00	42,819	7,170
2000-01	20,740	20,936
2001-02	13,837	8,039
2002-03	12,535	3,541
2003-04	10,652	5,961
2004-05	13,268	5,012
2005-06	17,419	4,572
2006-07[/b]	19,845	6,956

[/a] California Quotas 1992-03 through 1998-99. PFMC HGs from 1999-00 onward.
[/b] 2006-07 landings as of Feb, 2007 (CDFG wetfish tables).

Table 25. West coast landings (mt) and real[1] exvessel revenues (2006 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2006.

	Pacific	**Pacific**	**Pacific**	**Pacific**	**Jack**	**Jack**				
Year	**Sardine mt**	**Sardine Rev**	**Mackerel mt**	**Mackerel Rev**	**Mackerel mt**	**Mackerel Rev**	**Anchovy mt**	**Anchovy Rev**	**Squid mt**	**Squid Rev**
1981	15	$5,924	35,388	$14,293,545	17,778	$7,170,864	52,309	$6,424,811	23,510	$9,966,329
1982	2	$996	36,065	$13,438,936	19,617	$7,370,841	42,155	$4,005,322	16,308	$6,615,098
1983	1	$311	41,479	$14,299,851	9,829	$3,189,626	4,430	$742,648	1,824	$1,349,023
1984	1	$1,488	44,086	$14,202,181	9,154	$2,348,353	2,899	$711,995	564	$519,267
1985	6	$2,353	37,772	$10,924,361	6,876	$2,150,566	1,638	$397,118	10,276	$6,598,265
1986	388	$134,659	48,089	$12,676,472	4,777	$1,349,219	1,557	$381,945	21,278	$7,354,905
1987	439	$100,058	46,725	$10,583,117	8,020	$1,893,034	1,467	$490,602	19,984	$6,269,729
1988	1,188	$262,950	50,864	$12,591,601	5,068	$1,220,007	1,518	$639,400	37,316	$11,588,397
1989	837	$288,274	47,713	$10,419,902	10,745	$2,448,022	2,511	$1,030,442	40,974	$11,098,864
1990	1,664	$271,061	40,092	$7,620,158	3,254	$629,632	3,259	$889,245	28,447	$6,727,187
1991	7,587	$1,227,092	32,067	$7,339,630	1,712	$341,699	4,068	$895,026	37,389	$8,344,504
1992	18,056	$2,519,290	19,045	$5,382,574	1,526	$320,857	1,166	$300,560	13,112	$3,283,895
1993	15,347	$2,029,126	12,129	$1,978,885	1,950	$361,585	2,003	$627,543	42,830	$13,484,054
1994	11,644	$1,948,164	10,293	$1,847,339	2,906	$490,260	1,859	$707,787	55,383	$18,438,541
1995	40,256	$4,481,417	8,823	$1,449,266	1,877	$367,661	2,016	$464,481	70,252	$28,121,532
1996	32,553	$3,896,773	9,730	$1,628,614	2,437	$377,409	4,505	$866,011	80,561	$27,031,460
1997	43,290	$5,401,011	20,168	$3,382,844	1,533	$300,612	5,779	$987,084	70,329	$25,116,992
1998	43,312	$4,356,248	21,561	$3,054,436	1,777	$460,339	1,584	$294,878	2,895	$1,953,252
1999	60,476	$6,151,637	9,094	$1,296,391	1,557	$236,984	5,311	$1,137,530	92,101	$39,599,911
2000	67,982	$8,448,580	22,058	$3,404,346	1,451	$318,184	11,832	$1,677,828	118,903	$31,614,791
2001	75,801	$10,365,167	7,618	$1,366,236	3,839	$688,421	19,345	$1,624,610	86,203	$19,191,041
2002	96,897	$11,813,852	3,744	$584,887	1,026	$232,122	4,882	$694,326	72,895	$20,341,502
2003	71,923	$7,947,226	4,213	$718,570	231	$79,706	1,929	$372,901	45,056	$27,686,354
2004	89,339	$10,683,681	3,708	$609,704	1,160	$283,299	7,019	$868,720	40,068	$20,975,664
2005	86,383	$10,492,750	3,586	$596,294	294	$223,878	11,414	$1,160,108	55,708	$32,368,321
2006	86,452	$9,425,554	6,538	$897,381	1,174	$201,621	12,958	$1,333,730	49,070	$26,902,811

Source: PacFIN - 1981-2006 data extracted April 2007.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2007.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

Table 26. Pacific coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2006. (Page 1 of 5)

	Landings (mt)					Exvessel Revenues (2006 $)				
Year	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**
	San Diego									
1981		13.2	11.8	1.7	4.3		$18,125	$7,974	$1,284	$3,538
1982		29.9	0.1		0.1		$24,636	$241	*	
1983		18.4	0.4	1.7	1.2		$17,002	$948	$1,221	$1,276
1984	0.3	27.2	0.2			$451	$22,348	$705		
1985		18.8	0.1		0.3		$30,449	$145	*	
1986		9.4	0.1				$9,808	$341		
1987		9.7	0.8		2.7		$12,189	$1,532		$2,276
1988	0.1	17.4		5.5	18.6	$84	$18,352		$4,952	$10,737
1989	0.1	7.6		93.5	2.1	$231	$9,409		$350,139	$3,272
1990	0.2	7.7	0.1	18.4	1.2	$275	$8,212	$90	$59,144	$1,538
1991		11.3	0.1	399.9			$10,716	$108	$143,217	
1992	0.1	17.4	1.1	120.9	16.4	$238	$18,843	$1,284	$28,429 *	
1993	0.4	16.3	3.2	3.7	0.2	$696	$17,384	$3,438	$1,363 *	
1994	2.0	20.8	4.9	27.9	0.8	$1,123	$17,503	$3,293	$12,446	$278
1995	5.3	31.2	0.5	38.2	0.8	$5,166	$21,916	$552	$25,645 *	
1996	1.2	26.0		144.6	1.8	$1,377	$19,187		$83,420	$567
1997	2.7	15.7		13.0	2.6	$3,602	$12,177		$7,218	$875
1998	215.3	52.3		2.3	2.2	$24,205	$10,445		$1,226	$1,839
1999	592.3	15.3	0.1	1.9	4.1	$70,971	$5,412	$148	$788 *	
2000	19.2	1.7	0.2	4.3	34.8	$8,510	$2,484	$264	$2,012 *	
2001	0.2	2.8	0.1	1.5	11.0	$112	$2,878	$125	$841	$5,239
2002	90.5	0.5	0.1	5.2		$66,266	$999	$126	$3,451	
2003	28.1	0.9	2.5	13.6		$23,596	$1,062	$3,485	$8,838	
2004	44.4	0.2			14.2	$28,026	$281			$6,798
2005	21.5	1.0		18.2		$13,219	$887		$10,737	
2006	17.6	0.5		26.1	1.4	$10,327	$623		$15,073	$803
	Orange/LA									
1981	14.7	29,084.7	14,699.9	38,216.3	8,290.6	$5,908	$11,838,360	$5,922,295	$4,578,331	$1,888,578
1982	1.8	29,827.6	18,131.1	32,514.7	4,292.8	$916	$11,083,965	$6,829,081	$2,819,515	$1,068,074
1983	0.6	33,902.3	6,785.8	900.2	853.6	$287	$12,049,007	$2,453,120	$181,724	$579,844
1984	0.5	35,572.8	3,566.3	204.8	66.3	$582	$12,397,118	$1,207,599	$140,090	$62,065
1985	3.4	32,012.6	5,860.1	43.1	3,095.9	$1,356	$9,556,372	$1,821,210	$29,203	$1,696,260
1986	286.6	41,071.7	4,289.0	140.8	8,121.8	$98,439	$10,965,474	$1,167,704	$35,836	$2,999,043
1987	317.3	39,863.3	7,801.2	108.8	5,421.5	$74,173	$9,110,793	$1,836,196	$31,841	$1,762,888
1988	1,172.1	47,656.6	4,939.1	92.9	15,173.7	$257,157	$11,713,646	$1,171,977	$26,471	$4,778,291
1989	505.0	41,717.5	10,703.7	479.0	16,434.2	$86,118	$9,554,369	$2,399,823	$75,410	$4,220,341
1990	1,179.4	37,123.6	2,968.0	193.2	9,797.9	$182,302	$7,088,981	$560,440	$41,363	$1,951,221
1991	6,415.1	31,602.9	1,640.2	414.3	12,305.3	$1,048,725	$7,225,705	$314,421	$66,921	$2,216,722
1992	13,950.8	18,071.7	1,095.7	136.6	1,700.5	$1,851,283	$5,227,413	$292,276	$35,923	$349,441
1993	13,977.6	11,714.9	1,268.9	118.7	12,889.7	$1,845,459	$1,922,410	$232,025	$22,426	$3,544,738
1994	9,031.7	9,842.3	2,459.8	136.6	11,231.1	$1,210,603	$1,753,364	$349,442	$21,207	$3,070,760
1995	34,137.0	7,864.0	1,596.2	297.8	18,413.1	$3,776,652	$1,297,387	$244,562	$35,774	$6,496,473
1996	23,922.6	8,764.9	2,054.0	239.1	14,993.9	$2,693,341	$1,402,872	$340,105	$30,561	$5,425,803
1997	26,533.7	14,002.6	822.6	1,120.8	17,779.1	$3,088,711	$2,687,186	$219,264	$116,110	$7,097,955
1998	31,702.3	18,149.6	1,012.4	338.1	227.5	$3,443,702	$2,766,819	$384,351	$44,591	$157,374
1999	39,084.2	8,551.1	927.4	1,418.2	27,684.1	$4,162,530	$1,229,235	$219,634	$258,579	$10,838,647
2000	39,104.1	21,646.1	1,209.5	1,280.1	44,839.9	$4,857,497	$3,359,517	$262,155	$170,659	$13,182,224
2001	40,763.6	6,676.6	3,623.8	3,657.7	39,170.6	$5,074,283	$1,208,197	$636,424	$365,108	$9,623,275
2002	39,308.0	3,367.8	1,003.5	1,205.7	28,136.9	$4,265,710	$543,191	$225,247	$113,189	$7,158,013
2003	22,882.7	3,941.3	133.4	205.5	7,758.8	$2,001,541	$677,836	$55,962	$33,422	$4,855,894
2004	23,677.4	3,018.3	1,027.1	147.2	10,504.3	$2,393,430	$529,470	$263,643	$38,706	$5,138,400
2005	24,119.0	3,145.8	166.6	1,992.4	31,813.9	$2,415,314	$537,479	$50,497	$197,530	$19,211,758
2006	26,780.1	5,641.4	1,025.8	878.4	37,107.1	$3,255,870	$801,695	$168,442	$82,550	$20,396,661

Table 26. Pacific coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2006. (Page 2 of 5)

	Landings (mt)					Exvessel Revenues (2006 $)				
Year	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**
	Ventura/Santa Barbara									
1981		4,872.1	2,846.6	9,034.5	2,389.7		$1,970,767	$1,145,862	$1,096,493	$421,493
1982		4,095.4	1,195.0	6,440.7	1,403.2		$1,615,452	$432,332	$644,780	$275,067
1983		3,905.0	559.1	2,727.1	3.2		$1,262,639	$163,150	$278,656	$3,693
1984		1,263.2	52.1	141.0	7.1		$392,447	$17,304	$77,294	$14,467
1985		2,950.7	787.1	109.8	2,959.4		$760,284	$230,879	$51,138	$1,264,446
1986	17.5	5,004.5	296.9	160.9	6,411.8	$4,894	$1,299,091	$84,974	$69,019	$1,736,229
1987	74.3	5,877.7	8.0	140.2	8,406.6	$17,421	$1,269,797	$2,605	$59,052	$2,400,430
1988	13.2	3,119.6	6.5	154.3	16,334.4	$4,503	$820,619	$1,718	$71,793	$4,730,972
1989	93.3	5,907.6		160.9	16,861.9	$15,793	$821,194		$77,074	$4,416,656
1990	236.1	420.9	75.7	140.9	10,600.5	$30,259	$58,995	$9,706	$63,981	$2,733,715
1991	186.4	138.1	8.6	189.9	16,904.8	$29,417	$20,877	$1,309	$81,117	$3,401,139
1992	973.4	92.2		89.8	2,809.2	$93,432	$10,264		$38,439	$600,055
1993	691.7	34.5		298.1	17,367.2	$67,724	$4,752		$110,210	$4,803,115
1994	315.0	39.5	47.5	340.8	21,333.6	$29,653	$10,289	$4,139	$179,660	$6,597,693
1995	354.5	249.1	0.4	346.3	41,184.3	$50,307	$29,945	$237	$179,713	$17,605,580
1996	461.1	66.8	11.1	374.5	46,435.3	$47,806	$37,095	$1,949	$184,705	$15,056,816
1997	3,357.3	1,160.3	7.4	510.4	34,610.6	$285,650	$125,672	$3,110	$109,987	$11,315,933
1998	899.3	1,305.7		239.1	2,175.6	$109,491	$82,530		$95,097	$1,494,117
1999	2,545.1	215.0		2,233.2	52,718.7	$288,479	$42,696		$382,727	$23,834,618
2000	3,072.2	230.0	9.1	3,548.3	48,747.0	$346,036	$24,957	$1,012	$454,549	$11,599,505
2001	3,956.7	72.4		3,909.3	31,876.3	$418,485	$7,525		$510,730	$6,000,160
2002	5,064.5			732.2	11,814.1	$694,516			$202,368	$3,480,825
2003	2,365.9	39.3		625.4	13,199.8	$237,155	$4,705		$153,163	$8,142,467
2004	4,711.0	67.4		2,722.2	15,397.0	$457,310	$8,464		$433,880	$8,239,134
2005	1,885.7	96.0	44.3	2,948.5	13,639.5	$180,437	$16,655	$2,743	$505,639	$7,592,284
2006	1,924.4	126.3		4,164.7	5,901.4	$179,658	$8,689		$621,764	$3,245,922
	San Luis Obispo									
1981		1.0		17.2	0.1		$972		$12,611	$150
1982		2.5			0.3		$2,199			$444
1983		0.7			0.2		$571			$231
1984		5.0			0.1		$3,339			$132
1985	0.3	19.5	0.1	47.5	0.3	$104	$5,024	$59	$25,973	$443
1986		0.6		11.3	0.1		$377		$5,057	$137
1987		0.8		2.4	0.4		$727		$994	$411
1988		0.2			0.1		$319			$108
1989		1.2		0.2	19.2		$885		$47	$6,394
1990	121.1	1.9	16.5		0.1	$15,494	$1,203	$2,090		$76
1991		1.0					$649			
1992		0.4			0.2		$329			$134
1993		0.1		1.1	2,035.9		$57		$657	$1,057,165
1994	0.1	0.2		0.8	1,343.6	$28	$118		$463	$751,426
1995					182.5					$50,385
1996					216.8					$76,322
1997				22.6					$11,376	$15
1998		0.3					$179			
1999				2.0	16.7				*	$5,507
2000										
2001				3.5	79.4				$1,731	*
2002	101.9				356.2	*				$84,669
2003				3.2	650.2				*	$389,630
2004					905.7					$471,636
2005					40.0					*
2006	0.1					*				

Table 26. Pacific coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2006. (Page 3 of 5)

	Landings (mt)					Exvessel Revenues (2006 $)				
Year	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**
Monterey/Santa Cruz										
1981		1,359.2	211.5	4,617.0	12,822.7		$438,570	$88,688	$531,183	$7,650,502
1982		2,053.4	280.3	2,609.1	10,607.3	$80	$686,031	$103,532	$260,154	$5,267,852
1983		3,449.2	2,457.2	320.8	500.0	$22	$895,338	$546,725	$76,145	$394,005
1984	0.3	7,151.1	5,486.0	1,894.7	390.9	$455	$1,352,850	$1,107,631	$194,775	$347,091
1985	2.2	2,704.4	228.1	1,138.2	3,813.1	$893	$538,801	$98,034	$150,843	$3,279,899
1986	84.5	1,987.9	191.1	808.2	5,487.9	$31,325	$390,431	$96,075	$82,185	$2,160,050
1987	47.6	956.7	209.7	676.3	5,611.0	$8,288	$179,504	$52,102	$122,883	$1,926,762
1988	3.0	59.0	121.5	696.3	4,896.7	$1,172	$28,586	$45,804	$283,832	$1,767,818
1989	238.0	60.0	37.2	928.7	7,145.5	$185,840	$18,009	$43,602	$193,330	$2,325,209
1990	127.1	2,495.7	192.4	2,131.5	7,917.5	$42,549	$433,674	$56,259	$442,512	$1,996,334
1991	985.9	298.0	43.6	2,526.8	6,703.2	$148,951	$71,526	$22,300	$395,336	$2,248,501
1992	3,093.2	374.9	109.8	608.2	6,111.3	$566,151	$102,454	$24,817	$105,238	$1,691,840
1993	676.1	38.1	345.1	1,285.0	6,039.6	$114,404	$17,082	$112,168	$310,932	$2,618,419
1994	2,289.4	38.4	191.2	985.8	13,648.1	$704,149	$22,693	$122,732	$318,090	$5,779,539
1995	5,678.1	460.7	109.1	1,110.5	2,449.1	$636,230	$79,342	$97,643	$115,127	$1,032,227
1996	7,987.9	703.0	91.0	3,553.9	4,672.0	$1,097,618	$113,519	$16,295	$457,305	$1,701,208
1997	13,356.7	3,208.2	327.2	3,895.1	8,282.9	$1,936,546	$523,995	$75,310	$677,853	$3,554,868
1998	10,009.0	1,456.7	32.5	901.2		$736,838	$170,738	$13,285	$81,142	
1999	16,417.2	2.7	24.2	1,511.3	301.3	$1,417,652	$11,854	$2,072	$398,390	$94,469
2000	11,367.0	39.4	50.0	6,804.3	7,125.4	$1,124,616	$7,391	$31,275	$921,148	$2,225,496
2001	7,102.5	172.2		11,660.3	7,746.6	$1,625,259	$21,441		$644,991	$2,010,055
2002	13,607.4	0.1	1.8	2,689.5	25,084.8	$1,445,458	$80	$432	$284,157	$7,570,346
2003	7,907.3	1.0	19.8	705.7	13,921.4	$727,587	$4,600	$2,691	$89,393	$8,638,628
2004	15,443.8	489.9		3,890.8	5,542.5	$1,268,931	$55,876		$308,281	$3,024,873
2005	8,119.3	0.4	0.5	6,192.2	1,916.3	$585,064	$743	$309	$394,303	$1,014,591
2006	17,578.9	31.1	140.7	7,634.5	509.3	$1,633,143	$9,114	$30,127	$564,264	$254,141
San Francisco										
1981			1.9	203.9				$1,671	$92,361	
1982		4.2	0.2	394.6	2.3		$2,451	$296	$196,621 *	
1983		13.3	1.2	332.3	461.5		$5,383	$371	$134,214	$365,434
1984		13.8	0.3	537.7	97.0		$9,241	$161	$235,733	$92,769
1985		14.6		258.8	77.0		$9,350	$42	$109,080	$56,564
1986		12.0		392.7	831.9		$9,040		$149,566	$353,181
1987	0.3	6.3	0.5	424.4	342.8	$102	$5,966	$596	$167,150	$127,913
1988		6.2	0.4	492.3	299.2	$2	$5,699	$441	$187,753	$104,385
1989		9.0	4.3	755.3	3.4	$18	$7,979	$4,510	$240,063	$2,147
1990		13.8	1.6	714.0	128.8	$41	$10,037	$1,038	$217,926	$43,801
1991		2.7	0.2	459.2	1,471.4		$2,057	$96	$148,530	$476,035
1992	34.5	11.5	1.4	164.4	2,447.9	$8,168	$12,762	$470	$46,218	$629,799
1993		1.2	0.3	243.9	1,017.8		$1,303	$271	$143,072	$493,817
1994	0.8	1.7	0.4	279.6	2,235.6	$737	$1,972	$600	$106,838	$823,148
1995	1.6	0.6	0.2	93.2	746.8	$607	$677	$298	$11,025	$273,748
1996		4.4	0.8	105.1	332.9		$2,967	$701	$30,717 *	
1997	3.1	3.7	0.2	155.7	204.5	$1,573	$2,871	$434	$12,941	$84,197
1998	463.5	3.8	1.2	0.5	14.1	$37,430	$4,226	$980	$24	$18,644
1999	1,057.9	0.9		46.8	5.4	$107,867	$682		$17,372 *	
2000	0.5		0.4	116.5		$242		$787	$73,616	
2001		0.6		42.3	279.9		$1,880		$15,221	$83,920
2002	171.8			17.2	864.6	$35,590			$10,543	$239,179
2003	0.1				2,807.7	$550				$1,687,511
2004	370.1	0.1			164.5	$36,464	$126			$96,196
2005	309.0				0.6	$28,057			*	
2006	130.9	0.9		70.5		$9,244	$1,150		$4,662	

Table 26. Pacific coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2006. (Page 4 of 5)

	Landings (mt)					**Exvessel Revenues (2006 $)**				
Year	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**
	Northern California									
1981		1.9			2.1		$988			$1,958
1982		3.0	1.1		1.7		$1,023	$535		$1,682
1983		2.9	0.1				$1,421	$30		
1984		0.1		0.5	0.1		$75		$1,029	*
1985										
1986										
1987					0.1					*
1988					1.0					*
1989		0.1			0.6		$48			*
1990		0.4			0.8		$248			*
1991		0.1			1.3		$61			*
1992		0.4	1.0	0.7	0.5		$453	$609	$138	$1,487
1993		0.2	55.4	0.1			$148	$10,118	$67	
1994	4.9	0.3	0.1	8.4	37.6	$1,869	$204	$85	$3,685	$13,466
1995	1.5	0.1	0.1		1.8	*	*	*		*
1996	0.3	3.1				$144	$2,117			
1997		5.7	2.2		3.4		$3,819	$1,483		$2,400
1998	20.9	9.2	6.2			$3,528	$3,969	$4,823		
1999		2.9					$916			
2000		1.7	0.1		0.5		$389	$104		*
2001	0.1			2.3	0.1	$45			$7,189	$94
2002		0.2	0.1		3.9		$532	$39		*
2003	13.5					*				
2004	23.6					$11,018				
2005										
2006					1.9					*
	Other California									
1981										
1982										
1983										
1984		0.1					*			
1985										
1986		0.2					*			
1987										
1988										
1989										
1990										
1991										
1992										
1993										
1994		3.9		3.7	32.7		$11,907		$313	*
1995										
1996										
1997										
1998										
1999										
2000										
2001										
2002										
2003										
2004										
2005										
2006										

Table 26. Pacific coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2006. (Page 5 of 5)

	Landings (mt)					Exvessel Revenues (2006 $)				
Year	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**	**Sardine**	**P. Mackerel**	**J. Mackerel**	**Anchovy**	**Squid**
	Oregon									
1981										
1982				0.1					$185	
1983		8.3					$13,889			
1984		3.0					$1,385			
1985										
1986										
1987		1.5					$825			
1988		0.6					$526			
1989		4.7					$1,654			
1990		10.3					$5,118			
1991		0.5	19.3				$234	$3,332		
1992	3.9	462.3	316.5				$208	$1,071		
1993	0.2	279.9	276.6				$1,126	$3,493		
1994		252.2	202.3	0.9			$12,354	$9,956	$257	
1995		189.5	148.6	0.2			$4,488	$9,058	$611	
1996		61.4	257.7				$4,728	$9,480		
1997		1,611.0	373.0				$2,783	$913		
1998	1.0	537.7	686.0			$932	$10,389	$52,628		
1999	775.5	259.1	496.1			$101,836	$1,195	$5,507		
2000	9,527.9	119.1	160.8	0.1		$1,333,241	$7,095	$20,001	$348	
2001	12,780.4	322.0	183.1			$1,834,450	$36,316	$45,553		
2002	22,711.0	126.6	8.9	3.1		$3,140,216	$7,202	$4,264	$1,980	
2003	25,257.9	160.0	73.6	39.1		$3,207,601	$20,325	$17,354	$3,393	
2004	36,111.0	106.9	125.8	13.1		$5,164,281	$11,924	$17,924	$4,913	
2005	45,110.1	317.8	69.6	68.4		$6,380,678	$36,613	$167,010	$1,622	
2006	35,651.3	665.0	5.3	8.6	26.9	$3,887,627	$61,869	$2,598	$19	$15,777
	Washington									
1981				1.3					$580	
1982				5.1					*	
1983				2.9					*	
1984		0.1		10.1			*		*	
1985				11.7					*	
1986				22.1					*	
1987				77.6					*	
1988				40.4					$50,003	
1989		0.2		61.8			$74		$79,902	
1990		0.1		50.3			$221		$59,447	
1991		0.2		54.5			$55		$51,233	
1992		5.9		41.7			$3,720		$44,288	
1993		30.2		19.9			$5,462		$14,255	
1994		33.3		38.5			$3,779		$34,950	
1995		7.5		118.3			$1,030		$82,372	
1996		65.3	2.8	85.6			$24,598	$847	$78,376	
1997		152.5	0.7	59.1			$20,448	$97	$50,613	
1998		45.9	38.5	102.5			$4,943	$4,224	$72,798	
1999	1.4	46.8	108.4	97.8		$1,956	$4,343	$9,010	$78,608	
2000	4,841.9	19.1	20.3	78.7		$770,007	$2,265	$2,583	$55,411	
2001	11,127.2	370.6	32.1	68.0		$1,404,534	$87,554	$6,177	$78,798	
2002	15,832.5	248.2	11.5	228.7		$2,157,384	$32,780	$2,004	$78,639	
2003	11,920.2	53.8	1.8	213.8		$1,603,103	$7,852	$129	$71,917	
2004	8,934.3	22.2	7.1	213.4		$1,320,229	$2,469	$1,692	$67,773	
2005	6,721.1	23.6	10.8	163.7		$875,075	$3,692	$2,552	$36,788	
2006	4,363.1	41.2	1.8	161.1		*	*	*	*	

Source: PacFIN - 1981-2006 data extracted April 2007.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2006.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

*Exvessel revenue not reported because less than three vessels or less than three processors accounted for total landings.

Table 27. Average annual real[1] exvessel prices ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2006.

Year	Pacific Sardine $/lb	Pacific Mackerel $/lb	Jack Mackerel $/lb	Anchovy $/lb	Squid $/lb
1981	$0.18	$0.18	$0.18	$0.06	$0.19
1982	$0.23	$0.17	$0.17	$0.04	$0.18
1983	$0.14	$0.16	$0.15	$0.08	$0.34
1984	$0.67	$0.15	$0.12	$0.11	$0.42
1985	$0.18	$0.13	$0.14	$0.11	$0.29
1986	$0.16	$0.12	$0.13	$0.11	$0.16
1987	$0.10	$0.10	$0.11	$0.15	$0.14
1988	$0.10	$0.11	$0.11	$0.19	$0.14
1989	$0.16	$0.10	$0.10	$0.19	$0.12
1990	$0.07	$0.09	$0.09	$0.12	$0.11
1991	$0.07	$0.10	$0.09	$0.10	$0.10
1992	$0.06	$0.13	$0.10	$0.12	$0.11
1993	$0.06	$0.07	$0.08	$0.14	$0.14
1994	$0.08	$0.08	$0.08	$0.17	$0.15
1995	$0.05	$0.07	$0.09	$0.10	$0.18
1996	$0.05	$0.08	$0.07	$0.09	$0.15
1997	$0.06	$0.08	$0.09	$0.08	$0.16
1998	$0.05	$0.06	$0.12	$0.08	$0.31
1999	$0.05	$0.06	$0.07	$0.10	$0.19
2000	$0.06	$0.07	$0.10	$0.06	$0.12
2001	$0.06	$0.08	$0.08	$0.04	$0.10
2002	$0.06	$0.07	$0.10	$0.06	$0.13
2003	$0.05	$0.08	$0.16	$0.09	$0.28
2004	$0.05	$0.07	$0.11	$0.06	$0.24
2005	$0.06	$0.08	$0.35	$0.05	$0.26
2006	$0.05	$0.06	$0.08	$0.05	$0.25

Source: PacFIN - 1981-2006 data extracted April 2006.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2006.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

Table 28. West coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-06. (Page 1 of 3)

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
	California									
1981	15	$5,924	35,388	$14,293,542	17,778	$7,170,864	52,308	$6,424,231	23,510	$9,966,329
1982	2	$996	36,065	$13,438,859	19,617	$7,370,841	42,150	$3,987,600	16,308	$6,615,098
1983	1	$311	41,471	$14,285,962	9,829	$3,189,626	4,427	$733,083	1,824	$1,349,023
1984	1	$1,488	44,083	$14,200,648	9,154	$2,348,353	2,889	$694,831	564	$519,267
1985	6	$2,353	37,772	$10,924,358	6,876	$2,150,564	1,626	$377,363	10,276	$6,598,265
1986	388	$134,659	48,089	$12,676,471	4,777	$1,349,219	1,535	$349,659	21,278	$7,354,905
1987	439	$100,058	46,724	$10,582,292	8,020	$1,893,034	1,390	$397,490	19,984	$6,269,729
1988	1,188	$262,950	50,863	$12,591,075	5,068	$1,220,007	1,478	$589,395	37,316	$11,588,397
1989	837	$288,274	47,708	$10,418,174	10,745	$2,448,022	2,449	$950,518	40,974	$11,098,864
1990	1,664	$271,061	40,081	$7,614,806	3,254	$629,632	3,208	$829,798	28,447	$6,727,187
1991	7,587	$1,227,092	32,066	$7,339,341	1,693	$338,366	4,014	$843,793	37,389	$8,344,504
1992	18,052	$2,519,290	18,577	$5,378,646	1,209	$319,784	1,124	$256,272	13,112	$3,283,895
1993	15,346	$2,029,126	11,819	$1,972,296	1,673	$358,092	1,959	$591,998	42,830	$13,484,054
1994	11,644	$1,948,164	10,008	$1,831,206	2,704	$480,304	1,789	$645,665	55,383	$18,438,541
1995	40,256	$4,481,417	8,626	$1,443,748	1,728	$358,603	1,886	$367,362	70,252	$28,121,532
1996	32,553	$3,896,773	9,603	$1,599,288	2,177	$367,082	4,419	$787,635	80,561	$27,031,460
1997	43,290	$5,401,011	18,401	$3,358,969	1,160	$299,603	5,720	$936,470	70,329	$25,116,992
1998	43,311	$4,355,316	20,978	$3,039,098	1,052	$403,488	1,481	$222,080	2,895	$1,953,252
1999	59,700	$6,047,844	8,788	$1,290,853	952	$222,467	5,214	$1,058,922	92,101	$39,599,911
2000	53,612	$6,345,332	21,920	$3,394,986	1,269	$295,600	11,753	$1,622,069	118,903	$31,614,791
2001	51,893	$7,126,183	6,925	$1,242,351	3,624	$636,691	19,277	$1,545,812	86,203	$19,191,041
2002	58,353	$6,516,252	3,369	$544,906	1,005	$225,854	4,650	$613,708	72,895	$20,341,502
2003	34,745	$3,136,522	3,999	$690,393	156	$62,223	1,676	$297,591	45,056	$27,686,354
2004	44,293	$4,199,171	3,579	$595,311	1,027	$263,683	6,793	$796,034	40,068	$20,975,664
2005	34,552	$3,236,997	3,244	$555,989	213	$54,316	11,182	$1,121,698	55,708	$32,368,321
2006	46,438	$5,089,873	5,831	$822,012	1,167	$198,579	12,788	$1,296,119	49,044	$26,887,034

Table 28. West coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-06. (Page 2 of 3)

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
	Oregon									
1981			<1	$3						
1982			<1	$77			<1	$185		
1983			8	$13,889						
1984			3	$1,385						
1985			<1	$3	<1	$2	<1	$64		
1986										
1987			1	$825						
1988			1	$526			<1	$2		
1989			5	$1,654			<1	$22		
1990			10	$5,130						
1991			<1	$234	19	$3,332				
1992	4		462	$208	317	$1,073				
1993			280	$1,126	277	$3,493				
1994			252	$12,354	202	$9,956	1	$257		
1995			189	$4,488	149	$9,058	<1	$611		
1996			61	$4,728	258	$9,480				
1997			1,611	$2,783	373	$913				
1998	1	$932	538	$10,389	686	$52,628				
1999	776	$101,836	259	$1,195	496	$5,507				
2000	9,528	$1,333,241	119	$7,095	161	$20,001	<1	$348		
2001	12,780	$1,834,450	322	$36,316	183	$45,553				
2002	22,711	$3,140,216	127	$7,202	9	$4,264	3	$1,980		
2003	25,258	$3,207,601	160	$20,325	74	$17,354	39	$3,393		
2004	36,111	$5,164,281	107	$11,924	126	$17,924	13	$4,913		
2005	45,110	$6,380,678	318	$36,613	70	$167,010	68	$1,622		
2006	35,651	$3,887,627	665	$61,869	5	$2,598	9	$19	27	$15,777

Table 28. West coast landings (mt) and real[1] exvessel revenues ($ 2006) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-06. (Page 3 of 3)

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
	Washington									
1981							1	$580		
1982							5	*		
1983							3	*		
1984			<1	*			10	*		
1985							12	*		
1986							22	*		
1987							78	*		
1988							40	$50,003		
1989			<1	$74			62	$79,902		
1990			<1	$221			50	$59,447		
1991			<1	$55			54	$51,233		
1992			6	$3,720			42	$44,288		
1993			30	$5,462			44	$35,545		
1994			33	$3,779			70	$61,865		
1995			7	$1,030			130	$96,508		
1996			65	$24,598	3	$847	86	$78,376		
1997			156	$21,092	1	$97	59	$50,613		
1998			46	$4,949	39	$4,224	103	$72,798		
1999	1	$1,956	47	$4,343	108	$9,010	98	$78,608		
2000	4,842	$770,007	19	$2,265	20	$2,583	79	$55,411		
2001	11,127	$1,404,534	371	$87,569	32	$6,177	68	$78,798		
2002	15,833	$2,157,384	248	$32,780	12	$2,004	229	$78,639		
2003	11,920	$1,603,103	54	$7,852	2	$129	214	$71,917		
2004	8,934	$1,320,229	22	$2,469	7	$1,692	213	$67,773		
2005	6,721	$875,075	24	$3,692	11	$2,552	164	$36,788		
2006	4,363	$448,054	41	$13,500	2	$444	161	$37,593		

Source: PacFIN - 1981-2006 data extracted April 2007.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2006.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

*Exvessel revenue not reported because less than three vessels or less than three processors accounted for total landings.

Table 29. Pacific coast CPS landings (mt) and real[1] exvessel revenues ($ 2006) by gear group, 1981-2006.

Year	Roundhaul or Lampara	Dip Net	Pot or Trap	Trawl	Hook and Line	Gillnet	Other or Unknown
Landings (metric tons)							
1981	120,578	8,231	<1	11	9	80	
1982	110,254	3,693	1	13	27	82	
1983	56,944	490	<1	8	2	44	40
1984	56,285	64	<1	4	1	189	
1985	55,494	495	1	20	9	430	<1
1986	75,784	88	4	3	<1	135	
1987	75,048	213	1	6	7	1,314	<1
1988	94,190	140	1	39	1	1,395	<1
1989	102,026	248	<1	132	3	100	
1990	76,010	489	1	15	34	72	
1991	81,817	724	37	128	4	63	
1992	47,666	4,322	3	802	15	31	
1993	68,346	5,171	2	592	3	44	
1994	78,350	2,997	59	510	49	11	13
1995	120,940	1,410	1	386	121	9	42
1996	128,354	855	1	401	64	23	
1997	138,534	247	<1	2,157	90	14	
1998	69,660	37	<1	1,334	44	5	
1999	166,933	528	72	961	12	10	
2000	219,844	1,568	45	275	420	4	<1
2001	190,196	1,791	1	621	153	3	
2002	178,656	761	<1	10	10	2	
2003	123,128	133	<1	76	10	<1	<1
2004	140,277	790	<1	110	7	<1	63
2005	154,761	2,504	11	92	9	<1	
2006	154,473	1,582	15	33	84	<1	
Revenues (2006 $)							
1981	$36,086,136	$1,643,504	$293	$7,611	$9,393	$56,468	
1982	$30,476,988	$838,461	$3,963	$7,690	$16,268	$45,264	
1983	$19,167,229	$341,593	$1,649	$4,847	$2,344	$23,628	$12,528
1984	$17,546,604	$59,553	$3,027	$3,337	$1,604	$83,522	
1985	$19,254,371	$518,219	$1,163	$15,244	$6,478	$219,362	$1,381
1986	$21,733,781	$43,279	$1,670	$2,952	$213	$67,332	
1987	$18,822,958	$64,393	$3,085	$3,772	$2,803	$387,757	$14
1988	$25,741,043	$49,875	$1,081	$44,595	$758	$387,403	$2
1989	$24,850,737	$63,303	$64	$44,127	$1,285	$37,028	
1990	$15,921,164	$65,378	$1,040	$9,509	$41,047	$42,093	
1991	$17,945,449	$73,885	$9,437	$32,630	$6,398	$25,543	
1992	$11,061,629	$641,389	$2,563	$9,538	$26,294	$15,071	
1993	$17,311,750	$1,030,106	$2,289	$11,985	$4,694	$24,891	
1994	$22,642,926	$603,474	$22,614	$35,873	$52,987	$7,137	$3,090
1995	$34,210,657	$455,029	$662	$21,882	$67,374	$5,778	$11,308
1996	$33,366,171	$235,108	$612	$49,849	$77,251	$13,670	
1997	$34,886,204	$103,775	$122	$36,861	$110,900	$8,182	
1998	$9,905,781	$29,665	$163	$92,952	$69,646	$3,541	
1999	$48,093,123	$223,053	$18,834	$39,917	$30,135	$7,024	
2000	$44,821,205	$458,234	$11,707	$30,853	$102,663	$2,311	$111
2001	$32,565,923	$434,461	$451	$151,519	$45,044	$1,844	
2002	$33,420,529	$207,468	$133	$6,126	$26,856	$1,460	
2003	$36,670,846	$81,219	$71	$18,515	$29,285	$132	$21
2004	$32,946,342	$394,592	$2	$16,191	$20,610	$109	$36,587
2005	$43,109,538	$1,530,243	$6,452	$171,350	$16,990	$160	
2006	$37,849,285	$860,839	$8,977	$18,029	$20,261	$172	

Source: PacFIN - 1981-2006 data extracted April 2007.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2006.

Table 30-31. Number of vessels with Pacific coast landings of CPS finfish and/or market squid by landing area, 1981-2006.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
CPS Finfish											
1981	64	136	71	46	82	9	6	1	5	4	24
1982	60	135	38	53	109	18	7		4	1	30
1983	53	113	28	49	117	47	15		64	1	15
1984	54	103	35	44	121	65	3	1	3	2	26
1985	51	124	49	34	115	74			4	2	24
1986	39	116	37	33	85	48	1	1	1	2	13
1987	38	110	41	30	77	63	5		92	2	21
1988	39	104	40	22	97	77	2		79	3	21
1989	46	99	31	28	62	111	5	1	152	3	20
1990	48	95	34	50	122	106	6		162	4	30
1991	53	96	34	33	48	21	4		39	4	18
1992	53	86	12	27	152	138	7		38	11	26
1993	46	103	14	16	73	41	5		28	10	23
1994	49	94	17	7	52	53	8	4	38	12	14
1995	40	96	32	3	35	38	2		44	6	18
1996	35	99	29	1	41	37	4		41	14	31
1997	27	102	20	3	49	53	7		50	18	14
1998	21	77	15	10	35	56	11		46	9	10
1999	17	80	17	2	24	21	5		44	10	7
2000	17	83	18	2	40	35	7		43	19	10
2001	18	76	17	3	27	14	4		43	28	6
2002	8	80	9	2	22	7	4		42	24	7
2003	8	58	14	2	22	6	2		43	20	9
2004	6	60	11	1	19	9	4		46	21	17
2005	4	66	12		14	7	2		42	25	16
2006	4	56	20	1	20	13	5		39	27	6
Market Squid											
1981	6	61	26	9	53	1	10				3
1982	1	51	25	7	53	2	7				3
1983	4	44	12	4	32	22	3				7
1984	1	9	17	6	31	8	2				4
1985	1	44	32	5	59	10	1				23
1986	2	43	27	7	41	4	1				8
1987	7	41	30	3	33	17	1				7
1988	10	51	32	4	30	7	1				11
1989	3	48	31	7	28	3	2				5
1990	7	42	26	3	36	9	2				3
1991		36	24	2	30	7	1				3
1992	1	18	14	4	36	16	4				1
1993	1	43	25	13	33	13	1				9
1994	3	42	31	11	34	6	3	1			9
1995	2	59	44	8	28	4	2				27
1996	4	62	66	8	28	2					39
1997	3	55	50	3	28	4	11				22
1998	3	19	45	1		3	2				18
1999	1	76	80	3	13	1	2				43
2000	2	86	63	1	23	1	2				42
2001	4	62	50	2	18	3	3				27
2002		72	61	5	33	3	1				32
2003		43	54	9	36	17					29
2004	3	72	50	8	23	3	1				42
2005		90	40	1	12	2					28
2006	3	90	30		11	1	1		37		23

Source: PacFIN - 1981-2006 data extracted April 2007.

Table 32-33. Number of vessels with CPS finfish or market squid as principle species[1] by principle landing area[2], 1981-2006.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
					CPS Finfish						
1981	4	53	6	1	3	2				1	5
1982	10	49	8	2	2	1				1	7
1983	8	50	7		7					1	3
1984	3	35	4		18	1				1	4
1985	2	40	6	2	3	1				2	2
1986	1	33	8	1	3	1				2	
1987	2	39	6		1	2				2	
1988	3	28	3		1	2			1	2	
1989	6	32	6		4	1				2	1
1990	5	28	3		2					2	2
1991	6	37	4		5					2	1
1992	5	37	4		3	2	1			1	1
1993	2	23	3	1	1	1					1
1994	2	27	6	1	2			1			
1995	2	18	5		2				1		
1996	2	19	7		9						
1997	1	26	3	1	5						
1998	3	37	4		8		1				
1999	1	19	2		7	1			2	1	
2000		26	3		3				6	1	
2001		24	3		3				11	6	
2002	2	23	4		1				10	8	
2003	2	10	2		2		1		10	5	
2004	2	13	3		5				13	6	
2005	1	8	2		2				14	4	1
2006	1	6	3		4				8	3	1
					Market Squid						
1981	2	14	3		33					1	
1982		16	2		35					2	
1983		6			4	1			1	7	1
1984					2				4	7	
1985		6	6		28				3		2
1986		9	4		16	1					1
1987	2	6	8		14						
1988	3	18	18		15						1
1989	2	16	12		15						1
1990	1	7	13		12						
1991		5	15		12	1					
1992			4		16	2					
1993		15	13	3	16						2
1994		8	18		19	2					4
1995		24	31		3	2				2	6
1996		30	41		7					1	15
1997		28	33		8						9
1998		3	22								6
1999		31	47		1						19
2000	1	43	30		8						9
2001	1	32	22		8	1					5
2002		33	11		17	1					6
2003		20	21		15	1					15
2004	1	41	15		8						9
2005		59	12		1						8
2006		61	4								6

Source: PacFIN - 1981-2006 data extracted April 2007.

[1]Principle species is the species that accounts for the greatest share of a vessel's total exvessel revenues across all species landed.

[2]Principle landing area is the area that accounts for the greatest share of a vessel's total exvessel revenues accross all areas in which it had landings.

Table 34-35. Number of processors and buyers, by landing area, whose annual purchases of CPS finfish or market squid represents the largest share of their total annual exvessel expenditures, 1981-2006.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
CPS Finfish											
1981	1	5	4	2	1	1					2
1982		3	7							1	5
1983	1	4	5		2	1				1	3
1984	1	2	3		3	2				1	3
1985		5	2	1	2	1				1	1
1986		5	4		2	1				1	2
1987	1	6	5		1	2				2	1
1988		7	4		1	1				2	1
1989	3	8	3		1	1				2	1
1990	6	5	2		1	2				2	1
1991	2		3		2	1				2	1
1992	1	7	4		1	1				1	
1993		4	5		2	1				1	
1994	2	6	4		2	1		1		1	
1995	1	7	4			1			1		2
1996	2	4	6		1	1				1	1
1997	1	9	6		1	1				1	
1998	1		6		3	1	1			1	2
1999	2	5	4		2	3	1			1	
2000			4		3				2	1	1
2001		6	6	1		1	1		4	1	
2002	2	7	6		1	1			3	1	
2003	2	8	5		1		1		3	2	
2004	2	7	8	1	1		1		5		1
2005	1	3	3		1				6		
2006	1	2	3						5		1
Market Squid											
1981		1	2		5	4					
1982		1			7	1				2	
1983						3				3	
1984					1					2	
1985			3		5						1
1986		1	3		6	1					1
1987		1	3		4	1					
1988		2	3	2	2	2					
1989		1	11	1	3	2					
1990		2	6		4						
1991			6			1					
1992			4			3					
1993	1		8	1	1	1					
1994		2	16	1	2			1			1
1995		1	16								1
1996		4	10		2					1	3
1997		6	10		1						1
1998	1		3								
1999		6	19								5
2000	1		20	1	1						5
2001	1	3	14	1	1		1				2
2002		4	11	1							4
2003		4	11	1	2						1
2004		3	16	2	1						2
2005		2	11								1
2006		4	6	2							2

Source: PacFIN - 1981-2006 data extracted April 2007.

Figure 1. Distribution of jack mackerel and northern anchovy eggs collected with the Continuous Underway Fish Egg Sampler (CUFES) during CalCOFI cruise 0704 (April 2007).
http://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=218&id=1340.

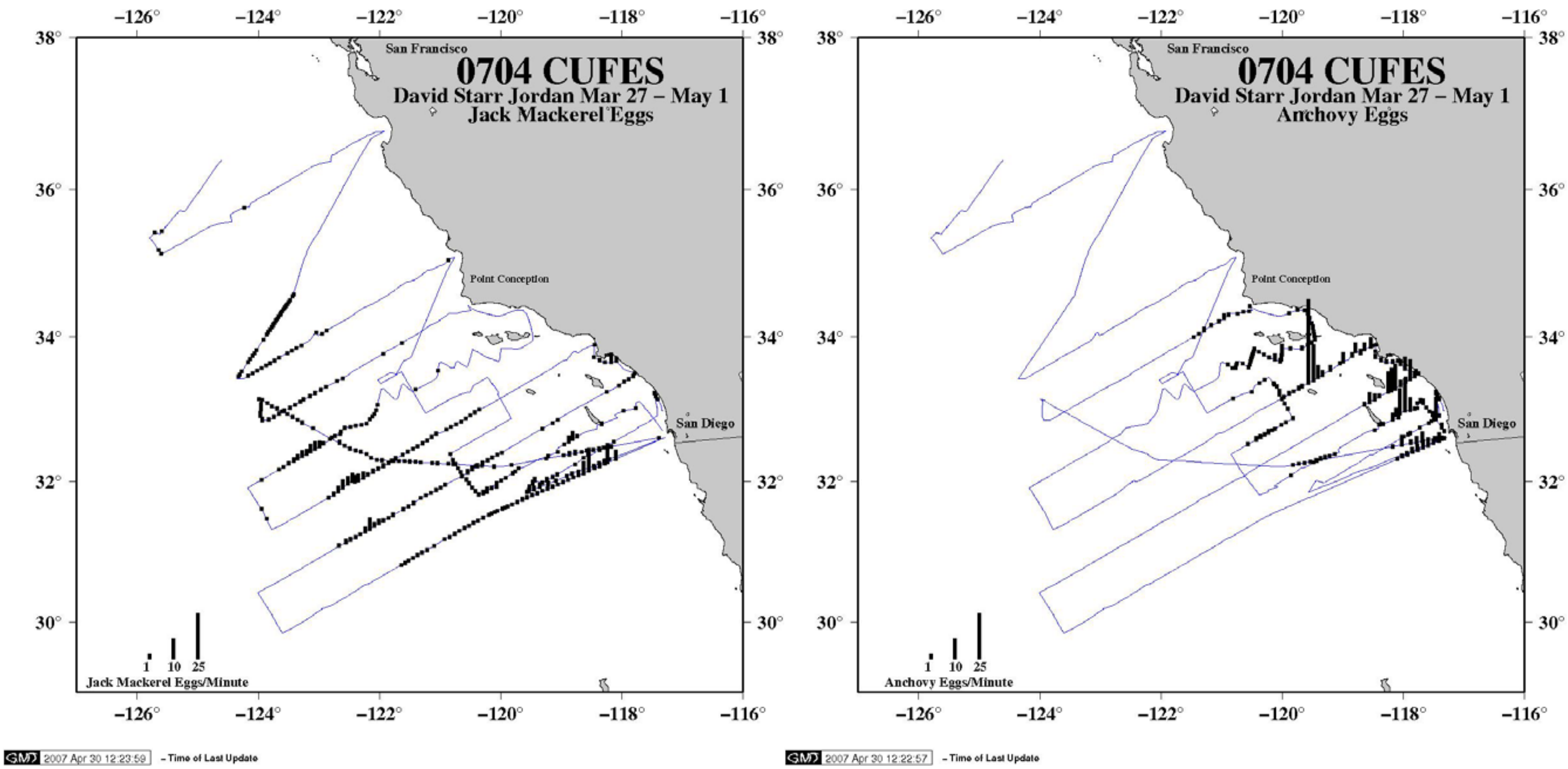


Figure 2. Annual Pacific coast landings and real exvessel revenues for all CPS species, 1981-2006.

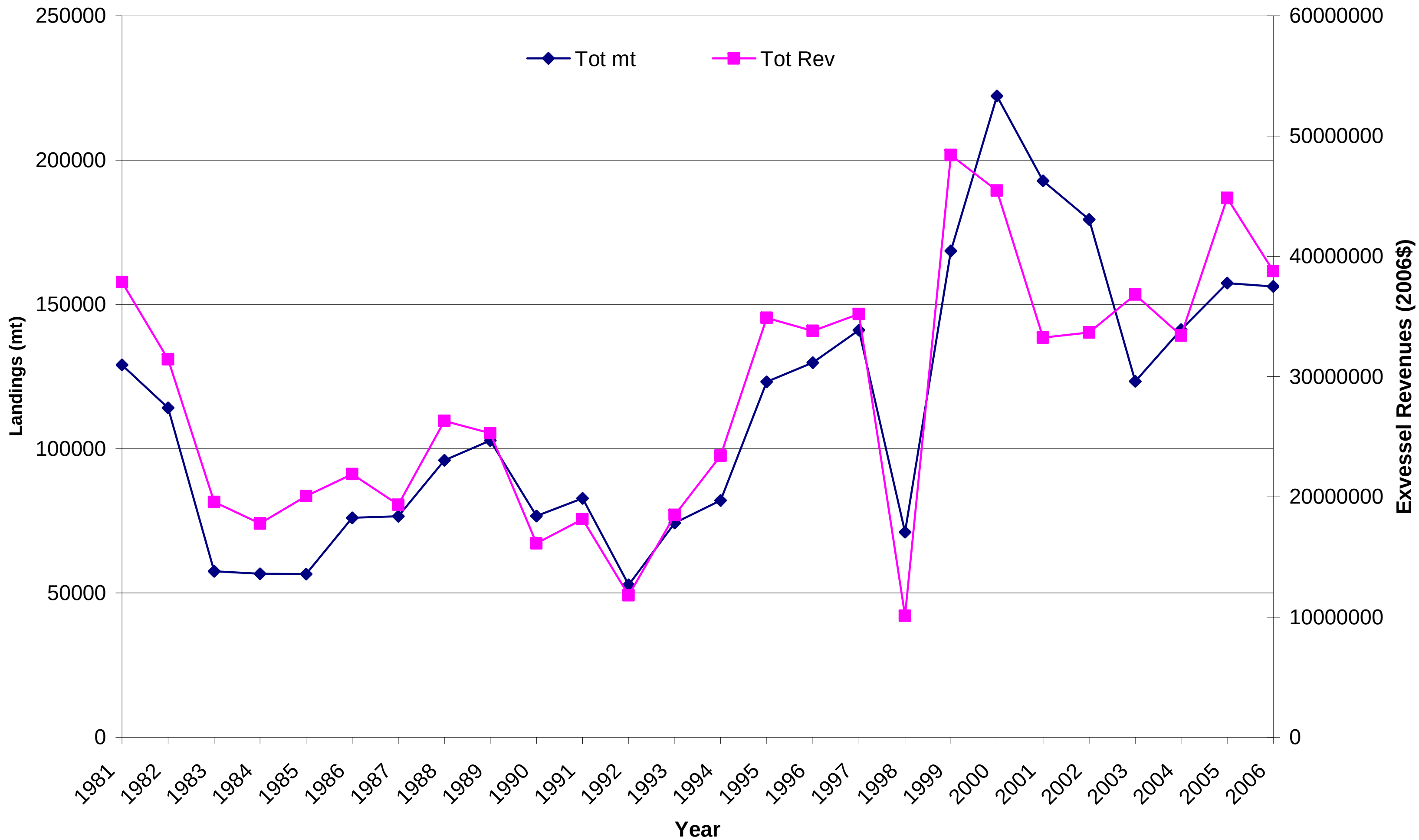


Figure 3. Percentage contribution of Pacific coast CPS finfish and market squid landings to the total exvessel value of all Pacific coast landings, 1981-2006.

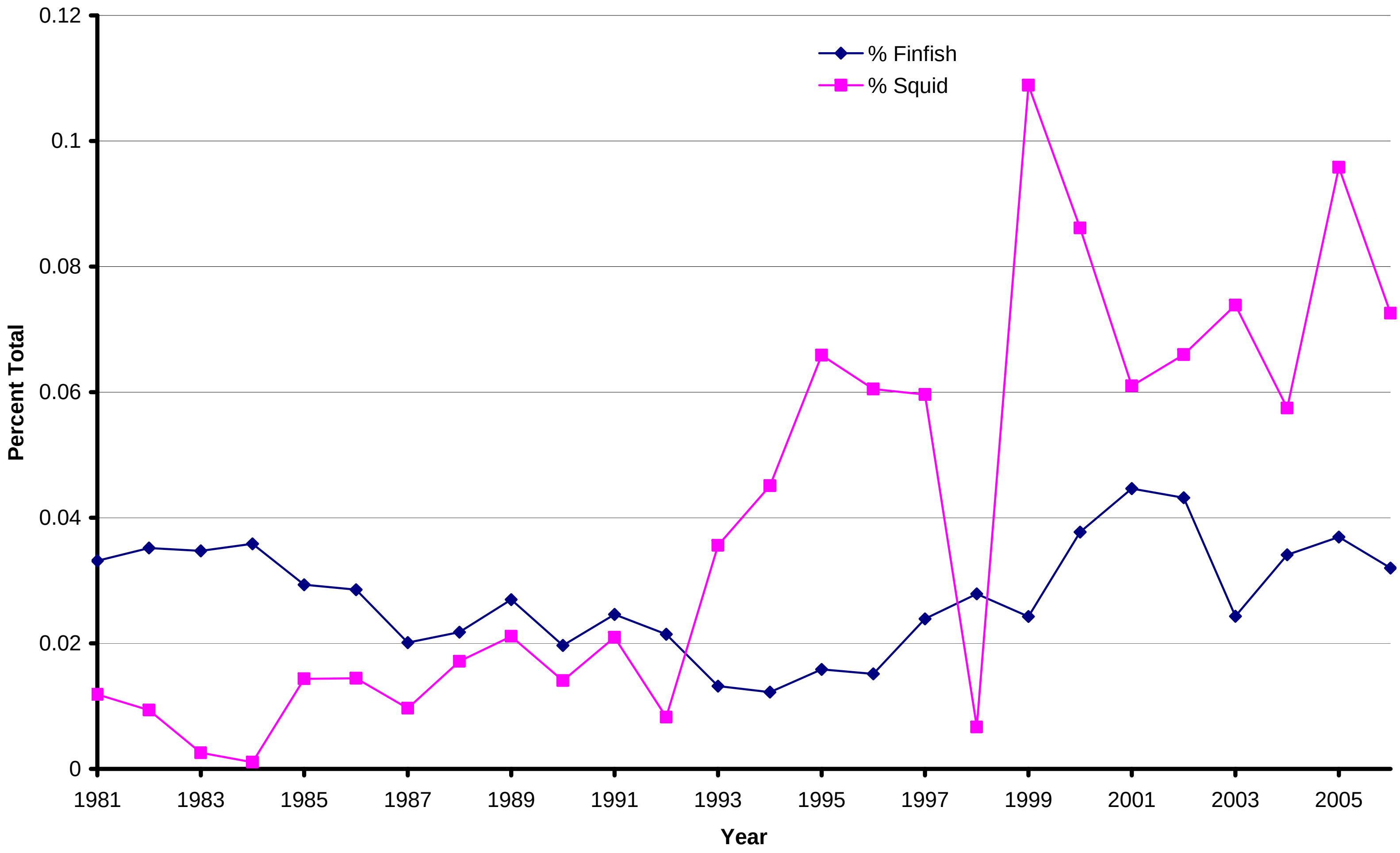


Figure 4. Pacific coast CPS finfish landings and real exvessel price ($/lb, 2006 $), 1981-2006.

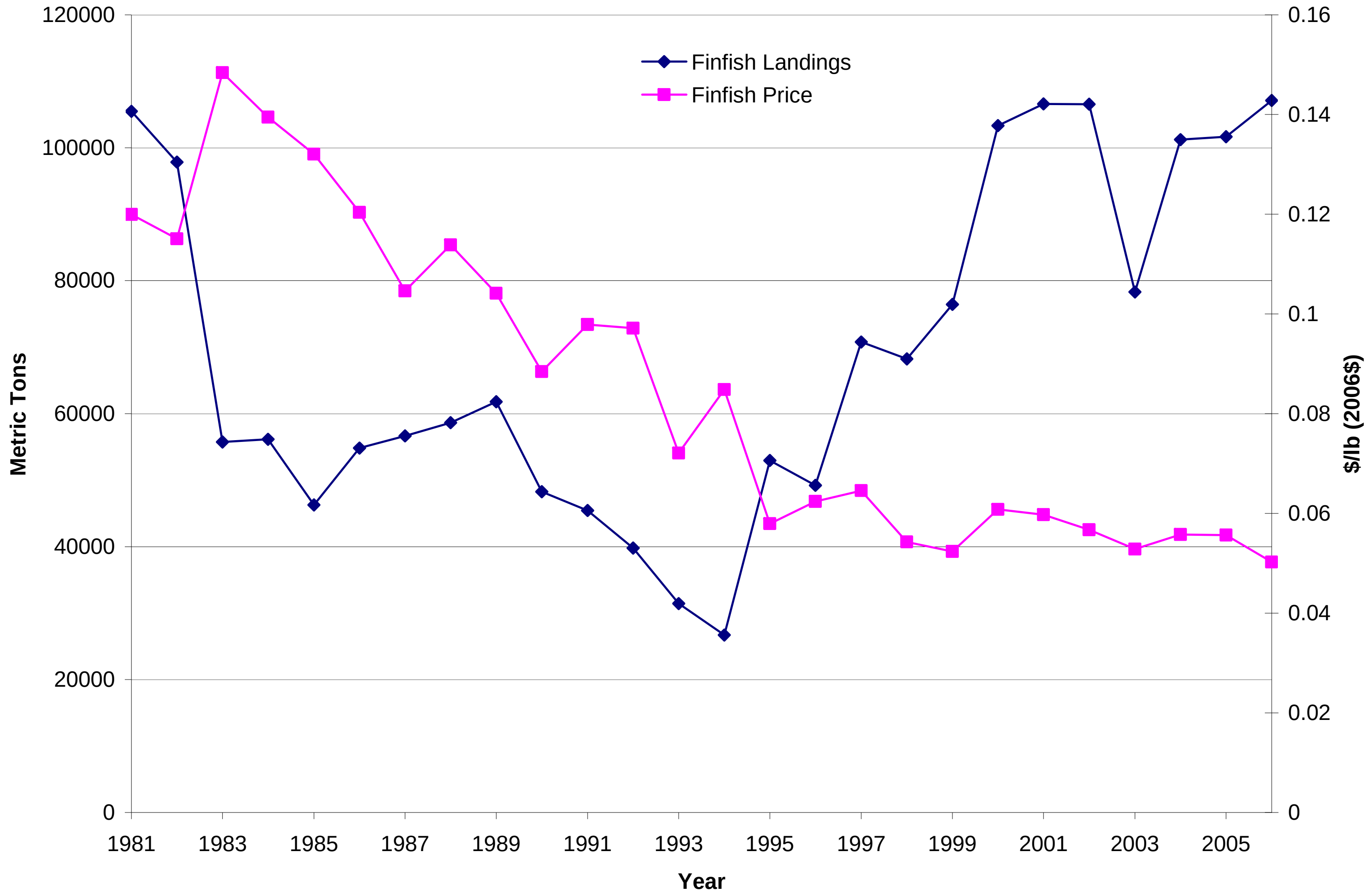


Figure 5. Pacific coast market squid landings and real exvessel price ($/lb, 2006 $), 1981-2006.

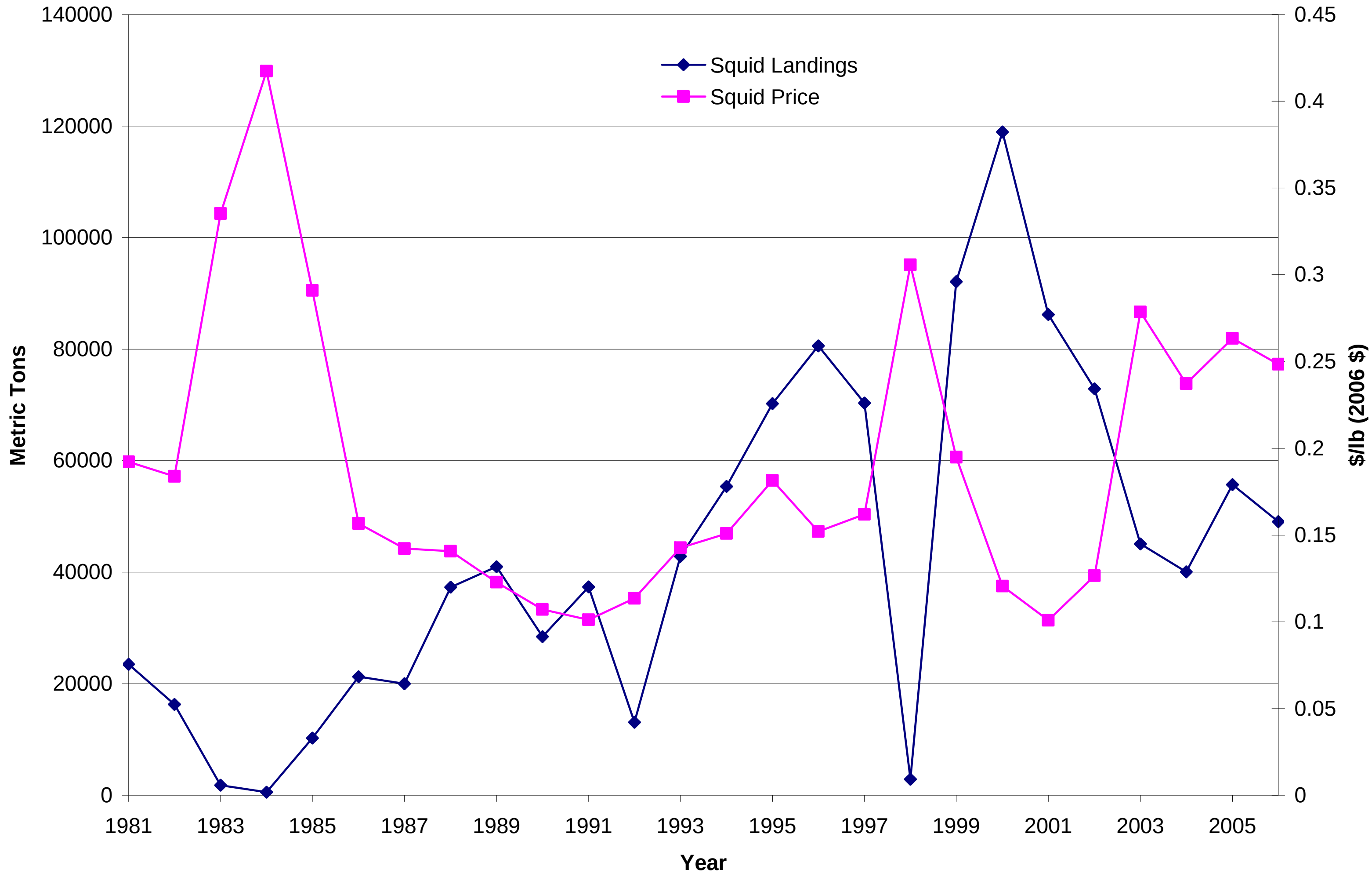


Figure 6. Number of vessels with Pacific coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2006.

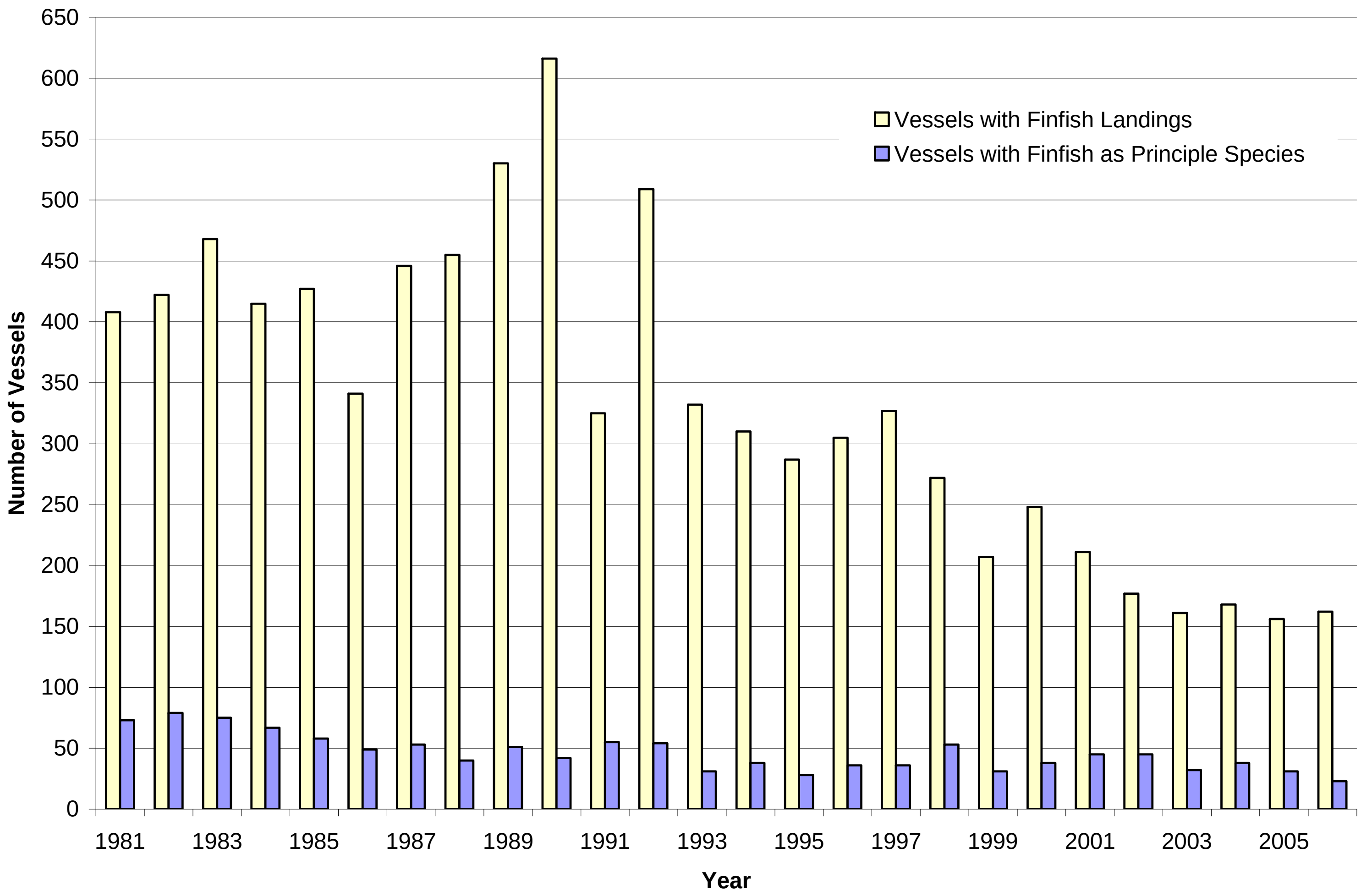


Figure 7. Number of vessels with Pacific coast landings of market squid, and number for which market squid was the principle species, 1981-2006.

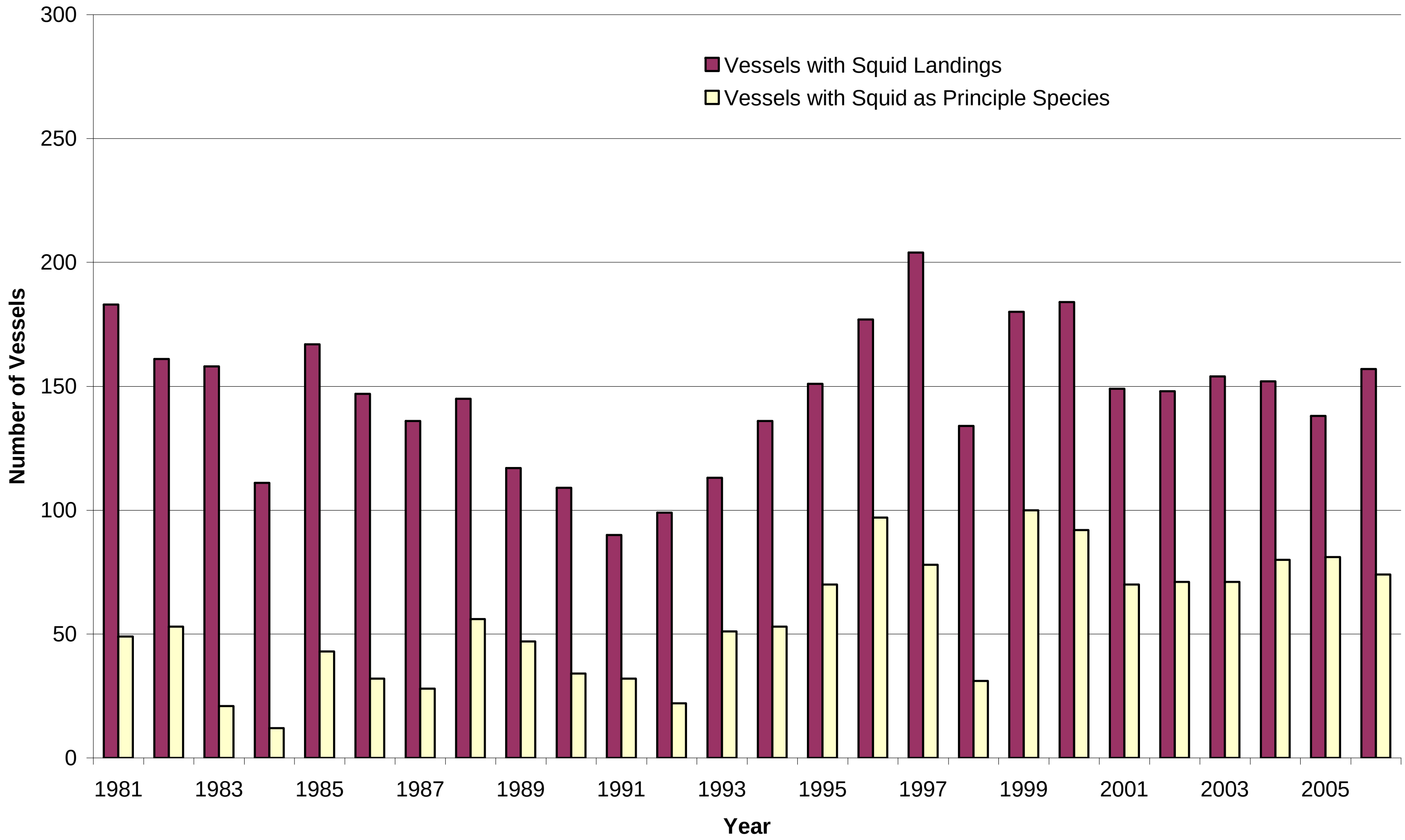
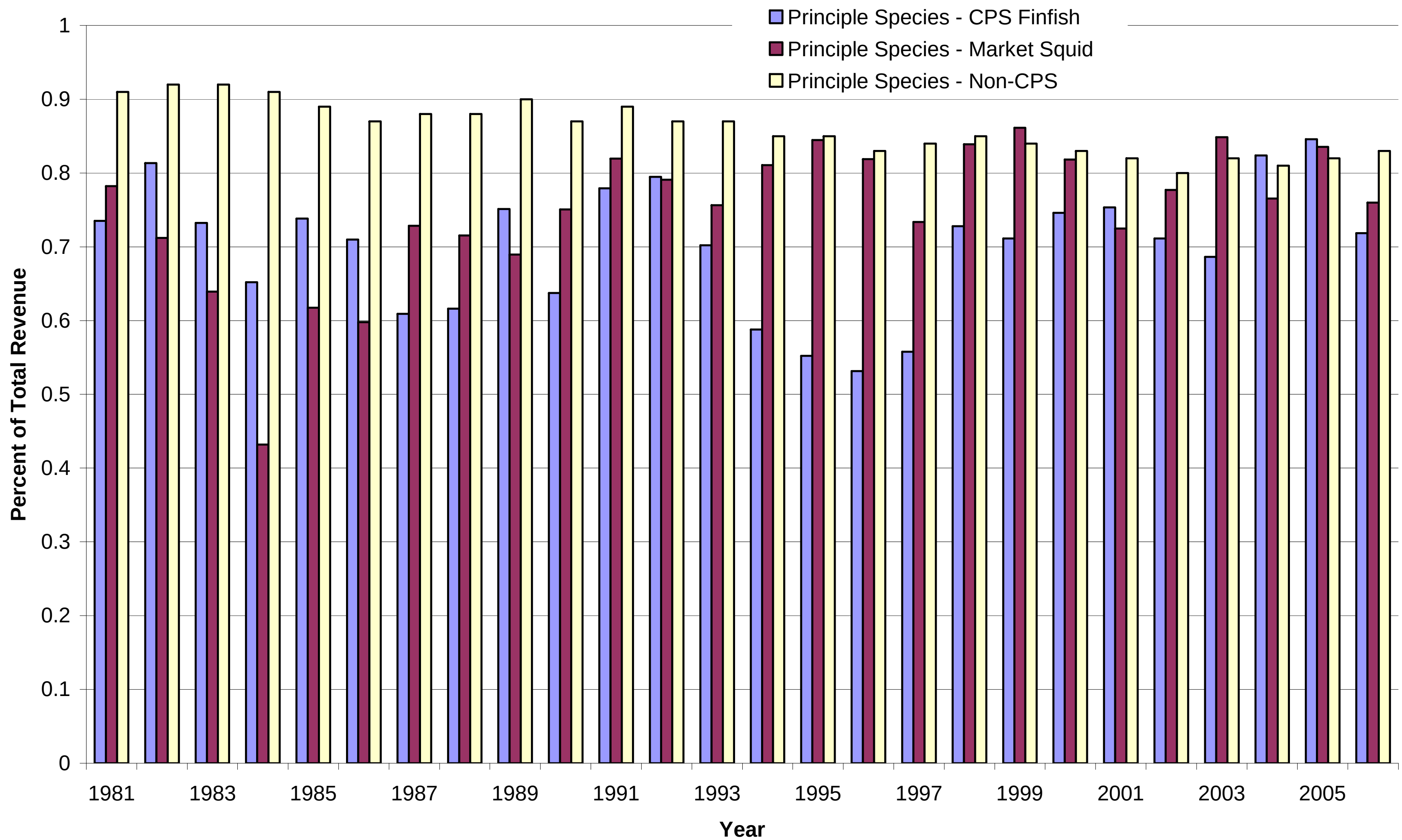


Figure 8. Average share principle species revenues of total revenues for vessels whose principle species was CPS finfish, market squid or non-CPS, 1981-2006.



APPENDIX 1

2007 PACIFIC SARDINE STOCK ASSESSMENT, NOVEMBER 2006 SCIENTIFIC AND STATISTICAL COMMITTEE STATEMENT, AND 2004 STOCK ASSESSMENT REVIEW PANEL REPORT

The 2007 Pacific sardine stock assessment and 2007 harvest guideline were approved at the November 2006 Council meeting and can be found at the Council web page at the link below.

www.pcouncil.org

APPENDIX 2

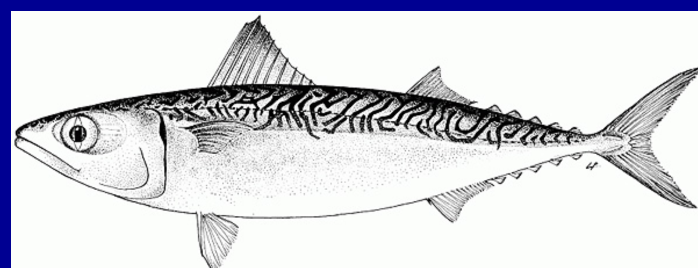
2007 PACIFIC MACKEREL STOCK ASSESSMENT, AND 2007 STOCK ASSESSMENT REVIEW PANEL REPORT

The 2007 Pacific mackerel stock assessment and harvest guideline for 2007-2008 fishery management will be reviewed at the June 2007 Council meeting and can be found at the Council web page at the address below.

www.pcouncil.org

Pacific Mackerel Stock Assessment For U.S. Management In The 2007-08 Fishing Season

E. Dorval, K. T. Hill, N. C. H. Lo, J. D. McDaniel



NOAA Fisheries
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037

Agenda Item F.2.b
Supplemental NMFS PowerPoint Presentation
June 2007

Background

Distribution

Spawning Area

Fisheries

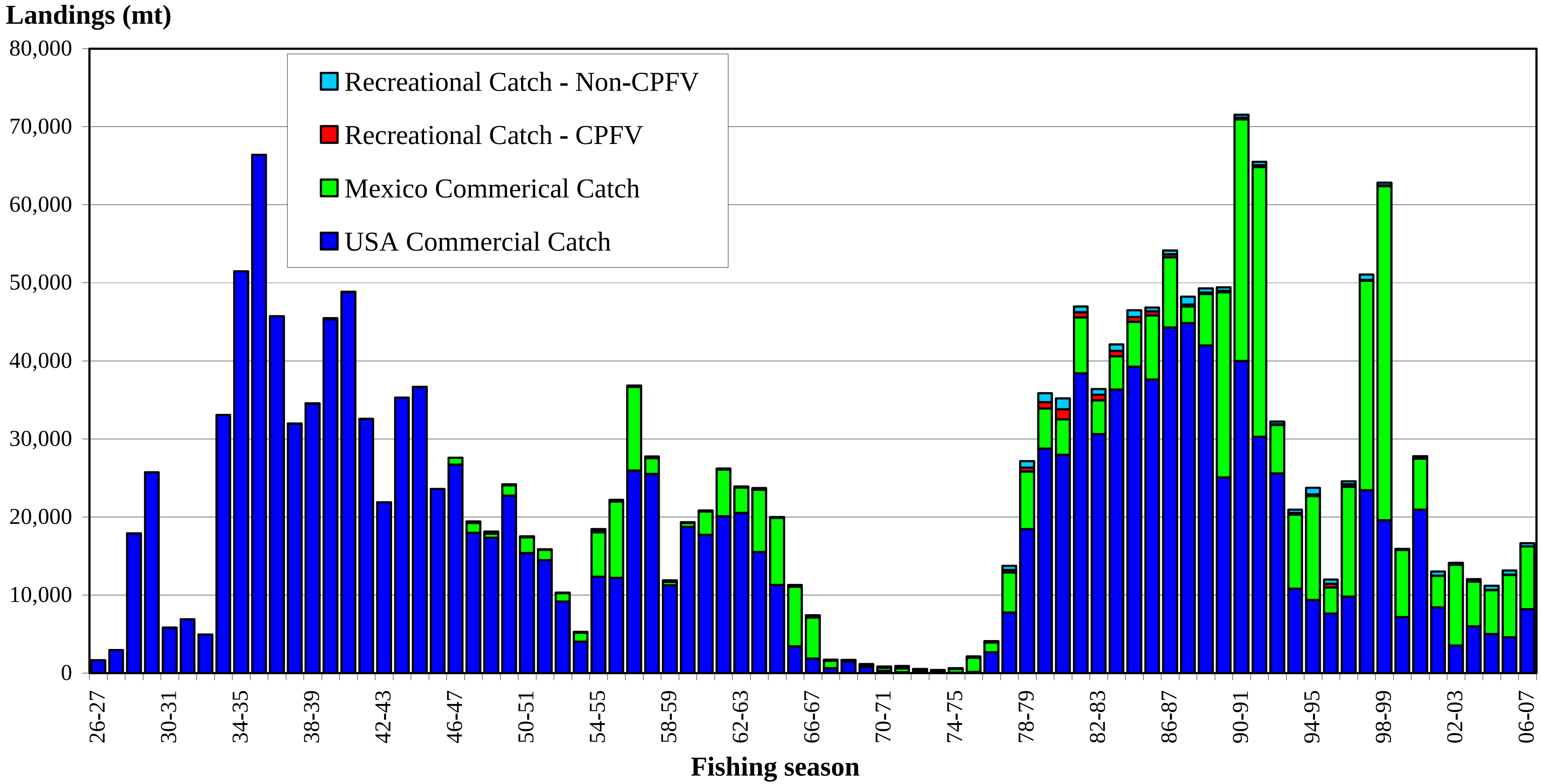
MANAGEMENT

- State of California Management 1978-1999:
  - Quotas based on population biomass (ages 1+),
  - No fishing when biomass <18,200 mt,
  - No quota restrictions when biomass >136,000 mt;
- Federal CPS Fishery Management Plan implemented Jan. 2000;
- No catch limitations by Mexico; min size=25.5 cm; limited entry
- No international management agreements

Landings

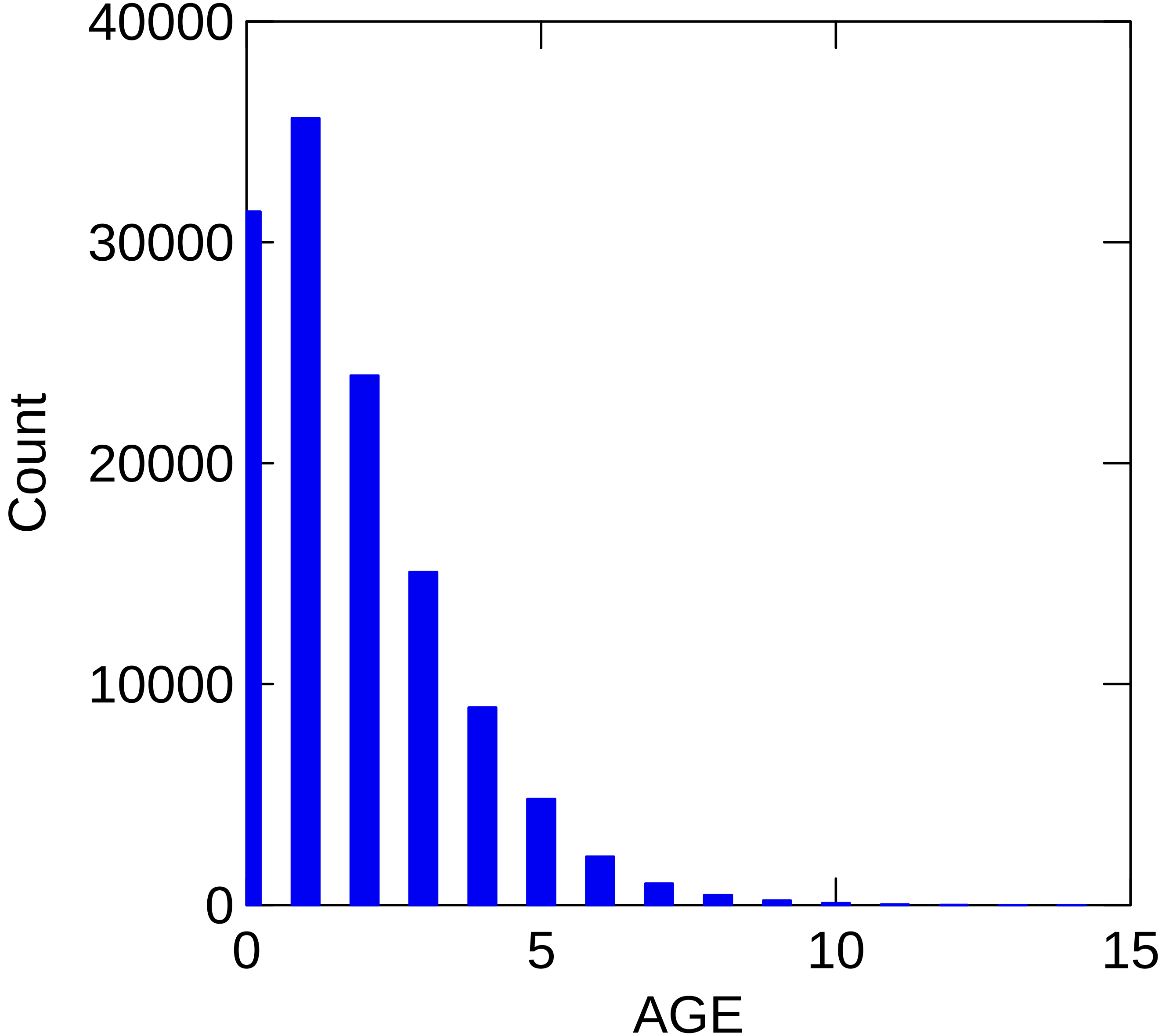
- California commercial 1926-27 onward
- Mexico commercial 1946-47 onward
- California recreational 1926-27 onward
  - Private boats, shore modes
  - Commercial Passenger Fishing Vessel (CPFV)

Landings



Landings (mt)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Recreational Catch - Non-CPFV
Recreational Catch - CPFV
Mexico Commerical Catch
USA Commercial Catch
26-27
30-31
34-35
38-39
42-43
46-47
50-51
54-55
58-59
62-63
66-67
70-71
74-75
78-79
82-83
86-87
90-91
94-95
98-99
02-03
06-07
Fishing season

Age Frequency (1939-2006)

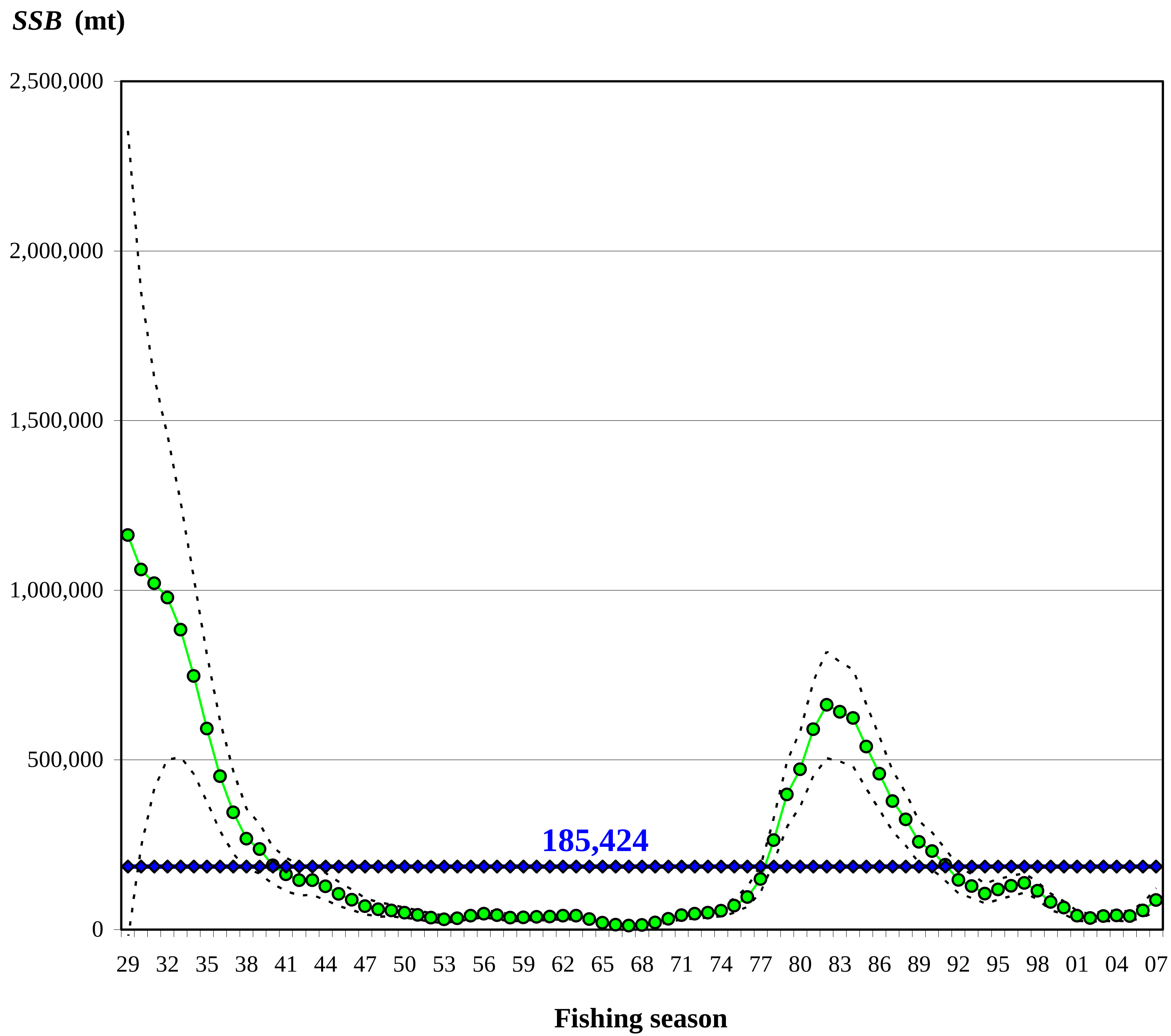


Assessment Model

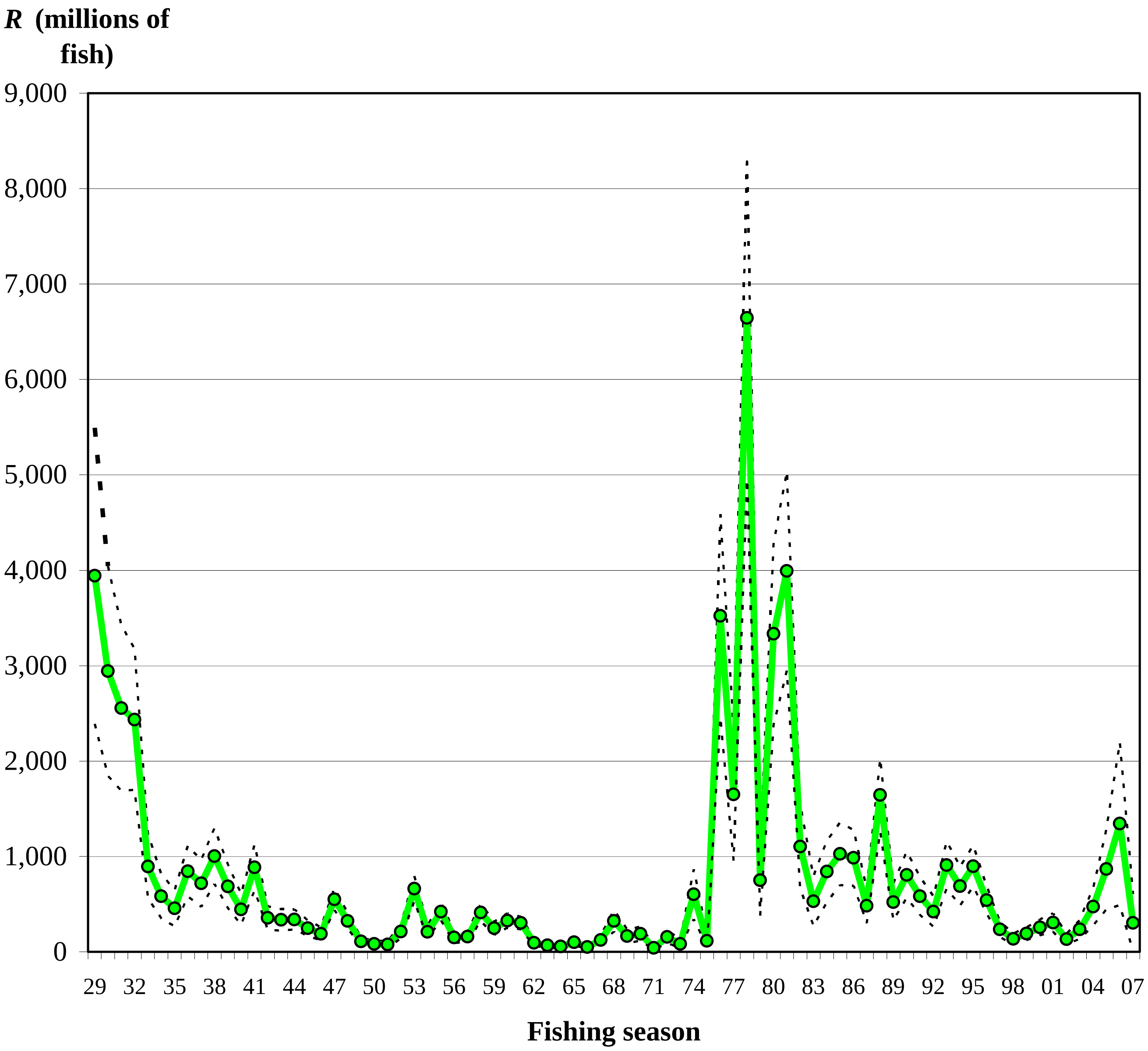
- *AGE-STRUCTURED ASSESSMENT PROGRAM (ASAP, Legault and Restrepo 1998)*

- *Major Change*
  - *2006 Sigma R: 0.25*
  - *2007 Sigma R: 0.70*

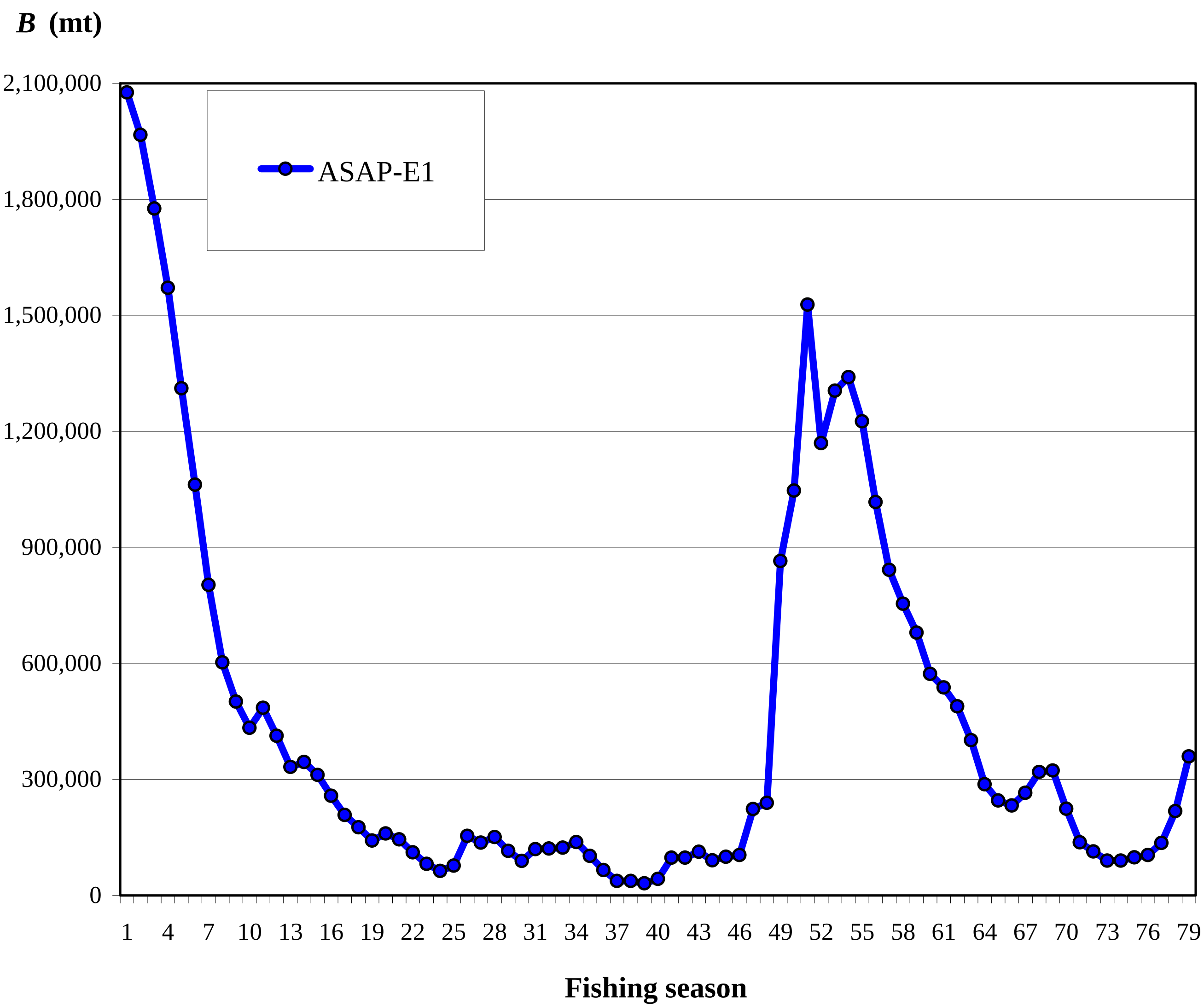
Spawning Stock Biomass



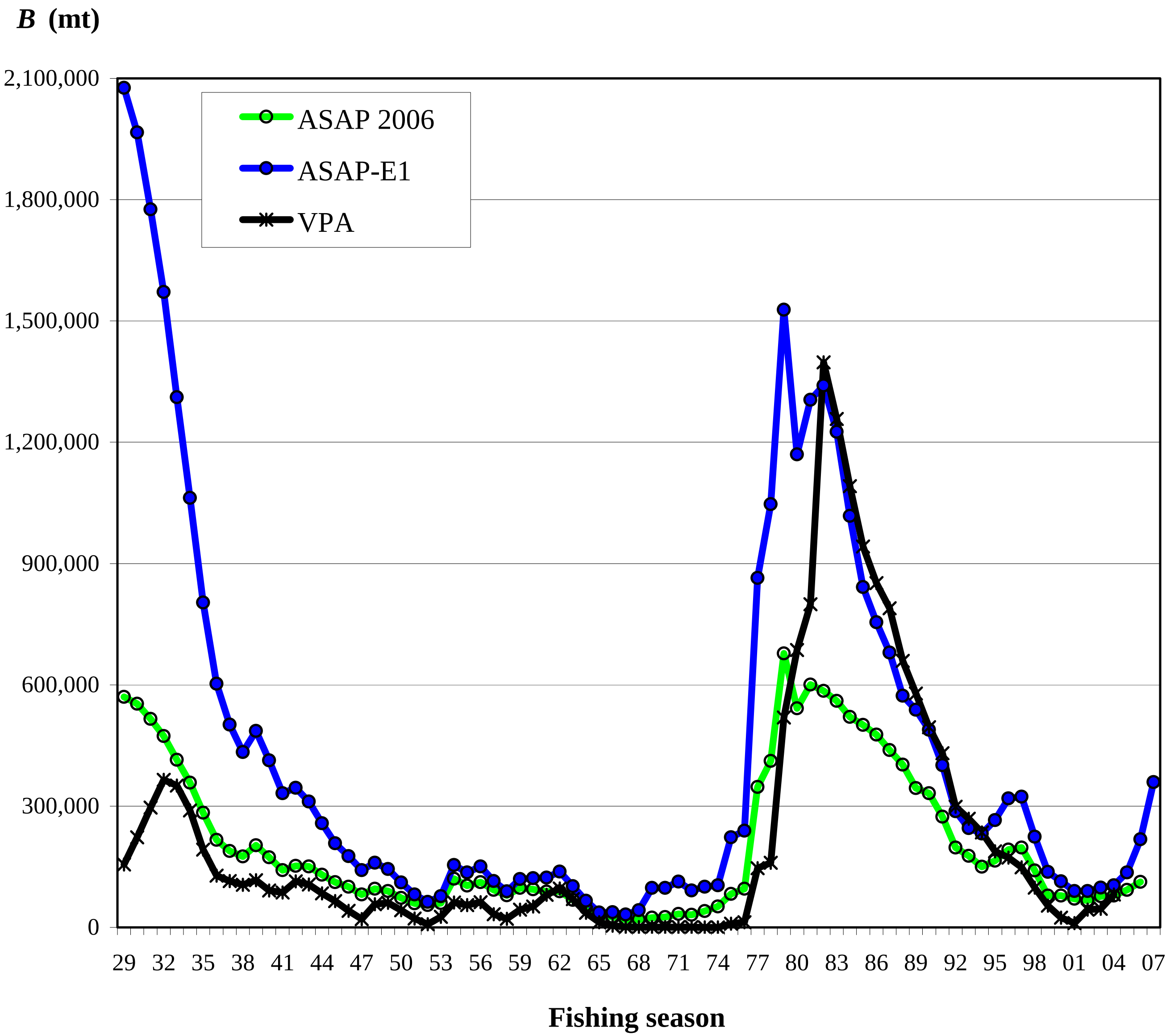
Abundance of Recruits (Age-0)



Age 1+ Biomass



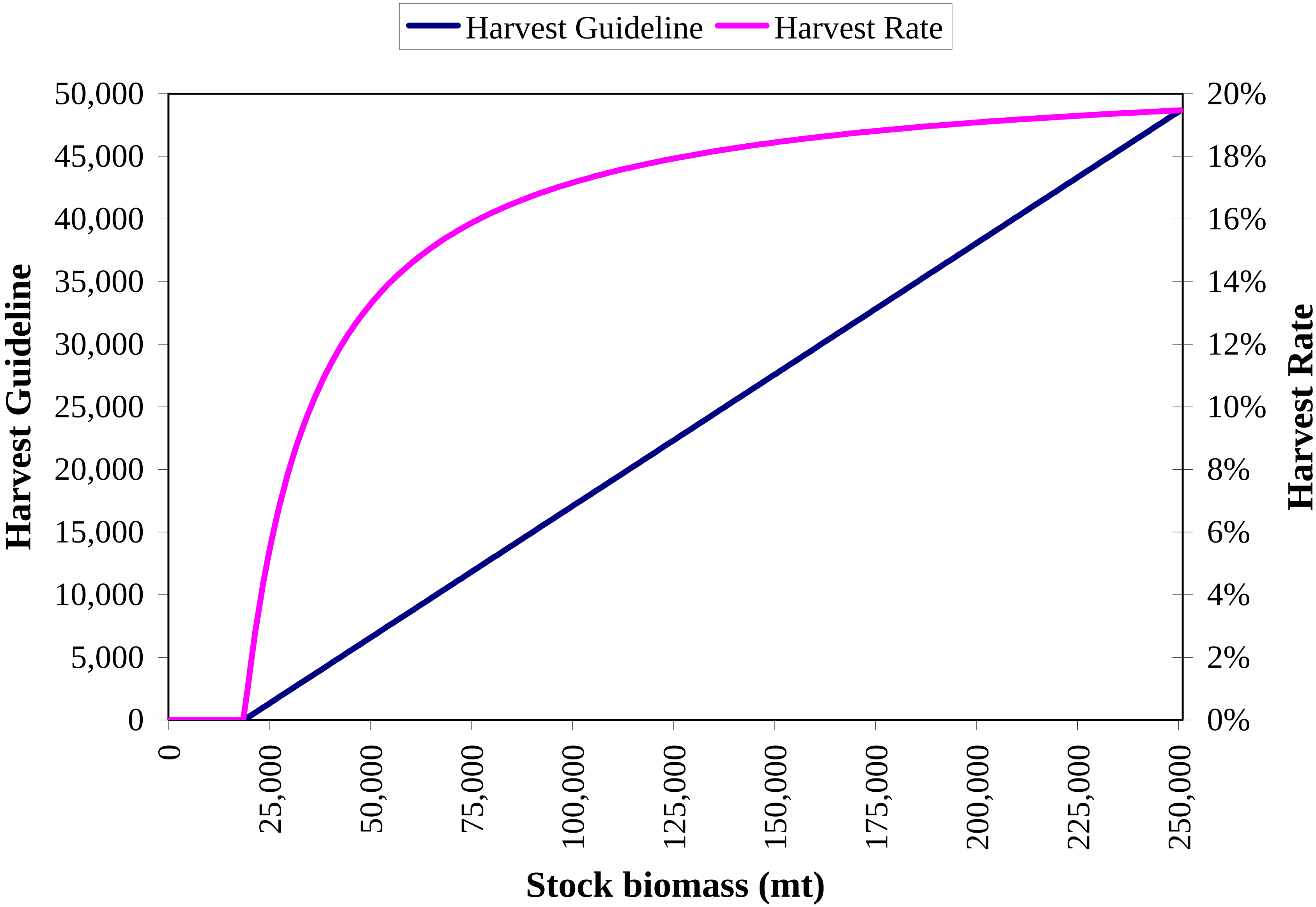
Age 1+ Biomass



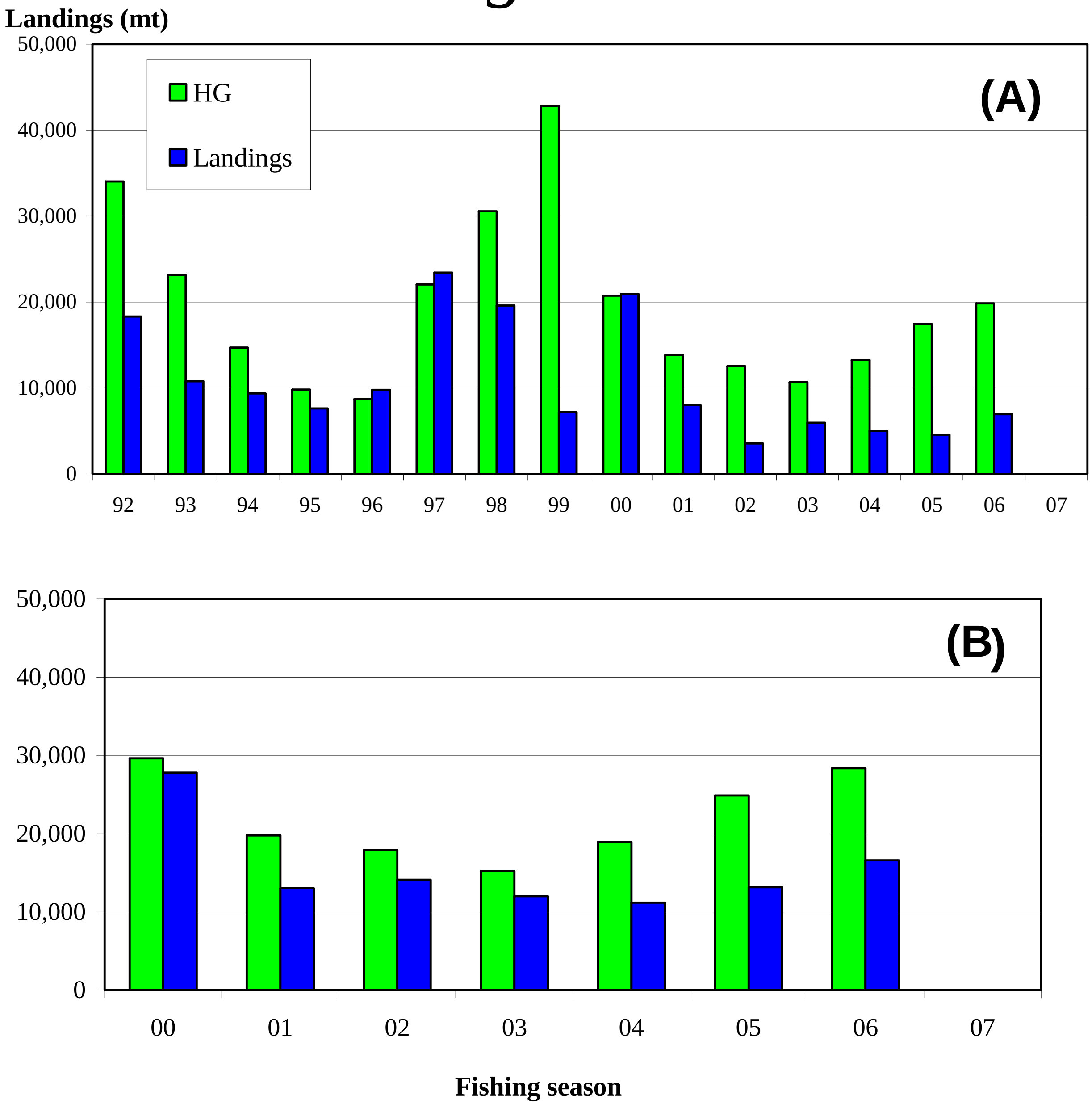
MSY CONTROL RULE – FEDERAL FMP:

Harvest Guideline = (Biomass$_{1+}$ – Cutoff) x Fraction x Distribution

Harvest Guideline = (Biomass$_{1+}$ – 18,200) x 0.30 x 0.70



Landings and HGs



Harvest Guideline ($HARVEST_{07}$) for 2007-08

$\mathbf{HARVEST_{07}}$ = ($BIOMASS_{07}$ - CUTOFF) ● FRACTION ● DISTRIBUTION

$\mathbf{HARVEST_{07}}$ = (359,290 – 18,200) * 0.30 * 0.70

$\mathbf{HARVEST_{07}}$ = 71,629 mt

Future Research and Data Needs

- Continuation of effort to obtain from Mexico
  - Biological data
  - Fishery-independent survey data
  - CPFV logbook data from Mexico
- Re-examination of the MSY control rule for Pacific mackerel

COASTAL PELAGIC SPECIES ADVISORY SUBPANEL REPORT ON PACIFIC MACKEREL HARVEST GUIDELINE FOR 2007-2008

The Coastal Pelagic Species Advisory Subpanel (CPSAS) heard a report from Dr. Emmanis Dorval and Dr. Kevin Hill of the Pacific Mackerel Stock Assessment Team regarding the Pacific mackerel stock assessment and proposed harvest guideline (HG) for the 2007-2008 season. The CPSAS thanks and commends Dr. Dorval, Dr. Hill, and the Pacific Mackerel Assessment Team for their dedication and hard work in developing the recommendation.

The CPSAS agrees with the assessment team and the Coastal Pelagic Species Management Team (CPSMT) that this assessment is based on the best available science. However, the CPSAS strongly recommends the Pacific Fishery Management Council (Council) actively engage in serious negotiations with the U.S. State Department to obtain essential Pacific mackerel and Pacific sardine biological data from Mexico.

Based on the current assessment and harvest control rule for Pacific mackerel, the acceptable biological catch (ABC) for the 2007-2008 is estimated to be 71,629 metric tons (mt). The CPSAS concurs with the CPSMT recommendation to set an HG below the ABC. The CPSAS recommends setting an HG of 40,000 mt, leaving a substantial buffer between the HG and the ABC as a precautionary measure.

The CPSAS further recommends that the Council provide guidance to the National Marine Fisheries Service (NMFS) that, in the event the directed fishery reaches 40,000 mt, NMFS close the directed fishery and revert to an incidental-catch-only fishery. Under this incidental-catch-only fishery, the CPSAS recommends a 45% incidental catch allowance when Pacific mackerel are landed with other coastal pelagic species (CPS), except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS.

The CPSAS recommends an in-season review of the mackerel season for the March 2008 Council meeting, if needed, with the possibility of re-opening the directed fishery as a routine action.

PFMC
05/23/07

COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON PACIFIC MACKEREL HARVEST GUIDELINE FOR 2007-2008

The Coastal Pelagic Species Management Team (CPSMT) met May 8-9, 2007 to review the latest stock assessment of Pacific mackerel. In 2007, a full assessment for Pacific mackerel was conducted and reviewed by a Stock Assessment Review (STAR) Panel in La Jolla, California May 1-4. The CPSMT heard presentations by Dr. Emmanis Dorval and Dr. Kevin Hill of the Stock Assessment Team and the STAR Panel chair, Mr. Tom Jagielo. The CPSMT supported conclusions from the most recent Pacific mackerel stock assessment and further recommends the Pacific Fishery Management Council (Council) adopt the resulting acceptable biological catch (ABC) associated with the harvest control rule stipulated in this species' fishery management plan for the 2007-2008 management season (i.e., July 1, 2007 through June 30, 2008). Based on a total stock biomass estimate of 359,290 mt, the ABC for U.S. fisheries is 71,629 mt.

Due to uncertainty associated with changes to modeling parameters recommended by the STAR Panel and the fact that the U.S. fishery appears to be market limited to roughly 40,000 mt, the CPSMT recommends setting the 2007-2008 harvest guideline (HG) no higher than 40,000 mt. This HG recommendation is roughly double the HG adopted by the Council for the 2006-2007 fishing year (19,845 mt). The significant improvement in the Pacific mackerel stock status is primarily the result of two factors: 1) adjusting stock recruitment variability (σ_R) to be more consistent with the biology of the species, and 2) an improvement in the catch-per-unit-effort in the commercial passenger fishing vessel time series.

Recent U.S. annual landings have been well below the established HGs for the directed fishery. The 'cutoff' value (18,200 mt) in the harvest control rule essentially serves as a proxy for a minimum stock size threshold. The current total stock biomass estimate (359,290 mt) is well above this threshold level. However, uncertainty still exists concerning the magnitude of fisheries in Mexico that harvest Pacific mackerel and thus, caution is recommended when evaluating fishery impacts on transboundary Pacific mackerel stocks.

PFMC
05/23/07

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON PACIFIC MACKEREL STOCK ASSESSMENT AND HARVEST GUIDELINE FOR 2007-2008

Dr. Emannis Dorval presented a clear and detailed overview of the Pacific mackerel stock assessment to the Scientific and Statistical Committee (SSC). The assessment was technically sound, and the modeling approach taken was not greatly different from previous assessments of this stock. The SSC endorses the Stock Assessment and Review (STAR) Panel conclusions that this assessment represents the best available science and can form the basis for Council decision-making.

Like previous versions, this stock assessment was done using the Age-structured Assessment Program (ASAP) modeling framework. An attempt was made to implement the assessment in SS2, but the Stock Assessment Team and the STAR Panel were not satisfied with the results: they could not determine why the model was unable to fit portions of the early catch history. It may be possible to resolve this issue in time to review an SS2 modeling methodology for Pacific mackerel during the September sardine STAR Panel meeting. The SS2 methodology could then be used in the future for Pacific mackerel but would not affect the current assessment or the 2007-2008 harvest guideline.

Opportunities to improve the Pacific mackerel assessment are limited due to fundamental problems – (1) lack of a cooperative agreement between Mexico and the United States and (2) lack of a reliable index of abundance. The STAR Panel report does a good job of describing these problems. The most likely remedies are to negotiate a formal agreement with Mexico to collect and share catch and abundance data and to develop a more reliable stock-wide abundance index.

All of the current abundance indices have problems that limit their usefulness for this assessment. Potential improvements could involve the use of acoustic or LIDAR surveys. If technical issues can be solved such surveys may be used to produce an abundance index over the entire range of the stock and provide data to improve the stock assessment in a relatively short time frame. It would also be desirable to combine acoustic or LIDAR surveys with an improved implementation of the egg and larval surveys. These techniques could be applied to sardine as well as mackerel.

PFMC
06/12/07