Agenda Item G.1
Situation Summary
June 2008

PACIFIC MACKEREL MANAGEMENT FOR 2008-2009

The Council is scheduled to review the current Pacific mackerel stock assessment and adopt a harvest guideline for the 2008-2009 Pacific mackerel fishing season, which opens July 1, 2008 and closes June 30, 2009.

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 last STAR process for Pacific mackerel occurred in 2007. New modeling efforts were a major focus of the 2007 STAR process but, unresolved technical issues led the Council to recommend no changes to Pacific mackerel assessment methodology for this year's assessment update. The next full assessment and STAR process for Pacific mackerel is scheduled for 2009.

The National Marine Fisheries Services, Southwest Fisheries Science Center, took the lead in developing the 2008 updated assessment of Pacific mackerel for the 2008-2009 fishing season (Agenda Item G.1.b, Attachment 1). The assessment update was reviewed by the Scientific and Statistical Committee's CPS Subcommittee, the Coastal Pelagic Species Management Team (CPSMT), and the Coastal Pelagic Species Advisory Subpanel (CPSAS) during a series of meetings May 13-15 2008 in Long Beach California. The CPSMT and CPSAS statements with recommendations on the harvest guideline and management measures for 2008-2009 are included in the reference materials under Agenda Item G.1.c. The Scientific and Statistical Committee (SSC) will prepare a supplemental statement at the June meeting.

The CPSMT has completed a draft of the eighth annual Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches – Stock Assessment and Fishery Evaluation 2008 document (Agenda Item G.1.a, Attachment 1). Once adopted, the 2008 Pacific Mackerel Stock Assessment and 2008-2009 management measures will be included in the 2008 CPS SAFE.

Council Action:

1. Approve Stock Assessment, Harvest Guideline, and Management Measures for the 2008-2009 Fishery.

Reference Materials:

1. Agenda Item G.1.a, Attachment 1 *Draft Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches – Stock Assessment and Fishery Evaluation 2008* (**electronic copy on Council Briefing Book CD**).
2. Agenda Item G.1.b, Attachment 1: *Pacific Mackerel (Scomber japonicus) Stock Assessment for U.S. Management in the 2008-2009 Season.*
3. Agenda Item G.1.c, CPSMT Report.
4. Agenda Item G.1.c, CPSAS Report.
5. Agenda Item G.1.c, Supplemental SSC Report
6. Agenda Item G.1.d, Public Comment.

Agenda Order:

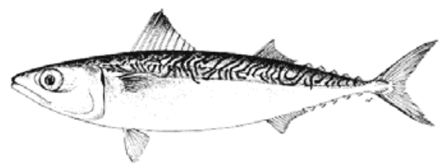
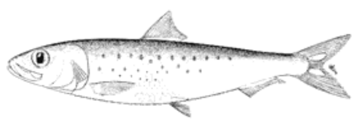
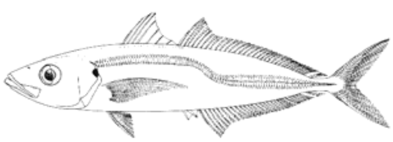
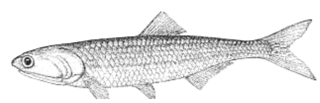
a. Agenda Item Overview — Mike Burner
b. NMFS Report — Emmanis Dorval
c. Reports and Comments of Advisory Bodies
d. Public Comment
e. **Council Action:** Approve Stock Assessment, Harvest Guideline, and Management Measures

PFMC
05/21/08

Agenda Item G.1.a
Attachment 1
2008

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

STOCK ASSESSMENT AND FISHERY EVALUATION 2008

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BRIEFING BOOK DRAFT
JUNE 2008

ACKNOWLEDGMENTS

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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
st	short ton
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 ninth *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 that 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: (1) the management unit species, (2) CPS fishery management areas, consisting of a limited entry (LE) zone and two subareas, (3) a procedure for setting annual specifications including harvest guidelines (HG), quotas, and allocations, (4) provisions for closing directed fisheries when the directed portion of a harvest guideline or quota is taken, (5) fishing seasons for Pacific sardine and Pacific mackerel, (6) 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, (7) a LE program, (8) authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited, and (9) 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 that 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 HG 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 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 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 HG:

(1) January 1, 35% of the harvest guideline to be allocated coastwide;
(2) July 1, 40% of the HG, 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, CPSMT, and 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.

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 anticipated 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 were 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 a letter dated October 30, 2007, the Office of Management and Budget questioned the necessity of the prohibition and returned NOAA’s proposed rule implementing Amendment 12 for additional analyses. In response, NMFS Southwest Regional Office is currently working to broaden the analysis of the alternatives and status quo to more clearly define the need for the prohibition and better describe the existing potential for krill harvest. It is anticipated NMFS will move forward with a revised rule after addressing the concerns raised by the Office of Management and Budget.

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 have typically sold as bait for Asian longline tuna fisheries. Beginning in 2006, this fishery has been expanding into human consumption markets.

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 65 permits and 61 vessels (Table 3a). The LE vessels range in age from 4 to 68 years, with an average age of 33 years (Table 3b). 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 3a) 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 3a and 3b). 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 State Limited Entry Fishery

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 Board 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 ten landings of at least five metric tons (mt) each, or landings totaling at least $40,000, based on exvessel 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 perm name is good enough it 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 LE 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 six permits for a total of 26 LE permits in 2006.

In 2007, twenty-six permits were issued, but only 25 permits were actively utilized in the fishery. Five of those 25 permits were transferred to actively fishing vessels with the intention of qualifying them under the renewal requirements. One (of 26) permit holder did not meet the minimum landing requirements for renewal of their LE permit. Table 3c contains information for vessels that participated in the 2007 fishery. Vessel information is from permit applications. Effective January 2008 permit holders must either own or operate a vessel that is permitted. Only one vessel may be identified at time of renewal to meet the minimum landing requirements required for renewal and those permit holders must either own or operate the vessel that is identified. Also, during the January 2008 Oregon Fish and Wildlife Commission meeting, the Commission established a new permit renewal deadline. Previously the permit renewal deadline was December 31 of the year the permit was issued. It is now December 31st of the year in which the permit is sought for renewal. For example, to renew a 2008 permit the permit must be renewed by Dec 31, 2009 in order to receive a 2009 permit and fish in 2009.

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 2007. 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 percent 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.

Table 3d lists vessels designated on 2007 Washington Sardine Experimental Fishery Permits. In 2007, limited experimental fishery permits were issued to fifteen fishers meeting the necessary permit criteria of previously holding such a permit and who also held a minimum of 50 percent ownership in the vessel designated on their 2007 sardine permit. Of the fifteen permits that were issued, only six permits participated in the 2007 fishery. In addition to limiting participation in the fishery, WDFW also restricts the cumulative seasonal total of sardines that can go toward reduction to 15 percent for both the individual vessels and for processors.

2.3.3 California's Market Squid Fishery

In 2001, legislation transferred the authority for management of the market squid fishery to the Commission. Legislation required that the Commission adopt a market squid fishery management plan and regulations to protect and manage the resource. In August and December of 2004, the Commission adopted the 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 on April 1.

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 st) 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 with 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 to achieve the goals and objectives of the MLMA 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 2007 a total of 171 permits were issued under 7 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 78 transferable and 11 non-transferable vessel permits were issued for the 2007/2008 fishing season. Brail permits allow a vessel to attract squid with lights and use brail gear to capture squid; a total of 18 transferable and no non-transferable brail permits were issued for the 2007/2008 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 and 3 non-transferable light boat permits were issued. Two experimental non-transferable market squid permits were issued in 2007/2008, which allow vessels to fish in areas not historically targeted by the market squid fishery (namely north of San Francisco). Landings of 2 st 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 2008 management (Hill *et al*. 2007; see Appendix 1) was conducted using 'Stock Synthesis 2' (SS2), a likelihood-based, length- and age-structured model. The general estimation approach used in the SS2 model is a flexible, 'forward-simulation' that allows for the efficient and reliable estimation of a large number of parameters. The general population dynamics and estimator theory that serves as the basis of forward estimation models such as SS2 is described in Fournier and Archibald (1982), Deriso et al. (1985), Megrey (1989), and Methot (1990, 1998, 2005).

The final SS2 model was based on fishery-dependent data from three fisheries (Ensenada, Mexico; U.S. California; and U.S. Pacific northwest; 1981-2007) and a time series of relative SSB estimated from the SWFSC annual egg production surveys (see Lo et al. 1996, 2005, 2006, 2007a). An environmental index (i.e., a time series of sea-surface temperatures recorded at Scripps Pier, La Jolla, California) is used to determine 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. (2007; see Appendix 1). For descriptions of methods used in previous Pacific sardine assessment models (CANSAR, CANSAR-TAM, and ASAP), see Deriso et al. (1996), Legault and Restrepo (1999), and Hill et al. (1999, 2006).

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 last full assessment of Pacific mackerel occurred in 2008.

The National Marine Fisheries Services, Southwest Fisheries Science Center, took the lead in developing an updated assessment of Pacific mackerel for the 2008-2009 fishing season. The CPS Subcommittee of the Scientific and Statistical Committee, the CPSMT, and the CPSAS reviewed the assessment at a series of meetings at the Southwest Regional Office in Long Beach, California May 13-15, 2008. A review copy of the assessment as wells fishery management measure recommendations of the CPSMT and the CPSAS can be found in the June 2008 Council Briefing book under Agenda Item G.1. 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:

Crone, P. R., K. T. Hill, and J. D. McDaniel. 2006. Assessment of the Pacific mackerel (*Scomber japonicus*) stock for U.S. management in the 2006-2007 season. PFMC June 2006 Briefing Book, Exhibit F.1. Pacific Fishery Management Council, Portland Oregon. 12 p.

Deriso, R., T. J. Quinn and P. R. Neal. 1985. Catch-age analysis with auxiliary information. Can. J. Fish. Aquat. Sci. 42:4.

Deriso, R. B., J. T. Barnes, L. D. Jacobson, and P. J. Arenas. 1996. Catch-at-age analysis for Pacific sardine (*Sardinops sagax*), 1983-1995. CalCOFI Rep. 37:175-187.

Dorval, E., K. T. Hill, N. C. H. Lo, and J. D. McDaniel. 2007. Assessment of Pacific mackerel (*Scomber japonicus*) stock for the U.S. management in the 2007-08 Season). PFMC June 2007 Briefing Book, Exhibit F.2. Pacific Fishery Management Council, Foster City California. 170 p.

Fournier, D., and C. P. Archibald. 1982. A general theory for analyzing catch at age data. Canadian Journal of Fisheries and Aquatic Sciences 39:1195-1207.

Hill, K.T., L.D. Jacobson, N.C.H. Lo, M. Yaremko, and M. Dege. 1999. Stock assessment of Pacific sardine for 1998 with management recommendations for 1999. Calif. Dept. Fish. Game. Marine Region Admin. Rep. 99-4. 92 pp.

Hill, K. T., and P. R. Crone. 2005. Assessment of the Pacific mackerel (*Scomber japonicus*) stock for U.S. management in the 2005-2006 season. PFMC June 2005 Briefing Book, Exhibit F.1. Pacific Fishery Management Council, Portland Oregon. 158 p.

Hill, K. T., N. C. H. Lo, B. J. Macewicz, and R. Felix-Uraga. 2006. Assessment of the Pacific sardine (*Sardinops sagax caerulea*) population for U.S. management in 2007. NOAA Tech. Mem. NOAA-TM-NMFS-SWFSC-396. 104 p.

Hill, K. T., E. Dorval, N. C. H. Lo, B. J. Macewicz, C. Show, and R. Felix-Uraga. 2007. Assessment of the Pacific sardine resource in 2007 for U.S. management in 2008. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-413. 176 p.

Legault, C. M., and V. R. Restrepo. 1999. A flexible forward age-structured assessment program. ICCAT Coll. Vol. Sci. Pap. 49(2): 246-253.

Lo, N. C. H., L. D. Jacobson, and J. L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

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.

Lo, N.C.H., B.J. Macewicz, and D.A. Griffith. 2005. Spawning biomass of Pacific sardine (Sardinops sagax) from 1994-2004 off California. Calif. Coop. Oceanic Fish. Invest. Rep. 46: 93-112.

Lo, N.C.H. and B. Macewicz. 2006. Spawning biomass of Pacific sardine (*Sardinops sagax*) off California in 2005. NOAA Technical Memorandum NMFS-SWFSC-387.

Lo, N.C.H.,B. Macewicz, and Richard L Charter 2007a. Spawning biomass of Pacific sardine (*Sardinops sagax*) off California in 2007. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-411. 31 p.

Lo, N. C. H.. 2007b. Spotter data analysis for the Pacific mackerel in 1962-2002 using Delta-GLM. In Dorval et al. 2007: Assessment of Pacific mackerel (*Scomber japonicus*) stock for the U.S. management in the 2007-08 Season), Appendix I, pp:92-105.

Lo, N.C.H. Y. Huang, and E. Dorval. 2007c. Daily larval production of Pacific mackerel (*Scomber japonicus*) off California in 1951-2006. In Dorval et al. 2007: Assessment of Pacific mackerel (*Scomber japonicus*) stock for the U.S. management in the 2007-08 Season, Appendix II pp:106-119.

Megrey, B. A. 1989. Review and comparison of age-structured stock assessment models from theoretical and applied points of view. American Fisheries Society Symposium 6:8-48.

Methot, R. D. 1990. Synthesis model: an adaptable framework for analysis of diverse stock assessment data. International North Pacific Fisheries Commission Bulletin 50:259-277.

Methot, R. 1998. Application of stock synthesis to NRC test data sets. Pages 59-80 in NOAA Tech. Memo. NMFS-F/SPO-30.

Methot, R. 2005. Technical description of the stock synthesis II assessment program. Version 1.17-March 2005.

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.

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:

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

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 2008.

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 15, 16, and 17.

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 ensure 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.

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.

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.

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 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.

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 incidental catch 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 samplers 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 2 most prevalent species were market squid at 79%, and northern anchovy at 12% incidence within samples (not by load composition). CDFG port samples provide useful information 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 5 years (2003 – 2007). The most commonly occurring animals in wetfish landings during 2007 were kelp, market squid, northern anchovy, white croaker, California halibut, jellyfish, Pacific sanddab, bat ray, Pacific electric ray, thornyhead turbot, California scorpionfish, unspecified flatfish, jacksmelt, surfgrass, plainfin midshipman, unspecified shrimp, thornback skate, CA lizardfish, sea star, unspecified rock crab, English sole, and Pacific whiting. One hundred-seven incidental species were observed in total.

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 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 market squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur intermittently. In 2007, about 4 percent of round haul market squid landings included reported incidental catch of CPS species (Table 10).

Although non-target catch in market squid landings is considered minimal, the presence of incidental catch (i.e., species that are landed along with market 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 incidental catch observed (i.e., presence or absence evaluations), but actual amounts of incidental catch have not been quantified to date. During 2007, incidental catch consisted of 34 species (Table 11). Similar to previous years, most of this catch was other pelagic species, including Pacific sardine, Pacific mackerel, northern anchovy, and jack mackerel. However, kelp was also observed frequently.

Finally, the extent that market 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 market 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 market squid eggs had a 1.8% frequency of occurrence. In 2004, market squid egg capsule bycatch was 5.1% statewide, a 0.2% increase over 2003 (4.9%). If bycatch of market 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). According to CDFG market squid logbooks, fishing nets in the northern fishery make contact with the bottom more frequently than in the southern fishery. In this context, further investigations regarding potential damage to market squid spawning beds from fishery-related operations would likely benefit status-based analyses concerning the overall market squid population off California, given eggs-per-recruit theory underlies the recently adopted market squid assessment method. In 2007, CDFG developed a protocol to retain 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. Based on market squid embryo development and the condition of the outside of the egg capsule, determining if the egg case was laid in the net or collected from the bottom is possible. Sample collection from the various port complexes will occur in 2008.

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 12 through 14.

6.3.1 Oregon

The 2007 Oregon sardine fishery saw the second highest harvest on record since the current Oregon fishery began in 1999. Vessels landed a total of 42,151 mt (92,927,053 lbs) of sardines in 2007; this a 16% increase from the 35,648 mt landed in 2006As in the past spotter planes, hired by the industry, were used to locate fish and the first landing of the year into Oregon was made on June 7th but major harvest activities did not start in earnest until mid July. Approximately 4,700 mt per week were landed during August, the peak of the fishery, and 3,909mt per week in September, with an overall fishery average of 48mt (105,960 lbs) of sardine per landing Individual landings ranged from 1,756 lbs (0.79 mt) to over 252,661 lb (114.6 mt) and the last directed landing occurred on October 13th. A total of 877 landings were made at eight different processors throughout Warrenton and Astoria. Sardine value varied from $0.01 to $0.16 per pound. Roughly 1,429 mt of sardines (3.4% of landings) were valued at less than $0.02/lb while less than 1% was valued greater than $0.08 per pound. About 87% of the fishery landings were valued between $0.04 and $0.06 per pound. The ex-vessel value of sardine in the 2007 sardine fishery is roughly $4.45 million at an average price per pound of $0.054 or $105 per mt.

Oregon's permit stipulations include at sea observers when requested by the Department or the Federal Government. Oregon did not have personnel dedicated to ride along on sardine vessels and observe bycatch of non-target species and no federal observers were place on the vessels. Available state staff was able to observe 6 of 877 trips (0.7%). Only two of the six observational trips were successful in catching fish therefore observation of bycatch in the 2007 fishery was extremely low. The state also requires the use of a grate over the hold opening to sort out larger species of fish (such as salmon or mackerel).

Based on state fish tickets and logbook data bycatch continues to be low. Various bycatch included mackerel, sharks and salmon (Table 13). Vessel skippers are required to record all species caught in a seine gear logbook. We received nearly 100% of the logbooks for trips in 2007and a total of 1152 sets were made with 99% of them successful for sardines. The estimated total catch of salmon for the fishery, based on log data, is 519 salmon and landed weight of sardines for those trips is 11,088 mt. Based on log data for these trips, the incidental catch rate is 0.045 salmon per mt of sardine landed. An estimated 67% of all salmon were released alive.

Incidental catch landed and recorded on fish tickets consisted of 699 mt of Pacific mackerel, 8 mt of jack mackerel, and 0.14 mt of thresher shark (Table 6). The 2007 Pacific mackerel ex-vessel value in the sardine fishery was roughly $49,700.

6.3.2 Washington

The Washington fishery opened by rule on April 1, 2007, however, the first landing into Washington did not occur until July 7. The Department issued a total of 15 permits and 6 of the permit holders participated in the fishery. Three primary vessels accounted for 62% of the harvest. A total of 4,662.6 mt of sardines were landed into Washington. Of the 106 landings into Washington, 99 (93%) of them occurred within the months of August and September. A total of 132 sets were made, with 119 (90%) of them successful. The average catch per successful set was 42.8 mt.

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.

Wiedoff, B., 2008. Oregon's Sardine Fishery, 2007 Summary. Oregon Department of Fish and Wildlife, Newport Oregon. 18. 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 15). 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 2007 have been appended to previously reported estimates from Thomson *et al.* (1991, 1992, 1994) (Table 16). 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. 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 17).

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.* (2007; 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 166,071 mt in 2006-07 (July-June 'biological year'; Table 19). In calendar year 2007, landings in California (89,231 mt) increased considerably from the previous year (51,029 mt in 2006; Table 20). Oregon-Washington landings were ~17% higher in 2007 (46,715 mt) than in 2006 (40,011 mt; Table 20). The U.S. sardine fisheries (California-Oregon-Washington) are regulated using a quota-based 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 2007 U.S. landings of sardine comprised about 89% (135,946 out of 152,564 mt) of the HG established for that peak year. Total annual harvest of Pacific sardine by the Ensenada (Mexico) fishery is not regulated, but there is a minimum legal size limit of 150 mm SL, along with some measures to control fleet capacity. The Ensenada fishery landed 41,441 mt in 2006 (Dr. Manuel Nevarrez, CRIP-INP Guaymas, Pers. Comm.). A retrospective of West Coast Pacific sardine landings, 1981-2007, is provided in Table 21.

Estimated stock biomass (ages 1+) from the assessment conducted in 2007 (Hill et al. 2007; see Appendix 1) indicates a decline in sardine abundance since the recent peak year (~1.7 million mt in July 2000), with an estimate of roughly 832,706 mt in July 2007. Recent year class sizes (1.01 to 5.28 billion age-0 fish) are considerably lower than the recent peak of 16.47 billion fish in 2003. Biomass and recruitment estimates (1981-2007) from the most recent assessment are provided in Table 19 and Appendix 1.

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 2008

The Pacific sardine harvest guideline established for the U.S. fishery in calendar year 2008 was 89,093 mt. Statistics used to determine this harvest guideline are discussed below and in Sections 4.3.1-4.3.2. 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 harvest guideline for 2008. This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over the long-term. The Amendment 8 harvest formula for sardine is:

$$HG_{2008} = (BIOMASS_{2007} – CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where HG_{2008} is the total USA (California-Oregon-Washington) harvest guideline in 2008, $BIOMASS_{2007}$ is the estimated July 1, 2007 stock biomass (ages 1+) from the current assessment (832,706 mt), CUTOFF is the lowest level of estimated biomass at which harvest is allowed (150,000 mt), FRACTION is an environment-based percentage (see below) of biomass above the CUTOFF that can be harvested by the fisheries, and DISTRIBUTION (87%) is the percentage of $BIOMASS_{2007}$ 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%; and this remains the case under current oceanic conditions (T_{2007} = 18.14 °C). The HG established for 2008 (89,093 mt) is ~42% lower than the 2007 HG (152,564 mt), and ~34% lower than the U.S. harvest in 2007 (135,946 mt; Table 20), so the U.S. fishery will likely be constrained at various points during the 2008 management season.

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 for the 2007 fishing/management year (i.e., a fishing season that spans from July 2007 through June 2008) was based on the 'forward estimation' assessment model ASAP (see sections 3.1 and 3.2 and Dorval *et al*. 2007; see Appendix 2).

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 359,290 mt as of July 1, 2007 (Dorval et al. 2007; Appendix 2 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 highest harvest guideline or ABC for all U.S. fisheries for the 2007 fishing year (July 2007 - June 2008), TOTAL STOCK $BIOMASS_{2007}$ is the estimated stock biomass in 2007 (i.e., 359,290 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.

Therefore, for the 2007-2008 fishery:

$$HG_{2007} = (359{,}290 \text{ mt} - 18{,}200) \bullet 0.30 \bullet 0.70 = 71{,}629 \text{ mt},$$

Adoption of the harvest guideline and management measures for the 2008 Pacific mackerel fishery is scheduled to occur at the June 2008 Council meeting in Foster City, California. The draft stock assessment and statements from the CPSAS and CPSMT are posted at the Council web page in the June 2008 Briefing Book under Agenda Item G.1. 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.

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; 12,788 mt in 2006 (mostly caught in the Monterey area), and 12,116 mt in 2007. 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; 68 mt in 2005, 9 mt in 2006, and 5 mt in 2007. 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. In 2007 148 mt were landed. Through the 1970s and early 1980s, Mexican landings increased, peaking at 258,700 mt in 1981 (Table 18). 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 3,500 mt through 2003. Anchovy landings in Ensenada increased to 5,604 in 2005; however, no landings were reported (or were not available) for 2002, 2004 or 2006. In 2007, reported anchovy landings from Ensenada were not reported.

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 one 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, 253 mt in 2005, 1,499 mt in 2006, and 1,065 in 2007. 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, 5 mt in 2006, and 8 mt in 2007. Washington reported 11.5 mt in 2002, 1.8 mt in 2003, and 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 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 determination of sustainable 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 1.

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 2007, the market squid fishery was California's second largest fishery in the state, with landings estimated at 49,801 mt. This is 1% larger than in 2006 (49,145 mt) and 59% less than the record high set in 2000 (118,827 mt). The ex-vessel price ranged from $22 - $1,654/mt, with an average of $597/mt (an increase compared to the 2006 average of $560/mt). The 2007 ex-vessel value was approximately $29.3 million, a 9% increase from 2006 ($26.9 million).

The fishing permit season for market squid extends from 1 April through 31 March of the following year. During the 2007–08 season (as opposed to the 2007 calendar year) 45,813 mt were landed, a 32% increase from the 2006–07 season (34,809 mt). There was a 90% decline in catch from the northern fishery near Monterey in the 2007–08 season with only 53 mt landed which was likely influenced by the La Niña Southern Oscillation event. In contrast, most of the market squid was taken from the southern California region during the season, accounting for 99.9% of the total catch (45,759 mt). This regional domination of catch last occurred during the 1998-99 and 1999–2000 seasons (99.7% and 99.8% respectively) and was also influenced by a La Niña event. At the beginning of the 2007–08 season, squid fishing was centered on northern Channel Island coastlines of Santa Cruz and Santa Rosa. However, at the end of the season, fishing was centered on the west coast of Santa Catalina Channel Island and along the coastline of La Jolla. This varies from the 2006–07 season where major landings were absent from Santa Catalina and La Jolla.

9.3 References

Crone, P. R., K. T. Hill, and J. D. McDaniel. 2006. Assessment of the Pacific mackerel (*Scomber japonicus*) stock for U.S. management in the 2006-2007 fishing year. PFMC June 2006 Briefing Book, Exhibit C.1a, Attachment 1, Pacific Fishery Management Council, Portland Oregon.

García F.W. and Sánchez R.F.J. 2003. Análisis de la pesquería de pelágicos menores de la costa occidental de Baja California durante la temporada del 2002. Boletín Anual 2003. Secretaria de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Instituto Nacional de la Pesca. Centro Regional de Investigación Pesquera de Ensenada, Cámara Nacional de la Industria Pesquera y Acuícola, Delegación Baja California. 15 p.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29: 12 p.

Jacobson, L. D., N. C. H. Lo, S. F. Herrick Jr., T. Bishop. 1995. Spawning biomass of the northern anchovy in 1995 and status of the coastal pelagic species fishery during 1994. NMFS, SWFSC, Admin. Rep.LJ-95-11.

Jacobson, L. D., N. C. H. Lo, and M. Yaremko. 1997. Status of the northern anchovy (Engraulis mordax) stock (central subpopulation) during the 1996-1997 season. NMFS, SWFSC, Admin. Rep. LJ-97-08.

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.

Hill, K. T., and P. R. Crone. 2005. Assessment of the Pacific mackerel (*Scomber japonicus*) stock for U.S. management in the 2005-2006 season. PFMC June 2005 Briefing Book, Exhibit F.1. Pacific Fishery Management Council, Portland Oregon. 158 p.

Hill, K. T., E. Dorval, N. C. H. Lo, B. J. Macewicz, C. Show, and R. Felix-Uraga. 2007. Assessment of the Pacific sardine resource in 2007 for U.S. management in 2008. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-413. 176 p.

MacCall, A.D. 1979. Population estimates for the waning years of the Pacific sardine fishery. California Cooperative Oceanic Fisheries Investigations Reports 20:72-82.

MacCall, A. D., R. A. Klingbeil, and R. D. Methot. 1985. Recent increased abundance and potential productivity of Pacific mackerel (Scomber japonicus). Calif. Coop. Oceanic Fish. Invest. Rep. 26: 119-129.

Mason, J. 2001. Jack Mackerel. In: W. S. Leet, C.M. Dewees, R. Klingbeil and E.J. Larson [Editors]. California's living marine resources: a status report. California Department of Fish and Game. Sacramento, California.

McFarlane, G.A., Baumgartner, T. R., Smith, P. E., Hunter, J. R. In press. Climate Variability and North Pacific Sardine Populations and Fisheries. Fisheries in a Changing Climate - American Fisheries Society Symposia 2001.

Murphy, G.I. 1966. Population biology of the Pacific sardine (Sardinops caerula). Proceedings of the California Academy of Sciences 34:1-84.

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.

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.

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 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?
- 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 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 CPS 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 inshore waters. It is possible that mackerel abundance could be strong south of the U.S. border and/or 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 cutoff 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. In response, CDFG is in the process of assessing the market squid logbook information to determine fishery impacts based on time of day, and has revised its fishery sampling program to evaluate gear-related impacts to squid egg beds by staging eggs within squid egg cases sampled as incidental catch from the fishery. The stage of egg development within the capsule can be used to determine approximate spawning date and to rule out the possible extrusion of capsules in the net at time of capture.

The differences between the two fisheries may have considerable influence on 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. 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 submitted to the CPSMT in fall 2008.

10.4 Management Issues

Emerging management issues include implementation of new provisions is the reauthorized MSA, ecosystem-based fishery management, market squid overfishing definition, international CPS fisheries, and standardized bycatch reporting, including at-sea observers in California-based CPS fisheries.

10.4.1 Implementation of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006.

Although not unique to CPS management, implementation of new provisions in the MSA as reauthorized in 2007 will involve a reevaluation and potentially amendment of the CPS FMP. In particular, the applications of provisions to prevent overfishing such as annual catch limits and overfishing and their application to data-poor or monitored CPS stocks will be focus of considerable review in the next few years. It is anticipated that NMFS guidance on implementation of these new provisions and on National Standard 1 and National Standard 2 will be proposed in the summer of 2008.

The following excerpt is from an April 17, 2007 letter from Council Executive Director Dr. Donald McIsaac that was submitted to NMFS under a scoping period on MSA reauthorization:

> *The Pacific Council's FMP for coastal pelagic species (CPS) contains actively managed species, and monitored species and was recently amended to include all species of krill as prohibited harvest species. The FMPs harvest control rules for actively managed species (Pacific mackerel and Pacific sardine) removes a fixed portion of the assessed biomass of these species from harvest consideration to minimize the potential for overfishing and to help ensure a sustainable spawning biomass. Therefore, the definition of an overfished stock is explicit in the harvest control rules as harvestable biomass automatically declines as the stock approaches an overfished state.*
>
> *Per the CPS FMP the Council must take action to prevent overfishing if exploitation rates are projected to exceed overfishing levels within two years. Under the CPS FMP, the Council can and does set a harvest guidelines or catch limits below the overfishing level. Often this precautionary approach is intended to prevent overfishing by reserving a portion of the harvestable biomass as an incidental landing allowance for CPS fisheries targeting other species.*
>
> *Like the HMS FMP. the CPS FMP also contains monitored species. Monitored species are either exploited at very low levels or are under State jurisdiction, or both. It is presumed that market squid, a monitored species, would be exempt from ACL and AM provisions due to its short life cycle. Much like monitored species in the HMS FMP and data-poor stocks in the groundfish FMP, assessing ACLs and AMs for monitored stocks could be problematic.*

10.4.2 Ecosystem Based Fishery Management

There is a growing national interest in augmenting existing single- species management approaches with ecosystem-based fishery management principles that could place fishery management decisions and actions in a the context of a broader scope. In many ways, the CPS FMP and its harvest control rules utilize ecosystem principles by applying a relatively conservative management strategy through the use of "CUTOFF" values which recognize the importance of CPS species as forage and are designed to buffer against overfishing. Specifically the harvest fraction value in the Pacific sardine harvest control rule is driven by an environmental indicator (sea surface temperature) which scales the harvestable fraction as ocean conditions fluctuate between favorable and unfavorable regimes to sardine survival. Additionally, under Amendment 12 to the CPS FMP the Council and NMFS are working to finalize a prohibition on krill harvest to protect these important forage species.

However, the harvest control rules in the CPS FMP are dated and in need of review and potential revision. Review of the harvest control rules in the CPS FMP has been characterized as a high priority research and data need by the Council and its advisory bodies (see chapter 11). NMFS Science Centers around the country have been working on improving the science behind ecosystem-based fishery management including status monitoring and reporting on ecosystem health. The CPS FMP calls for "ecosystem information" to be included in the CPS SAFE. Appendix A of Amendment 8 to the CPS FMP provides a review of the life-cycles, distributions, and population dynamics of CPS and discusses their roles as forage and can be found on the Council's web site. Additionally, Appendix D provided a description of CPS essential fish habitat that is closely related to ecosystem health and fluctuation. Recent efforts to learn more about ecosystem functions and trophic interactions will likely result in future research results that will improve our knowledge base for improved CPS management decisions.

The Council has initiated development an Ecosystem Fishery Management Plan is intended to act as an "umbrella" type of plan, potentially providing ecosystem-based fishery management principles, status reports on the health of the West Coast's California Current Ecosystem, coastwide research planning, and policy guidance for better informed decisions-making under the Council's four FMPs (Salmon, Groundfish, Highly Migratory Species, and CPS). The Ecosystem FMP envisioned by the Council would not replace theses existing FMPs but would advance fishery management under these FMPs by introducing new theories, new scientific findings, and new authorities to the current successful Council process. The Council is poised to move forward with an Ecosystem Fishery Management plan pending dedicated funding.

In a letter to the chairs of the CPSMT and the CPSAS dated May 6, 2008, Oceana requested the following specific information be included in the 2008 CPS SAFE.

- A description of the California Current Large Marine Ecosystem,
- An explanation of the influence of oceanographic conditions on CPS, and
- Food web analyses including information such as
- The role of CPS in the food web, including analysis of the relative interaction strengths between predators and CPS,
- Consumption levels of CPS by other species including marine mammals, seabirds, and fish,
- Shared prey analysis that will help provide an understanding of relative competition for CPS between predators and fisheries,
- Species sensitivity analysis to determine how impacts to one species might transmit to other species through food web relationships, and
- Spatial and temporal interactions.
- Recommendations for setting appropriate levels of allocation of CPS to their predators prior to setting optimum yield in the current harvest guidelines.

The CPSMT discussed this request at their May 14, 2008 meeting in Long Beach. The CPSMT agreed with many of the recommendations and noted that many of these considerations were undertaken under Amendment 8 to the CPS FMP. There was insufficient time to conduct a thorough review of available data and to fully respond to the requests from Oceana. The May 6 letter form Oceana as well as a response letter from Dr. Richard Parrish, a former NMFS scientist involved with the early development of the CPS FMP, will be included in the briefing materials for Council and public review at the June 2008 Council meeting. The Council and the CPSMT will continue to review these materials and will consider incorporating additional ecosystem information in either the CPS SAFE or the Council's Ecosystem Fishery Management Plan as appropriate.

10.4.2.1 Sardines as Forage

Under a comprehensive, ecosystem-based fishery conservation and management approach (EBFM), the impacts of harvesting sardines will extend beyond directed commercial fisheries to consideration of the corresponding effects on sardine predators that constitute higher trophic level commercial and recreational fisheries, as well as non-commercial but ecologically important predators (e.g., marine mammals, seabirds). In this context, information about the tradeoffs the public is willing to make across the alternative ecological services sardines provide ~~are~~ is critical in evaluating the desirability of alternative EBFM policy options. To make these evaluations, the tradeoffs associated with different policies need to be expressed in terms of a common denominator that reflects the range of benefits under each policy option; i.e., economic values. As applied here this relates to the benefits that the Pacific sardine resource provides society in terms of satisfying human needs and wants through its consumptive use as directed commercial harvests, as well as to the benefits it provides through its use as forage (see for example Constanza et al. 1997).

One dimension of a change in sardine harvest policy would then be the tradeoff between harvesting sardines and leaving them in the ocean as forage for commercial predators. From an economic standpoint, harvesting sardines is justified if the expected net benefits from harvesting sardines exceed the loss in net benefits that can be attributed to a decrease in the availability of sardine biomass to the commercial predators. To make this evaluation one needs to know the respective ex-vessel prices and harvesting costs for sardines and for their commercial predators, and the ecological parameters that affect the transfer efficiency of converting sardine biomass into commercial predator biomass~~.~~

The same rationale can be used to evaluate a change in sardine harvest policy in terms of the tradeoffs between harvesting sardines and leaving them in the ocean as food for non-commercial, but recreationally and ecologically important predators. The problem here is that by virtue of either their recreational nature or ecological (public) good nature, predators in these categories are not subject to market exchange. So evaluating the tradeoffs between harvesting sardines and leaving them in the ocean as food for non-commercial predators will require non-market valuation techniques to enumerate the related benefits and costs -- as in the case of commercial predators above – of the ecosystem services sardine provide in this role (see section 11.5). Also, as in the case of commercial predators, one needs to know the ecological parameters that affect the transfer efficiency of converting sardine biomass into non-commercial predator biomass.

10.4.3 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 corresponding state observer programs have been discontinued, and possibly consider alternative ways to address any bycatch issues identified, as required by the Magnuson-Stevens Act.

10.4.4 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 to 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.

10.4.5 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 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. The United States will host the next Trinational Sardine Forum in Oregon in 2008.

10.5 References

Constanza R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253-60.

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 be 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.

- 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

High priority research and data needs for Pacific sardine include:

1) gaining better information about Pacific sardine status through annual coastwide surveys that include ichthyoplankton, hydroacoustic, and trawl sampling;
2) standardizing fishery-dependent data collection among agencies, and improving exchange of raw data or monthly summaries for stock assessments;
3) obtaining more fishery-dependent and fishery-independent data from northern Baja California, México;
4) further refinement of ageing methods and improved ageing error estimates through a workshop of all production readers from the respective agencies;
5) further developing methods (e.g. otolith microchemistry, genetic, morphometric, temperature-at-catch analyses) to improve our knowledge of sardine stock structure. If sardine captured in

Ensenada and San Pedro represent a mixture of the southern and northern stocks, then objective criteria should be applied to the catch and biological data from these areas;

6) exploring environmental covariates (e.g. SST, wind stress) to inform the assessment model.

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 began 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-implemented 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 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 market 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 market 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 market 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 affecting coastal pelagic fisheries requires detailed, representative cost and earnings data for the sardine harvesters and processors making up each fishery sector. These data are used to evaluate the impact on net economic benefits in the commercial fisheries associated with a proposed management action. 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 often makes them suspect in a number of regards, particularly in terms of strategic bias.

Under Ecosystem-based fishery conservation and management we will have to expand the economic analyses to evaluate changes in yields from a number of different species. Such an undertaking inherently involves finding a socially optimum balance among the variety of ecosystem services CPS are capable of generating. The tradeoffs of interest are between benefits CPS provide as: (1) directed harvests; (2) food for higher trophic level commercial predators; (3) food for recreationally important predators; and, (4) food for non-commercial but ecologically important predators. The economic data required to evaluate tradeoffs involving species in categories (3) and (4) will entail the development of non-market data acquisition and valuation techniques.

11.5.1 Commercial Fisheries

Economic analyses of management actions effecting coastal pelagic fisheries require basic 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 when 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 would be a comprehensive CPS vessel logbook program for Washington, Oregon, and California vessels. Such a program will serve not only as a means of collecting biological and stock assessment related data, but also vessel-trip-level fishery economic data (e.g., fuel cost and consumption, number of crew, cost of provisions) across all CPS fishery operations. Moreover, the logbook program would want to include all fishery operations in which these vessels engage to be able to fully evaluate their economic opportunities. To get the full picture in terms of fleet economics the at sea data would have to be supplemented with annual expenditure data, and other data that is not trip-specific (e.g. interest payments). These data will have to be collected separately 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.

11.5.2 Non-market Values

Economic analyses of conservation and management actions affecting the availability of sardines as forage for non-commercial predators will entail developing a framework and compiling the data to estimate the non-market values of recreationally and ecologically important sardine predators. These nonmarket values can then be used to impute the economic value (shadow prices) of Pacific sardine as forage for these predators.

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 2007

This section summarizes economic data presented in tables 25-35 and figures 2-8. West coast landings of CPS totaled 194,152 mt in 2007, a 24% increase from 2006. Market squid landings, all in California, totaled 49,439 mt in 2007, up 1% from 2006. Pacific sardine landings of 127,760 mt in 2007 increased 48% from 2006 (86,608 mt). The exvessel revenue from all CPS landings was $44.9 million in 2007, up 12% from 2006 (2006 converted to 2007 dollars). Market squid accounted for 25%, and Pacific sardine 66% of total West coast, CPS landings in 2007. Landings of Pacific mackerel decreased 13%, and landings of northern anchovy fell 19% from 2006 to 2007. Real exvessel market squid revenues (2007 $) increased 5% from 2006. The slight increase in market squid landings was accompanied by a 5% increase in exvessel price from $563 to $590 per mt (2007 $). There was a 35% increase in aggregate CPS finfish landings from 2006; exvessel revenue increased 28%, while the overall finfish exvessel price declined 5% from 2006. In 2007, market squid made up 8% of total West coast exvessel revenues, and CPS finfish accounted for almost 4%. Washington, Oregon and California shares of West coast CPS landings in 2007 were virtually unchanged from 2006 at 3%, 22% and 75% respectively.

California sardine landings were 80,951 mt in 2007 up 75% from 2006, 46,438 mt. Market squid ranked first in exvessel revenue generated by California commercial fisheries in 2007, with exvessel revenue of, $29.2 million, $2.4 million greater than that for Dungeness crab, in second place. Landings of Pacific sardine ranked third highest in California exvessel revenues in 20076 at $8.3 million. California Pacific mackerel landings were 5,018 mt in 2007, down 15% from 2006. California landings of Northern anchovy were 10,390 mt in 2007, down 19% from 2006.

Oregon’s landings of Pacific sardine increased 18% in 2007, from 35,668 mt to 42,144 mt. Sardine generated $4.7 million in exvessel revenue for Oregon in 2007, 5% of the state’s total exvessel revenues, ranking it sixth behind Dungeness crab in total exvessel revenues. Washington landings of Pacific sardine increased 7% from 4,363 mt in 2006 to 4,665 mt in 2007. With exvessel revenue less than 1% of the Washington total in 2007, sardine ranked 17th behind Dungeness crab in exvessel value.

Oregon landings of Pacific mackerel increased from 665 mt in 2006 to 702 mt in 2007. Washington landings of Pacific mackerel decreased from 41 mt in 2006 to 38 mt in 2007 while anchovy landings fell from 161 mt to 153 mt.

In 2007, the number of vessels with West coast landings of CPS finfish was 183, up from 161 in 2006. With the increase in vessels and an increase in total CPS finfish landings, finfish landings per vessel, 791 mt in 2007, increased 19% from 2006. Of the vessels landing CPS finfish in 2007, 15% depended on CPS finfish for the greatest share of their 2007 exvessel revenues. From 2006 to 2007, the number of vessels with West coast landings of market squid decreased from 142 to 113, with 58% of these vessels dependent on market squid for the largest share of their total 2006 exvessel revenue. Market squid landings were 438 mt per vessel in 2007, up 26% from 2006. Market squid total exvessel revenue shares for vessels that depend mainly on market squid, and finfish total exvessel revenue shares for vessels that depend mainly on CPS finfish have averaged about 78% per vessel since 2000. By far, roundhaul gear accounted for the largest share of total CPS landings and exvessel revenue by gear in 2007, 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 2007, 38,080 mt of market squid were exported through West coast customs districts with an export value of $51.5 million; a 19% decrease in quantity, and a 12% decrease in the real value of West coast market squid exports from 2006. The primary country of export was China, 59% of the total, which received 22,553 mt, down 15% from the quantity exported to China in 2006. Eighty-five percent of market squid exports went to China and four additional countries: Japan (6,129 mt), Greece (1,865 mt), Mexico (1,230 mt) and Philippines (837 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or for use as bait.

In 2007, 109,496 mt, of sardines were exported through West coast customs districts up 52% from 2006. Sardine exports were valued at $72.7 million in 2007, up 50% from 2006. Almost 87% of sardine exports were in the frozen form, the balance were in the preserved form. Thailand was the primary export market in 2007, receiving 29,796 mt, more than 10 times its imports in 2006, and representing 27% of total West coast sardine exports in 2007. Australia was second with 19,796 mt, 18% of the total a 16% decrease from 2006, followed by Brazil, Japan and Malaysia with 13%, 12% and 6% respectively. Together these four countries accounted for over 75% of total west coast sardine exports in 2007

TABLE 1. HISTORY OF COUNCIL ACTIONS

- The Pacific Fishery Management Council (Council) initiated development of the fishery management plan (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. Exclusive Economic Zone (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. Additionally, 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 coastal pelagic species (CPS) on a motion from National Marine Fisheries Service (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 Coastal Pelagic Species Plan Development Team (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 (CPSAS) on August 24, 1999. At its September 1999 meeting, the Council gave further direction to the CPSMT regarding maximum sustainable yield (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 U.S. 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 (HG) 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 HG 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 coastwide. 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 HG were at least 90 percent of the 2003 HG.

- The regulatory amendment for allocation of the Pacific sardine HG 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 HG of 122,747 metric tons (mt) for the 2004 Pacific sardine fishery, within an incidental catch allowance of up to 45 percent. This HG is based on a biomass estimate of 1,090,587 mt. Per the revised allocation framework, on January 1, the HG will be allocated 33 percent to the northern subarea and 66 percent to the southern subarea, with a subarea dividing line at Point Arena, CA. The final rule implementing the HG 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 HG 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 percent 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 HG. 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 CPSMT 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. The Council 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 essential fish habitat (EFH).

- At the November 2004 Council meeting, the Council adopted a HG of 136,179 mt for the 2005 Pacific sardine fishery. This HG is based on a biomass estimate of 1.2 million mt. Per the FMP allocation framework, on January 1 the HG will be allocated 33 percent to the northern subarea and 66 percent to the southern subarea with a subarea dividing line at Point Arena, California. Additionally, the Council directed the CPSMT 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 EEZ and National Marine Sanctuaries under the auspices of the CPS 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 CPS advisory bodies, the Council eliminated two alternatives (Alternatives 2 and 5) from further consideration. The Council recommended that the CPSMT 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 HG and management measures, long term Pacific sardine allocation and CPS 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 HG 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 percent, when mackerel are landed with other CPS, 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 HG. The Council approved a modified version of Alternative 3, which provides the following allocation formula for the non-tribal share of the HG:

1. A seasonal allocation structure with 35 percent of the HG to be allocated coastwide on January 1.
2. 40 percent of the HG, plus any portion not harvested from the initial allocation, to be reallocated coastwide on July 1.
3. On September 15 the remaining 25 percent of the HG, 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 Stock Assessment Fishery Evaluation (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 HG 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 EEZ. 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 HG and management measures, long term Pacific sardine allocation and CPS EFH.

- At the March 2006 Council meeting, the Council took final action adopting CPS FMP Amendment 12 to prohibit harvest of all species of krill in the U.S. EEZ. Additionally, the Council adopted an EFH 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 HG of 19,845 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 percent when mackerel are landed with other CPS, 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 HG of 152,654 mt for the 2007 Pacific sardine fishery. This HG 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 percent of the HG to be allocated coastwide January 1, 40 percent of the HG, plus any portion not harvested from the initial allocation reallocated coastwide July 1; and the remaining 25 percent of the HG, plus any portion not harvested from earlier allocations, to be reallocated coastwide September 15. The Council also recommended a 45 percent incidental catch rate be allowed for other 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 CPSAS, the CPSMT, 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.

- At the March 2007 Council meeting, the Council approved the final Terms of Reference for the 2007 CPS stock assessment process. The final document was posted on the Council website and distributed for use during the review of full assessments for Pacific mackerel and Pacific sardine May 1-3 and September 18-21 respectively.

- At the June 2007 Council meeting, he Council adopted the new assessment model and the following management measures for the July 2007-June 2008 Pacific mackerel fishery: an acceptable biological catch (ABC) for U.S. fisheries of 71,629 mt, a directed fishery HG of 40,000 mt, and in the event the directed fishery reaches 40,000 mt, the directed fishery will revert to an incidental-catch-only fishery with a 45 percent incidental catch allowance when Pacific mackerel are landed with other CPS, except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS. The Council and NMFS will track the 2007-08 Pacific mackerel fishery and will recommend 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. Additionally, the Council directed Council staff to send a letter to the U.S. State Department requesting increased coordination with Mexico on the exchange of data for the improvement of international management of CPS.

- In November 2007, the Council adopted an ABC or total harvest guideline (HG) of 89,093 mt for the 2008 Pacific sardine fishery. This ABC is based on a biomass estimate of 832,706 mt and the harvest control rule in the coastal pelagic species (CPS) fishery management plan. The Council recommends 80,083 mt of the HG for the directed fishery to be allocated seasonally per the Amendment 11 framework. To allow for incidental landings of Pacific sardines in other CPS fisheries and to ensure the fishery does not exceed the ABC, the Council recommends a set aside of 8,910 mt allocated across seasonal periods as follows:

	Jan 1- June 30	July 1- Sept 14	Sept 15 - Dec 31	Total
Seasonal Allocation (mt)	31,183	35,637	22,273	89,093
Set Aside %	5.2%	1.2%	3.6%	10%
Set Aside (mt)	4,632	1,070	3,208	8,910
Adjusted Allocation (mt)	26,550	34,568	19,065	80,083

  Regarding Pacific mackerel, the Council recommended no changes to Pacific mackerel assessment methodology for the 2008 assessment update and recommends the next CPS stock assessment review panel be convened in 2009 rather than 2010 to fully review the status of Pacific sardine and Pacific mackerel.

TABLE 2. REGULATORY ACTIONS

January 25, 2000. NMFS published HGs for Pacific sardine and Pacific mackerel for the fishing year beginning January 1, 2000. A HG of 186,791 mt was established for Pacific sardine, based on a biomass estimate of 1,581,346 mt. The HG 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 HG was in effect until December 31, 2000, or until it was reached and the fishery closed. A HG of 42,819 mt was established for Pacific mackerel based on a biomass estimate of 239,286 mt. The HG 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 HG for Pacific mackerel in the EEZ off the Pacific Coast. Based on the estimated biomass of 116,967 mt and the formula in the FMP, a HG of 20,740 mt was calculated for the fishery beginning on July 1, 2000. This HG 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 HG for Pacific mackerel based on a formula in the FMP and to close the fishery when the HG is reached. The HG 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 CPS 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 percent 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 percent 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 HG for Pacific sardine in the EEZ off the Pacific Coast for the January 1, 2001, through December 31, 2001, fishing season. This HG 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 HG of 134,737 mt was calculated for the fishery beginning January 1, 2001. The HG 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 OY 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 percent 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 HG 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 HG 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 percent 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 HG for Pacific mackerel based on a formula in the FMP and to close the fishery when the HG is reached. The HG 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 HG 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 percent of Pacific mackerel in a landing of any CPS. If a significant amount of the HG 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 HG'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 HG 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 percent 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 HG 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 HG for Pacific sardine for the fishing season beginning January 1, 2002. A HG of 118,442 mt was established for Pacific sardine based on a biomass estimate of 1,057,599 mt. The HG 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 HG 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 HG 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 percent Pacific mackerel. This action was taken to help ensure that the HG is attained. If the HG 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 HG for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual HG 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 HG of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the HG 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 coastwide HG 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 HG 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 HG, with 50 percent 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 HG 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 HG for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual HG 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 HG of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the HG 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 HG will be utilized for incidental landings following the closure of the directed fishery. After closure of the directed fishery, no more than 40 percent 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 HG remains before June 30, 2003, the directed fishery will be reopened. The goal is to achieve the HG 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 HG for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This HG 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 HG of 110,908 mt was determined for the fishery beginning January 1, 2003. The HG 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 HG for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This HG 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 HG of 110,908 mt was determined for the fishery beginning January 1, 2003. The HG 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 HG is reached, up to 45 percent 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 HG for Pacific mackerel in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual HG 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 HG in the EEZ off the Pacific Coast. On September 1, 2003, 59,508 mt of the 110,908 mt HG is expected to remain unharvested. The CPS FMP requires that a review of the fishery be conducted and any uncaught portion of the HG 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 HG 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 HG 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 HG of 10,652 mt, which is lower than last year but similar to low HGs 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 HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2004, through December 31, 2004. This HG 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 HG 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 HG 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 HG 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 HG 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 HG 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 HG 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 HG 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 HG, with 20 percent allocated north of Point Area, California, and 80 percent allocated south of Point Arena, California. (69 *FR* 55360)

October 21, 2004. NMFS issued a final rule to implement the annual HG 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 HG 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 HG of 13,268 mt. (69 *FR* 61768)

December 8, 2004. NMFS proposed a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2005, through December 31, 2005. This HG 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 HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2005, through December 31, 2005. This HG 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 mt (in U.S. and Mexican waters) and using the FMP formula, NMFS calculated a HG of 136,179 mt for Pacific sardine in U.S. waters. Under the FMP, the HG 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 HG for Pacific mackerel in the U.S. 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 HG for Pacific mackerel in the U.S. EEZ off the Pacific coast. The biomass estimate for July 1, 2005, would be 101,147 mt. Applying the formula in the FMP results in a HG of 17,419 mt, which is 32 percent greater than last year but similar to low HGs of recent years. For the last three years, the fishing industry has recommended dividing the HG into a directed fishery and an incidental fishery, reserving a portion of the HG 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 allowing 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 CPS FMP for Secretarial review. Amendment 11 would change the framework for the annual apportionment of the Pacific sardine HG 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 HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season of January 1, 2006, through December 31, 2006. This HG has been calculated according to the regulations implementing the CPS 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 CPS FMP which changes the framework for the annual apportionment of the Pacific sardine HG 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 HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season of January 1, 2006, through December 31, 2006. This HG 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 HG 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 HG 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 HG for Pacific mackerel in the U.S. EEZ off the Pacific coast. (71 *FR* 61944).

December 7, 2006. NMFS proposes a regulation to implement new reporting and conservation measures under the CPS FMP. These reporting requirements and prohibitive measures would 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. 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).

January 31, 2007. NMFS issues a final rule to implement the annual HG and management measure for the 2006-2007 Pacific Mackerel fishery. Based on the estimated biomass of 112,700 mt and the formula in the FMP, a HG of 19,845 mt is in effect for the fishery which began on July 1, 2006. This HG applies to Pacific mackerel harvested in the U.S. EEZ off the Pacific coast from July 1, 2006, through June 30, 2007, unless the HG is attained and the fishery is closed before June 30, 2007. All landings made after July 1, 2006, will be counted toward the 2006–2007 HG of 19,845 mt. There shall be a directed fishery of 13,845 mt, followed by an incidental fishery of 6,000 mt. An incidental allowance of 40 percent of Pacific mackerel in landings of any CPS will become effective after the date when 13,845 mt of Pacific mackerel is estimated to have been harvested. A landing of 1 mt of Pacific mackerel per trip will be permitted during the incidental fishery for trips in which no other CPS is landed. (72 *FR* 4464).

May 30, 2007. This action implements new reporting and conservation measures under the CPS 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. (72 *FR* 29891).

September 28, 2007 NMFS proposes a regulation to implement the annual HG for Pacific mackerel in the U.S. EEZ Based on a total stock biomass estimate of 359,290 mt, the ABC for U.S. fisheries for the 2007/2008 management season is 71,629 mt. The estimated stock biomass for the 2006/2007 season was 112,700 mt, resulting in an ABC of 19,845 mt.off the Pacific coast for the fishing season of July 1, 2007, through June 30,2008.. (72 *FR* 55170).

October 25, 2007 NMFS issues this final rule to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast (California, Oregon, and Washington) for the fishing season of January 1, 2007, through December 31,2007. The Pacific sardine HG is apportioned based on the following allocation scheme established by Amendment 11to the CPS FMP: 35 percent (53,397 mt) is allocated coastwide on January 1; 40 percent (61,025 mt), plus any portion not harvested from the initial allocation is reallocated coastwide on July 1; and on September 15 the remaining 25 percent (38,141 mt), plus any portion not harvested from earlier allocations is released. (72 *FR* 60586).

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				
Provider	D572344	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
Sea Venture	D238969	1939	66	71.40	21.20	9.70	107.3	3	98.4	108.2
Barbara H	D643518	1981	24	64.90	24.00	11.60	121.1	4	121.1	133.2
Pacific Bully	D1186583	1937	68	72.10	19.50	8.70	82.0	5	82.0	90.2
Mary Vincent	D632207	---	---	---	---	---	---	6	98.1	---
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
Sunrise	D238918	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
	---	---	---	---	---	---	---	16	137.5	---
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	D583781	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	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
Sheelagh B	D697944	---	---	---	---	---	112	27	55.5	61.1
Mineo Bros.	D939449	1989	16	58.00	21.00	9.00	73.4	28	73.4	80.7
Long Beach Carnage	D955501	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
Sea Princess	D630024	1980	25	87.00	26.00	12.80	194.0	33	194.0	213.4
Jennifer Lynn	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	D1061917	1997	8	66.00	26.00	12.00	137.0	44	137.0	151.8
Trionfo	D625449	1980	25	63.80	19.30	9.60	79.2	45	79.2	87.1
Corva May	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 3a. 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
Unbelievable	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
St. Katherine	D542513	1972	33	56.40	18.00	8.80	59.9	61	59.9	65.9
Lethal Weapon	D979365	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
Sheelagh B	D697944	---	---	---	---	---	112	64	54.5	60.0
Bounty	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%. (The CPSMT is working on discrepancies between Tables 3a-3d.)

Table 3b. Vessel age and calculated gross tonnage (GT) for the initial and current Federal limited entry fleet.

	Initial Fleet	Current Fleet
Number of Vessels	65	63
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 3c. 2007 Oregon limited entry sardine vessel information. Vessel information is from permit applications and not USCG information. Vessels listed participated in the 2007 fishery. The CPSMT is working on discrepancies between Tables 3a-3d.

Vessel Name	Coast Guard Number	Registered Measurements		
		Length	Horsepower	Gross Tonnage
EXCELLER	659770	58	440	74
ANTHONY G	605599	58	350	50
PACIFIC PURSUIT	OR873ABY	73	590	1
D C COLE	566145	49	325	52
DARLENE Z	611694	50	300	52
PACIFIC JOURNEY	OR661ZK	71	600	81
LAUREN L KAPP	OR072ACX	72	700	3
EVERMORE	248555	76	500	103
PACIFIC RAIDER	972638	58	540	77
PACIFIC KNIGHT	OR155ABZ	62	365	4
CRYSTAL SEA	1061917	66	600	110
SUNRISE	238918	82	425	62
PAPA GEORGE	549243	72	700	73
DELTA DAWN	647246	50	365	10
SPARTAN	607367	50	365	51
RESOLUTION II	WN9665RJ	66	400	3
EMERALD SEA	626289	62	365	69
ST TERESA	623983	58	365	56
LADY LAW	1131965	82	700	128
OCEAN ANGEL II	622522	74	10	45
SEABOUND	AK9671AF	64	365	4
OCEAN ANGEL I	584336	49	10	53

Table 3d. Vessels designated on a Washington Sardine Experimental Fishery Permit in 2007.

Vessel Name	Coast Guard Number	Year Built	Vessel Age	Registered Measurements (ft)[1/]			Calculated Vessel GT [2/]
				Length	Breadth	Depth	
ATLANTIS	649333	1982	26	49.6	19.0	10.1	63.8
BAINBRIDGE	236505	1937	71	78.6	22.7	9.6	114.8
DELTA DAWN	647246	1982	26	49.6	19.0	10.1	63.8
HUSTLER	943301	1989	19	55.0	17.0	8.2	51.4
KING PHILIP	1061827	1997	11	79.0	26.0	11.4	156.9
MARAUDER	975597	1991	17	58.0	22.8	10.5	93.0
	OR761ABL	2004	4	25.7			0.0
PACIFIC JOUNEY	OR661ZK	2001	7	64.3	22.0	10.3	97.7
PACIFIC LEADER	643138	1981	27	59.5	21.0	9.2	77.0
PACIFIC RAIDER	972638	1991	17	57.7	22.7	11.0	96.5
PAPA GEORGE	549243	1973	35	70.4	22.8	12.0	129.1
SPARTAN	607367	1979	29	58.0	19.0	10.1	74.6
ST. TERESA	623983	1980	28	49.0	18.5	8.5	51.6
ST. ZITA	648115	1982	26	49.6	21.5	10.5	75.0
VOYAGER	248217	1945	63	66.7	20.2	9.3	84.0
	WN1264JE	1973	35	16.0			0.0

1/ Vessel dimension information was obtained from NOAA at www.st.nmfs.noaa.gov/st1/CoastGuard/VesselByName.html
2/ Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100 (The CPSMT is working on discrepancies between Tables 3a-3d.)

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, 2003-2007. (Page 1 of 4). *Includes Santa Barbara port complex.

	All Ports					San Pedro					Monterey				
Common Name	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007**
Finfish															
Anchovy, northern	3.7	7.4	6.1	9.2	5.8	4.1	4.2	5.8	3.5	1.7	2.1	32.6	18.2	24.0	11.4
Barracuda, California		0.5	0.4	0.4	0.9		0.6	0.4	0.3	0.9				0.4	1.0
Bass, barred sand	1.1	1.1	1.1	0.6	0.6	1.4	1.2	1.2	0.9	1.0					
Bass, kelp	1.1		1.1	0.7		1.4		1.2	1.0						
Blacksmith				0.1	0.2				0.2	0.3					
Bonito, Pacific				2.1	0.7				2.9	1.3					
Butterfish, Pacific (Pompano)	2.8	4.7	5.5	6.0	2.9	2.7	5.1	5.2	6.4	3.3	3.1	2.3	18.2	4.9	2.3
Cabezon				0.1										0.4	
Combfish, longspine	0.2			0.7	0.3				1.0	0.1					0.6
Corbina, California				0.5	0.6				0.7	1.0					
Croaker, white (kingfish)	7.8	6.9	0.2	5.8	4.4	7.4	5.7	0.2	6.4	5.1	9.4	16.3		4.4	3.3
Croaker, yellowfin					0.2					0.4					
Cusk-eel, spotted				0.9	0.5				0.9	0.4				0.9	0.6
Cusk-eel, unspecified	1.1	1.3	4.7	2.1	0.5	1.4	1.5	4.8	2.9	0.9					
Eel, yellow snake	0.2					0.3									
Eel, wolf	0.2										1.0				
Fish, unspecified	0.9				0.3	1.1				0.4					0.2
Flatfish, unspecified	2.2	1.8	0.2	0.6	2.3	2.7	2.1	0.2	0.7	3.4				0.4	0.8
Flounder, starry	0.4	0.3		0.5	0.7						2.1	2.3		1.8	1.6
Flyingfish	0.4	0.3	0.6			0.5	0.3	0.6							
Greenling, kelp					0.1										0.2
Grunion, California		0.3		0.1					0.2			2.3			
Hagfish					0.1					0.1					
Halfmoon				0.1										0.4	
Halibut, California	6.9	4.2	7.6	2.5	3.8	7.1	4.8	7.7	3.3	6.0	6.3			0.4	0.8
Herring, Pacific	0.4			0.1	0.2						2.1			0.4	0.6
Jacksmelt	1.1	0.8	1.5	1.9	2.3	0.3	0.6	1.0	0.9	2.4	4.2	2.3	27.3	4.4	2.2
Kelpfish, giant				0.1	0.2				0.2	0.3					
Lingcod					0.1										0.2
Lizardfish, California	0.9	2.1	5.7	2.1	1.6	1.1	2.4	5.8	2.9	2.7					
Midshipman, plainfin				1.6	1.9				1.7	2.0				1.3	1.8
Midshipman, specklefin	0.4	1.3		1.6	0.7	0.5	1.5		2.2	1.1					
Midshipman, unspecified	3.5	2.1	0.6			4.4	2.4	0.6							
Pipefish, bay					0.2					0.1					0.1
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	0.8				4.3	1.4					
Rockfish, chilipepper				0.1										0.4	
Rockfish, unspecified					0.5					0.9					
Salema				0.1					0.2						
Salmon, chinook					0.1										0.2
Sanddab, longfin				0.2	0.1				0.3	0.1					
Sanddab, Pacific	0.2			1.4	3.5				1.9	1.1	1.0				6.7
Sanddab, speckled				0.1	0.7				0.2	0.4					1.2
Sanddab, unspecified	3.0	4.0	2.1	2.6	0.9	2.2	3.9	1.9	1.4	1.0	6.3	4.7	9.1	5.8	0.8
Scorpionfish, California	8.0	10.0	8.7	3.4	2.6	9.9	11.3	8.9	4.7	4.4	1.0				
Sculpin, pithead	0.2	1.3	0.2	0.1			0.3	0.2	0.2		1.0	9.3			
Sculpin, roughback					0.1										0.2

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2003-2007. (Page 2 of 4). *Includes Santa Barbara port complex.

	All Ports					San Pedro					Monterey				
Common Name	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007**
Sculpin, staghorn	0.4			0.1	0.4					0.1	2.1			0.4	0.8
Sculpin, unspecified				0.2					0.3						
Seabass, giant (black)				0.1					0.2						
Shad, American				0.9	0.8									3.1	2.0
Sheephead, California				0.1					0.2						
Silversides				0.5	0.1				0.7	0.1					
Smelt, surf					0.2										0.4
Smelt, true					0.1					0.1					
Smelt, whitebait	0.7										3.1				
Snapper, Mexican					0.1					0.1					
Sole, C-O				0.6	0.2				0.3	0.1				1.3	0.2
Sole, curlfin	0.2					0.3									
Sole, English				0.2	1.3					0.3				0.9	2.7
Sole, fantail	0.0				0.2					0.3					
Sole, petrale					0.2										0.6
Sole, sand	2.2	0.3		0.5	0.2						10.4	2.3		1.8	0.4
Sole, slender				0.1					0.2						
Sole, unspecified	0.2			0.2	0.1						1.0			0.9	0.2
Sturgeon, unsp.	0.2										1.0				
Sunfish, ocean				0.1										0.4	
Surfperch, barred				0.1										0.4	
Surfperch, black				0.1	0.1				0.2						0.2
Surfperch, kelp					0.1										0.2
Surfperch, pink				1.1	0.5				0.9	0.4					0.6
Surfperch, rainbow					0.1										0.2
Surfperch, rubberlip				0.1					0.2					1.8	
Surfperch, shiner				0.9	0.5				1.0					0.4	0.2
Surfperch, unspecified	0.3			0.4	0.4				0.3	0.7	2.3			0.4	
Surfperch, walleye		0.3			0.2					0.3		2.3			
Surfperch, white				0.1					0.2						
Tonguefish	0.9	2.1	1.9	1.4	0.9	1.1	2.4	1.9	1.7	1.1				0.4	0.6
Topsmelt					0.4					0.7					
Turbot, curlfin				0.1	0.2				0.2	0.1					0.2
Turbot, diamond				0.2	0.6				0.3	0.1					
Turbot, hornyhead	3.5	4.0	6.1	2.9	2.7	4.4	4.5	6.2	3.6	3.7					1.4
Turbot, spotted				0.6	0.1					0.1					
Turbot, unspecified	0.7		1.1	1.0		0.3		1.2	1.4		2.1				
Whiting, Pacific				0.1	1.0									0.4	2.3
Total % Freq. Incidents	**56.0**	**58.0**	**55.9**	**65.2**	**647**	**55.1**	**55.7**	**55.5**	**64.6**	**384**	**59.4**	**76.7**	**72.7**	**63.6**	**263**
Elasmobranchs															
Guitarfish, shovelnose	2.0		1.5	0.2	0.7	2.5		1.5	0.3	1.1					
Ratfish, spotted				0.1	0.3				0.2	0.1					0.6
Ray, Bat	7.8	7.4	6.3	3.0	3.4	9.3	7.1	6.4	3.6	5.3	2.1	9.3		1.3	0.8
Ray, California butterfly			0.2					0.2							
Ray, Pacific electric	0.4	0.3		1.2	3.2		0.3		0.9	0.3	2.1			2.2	7.2
Ray, Unspecified	0.2				0.2	0.3				0.4					
Shark, brown smoothhound	0.0			0.1	0.4				0.2	0.7					
Shark, gray smoothhound	0.2			0.2	0.3				0.3	0.6	1.0				

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2002-2006. (Page 3 of 4). *Includes Santa Barbara port complex.

	All Ports					**San Pedro**					**Monterey**				
Common Name	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007**
Shark, horn				0.6	0.2				0.9	0.4					
Shark, leopard					0.2					0.1					0.2
Shark, Pacific angel				0.2	0.2				0.3	0.3					
Shark, shortfin mako	0.4										2.1				
Shark, spiny dogfish		0.3		0.1	0.7							2.3		0.4	1.8
Shark, Unspecified					0.1					0.1					
Skate, Big	0.4			0.6	0.8				0.2	0.3	2.1			1.8	1.6
Skate, California	0.2			0.5	0.3				0.7	0.1	1.0				0.6
Skate, longnose	0.4	0.8				0.5	0.9								
Skate, thornback	3.7	2.4	3.6	1.6	1.9	3.6	2.7	3.7	1.9	3.1	4.2				0.2
Skate, Unspecified	0.4			0.1					0.2		2.1				
Stingray, round	1.1	0.3	1.5	0.2	0.7	1.4	0.3	1.5	0.3	1.3					
Total % Freq. Incidents	**17.4**	**11.3**	**13.1**	**9.1**	**14.2**	**17.5**	**11.3**	**13.3**	**10.0**	**14.5**	**16.7**	**11.6**	**0.0**	**5.8**	**13.7**
Invertebrates and Plants															
Algae, marine				1.2	0.1									1.2	0.2
Bryozoans				0.1	0.1									0.1	0.2
Crab shells	0.2	0.8		0.3		0.3	0.9		0.3					0.4	
Crab, box				0.1	0.3				0.2	0.6				0.1	
Crab, decorator	0.2			0.2							1.0			0.2	
Crab, Dungeness	1.1			0.1	0.2						5.2			0.1	0.4
Crab, elbow	0.2					0.3									
Crab, globe					0.3					0.6					
Crab, pelagic red															
Crab, rock unspecified	0.9	1.3	0.2	0.2	1.5	0.8	1.5	0.2	0.3	2.4	1.0			0.2	0.2
Crab, sheep	0.2			0.1	0.2	0.3			0.2	0.3				0.1	
Crab, slender	0.4				0.2						2.1				0.6
Crab, swimming				0.3	0.2				0.5	0.3				0.4	
Crab, unspecified				0.5	0.3				0.7	0.4				0.5	0.2
Eelgrass	0.9	1.1	1.5	2.0	0.6	1.1	1.2	1.5	1.4	0.7				2.1	0.4
Gorgonians				0.6					0.9					0.6	
Jellies	1.1	1.3	2.3	0.2	3.5	0.5	0.3	2.3	0.3	0.1	3.1	9.3		0.2	8.2
Kelp	10.4	15.3	15.0	10.4	10.9	12.6	17.3	14.9	10.4	11.9	2.1		18.2	11.2	9.4
Kelp, feather boa				0.3	0.2					0.4				0.4	
Lobster, California spiny					0.2					0.4				0.9	
Nudibranch					0.1										0.2
Octopus, unspecified				0.8	0.5				1.0	0.9				0.1	
Pleurobranch														0.5	
Prawn, ridgeback					0.2					0.3					
Prawn, spot				0.1					0.2					1.7	
Salps	0.7	0.5	0.2		0.1	0.8	0.6	0.2	0.7	0.1				0.1	
Sea cucumber	0.9	0.3	0.6	0.5	0.7	1.1	0.3	0.6		1.1				0.1	
Sea pansies	0.2		0.2		0.1	0.3	0.0	0.2	1.2					4.2	0.2
Sea star	2.2	0.3	0.8	1.6	1.6	1.9	0.3	0.8		1.6	3.1				1.8
Shrimp, black-spotted bay	0.4		0.2			0.5	0.0	0.2							
Shrimp, unspecified				7.6	1.9				0.2	3.3					
Snail, top					0.1					0.1					
Snail, Unspecified					0.2					0.3					
Sponge, unspecified				0.1					0.2						

Table 9. Percent frequency of bycatch in observed incidents of CPS finfish, by port, 2002-2006. (Page 4 of 4). *Includes Santa Barbara port complex.

	All Ports					San Pedro					Monterey				
Common Name	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007***	**2003**	**2004**	**2005**	**2006**	**2007**
Squid, jumbo					0.1					0.1					
Squid, market (Egg Cases)	0.2	0.5			0.1		0.6				1.0				0.2
Squid, market	6.1	9.2	10.2	3.9	6.0	6.8	10.1	10.3	5.9	4.8	3.1	2.3	9.1		7.6
Surfgrass					2.1										4.9
Tunicates					0.2					0.1					0.2
Total % Freq. Incidents	**27.1**	**31.9**	**31.3**	**31.3**	**32.6**	**28.2**	**34.5**	**31.1**	**24.5**	**31.0**	**22.9**	**11.6**	**27.3**	**25.7**	**34.8**
Total All Incidents	**461**	**379**	**528**	**804**	**1,215**	**365**	**336**	**517**	**579**	**704**	**96**	**43**	**11**	**225**	**511**
Total Observed Landings	**200**	**205**	**199**	**266**	**253**	**167**	**180**	**199**	**172**	**142**	**27**	**33**	**25**	**94**	**111**

Table 10. Market squid incidental catch for 2003 - 2007. Incidental catch includes species landed with market squid and recorded on landing receipts (round haul gear).

	2003		**2004**		**2005**		**2006**		**2007**	
Species name	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**	**Number of Landings**	**Tons**
Anchovy, northern	8	91.9	17	616.1	31	1,042.9	19	122.3	38	89.7
Bonito			1	<0.1	1	1.3	3	3.3		
Herring, Pacific					2	34.0				
Jacksmelt	1	1.9			2	0.2			1	<0.1
Kelpfish			1	2.2						
Mackerel, jack	14	33.6	19	38.8	19	21.0	28	45.6	36	47.1
Mackerel, Pacific	16	163.2	23	143.1	187	571.5	169	360.3	127	351.9
Ray, bat									1	2.4
Ray, Pacific electric									2	<0.1
Sardine, Pacific	109	1,447.9	122	1,525.7	179	1,076.9	184	534.6	287	1,596.7
Seabass, white					1	<0.1				
Shark, Pacific angel									1	<0.1
Stingray									28	0.6
Surfperch	1	0.1								

Table 11. Percent frequency of bycatch in observed loads of California market squid by port, 2003-2007 (Page 1 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Finfish																				
Anchovy, northern	4.4	5.8	5.7	5.1	7.6	4.2	4.1	5.9	5.0	2.9	5.8	7.4	3.8	7.8	9.1	3.2	5.8	6.5	3.2	11.1
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	0.4	0.2								2.0	0.5					
Butterfish, Pacific (Pompano)	3.3	1.6	0.5	2.6		1.7	2	0.7	4.2		4.2			2.0		4.1	1.2	0.7		
Cabezon	0.2					0.2														
Combfish, longspine		0.7					0.7													
Croaker, queenfish	0.5					0.5														
Croaker, white (kingfish)	0.5	0.6			0.4	0.5				1.5							0.6			
Croaker, unspecified		0.7					0.7													
Cusk-eel		0.7					0.7													
Eel, wolf		1.2															1.2			
Fish, unspecified																				
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	0.9	1.8	0.5													0.9	1.8	1.3		
Herring, round	0.2	0				0.2	0													
Jacksmelt	4	7.7	3.1	0.4	0.4	0.7	0.7	0.7							0.5	7.3	14.6	7.2	1.6	
Lizardfish, California	0.5	0.7				0.5	0.7													
Mackerel, jack	8.1	7.5	6.5	12.4	6.2	10.5	8.2	10.5	15.0	4.4	4.2	7.4		2.0	6.5	9.6	7	5.9	15.9	11.1
Mackerel, Pacific	9.9	13.8	21.0	18.8	17.4	10.3	10.9	25.7	17.5	20.6	15.8	25.9	41.3	33.3	17.1	3.7	4.7	5.9	9.5	
Mackerel, unspecified					1.5										2.0					
Midshipman, plainfin																				
Midshipman, specklefin				0.4	1.1				0.8	2.9					0.5					
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				0.4	0.2				1.5										
Pomfret, Pacific																				
Rockfish, blue	0.5		0.3		0.4			0.7							0.5	0.5				

Table 11. Percent frequency of bycatch in observed loads of California market squid by port, 2003-2007 (Page 2 of 4).

	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
Common Name	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**
Rockfish, bocaccio	0.8	0.7				0.7	0.7									0.9				
Rockfish, chilipepper		1.8	0.3														1.8	0.7		
Rockfish, olive	0.2					0.2														
Rockfish, shortbelly	0.5															0.5				
Rockfish, unspecified	0.4					0.2										0.5				
Roughback Sculpin		0.7					0.7													
Salema	1.4															1.4				
Salmon, chinook	0.5	0.6		0.4												0.5	0.6		1.6	
Salmon, unspecified	0.5															0.5				
Sanddab, longfin	0.7	0.7				0.7	0.7													
Sanddab, Pacific	1.3	1.6	2.1	1.3	1.8	1.7	2	1.3	0.8	1.5			1.3		1.5	0.9	1.2	3.3	3.2	11.1
Sanddab, speckled	0.4	0.7				0.2	0.7									0.5				
Sanddab, unspecified	4.4	3	0.5		0.4	3.7	0.7				6.7				0.5	2.7	5.3	1.3		
Sardine, Pacific	24.2	24.8	21.6	22.2	26.8	18.1	21.1	23.7	26.7	27.9	42.5	44.4	25.0	33.3	27.1	11.9	8.8	17.6	4.8	11.1
Saury, Pacific	0.8					0.2										1.4				
Scorpionfish, California	3.2	1.4	0.8		1.8	3.2	1.4	2.0		4.4					1.0					
Sculpin, pithead					0.4					1.5										
Sculpin, staghorn			0.3		0.4			0.7							0.5					
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														
Sole, curlfin	0.2					0.2														
Sole, English	0.6					0.2										0.9				
Sole, fantail	0.5					0.5														
Sole, sand	0.9	0.6														0.9				
Sole, Petrale																				
Sole, unspecified	0.8	3.7									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			0.4		0.2														
Surfperch, shiner		2		0.4			2		0.8											
Surfperch, unspecified	0.4					0.2			0.8							0.5				
Topsmelt	0.2	3.7	0.3			0.2						3.7	1.3							

Table 11. Percent frequency of bycatch in observed loads of California market squid by port, 2003-2007 (Page 3 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2003	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**
Thornyhead, unspecified	0.2					0.2														
Triggerfish																				
Turbot, curlfin	0.6					0.2										0.9				
Turbot, diamond	0.2					0.2														
Turbot, hornyhead	1	0.7	0.3		0.4	1	0.7			1.5								0.7		11.1
Turbot, unspecified	3.7	0.7	0.3				0.7									3.7		0.7		
Whitefish, ocean					0.4										**0.5**					
Total Percent Frequency Fish Incidents	**89.3**	**94.0**	**64.9**	**67.9**	**68.1**	**65.8**	**62.2**	**72.4**	**74.2**	**72.1**	**80.0**	**92.5**	**73.8**	**86.3**	**67.8**	**62.6**	**58.2**	**52.9**	**41.3**	**55.6**
Elasmobranchs																				
Guitarfish, shovelnose																				
Ray, bat	1.2	1.3	2.1	1.3	1.8	1.5	1.4	3.3	0.8		0.8		3.8	3.9	2.5	1.4				
Ray, Pacific electric		6.4	3.9	0.4													1.2	9.8	1.6	
Ray , thornback	0.5					0.5											6.4			
Ray, unspecified	0.2					0.2														
Shark, horn	0.7		0.3		0.7	0.5		0.7		1.5	0.8				0.5					
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	0.7	3.4				0.5	3.4				0.8									
Total Percent Frequency Elasmobranch Incidents	**3.5**	**11.1**	**6.5**	**2.1**	**2.5**	**3.4**	**4.8**	**3.9**	**0.8**	**1.5**	**2.4**	**0.0**	**3.8**	**3.9**	**3.0**	**1.4**	**7.6**	**10.5**	**3.2**	
Invertebrates and Plants																			3.2	
Algae, marine				0.9	0.4															11.1
Barnacle																				
Cnideria (Sea Anenomes)	3			0.4		0.5										5.5			1.6	
Crab shells	0.7					0.7														
Crab, box	0.2					0.2														
Crab, decorator	0.2					0.2														
Crab, Dungeness	5	1.2					0.7									5				

Table 11. Percent frequency of bycatch in observed loads of California market squid by port, 2003-2007 (Page 4 of 4).

Common Name	Total All Ports					San Pedro					Santa Barbara/Ventura					Monterey/Moss Landing				
	2003	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**	**2003**	**2004**	**2005**	**2006**	**2007**
Crab, elbow																	1.8			
Crab, hermit	0.2					0.2														
Crab, pelagic red																				
Crab, purple globe	0.5					0.5														
Crab, sheep	0.7		0.3		0.7	0.7		0.7							1.0					
Crab, slender					0.4										0.5					
Crab, swimming					0.4										0.5					
Crab, rock unspecified	0.5		0.3		1.1	0.5		0.7							1.5					
Eelgrass	1.5	5.4	0.8	0.9	0.7	1.5	5.4	2.0	1.7						0.5					
Gorgonians		0.7		0.4			0.7		0.8											
Invertebrates, colonial																				
Jellies	7.1	15.8	2.6	0.4		0.5							1.3			13.7		5.9	1.6	
Kelp	10.7	8.9	17.4	16.7	20.7	13.9	13.6	18.4	15.0	22.1	14.2	3.7	13.8	7.8	20.1	4.1	15.8	18.3	27.0	22.2
Lobster, California spiny			0.3		0.4			0.7							0.5					
Mussels																				
Octopus, unspecified	0.7					0.7											9.4			
Salps	0.2	2.7				0.2	2.7													
Sea cucumber	1.5				0.4	1.5									0.5					
Sea cucumber, warty					0.4					1.5										
Sea star	1.1	1.9	0.5	1.3	1.1	1	0.7	1.3	0.8	1.5	0.8	3.7			1.1	1.4			3.2	
Squid, market, egg cases	4.9	5.1	1.6	8.5	1.1	5.4	8.8		5.8		2.5	0		2.0	1.5	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														
Turkish towel																				
Turtle grass					0.7										0.5					11.1
Urchin, purple	0.7				0.4	0.7									0.5					
Total Percent Frequency Invert/Plant Incidents	**40.1**	**42.4**	**28.6**	**29.9**	**29.4**	**29.6**	**33.3**	**23.7**	**25.0**	**26.5**	**17.5**	**7.4**	**22.5**	**9.8**	**29.2**	**36.5**	**34.6**	**36.6**	**52.4**	**44.4**
Total All Incidents	**802**	**345**	**384**	**234**	**276**	**449**	**147**	**152**	**120**	**68**	**120**	**27**	**79**	**51**	**199**	**233**	**171**	**153**	**63**	**9**
Total Observed Landings	**395**	**160**	**178**	**136**	**114**	**192**	**86**	**100**	**73**	**61**	**117**	**32**	**42**	**37**	**51**	**86**	**42**	**36**	**26**	**2**

Table 12. Expanded salmonid bycatch in Pacific sardine fisheries in Oregon and Washington, 2000-2007.

	Chinook (live)	Chinook (dead)	Coho (live)	Coho (dead)	Pink (live)	Unid (live)	Unid (dead)	Total (live)	Total (dead)	Grand Total
2007										
Oregon								349	170	519
Washington[3/]	33	108	20	124				53	232	285
2006										
Oregon[1/]								164	93	257
Washington[3/]	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, 2007.

Species	2006 Logbook data	2007 Logbook data
Blue shark	3	0
Thresher shark	2	3 (2 of 3 released alive)
unknown shark	1	5
Salmonids	257 (55% alive; 45% dead)	519 (67% alive; 33% dead)
Mackerel	292,150 lb	473,441
Anchovy	1000 lb	500
Squid	150	0
Jelly fish	<100 lb	0

Table 14. Recorded incidental catch (mt) in Oregon sardine fishery, 2001-2007 (from fish ticket data).

	2001	2002	2003	2004	2005	2006	2007
Pacific mackerel	52.8	126.3	158.3	161.5	316.1	665	699.7
Jack mackerel	1.2	0.3	3.2	24.1	3.6	1.4	8
Pacific herring	-	3.3	-	10.3	0.1	1.2	-
Northern anchovy	-	0.2	-	1.0	68.4	8.6	-
American shad	-	0.3	-	1.2	-	0.44	-
Pacific hake	-	-	0.1	-	-	-	-
thresher shark	-	-	0.3	0.3	0.4	0.16	0.14
squid	-	-	-	13.9	-	-	-
jellyfish	-	-	-	5.5	-	-	-

Table 15. Species noted as encountered on CDFG Live Bait Logs, 1996-2007.

Year	Days Fished	Jack Mackerel	Pacific Mackerel	Barracuda	Herring	Grunion	Smelts (Atherinids)	Shiner Surfperch	White Croaker	Queenfish	Market Squid	Pacific Bonito
2007	970	2	245	22			2		1	1	7	12
2006	940	7	169	3								2
2005	1,045	49	188	27							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 1993-2007 from CDFG logs.

Year	Anchovy	Sardine	Year	Anchovy	Sardine
1939	1,364	0	1974	5,126	0
1940	1,820	0	1975	5,577	0
1941	1,435	0	1976	6,202	0
1942	234	0	1977	6,410	0
1943	World War II	World War II	1978	6,013	107
1944	World War II	World War II	1979	5,364	0
1945	World War II	World War II	1980	4,921	12
1946	2,493	0	1981	4,698	6
1947	2,589	0	1982	6,978	38
1948	3,379	0	1983	4,187	193
1949	2,542	0	1984	4,397	53
1950	3,469	0	1985	3,775	11
1951	4,665	0	1986	3,956	17
1952	6,178	0	1987	3,572	216
1953	5,798	0	1988	4,189	50
1954	6,066	0	1989	4,594	100
1955	5,557	0	1990	4,842	543
1956	5,744	0	1991	5,039	272
1957	3,729	0	1992	2,572	1,807
1958	3,843	0	1993	669	176
1959	4,297	0	1994	2,076	1,506
1960	4,225	0	1995	1,278	2,055
1961	5,364	0	1996	703	1,801
1962	5,595	0	1997	1,077	2,344
1963	4,030	0	1998	304	2,037
1964	4,709	0	1999	453	2,411
1965	5,645	0	2000	834	1,270
1966	6,144	0	2001	1,238	1,245
1967	4,898	0	2002	965	1,701
1968	6,644	0	2003	1,085	3,028
1969	4,891	0	2004	192	3,900
1970	5,543	0	2005	1,464	2,949
1971	5,794	0	2006	476	3,629
1972	5,307	0	2006	476	3,629
1973	5,639	0	2007	700	3,358

Table 17. Ratio of anchovy to sardine in reported live bait catch in California, 1994-2007. Values are in metric tons with the assumption that 1 scoop =12.5 lbs.

Year	Anchovy	Sardine	Total	Proportion Anchovy	Proportion Sardine
2007	700	3,358	4,058	0.17	0.83
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 1978-2007[1,2,3,4,5/]. Market squid are not commercially fished off Ensenada.

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	n/a
2006	41,441	n/a	n/a	n/a
2007	n/a	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-INP Ensenada (pers. comm.).
3/ 2005 data from Cota et al. (2006).
4/ Sardine landings for 1989 through 2006 provided by Dr. Manuel Nevarrez, CRIP-INP Guaymas (pers. comm.).
5/ 2007 landings data not yet available from CRIP-INP.

Table 19. Pacific sardine population numbers (millions), spawning and age 1+ biomasses (mt) at the beginning of each biological year, 1981-82 to 2007-08 (July-June) (Hill et al. 2007). Recruitment is defined as number at age-0. Age 1+ biomass as of July 2007 (bold) served as the basis for setting a HG for the U.S. fishery in calendar year 2008. Total landings (mt) include Ensenada to Canada.

Biological	---------- Population Numbers-at-age (millions) ----------									Spawning	Age 1+	Total
Year	0	1	2	3	4	5	6	7	8+	Biomass	Biomass	Landings
1981-82	22	15	3	1	0	0	0	1	1	1353	1404.48	62.94
1982-83	48	15	10	2	1	0	0	0	1	1,948	2,013	487
1983-84	99	32	9	5	1	0	0	0	1	2,859	2,891	372
1984-85	116	67	21	5	3	0	0	0	0	3,138	5,445	3,571
1985-86	147	78	35	5	0	0	0	0	0	5,881	6,420	1,838
1986-87	553	99	49	17	2	0	0	0	0	10,305	10,053	2,667
1987-88	977	370	61	25	7	1	0	0	0	22,315	22,622	5,887
1988-89	1,121	654	231	29	9	2	0	0	0	49,601	48,341	4,795
1989-90	1,122	751	429	138	16	5	1	0	0	75,769	84,604	15,322
1990-91	2,387	751	482	239	69	8	2	1	0	100,884	111,509	20,602
1991-92	3,821	1,598	479	270	123	35	4	1	0	137,650	158,755	35,022
1992-93	2,571	2,560	1,023	255	125	54	15	2	1	193,912	243,062	74,214
1993-94	7,363	1,686	1,280	471	134	73	33	10	2	257,332	272,461	31,540
1994-95	11,290	4,880	1,012	749	289	85	47	22	7	413,667	430,463	66,295
1995-96	4,381	7,431	2,815	580	457	184	55	31	19	655,038	702,406	62,677
1996-97	5,578	2,914	4,576	1,709	366	296	121	37	33	761,499	864,060	65,968
1997-98	11,436	3,711	1,790	2,761	1,075	237	195	80	46	743,771	917,855	131,380
1998-99	24,583	7,548	2,037	933	1,589	663	151	126	82	904,689	1,002,920	113,901
1999-00	5,201	16,299	4,377	1,162	568	1,009	430	99	137	1,368,780	1,495,910	119,258
2000-01	2,603	3,421	9,754	2,716	758	377	673	287	158	1,462,240	1,713,280	121,295
2001-02	9,672	1,688	1,939	5,884	1,739	495	247	442	292	1,251,100	1,548,940	125,612
2002-03	1,555	6,135	821	1,062	3,645	1,119	322	161	479	1,087,930	1,397,530	141,775
2003-04	16,469	998	3,080	445	647	2,314	718	207	412	913,186	1,137,720	106,551
2004-05	5,164	10,678	537	1,726	271	408	1,471	458	395	997,300	1,211,000	140,985
2005-06	5,277	3,385	6,078	301	1,044	170	258	933	542	972,299	1,219,480	153,541
2006-07	1,010	3,413	1,846	3,364	182	653	107	163	936	826,656	1,101,890	166,071
2007-08	3,677	608	1,424	909	1,972	113	413	68	700	566,222	**832,706**	n/a

Table 20. Annual U.S. Pacific sardine landings and HGs (metric tons) by state and management subarea, 1981-2008.

	California						Management Subarea[1,2] Landings			HGs 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	15,820.0	44,464.0	52,411.8	96,875.8	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	8,911.0	47,678.2	45,045.3	92,723.5	81,831.3	40,915.7	122,747.0
2005	30,252.6	7,940.1	0.0	38,192.7	45,109.7	6,714.0	38,192.7	51,823.7	90,016.4	90,786.0	45,393.0	136,179.0
2006	33,285.8	17,743.1	0.0	51,028.9	35,648.2	4,362.3	51,028.9	40,010.5	91,039.4	n/a	n/a	118,937.0
2007	54,713.8	34,517.0	0.0	89,230.8	42,052.3	4,662.6	89,230.8	46,714.9	135,945.7	n/a	n/a	152,564.0
2008	---	---	---	---	---	---	---	---	---	n/a	n/a	89,093.0

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 HG 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, 1981-2007. 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	96,875.8	1,044.0	141,369.2
2003	30,540.0	69,917.2	954.0	101,411.2
2004	44,382.0	92,723.5	4,258.8	141,387.6
2005	56,715.0	90,016.4	3,200.0	149,938.5
2006	41,441.0	91,039.4	1,558.0	129,692.5
2007	n/a	135,945.7	1,520.0	n/a

Table 22. RecFIN estimated recreational harvest of Pacific (chub) mackerel by state (type A+B1estimate in metric tons), 1980-2007.

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	0.00	0.33	196.37
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	286.28	0.07	0.00	286.35
2006	462.49	0.11	0.00	462.59
2007	237.68	0.92	0.00	238.60

Table 23. RecFIN estimated recreational harvest of Pacific (chub) mackerel by fishing mode (type A+B1 estimate in metric tons), 1980-2007. 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	60.7	73.3	196.4
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	224.8	20.1	41.4	286.4
2006	406.1	14.3	42.2	462.6
2007	186.2	18.2	34.2	238.6

Table 24. Pacific mackerel HGs and landings (mt) by July-June management season.

Season	Quota or HG[a]	Landings
1992-93	34,010	25,584
1993-94	23,147	10,787
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	8,436
2002-03	12,535	3,541
2003-04	10,652	5,972
2004-05	13,268	5,012
2005-06	17,419	4,572
2006-07	19,845	7,870
2007-08[b]	40,000	5,483

a/ California Quotas 1992-03 through 1998-99. PFMC HGs from 1999-00 onward.
b/ 2007-08 landings as of Feb, 2008 (CDFG wetfish tables).

Table 25. West coast landings (mt) and real[1] exvessel revenues (2007 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2007.

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
1981	15	$6,110	35,388	$14,742,026	17,778	$7,395,861	52,309	$6,626,399	23,510	$10,279,038
1982	2	$1,027	36,065	$13,862,109	19,617	$7,602,938	42,155	$4,131,444	16,308	$6,823,397
1983	1	$321	41,479	$14,743,278	9,829	$3,288,534	4,430	$765,677	1,824	$1,390,855
1984	1	$1,535	44,086	$14,654,639	9,154	$2,423,167	2,899	$734,678	564	$535,810
1985	6	$2,429	37,772	$11,277,244	6,876	$2,220,034	1,638	$409,946	10,276	$6,811,405
1986	388	$138,959	48,089	$13,081,267	4,777	$1,392,304	1,557	$394,142	21,278	$7,589,767
1987	439	$103,131	46,725	$10,908,219	8,020	$1,951,186	1,467	$505,672	19,984	$6,462,328
1988	1,188	$271,396	50,864	$12,996,047	5,068	$1,259,194	1,518	$659,938	37,316	$11,960,619
1989	837	$297,503	47,713	$10,753,466	10,745	$2,526,389	2,511	$1,063,429	40,974	$11,454,163
1990	1,664	$279,447	40,092	$7,855,914	3,254	$649,112	3,259	$916,756	28,447	$6,935,315
1991	7,587	$1,264,809	32,067	$7,565,225	1,712	$352,201	4,068	$922,536	37,389	$8,600,985
1992	18,056	$2,597,451	19,045	$5,549,568	1,526	$330,811	1,166	$309,885	13,112	$3,385,778
1993	15,347	$2,094,014	12,129	$2,042,166	1,950	$373,148	2,003	$647,611	42,830	$13,915,251
1994	11,644	$2,009,658	10,293	$1,905,650	2,906	$505,735	1,859	$730,128	55,383	$19,020,553
1995	40,256	$4,619,352	8,823	$1,493,873	1,877	$378,977	2,016	$478,777	70,252	$28,987,091
1996	32,553	$4,020,039	9,730	$1,680,132	2,437	$389,347	4,505	$893,406	80,561	$27,886,536
1997	43,290	$5,571,783	20,168	$3,489,805	1,533	$310,117	5,779	$1,018,294	70,329	$25,911,155
1998	43,312	$4,492,989	21,561	$3,150,313	1,777	$474,789	1,584	$304,134	2,895	$2,014,564
1999	60,476	$6,342,653	9,094	$1,336,646	1,557	$244,343	5,311	$1,172,852	92,101	$40,829,541
2000	67,982	$8,708,303	22,058	$3,509,001	1,451	$327,965	11,832	$1,729,407	118,903	$32,586,681
2001	75,801	$10,684,840	7,618	$1,408,372	3,839	$709,653	19,345	$1,674,715	86,203	$19,782,914
2002	96,897	$12,177,355	3,744	$602,884	1,026	$239,264	4,882	$715,690	72,895	$20,967,394
2003	71,923	$8,196,639	4,213	$741,121	231	$82,207	1,929	$384,604	45,056	$28,555,251
2004	89,339	$11,010,613	3,708	$628,362	1,160	$291,968	7,019	$895,303	40,068	$21,617,543
2005	86,464	$10,804,092	3,586	$613,664	294	$230,678	11,414	$1,193,904	55,755	$33,339,739
2006	86,608	$9,745,138	6,610	$931,614	1,174	$207,337	12,960	$1,370,650	49,180	$27,680,813
2007	127,760	$13,494,019	5,759	$882,627	646	$145,888	10,548	$1,194,495	49,439	$29,170,969

Source: PacFIN - 2005-2007 data extracted March 2008.

[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. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2007.

	Landings (mt)					Exvessel Revenues (2007 $)				
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		$18,694	$8,225	$1,324	$3,649
1982		29.9	0.1		0.1		$25,412	$248		*
1983		18.4	0.4	1.7	1.2		$17,529	$978	$1,259	$1,316
1984	0.3	27.2	0.2		<0.1	$466	$23,060	$728		*
1985		18.8	0.1		0.3		$31,433	$150		*
1986		9.4	0.1		<0.1		$10,121	$352		*
1987	<0.1	9.7	0.8	<0.1	2.7	$55	$12,564	$1,580	$18	$2,346
1988	0.1	17.4	<0.1	5.5	18.6	$87	$18,941	$1	$5,111	$11,082
1989	0.1	7.6	<0.1	93.5	2.1	$239	$9,710	$22	$361,348	$3,377
1990	0.2	7.7	0.1	18.4	1.2	$284	$8,466	$93	$60,973	$1,586
1991		11.3	0.1	399.9			$11,045	$112	$147,618	
1992	0.1	17.4	1.1	120.9	16.4	$245	$19,428	$1,324	$29,311	*
1993	0.4	16.3	3.2	3.7	0.2	$718	$17,939	$3,548	$1,407	*
1994	2.0	20.8	4.9	27.9	0.8	$1,159	$18,056	$3,397	$12,839	$287
1995	5.3	31.2	0.5	38.2	0.8	$5,325	$22,591	$569	$26,434	*
1996	1.2	26.0		144.6	1.8	$1,421	$19,794		$86,058	$585
1997	2.7	15.7	<0.1	13.0	2.6	$3,716	$12,562	$3	$7,447	$902
1998	215.3	52.3		2.3	2.2	$24,965	$10,773		$1,265	$1,897
1999	592.3	15.3	0.1	1.9	4.1	$73,175	$5,580	$153	$813	*
2000	19.2	1.7	0.2	4.3	34.8	$8,771	$2,560	$272	$2,074	*
2001	0.2	2.8	0.1	1.5	11.0	$116	$2,966	$129	$867	$5,401
2002	90.5	0.5	0.1	5.2		$68,305	$1,030	$130	$3,557	
2003	28.1	0.9	2.5	13.6		$24,337	$1,095	$3,594	$9,115	
2004	44.4	0.2			14.2	$28,883	$290			$7,006
2005	21.5	1.0		18.2		$13,604	$913		$11,050	
2006	17.6	0.5		26.1	1.4	$10,602	$640		$15,475	$824
2007	<0.1	0.4	<0.1	<0.1	<0.1	$75	$416	$6	$47	*
					Orange/LA					
1981	14.7	29,084.7	14,699.9	38,216.3	8,290.6	$6,094	$12,209,807	$6,108,116	$4,721,983	$1,947,835
1982	1.8	29,827.6	18,131.1	32,514.7	4,292.8	$945	$11,432,983	$7,044,119	$2,908,297	$1,101,706
1983	0.6	33,902.3	6,785.8	900.2	853.6	$296	$12,422,637	$2,529,190	$187,359	$597,825
1984	0.5	35,572.8	3,566.3	204.8	66.3	$600	$12,792,070	$1,246,071	$144,553	$64,042
1985	3.4	32,012.6	5,860.1	43.1	3,095.9	$1,400	$9,865,066	$1,880,039	$30,147	$1,751,053
1986	286.6	41,071.7	4,289.0	140.8	8,121.8	$101,583	$11,315,632	$1,204,992	$36,980	$3,094,811
1987	317.3	39,863.3	7,801.2	108.8	5,421.5	$76,452	$9,390,667	$1,892,602	$32,819	$1,817,042
1988	1,172.1	47,656.6	4,939.1	92.9	15,173.7	$265,417	$12,089,891	$1,209,621	$27,321	$4,931,771
1989	505.0	41,717.5	10,703.7	479.0	16,434.2	$88,875	$9,860,225	$2,476,647	$77,824	$4,355,443
1990	1,179.4	37,123.6	2,968.0	193.2	9,797.9	$187,942	$7,308,303	$577,779	$42,643	$2,011,589
1991	6,415.1	31,602.9	1,640.2	414.3	12,305.3	$1,080,959	$7,447,798	$324,085	$68,978	$2,284,857
1992	13,950.8	18,071.7	1,095.7	136.6	1,700.5	$1,908,719	$5,389,593	$301,344	$37,038	$360,282
1993	13,977.6	11,714.9	1,268.9	118.7	12,889.7	$1,904,473	$1,983,886	$239,445	$23,143	$3,658,093
1994	9,031.7	9,842.3	2,459.8	136.6	11,231.1	$1,248,816	$1,808,709	$360,472	$21,877	$3,167,688
1995	34,137.0	7,864.0	1,596.2	297.8	18,413.1	$3,892,894	$1,337,319	$252,089	$36,875	$6,696,430
1996	23,922.6	8,764.9	2,054.0	239.1	14,993.9	$2,778,538	$1,447,249	$350,863	$31,528	$5,597,436
1997	26,533.7	14,002.6	822.6	1,120.8	17,779.1	$3,186,372	$2,772,151	$226,197	$119,781	$7,322,383
1998	31,702.3	18,149.6	1,012.4	338.1	227.5	$3,551,799	$2,853,668	$396,416	$45,991	$162,314
1999	39,084.2	8,551.1	927.4	1,418.2	27,684.1	$4,291,782	$1,267,404	$226,453	$266,608	$11,175,201
2000	39,104.1	21,646.1	1,209.5	1,280.1	44,839.9	$5,006,825	$3,462,794	$270,214	$175,905	$13,587,467
2001	40,763.6	6,676.6	3,623.8	3,657.7	39,170.6	$5,230,779	$1,245,459	$656,052	$376,368	$9,920,068
2002	39,308.0	3,367.8	1,003.5	1,205.7	28,136.9	$4,396,963	$559,904	$232,178	$116,671	$7,378,260
2003	22,882.7	3,941.3	133.4	205.5	7,758.8	$2,064,356	$699,108	$57,719	$34,471	$5,008,289
2004	23,677.4	3,018.3	1,027.1	147.2	10,504.3	$2,466,672	$545,672	$271,711	$39,890	$5,295,641
2005	24,119.0	3,145.8	166.6	1,992.4	31,846.0	$2,485,676	$553,136	$51,968	$203,284	$19,792,077
2006	26,782.2	5,713.6	1,025.8	878.4	37,107.1	$3,342,987	$834,533	$172,938	$84,753	$20,941,086
2007	42,984.0	4,885.0	446.8	927.8	13,344.7	$4,727,041	$768,916	$104,518	$83,363	$8,114,112

Table 26. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2007.

	Landings (mt)					Exvessel Revenues (2007 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
					Ventura/Santa Barbara					
1981	<0.1	4,872.1	2,846.6	9,034.5	2,389.7	$15	$2,032,603	$1,181,815	$1,130,897	$434,718
1982		4,095.4	1,195.0	6,440.7	1,403.2		$1,666,320	$445,945	$665,084	$283,728
1983	<0.1	3,905.0	559.1	2,727.1	3.2	$2	$1,301,792	$168,209	$287,297	$3,808
1984		1,263.2	52.1	141.0	7.1		$404,950	$17,856	$79,757	$14,928
1985		2,950.7	787.1	109.8	2,959.4		$784,843	$238,337	$52,790	$1,305,290
1986	17.5	5,004.5	296.9	160.9	6,411.8	$5,050	$1,340,574	$87,688	$71,223	$1,791,671
1987	74.3	5,877.7	8.0	140.2	8,406.6	$17,956	$1,308,804	$2,685	$60,866	$2,474,169
1988	13.2	3,119.6	6.5	154.3	16,334.4	$4,647	$846,977	$1,774	$74,099	$4,882,932
1989	93.3	5,907.6		160.9	16,861.9	$16,298	$847,482		$79,542	$4,558,043
1990	236.1	420.9	75.7	140.9	10,600.5	$31,195	$60,820	$10,006	$65,961	$2,818,292
1991	186.4	138.1	8.6	189.9	16,904.8	$30,321	$21,518	$1,349	$83,610	$3,505,678
1992	973.4	92.2	<0.1	89.8	2,809.2	$96,331	$10,583	$3	$39,632	$618,672
1993	691.7	34.5	<0.1	298.1	17,367.2	$69,890	$4,904	$11	$113,734	$4,956,711
1994	315.0	39.5	47.5	340.8	21,333.6	$30,589	$10,614	$4,270	$185,331	$6,805,949
1995	354.5	249.1	0.4	346.3	41,184.3	$51,855	$30,867	$244	$185,244	$18,147,466
1996	461.1	66.8	11.1	374.5	46,435.3	$49,318	$38,269	$2,011	$190,548	$15,533,103
1997	3,357.3	1,160.3	7.4	510.4	34,610.6	$294,682	$129,646	$3,208	$113,464	$11,673,726
1998	899.3	1,305.7		239.1	2,175.6	$112,928	$85,121		$98,082	$1,541,017
1999	2,545.1	215.0	<0.1	2,233.2	52,718.7	$297,437	$44,022	$10	$394,612	$24,574,715
2000	3,072.2	230.0	9.1	3,548.3	48,747.0	$356,673	$25,724	$1,043	$468,523	$11,956,093
2001	3,956.7	72.4	<0.1	3,909.3	31,876.3	$431,392	$7,757	$35	$526,481	$6,185,211
2002	5,064.5	<0.1	<0.1	732.2	11,814.1	$715,885	$16	$2	$208,595	$3,587,928
2003	2,365.9	39.3	<0.1	625.4	13,199.8	$244,598	$4,853	$28	$157,969	$8,398,007
2004	4,711.0	67.4	<0.1	2,722.2	15,397.0	$471,304	$8,723	$9	$447,158	$8,491,261
2005	1,885.7	96.0	44.3	2,948.5	13,639.5	$185,693	$17,140	$2,823	$520,369	$7,813,457
2006	1,928.9	126.6		4,167.0	6,003.5	$184,916	$8,730		$639,678	$3,390,339
2007	3,157.3	5.3	13.4	1,740.7	17,796.3	$298,604	$760	$2,413	$214,583	$10,436,444
					San Luis Obispo					
1981		1.0	<0.1	17.2	0.1		$1,002	$17	$13,007	$154
1982		2.5	<0.1		0.3		$2,268	$10		$458
1983		0.7			0.2		$589			$238
1984		5.0			0.1		$3,446			$137
1985	0.3	19.5	0.1	47.5	0.3	$107	$5,187	$60	$26,812	$458
1986		0.6	<0.1	11.3	0.1		$389	$26	$5,218	$142
1987		0.8		2.4	0.4		$749		$1,025	$424
1988	<0.1	0.2			0.1	$1	$329			$111
1989		1.2	<0.1	0.2	19.2		$914	$4	$48	$6,599
1990	121.1	1.9	16.5		0.1	$15,973	$1,240	$2,155		$79
1991		1.0	<0.1		<0.1		$669	$12		*
1992		0.4	<0.1		0.2		$339	$75		$138
1993		0.1	<0.1	1.1	2,035.9		$59	$17	$678	$1,090,971
1994	0.1	0.2	<0.1	0.8	1,343.6	$29	$121	$5	$477	$775,145
1995		<0.1	<0.1		182.5		$20	$4		$51,936
1996		<0.1			216.8		*			$78,736
1997	<0.1	<0.1		22.6	<0.1	$24	$3		$11,736	$15
1998	<0.1	0.3	<0.1		<0.1	$40	$185	$50		*
1999		<0.1		2.0	16.7		*		*	$5,678
2000		<0.1	<0.1		<0.1		*	*		*
2001		<0.1		3.5	79.4		$21		$1,784	*
2002	101.9				356.2	*				$87,274
2003		<0.1	<0.1	3.2	650.2		*	*	*	$401,858
2004		<0.1			905.7		*			$486,068
2005					40.0					*
2006	0.1					*				
2007		<0.1			0.1		*			$82

Table 26. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2007.

	Landings (mt)					Exvessel Revenues (2007 $)				
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		$452,331	$91,471	$547,849	$7,890,548
1982	<0.1	2,053.4	280.3	2,609.1	10,607.3	$82	$707,633	$106,792	$268,346	$5,433,729
1983	<0.1	3,449.2	2,457.2	320.8	500.0	$23	$923,101	$563,679	$78,506	$406,223
1984	0.3	7,151.1	5,486.0	1,894.7	390.9	$470	$1,395,949	$1,142,919	$200,981	$358,149
1985	2.2	2,704.4	228.1	1,138.2	3,813.1	$922	$556,206	$101,201	$155,716	$3,385,848
1986	84.5	1,987.9	191.1	808.2	5,487.9	$32,325	$402,899	$99,143	$84,809	$2,229,027
1987	47.6	956.7	209.7	676.3	5,611.0	$8,543	$185,018	$53,703	$126,658	$1,985,951
1988	3.0	59.0	121.5	696.3	4,896.7	$1,210	$29,504	$47,275	$292,949	$1,824,600
1989	238.0	60.0	37.2	928.7	7,145.5	$191,789	$18,586	$44,997	$199,519	$2,399,644
1990	127.1	2,495.7	192.4	2,131.5	7,917.5	$43,865	$447,091	$57,999	$456,202	$2,058,097
1991	985.9	298.0	43.6	2,526.8	6,703.2	$153,529	$73,725	$22,985	$407,487	$2,317,612
1992	3,093.2	374.9	109.8	608.2	6,111.3	$583,716	$105,632	$25,587	$108,503	$1,744,330
1993	676.1	38.1	345.1	1,285.0	6,039.6	$118,063	$17,628	$115,755	$320,876	$2,702,152
1994	2,289.4	38.4	191.2	985.8	13,648.1	$726,376	$23,410	$126,606	$328,130	$5,961,970
1995	5,678.1	460.7	109.1	1,110.5	2,449.1	$655,812	$81,784	$100,648	$118,670	$1,063,998
1996	7,987.9	703.0	91.0	3,553.9	4,672.0	$1,132,338	$117,110	$16,810	$471,771	$1,755,021
1997	13,356.7	3,208.2	327.2	3,895.1	8,282.9	$1,997,777	$540,563	$77,692	$699,285	$3,667,267
1998	10,009.0	1,456.7	32.5	901.2		$759,967	$176,097	$13,702	$83,689	
1999	16,417.2	2.7	24.2	1,511.3	301.3	$1,461,672	$12,222	$2,136	$410,761	$97,402
2000	11,367.0	39.4	50.0	6,804.3	7,125.4	$1,159,188	$7,618	$32,236	$949,466	$2,293,911
2001	7,102.5	172.2		11,660.3	7,746.6	$1,675,384	$22,102		$664,884	$2,072,047
2002	13,607.4	0.1	1.8	2,689.5	25,084.8	$1,489,934	$83	$445	$292,900	$7,803,280
2003	7,907.3	1.0	19.8	705.7	13,921.4	$750,421	$4,744	$2,775	$92,198	$8,909,739
2004	15,443.8	489.9	<0.1	3,890.8	5,542.5	$1,307,762	$57,586	$5	$317,714	$3,117,437
2005	8,200.3	0.4	0.5	6,192.2	1,916.3	$607,778	$765	$318	$405,790	$1,044,148
2006	17,711.0	31.1	140.7	7,634.5	509.3	$1,686,641	$9,358	$30,932	$579,326	$260,925
2007	34,756.1	123.4	166.8	7,704.4	32.3	$3,236,875	$18,926	$36,236	$855,251	$7,659
San Francisco										
1981	<0.1	<0.1	1.9	203.9	<0.1	$1	$54	$1,724	$95,259	*
1982		4.2	0.2	394.6	2.3		$2,528	$305	$202,812	*
1983		13.3	1.2	332.3	461.5		$5,550	$383	$138,375	$376,765
1984		13.8	0.3	537.7	97.0		$9,535	$166	$243,243	$95,725
1985		14.6	<0.1	258.8	77.0		$9,652	$44	$112,604	$58,391
1986		12.0		392.7	831.9		$9,328		$154,342	$364,459
1987	0.3	6.3	0.5	424.4	342.8	$105	$6,150	$615	$172,285	$131,843
1988	<0.1	6.2	0.4	492.3	299.2	$2	$5,882	$455	$193,783	$107,738
1989	<0.1	9.0	4.3	755.3	3.4	$18	$8,235	$4,654	$247,748	$2,215
1990	<0.1	13.8	1.6	714.0	128.8	$42	$10,348	$1,070	$224,669	$45,156
1991		2.7	0.2	459.2	1,471.4		$2,120	$99	$153,095	$490,667
1992	34.5	11.5	1.4	164.4	2,447.9	$8,421	$13,158	$484	$47,652	$649,339
1993		1.2	0.3	243.9	1,017.8		$1,345	$280	$147,647	$509,609
1994	0.8	1.7	0.4	279.6	2,235.6	$761	$2,034	$619	$110,211	$849,131
1995	1.6	0.6	0.2	93.2	746.8	$626	$698	$307	$11,364	$282,173
1996		4.4	0.8	105.1	332.9		$3,061	$723	$31,689	*
1997	3.1	3.7	0.2	155.7	204.5	$1,622	$2,962	$448	$13,350	$86,860
1998	463.5	3.8	1.2	0.5	14.1	$38,605	$4,358	$1,011	$25	$19,229
1999	1,057.9	0.9	<0.1	46.8	5.4	$111,217	$703	$35	$17,912	*
2000	0.5	<0.1	0.4	116.5	<0.1	$250	$24	$812	$75,880	*
2001	<0.1	0.6		42.3	279.9	$110	$1,938		$15,691	$86,508
2002	171.8	<0.1		17.2	864.6	$36,685	$2		$10,867	$246,538
2003	0.1	<0.1	<0.1		2,807.7	$567	$162	$25		$1,740,471
2004	370.1	0.1	<0.1	<0.1	164.5	$37,580	$130	$7	$30	$99,139
2005	309.0	<0.1	<0.1	<0.1	0.6	$28,875	$25	$4	$31	*
2006	130.9	0.7	0.2	70.5	<0.1	$9,391	$853	$335	$4,786	*
2007	2.0	<0.1	<0.1	0.5	16.7	$129	$54	$16	$1,253	*

Table 26. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2007.

	Landings (mt)					Exvessel Revenues (2007 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
Northern California										
1981		1.9	<0.1		2.1		$1,019	$17		$2,019
1982		3.0	1.1		1.7		$1,055	$552		$1,735
1983		2.9	0.1		<0.1		$1,466	$31		$60
1984		0.1	<0.1	0.5	0.1		$77	$2	$1,062	*
1985					<0.1					*
1986		<0.1			<0.1		*			*
1987		<0.1	<0.1		0.1		$17	$3		*
1988			<0.1		1.0			*		*
1989		0.1	<0.1		0.6		$49	$2		*
1990		0.4			0.8		$256			*
1991		0.1			1.3		$63			*
1992		0.4	1.0	0.7	0.5		$467	$628	$142	$1,533
1993		0.2	55.4	0.1	<0.1		$153	$10,442	$69	*
1994	4.9	0.3	0.1	8.4	37.6	$1,928	$210	$88	$3,801	$13,891
1995	1.5	0.1	0.1		1.8	*	*	*		*
1996	0.3	3.1				$149	$2,184			
1997		5.7	2.2		3.4		$3,940	$1,529		$2,475
1998	20.9	9.2	6.2		<0.1	$3,639	$4,093	$4,974		*
1999		2.9	<0.1		<0.1		$944	$17		*
2000		1.7	0.1		0.5		$401	$107		*
2001	0.1			2.3	0.1	$46			$7,411	$97
2002		0.2	0.1		3.9		$548	$41		*
2003	13.5		<0.1			*		*		
2004	23.6	<0.1	<0.1		<0.1	$11,355	$80	$4		*
2005		<0.1	<0.1				*	*		
2006		<0.1	<0.1		1.9		$2	$13		*
2007										
Oregon										
1981		<0.1					$3			
1982		<0.1		0.1			$79		$190	
1983		8.3					$14,320			
1984		3.0					$1,430			
1985		<0.1	<0.1	<0.1			$3	$2	$67	
1986		<0.1					*			
1987		1.5					$851			
1988		0.6		<0.1			$543		$2	
1989		4.7		<0.1			$1,707		$23	
1990		10.3					$5,276			
1991		0.5	19.3				$241	$3,435		
1992	3.9	462.3	316.5				$214	$1,105		
1993	0.2	279.9	276.6				$1,162	$3,604		
1994		252.2	202.3	0.9			$12,744	$10,270	$265	
1995		189.5	148.6	0.2			$4,626	$9,337	$630	
1996		61.4	257.7				$4,878	$9,780		
1997		1,611.0	373.0				$2,871	$942		
1998	1.0	537.7	686.0			$962	$10,715	$54,280		
1999	775.5	259.1	496.1			$104,999	$1,233	$5,678		
2000	9,527.9	119.1	160.8	0.1		$1,374,227	$7,313	$20,615	$359	
2001	12,780.4	322.0	183.1			$1,891,027	$37,436	$46,958		
2002	22,711.0	126.6	8.9	3.1		$3,236,838	$7,423	$4,395	$2,040	
2003	25,257.9	160.0	73.6	39.1		$3,308,267	$20,963	$17,898	$3,500	
2004	36,111.0	106.9	125.8	13.1		$5,322,313	$12,289	$18,473	$5,063	
2005	45,110.1	317.8	69.6	68.4	14.5	$6,566,556	$37,679	$171,875	$1,669	$7,830
2006	35,668.1	665.0	5.3	8.6	27.2	$4,048,891	$62,885	$2,664	$19	$16,382
2007	42,143.9	702.3	13.5	5.0	0.6	$4,740,408	$82,608	$1,493	$2,220	$336

Table 26. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2007.

	Landings (mt)					Exvessel Revenues (2007 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
					Washington					
1981				1.3					$598	
1982				5.1					*	
1983				2.9					*	
1984		0.1		10.1			*		*	
1985				11.7					*	
1986				22.1					*	
1987				77.6					*	
1988				40.4					$51,609	
1989		0.2		61.8			$76		$82,460	
1990		0.1		50.3			$228		$61,286	
1991		0.2		54.5			$56		$52,807	
1992		5.9		41.7			$3,835		$45,662	
1993		30.2		19.9			$5,637		$14,711	
1994		33.3		38.5			$3,898		$36,053	
1995		7.5		118.3			$1,061		$84,907	
1996		65.3	2.8	85.6			$25,376	$874	$80,855	
1997		152.5	0.7	59.1			$21,095	$100	$52,214	
1998		45.9	38.5	102.5			$5,098	$4,357	$75,083	
1999	1.4	46.8	108.4	97.8		$2,017	$4,478	$9,290	$81,049	
2000	4,841.9	19.1	20.3	78.7		$793,678	$2,335	$2,663	$57,115	
2001	11,127.2	370.6	32.1	68.0		$1,447,851	$90,254	$6,367	$81,228	
2002	15,832.5	248.2	11.5	228.7		$2,223,765	$33,788	$2,065	$81,059	
2003	11,920.2	53.8	1.8	213.8		$1,653,414	$8,098	$133	$74,174	
2004	8,934.3	22.2	7.1	213.4		$1,360,630	$2,545	$1,744	$69,847	
2005	6,721.1	23.6	10.8	163.7		$900,571	$3,799	$2,904	$37,860	
2006	4,363.1	41.2	1.8	161.1		*	*	*	*	
2007	4,664.9	38.2	1.3	153.0		$489,635	$9,805	$228	$35,883	
					Other Unknown					
1981		55.9	6.3	217.1	0.2		$26,514	$4,476	$115,482	$100
1982		48.5	9.5	190.9	0.4		$23,830	$4,967	$68,624	$987
1983		179.1	25.5	144.7	3.9		$56,294	$26,065	$63,018	$4,621
1984		49.7	49.3	110.1	2.7		$23,971	$15,426	$47,371	$2,637
1985		51.8	0.2	28.5	330.3		$24,856	$201	$11,485	$310,097
1986		3.1	0.1	21.4	424.1		$2,289	$104	$8,252	$109,617
1987	<0.1	9.0		37.6	199.2	$21	$3,400		$16,030	$50,489
1988	0.1	4.0	<0.1	36.6	592.1	$32	$3,979	$66	$15,063	$201,376
1989	0.2	4.9	0.1	31.7	506.8	$284	$6,483	$62	$14,917	$128,283
1990	0.3	17.3	<0.1	10.5	0.3	$146	$13,887	$10	$5,022	$305
1991		11.8	0.1	23.8	2.6		$7,988	$126	$8,940	$1,542
1992	<0.1	8.1	0.3	3.3	26.5	$18	$6,320	$261	$1,946	$6,482
1993	0.7	13.4	<0.1	32.1	3,479.5	$869	$9,453	$46	$25,347	$997,656
1994		64.6	<0.1	40.2	5,553.0		$25,854	$7	$31,144	$1,446,492
1995	77.5	20.2	21.9	11.4	7,273.2	$11,736	$14,868	$15,738	$14,653	$2,743,733
1996	180.3	35.2	19.6	2.2	13,908.6	$58,274	$22,206	$8,287	$957	$4,783,866
1997	36.1	8.2		2.4	9,445.5	$87,590	$4,012		$1,016	$3,157,526
1998	0.9	0.3			475.0	$85	$205			$290,054
1999	3.0	0.2	0.8	0.1	11,370.7	$354	$26	$571	$8	$4,968,874
2000	49.0	0.6	<0.1	<0.1	18,154.9	$8,691	$229	$2	$87	$4,735,870
2001	70.4	0.5	0.1		7,038.8	$8,135	$438	$112		$1,495,365
2002										
2003										
2004										
2005	97.4	1.1	1.9	30.7	8,297.7	$15,340	$207	$764	$13,851	$4,658,727
2006	6.3	30.9		14.2	5,530.1	$1,577	$751		$8,015	$3,071,021
2007	51.6	4.0	4.6	16.9	18,247.9	$1,253	$1,129	$978	$1,896	$10,601,587

Source: PacFIN - 2005-2007 data extracted March 2008.

[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.

*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 ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2007.

Year	Pacific Sardine $/lb	Pacific Mackerel $/lb	Jack Mackerel $/lb	Anchovy $/lb	Squid $/lb
1981	$0.18	$0.19	$0.19	$0.06	$0.20
1982	$0.23	$0.17	$0.18	$0.04	$0.19
1983	$0.15	$0.16	$0.15	$0.08	$0.35
1984	$0.70	$0.15	$0.12	$0.11	$0.43
1985	$0.18	$0.14	$0.15	$0.11	$0.30
1986	$0.16	$0.12	$0.13	$0.11	$0.16
1987	$0.11	$0.11	$0.11	$0.16	$0.15
1988	$0.10	$0.12	$0.11	$0.20	$0.15
1989	$0.16	$0.10	$0.11	$0.19	$0.13
1990	$0.08	$0.09	$0.09	$0.13	$0.11
1991	$0.08	$0.11	$0.09	$0.10	$0.10
1992	$0.07	$0.13	$0.10	$0.12	$0.12
1993	$0.06	$0.08	$0.09	$0.15	$0.15
1994	$0.08	$0.08	$0.08	$0.18	$0.16
1995	$0.05	$0.08	$0.09	$0.11	$0.19
1996	$0.06	$0.08	$0.07	$0.09	$0.16
1997	$0.06	$0.08	$0.09	$0.08	$0.17
1998	$0.05	$0.07	$0.12	$0.09	$0.32
1999	$0.05	$0.07	$0.07	$0.10	$0.20
2000	$0.06	$0.07	$0.10	$0.07	$0.12
2001	$0.06	$0.08	$0.08	$0.04	$0.10
2002	$0.06	$0.07	$0.11	$0.07	$0.13
2003	$0.05	$0.08	$0.16	$0.09	$0.29
2004	$0.06	$0.08	$0.11	$0.06	$0.24
2005	$0.06	$0.08	$0.36	$0.05	$0.27
2006	$0.05	$0.06	$0.08	$0.05	$0.26
2007	$0.05	$0.07	$0.10	$0.05	$0.27

Source: PacFIN - 2005-2007 data extracted March 2008.

[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 28. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-07.

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	$6,110	35,388	$14,742,024	17,778	$7,395,861	52,308	$6,625,801	23,510	$10,279,038
1982	2	$1,027	36,065	$13,862,030	19,617	$7,602,938	42,150	$4,113,163	16,308	$6,823,397
1983	1	$321	41,471	$14,728,958	9,829	$3,288,534	4,427	$755,815	1,824	$1,390,855
1984	1	$1,535	44,083	$14,653,058	9,154	$2,423,167	2,889	$716,967	564	$535,810
1985	6	$2,429	37,772	$11,277,241	6,876	$2,220,032	1,626	$389,553	10,276	$6,811,405
1986	388	$138,959	48,089	$13,081,265	4,777	$1,392,304	1,535	$360,825	21,278	$7,589,767
1987	439	$103,131	46,724	$10,907,368	8,020	$1,951,186	1,390	$409,701	19,984	$6,462,328
1988	1,188	$271,396	50,863	$12,995,504	5,068	$1,259,194	1,478	$608,326	37,316	$11,960,619
1989	837	$297,503	47,708	$10,751,683	10,745	$2,526,389	2,449	$980,946	40,974	$11,454,163
1990	1,664	$279,447	40,081	$7,850,396	3,254	$649,112	3,208	$855,471	28,447	$6,935,315
1991	7,587	$1,264,809	32,066	$7,564,927	1,693	$348,767	4,014	$869,728	37,389	$8,600,985
1992	18,052	$2,597,451	18,577	$5,545,518	1,209	$329,705	1,124	$264,223	13,112	$3,385,778
1993	15,346	$2,094,014	11,819	$2,035,367	1,673	$369,543	1,959	$610,929	42,830	$13,915,251
1994	11,644	$2,009,658	10,008	$1,889,007	2,704	$495,465	1,789	$666,045	55,383	$19,020,553
1995	40,256	$4,619,352	8,626	$1,488,186	1,728	$369,640	1,886	$378,669	70,252	$28,987,091
1996	32,553	$4,020,039	9,603	$1,649,878	2,177	$378,694	4,419	$812,550	80,561	$27,886,536
1997	43,290	$5,571,783	18,401	$3,465,175	1,160	$309,076	5,720	$966,080	70,329	$25,911,155
1998	43,311	$4,492,027	20,978	$3,134,494	1,052	$416,153	1,481	$229,051	2,895	$2,014,564
1999	59,700	$6,235,638	8,788	$1,330,936	952	$229,375	5,214	$1,091,803	92,101	$40,829,541
2000	53,612	$6,540,398	21,920	$3,499,353	1,269	$304,687	11,753	$1,671,934	118,903	$32,586,681
2001	51,893	$7,345,962	6,925	$1,280,666	3,624	$656,328	19,277	$1,593,487	86,203	$19,782,914
2002	58,353	$6,716,752	3,369	$561,672	1,005	$232,803	4,650	$632,591	72,895	$20,967,394
2003	34,745	$3,234,958	3,999	$712,060	156	$64,175	1,676	$306,931	45,056	$28,555,251
2004	44,293	$4,327,670	3,579	$613,528	1,027	$271,752	6,793	$820,394	40,068	$21,617,543
2005	34,633	$3,336,965	3,244	$572,186	213	$55,898	11,182	$1,154,374	55,740	$33,331,908
2006	46,577	$5,236,233	5,904	$854,868	1,167	$204,218	12,791	$1,332,035	49,153	$27,664,432
2007	80,951	$8,263,976	5,018	$790,214	632	$144,167	10,390	$1,156,392	49,438	$29,170,633

Table 28. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-07.

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			<0.1	$3						
1982			<0.1	$79			0.1	$190		
1983			8	$14,320						
1984			3	$1,430						
1985			<0.1	$3	<0.1	$2	<0.1	$67		
1986			<0.1	*						
1987			2	$851						
1988			1	$543			<0.1	$2		
1989			5	$1,707			<0.1	$23		
1990			10	$5,276						
1991			1	$241	19	$3,435				
1992			462	$214	317	$1,105				
1993			280	$1,162	277	$3,604				
1994			252	$12,744	202	$10,270	0.9	$265		
1995			190	$4,626	149	$9,337	0.2	$630		
1996			61	$4,878	258	$9,780				
1997			1,611	$2,871	373	$942				
1998	1	$962	538	$10,715	686	$54,280				
1999	776	$104,999	259	$1,233	496	$5,678				
2000	9,528	$1,374,227	119	$7,313	161	$20,615	0.1	$359		
2001	12,780	$1,891,027	322	$37,436	183	$46,958				
2002	22,711	$3,236,838	127	$7,423	9	$4,395	3.1	$2,040		
2003	25,258	$3,308,267	160	$20,963	74	$17,898	39.1	$3,500		
2004	36,111	$5,322,313	107	$12,289	126	$18,473	13.1	$5,063		
2005	45,110	$6,566,556	318	$37,679	70	$171,875	68.4	$1,669	15	$7,830
2006	35,668	$4,048,891	665	$62,885	5	$2,664	8.6	$19	27	$16,382
2007	42,144	$4,740,408	702	$82,608	14	$1,493	5.0	$2,220	1	$336

Table 28. West coast landings (mt) and real[1] exvessel revenues ($ 2007) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-07.

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	$598		
1982							5	*		
1983							3	*		
1984			<1	*			10	*		
1985							12	*		
1986							22	*		
1987							78	*		
1988							40	$51,609		
1989			<1	$76			62	$82,460		
1990			<1	$228			50	$61,286		
1991			<1	$56			55	$52,807		
1992			6	$3,835			42	$45,662		
1993			30	$5,637			20	$14,711		
1994			33	$3,898			39	$36,053		
1995			8	$1,061			118	$84,907		
1996			65	$25,376	3	$874	86	$80,855		
1997			153	$21,095	1	$100	59	$52,214		
1998			46	$5,098	39	$4,357	103	$75,083		
1999	1	$2,017	47	$4,478	108	$9,290	98	$81,049		
2000	4,842	$793,678	19	$2,335	20	$2,663	79	$57,115		
2001	11,127	$1,447,851	371	$90,254	32	$6,367	68	$81,228		
2002	15,833	$2,223,765	248	$33,788	12	$2,065	229	$81,059		
2003	11,920	$1,653,414	54	$8,098	2	$133	214	$74,174		
2004	8,934	$1,360,630	22	$2,545	7	$1,744	213	$69,847		
2005	6,721	$900,571	24	$3,799	11	$2,904	164	$37,860		
2006	4,363	*	41	*	2	*	161	*		
2007	4,665	$489,635	38	$9,805	1	$228	153	$35,883		

Source: PacFIN - 2005-2007 data extracted March 2008.

[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.

*Exvessel revenue not reported because less than three vessels or less than three processors accounted for total landings.

Table 29. West coast CPS landings (mt) and real[1] exvessel revenues ($ 2007) by gear group, 1981-2007.

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	154,875	2,504	11	106	9	<1	
2006	154,731	1,582	97	33	84	<1	
2007	193,075	835	47	15	88	<1	65
	Revenues (2007 $)						
1981	$37,218,393	$1,695,071	$302	$7,849	$9,688	$58,240	
1982	$31,436,664	$864,863	$4,087	$7,932	$16,780	$46,689	
1983	$19,761,589	$352,185	$1,700	$4,997	$2,417	$24,360	$12,917
1984	$18,105,610	$61,451	$3,124	$3,443	$1,655	$86,183	
1985	$19,876,334	$534,959	$1,201	$15,736	$6,687	$226,447	$1,426
1986	$22,427,801	$44,661	$1,723	$3,046	$220	$69,482	
1987	$19,401,180	$66,371	$3,179	$3,888	$2,890	$399,669	$15
1988	$26,567,852	$51,477	$1,116	$46,027	$783	$399,846	$2
1989	$25,646,264	$65,329	$66	$45,540	$1,326	$38,214	
1990	$16,413,739	$67,401	$1,072	$9,803	$42,317	$43,395	
1991	$18,497,030	$76,156	$9,727	$33,633	$6,595	$26,329	
1992	$11,404,815	$661,288	$2,642	$9,834	$27,110	$15,539	
1993	$17,865,351	$1,063,047	$2,362	$12,368	$4,844	$25,687	
1994	$23,357,650	$622,523	$23,328	$37,005	$54,659	$7,362	$3,187
1995	$35,263,635	$469,035	$683	$22,555	$69,448	$5,956	$11,656
1996	$34,421,632	$242,545	$631	$51,426	$79,694	$14,102	
1997	$35,989,256	$107,056	$126	$38,026	$114,407	$8,441	
1998	$10,216,719	$30,596	$168	$95,870	$71,832	$3,652	
1999	$49,586,479	$229,979	$19,418	$41,156	$31,071	$7,242	
2000	$46,199,081	$472,320	$12,067	$31,801	$105,819	$2,382	$115
2001	$33,570,293	$447,861	$465	$156,192	$46,433	$1,901	
2002	$34,448,853	$213,851	$138	$6,314	$27,683	$1,505	
2003	$37,821,708	$83,768	$74	$19,096	$30,204	$136	$22
2004	$33,954,536	$406,667	$2	$16,686	$21,241	$112	$37,706
2005	$44,391,701	$1,574,821	$6,640	$184,447	$17,485	$165	
2006	$38,992,647	$883,847	$15,642	$18,994	$20,776	$177	
2007	$44,263,483	$506,638	$21,616	$4,341	$34,325	$58	$51,450

Source: PacFIN - 2005-2007 data extracted March 2008.

[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.

Tables 30 (finfish) and 31 (squid). Number of vessels with landings of CPS finfish or market squid by landing area, 1981-2007.

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	26	7
2007	6	52	25	2	22	10		1	47	34	22

Tables 30 (finfish) and 31 (squid). Number of vessels with landings of CPS finfish or market squid by landing area, 1981-2007.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
					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		28
2006	3	89	30		11	1	1		37		24
2007	2	61	41	4	4	2		1	13		40

Source: PacFIN - 2005-2007 data extracted March 2008.

Tables 32 (finfish) and 33 (squid). Number of vessels with CPS finfish or market squid as principle species[1] by principle landing area[2], 1981-2007.

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
2007		9	2		6				8	2	1

Tables 32 (finfish) and 33 (squid). Number of vessels with CPS finfish or market squid as principle species[1] by principle landing area[2], 1981-2007.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
					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
2007		29	14								22

Source: PacFIN - 2005-2007 data extracted March 2008.

[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.

Tables 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, 1981-2007.

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	10	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	11	6		3	1	1			1	2
1999	2	5	4		2	3	1			1	
2000		10	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	1	3		1				6		
2006	1	1	3		2				5		1
2007		2	2	1	3				4		

Tables 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, 1981-2007.

Year	San Diego	Orange & LA	Ventura & Santa Barbara	San Luis Obispo	Monterey & Santa Cruz	San Francisco	Northern CA	Other CA	Oregon	Washington	Other
					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		1	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	9	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		7	9		2						3
2006		8	5	2							3
2007		1	6			1		1			4

Source: PacFIN - 2005-2007 data extracted March 2008.

Figure 1. Distribution of jack mackerel and northern anchovy eggs collected with the Continuous Underway Fish Egg Sampler (CUFES) during CalCOFI cruise 0804JD (April 2008).

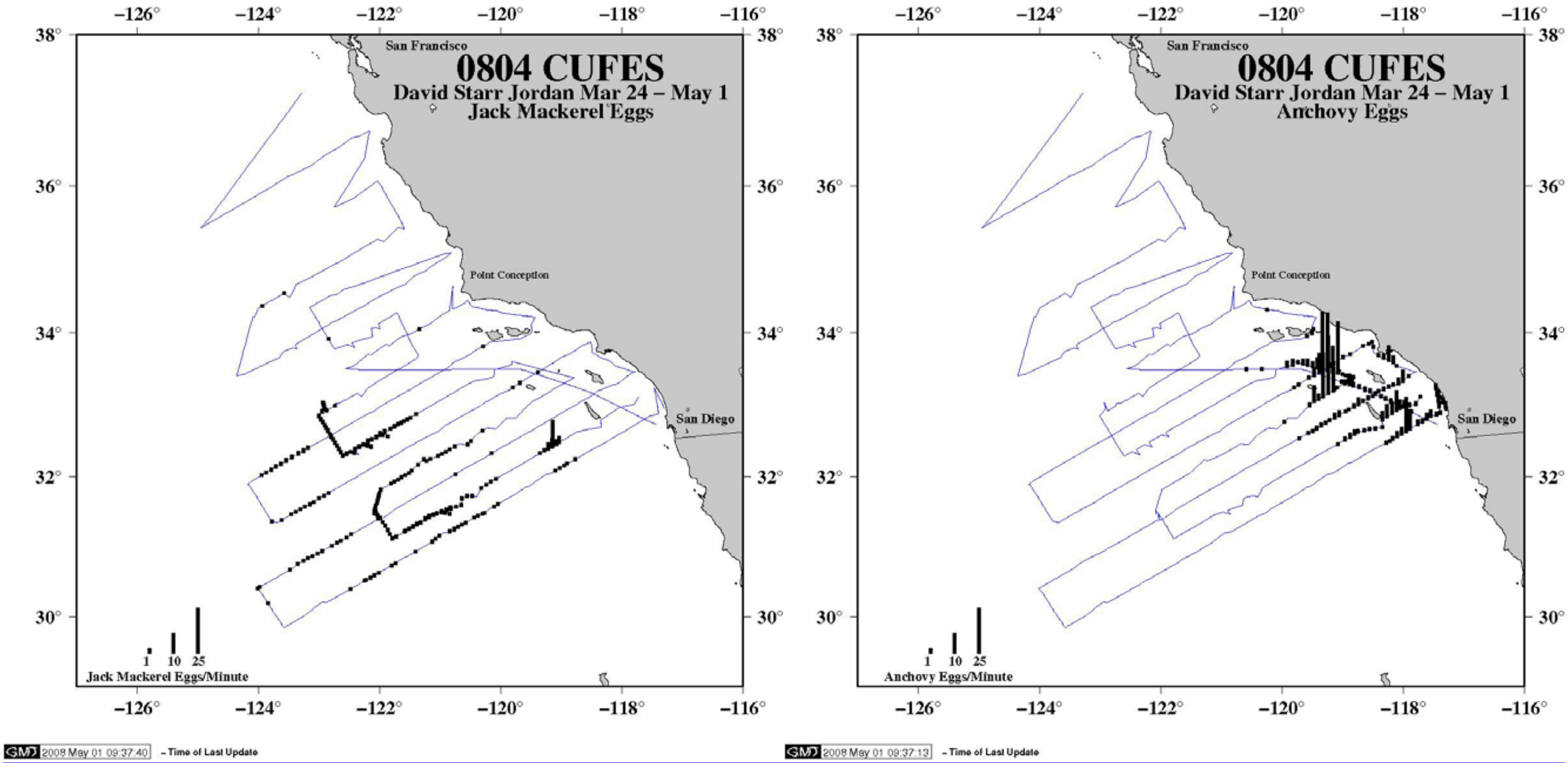


Figure 2. Annual West coast landings and real exvessel revenues for all CPS species, 1981-2007.

Figure 3. Percentage contribution of West coast CPS finfish and market squid landings to the total exvessel value of all West coast landings, 1981-2007.

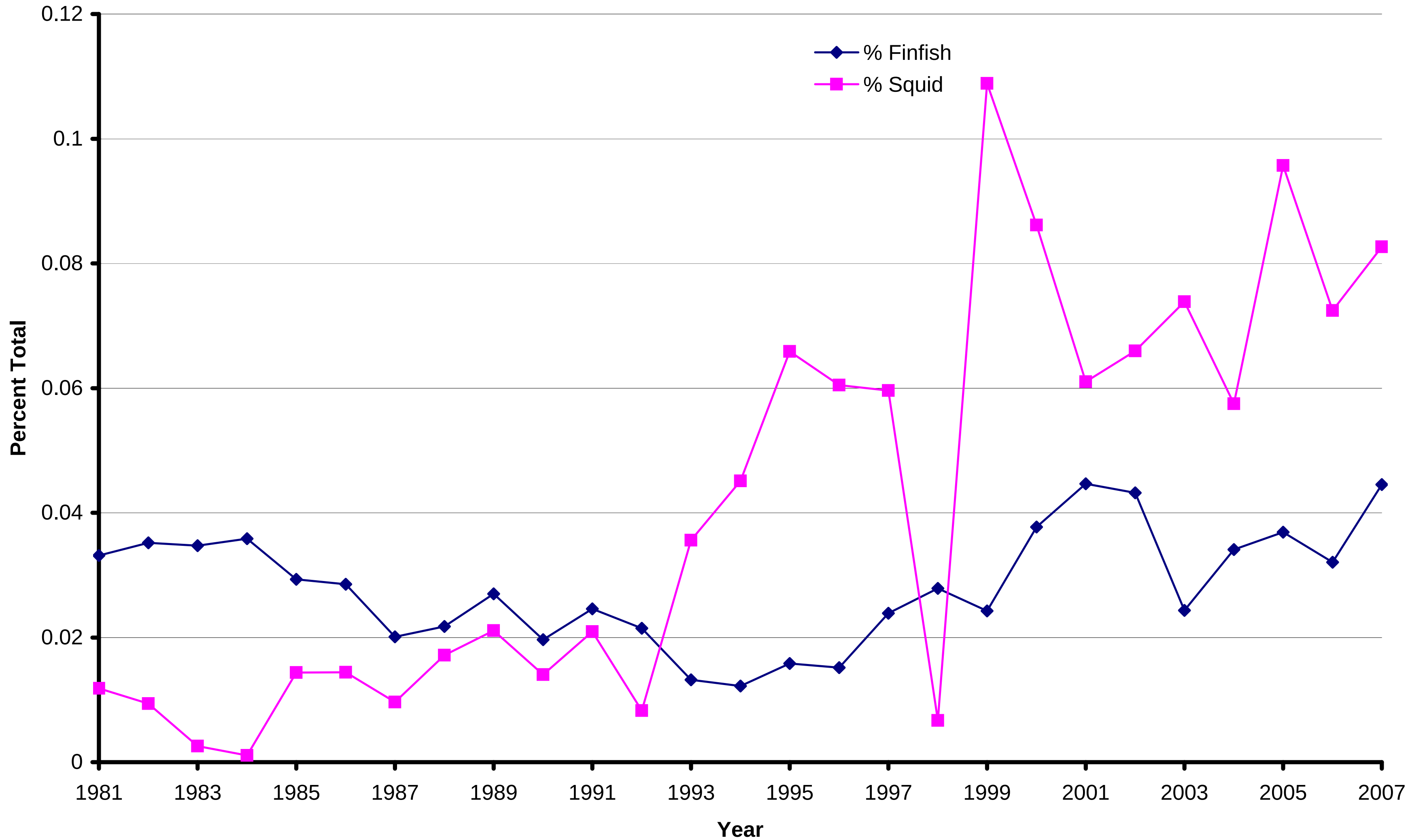


Figure 4. West coast CPS finfish landings and real exvessel price ($/lb, 2007 $), 1981-2007.

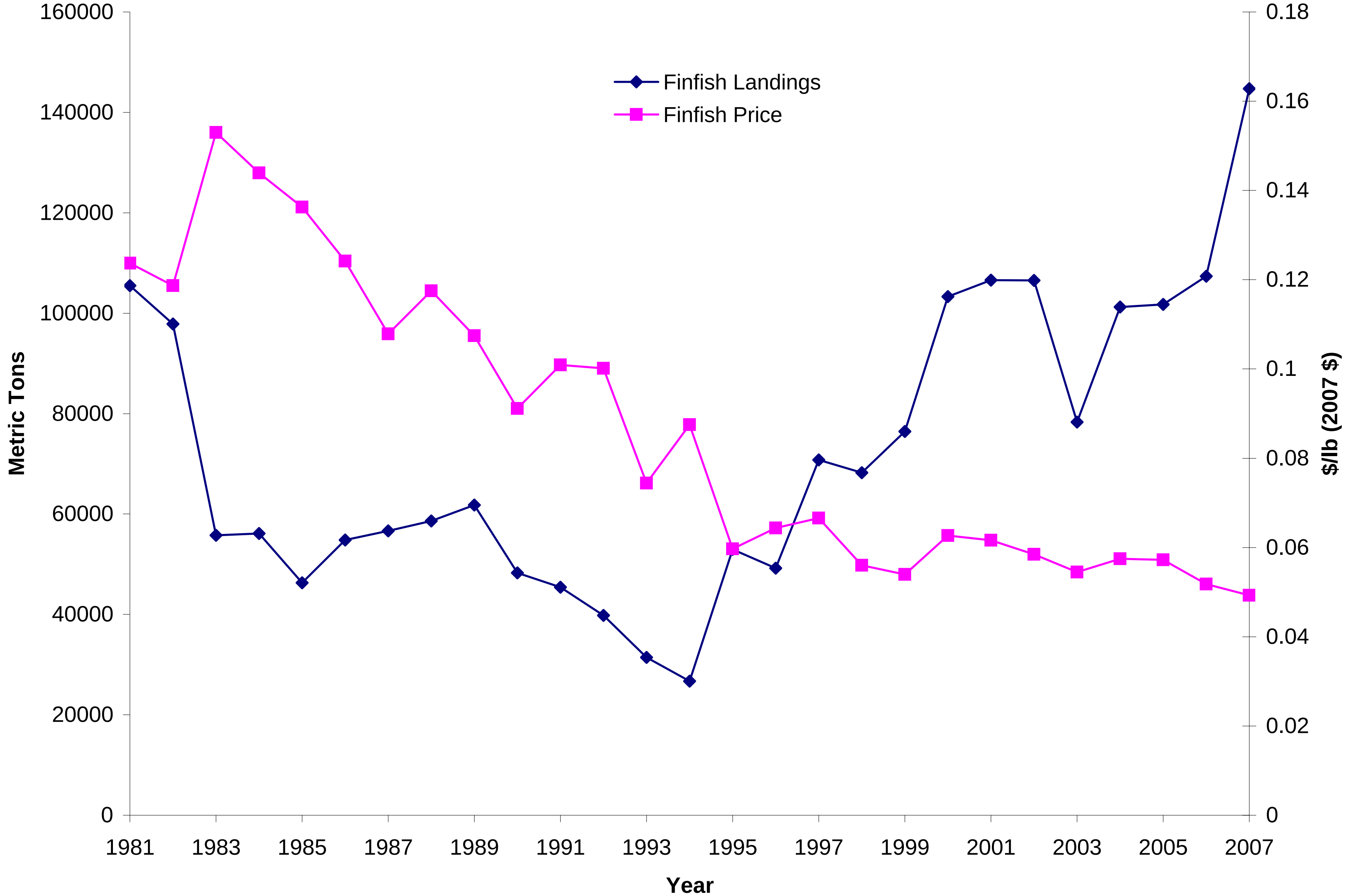


Figure 5. West coast market squid landings and real exvessel price ($/lb, 2007 $), 1981-2007.

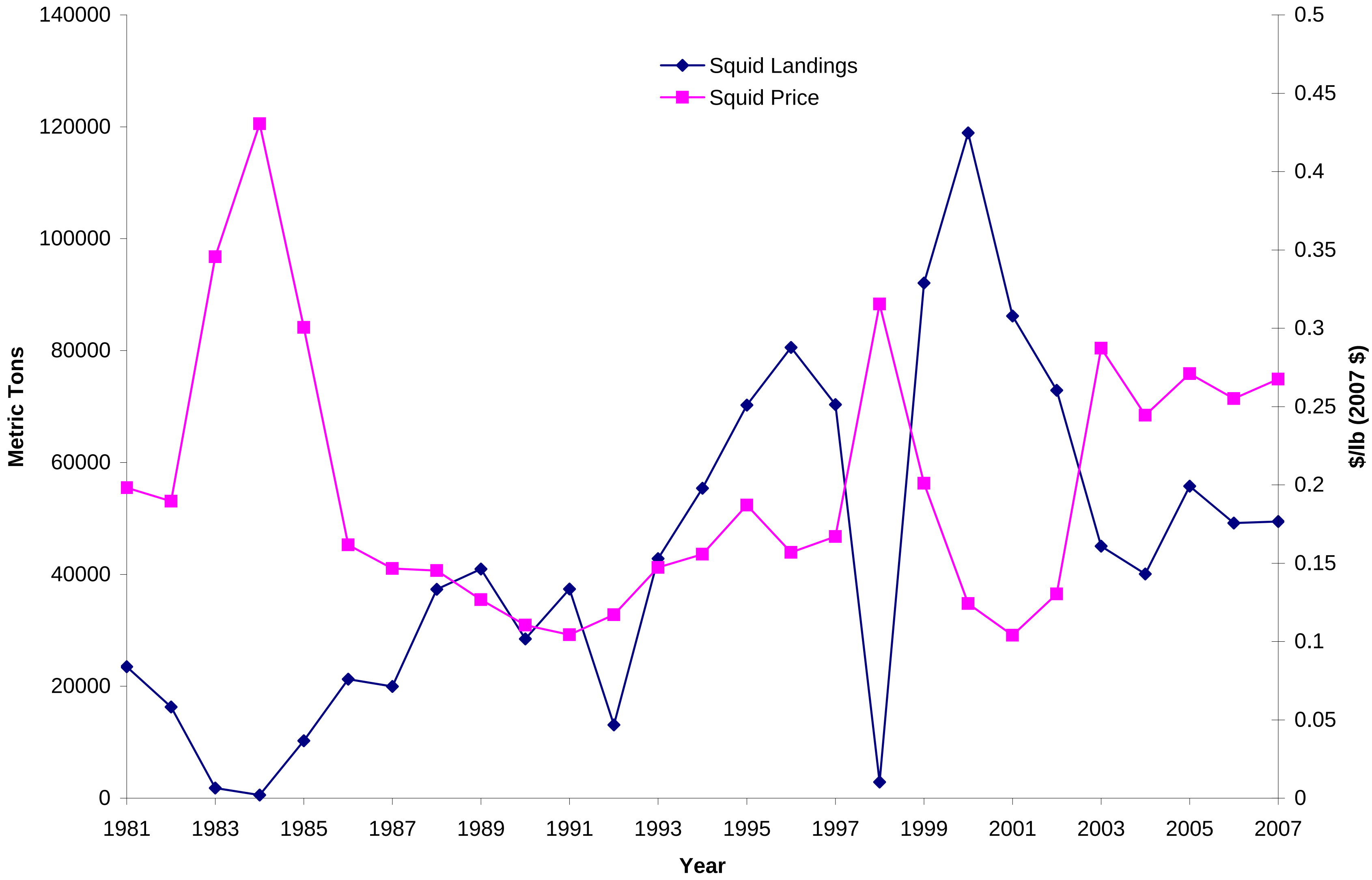


Figure 7. Number of vessels with West coast landings of market squid, and number for which market squid was the principle species, 1981-2007.

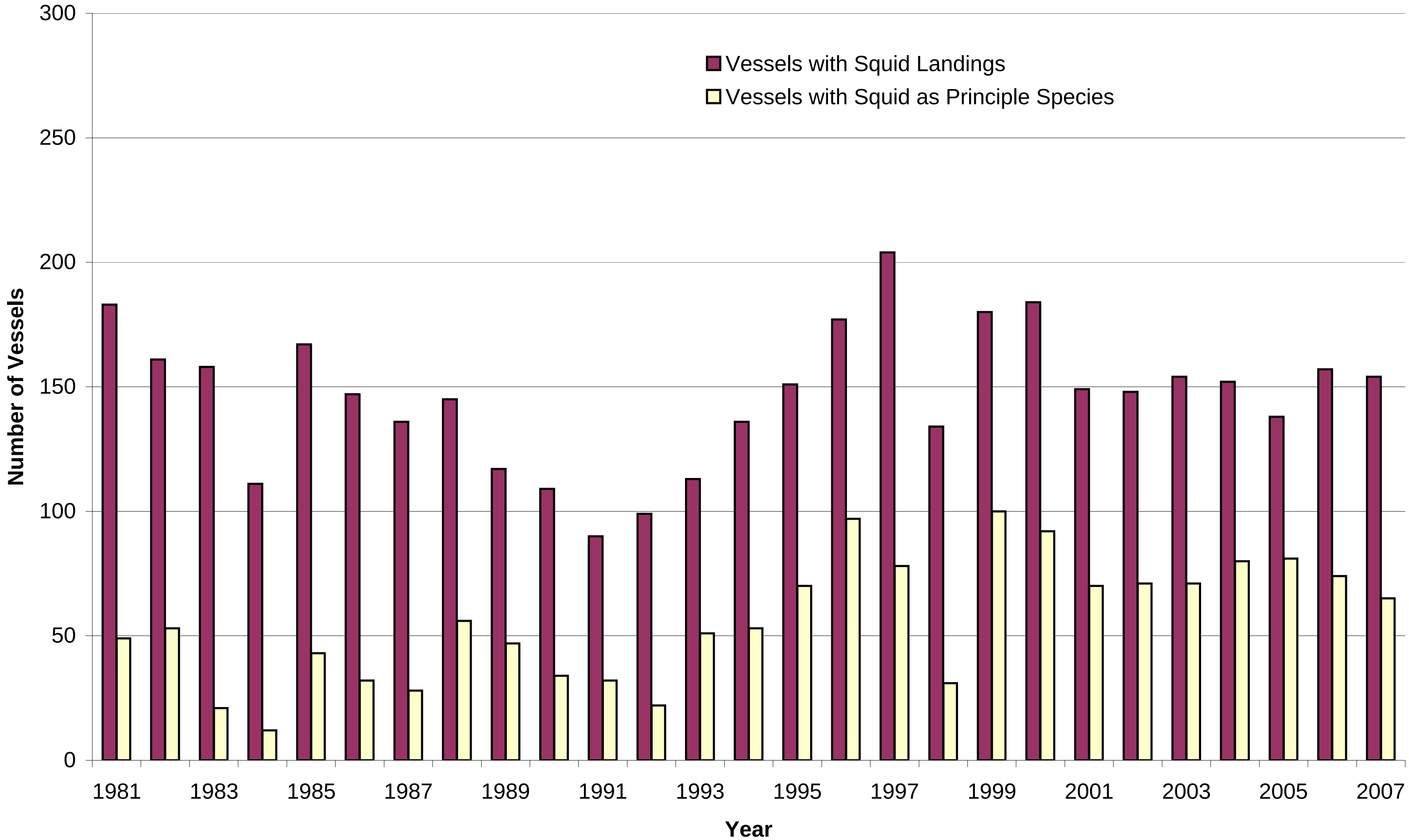


Figure 6. Number of vessels with West coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2007.

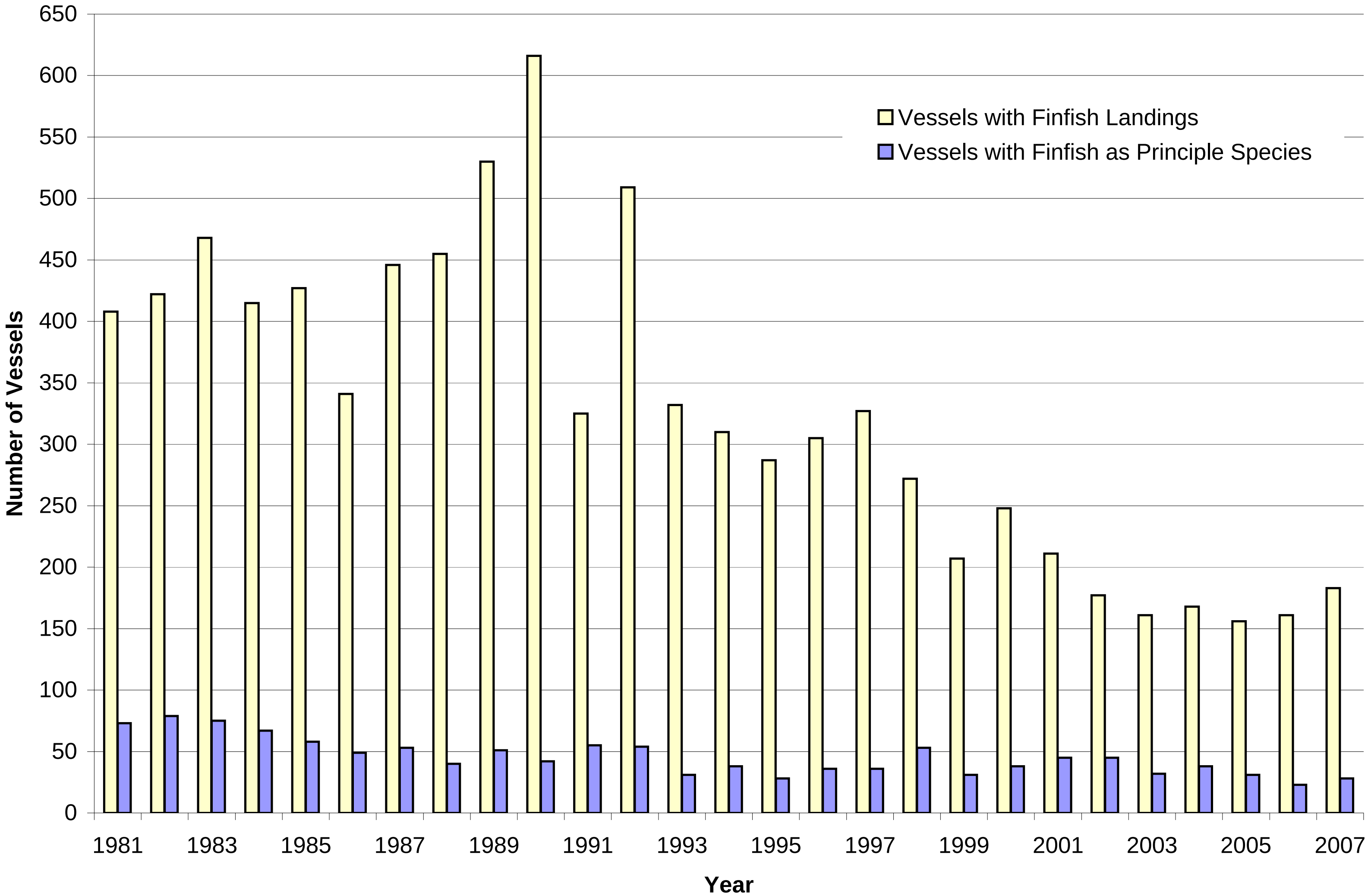
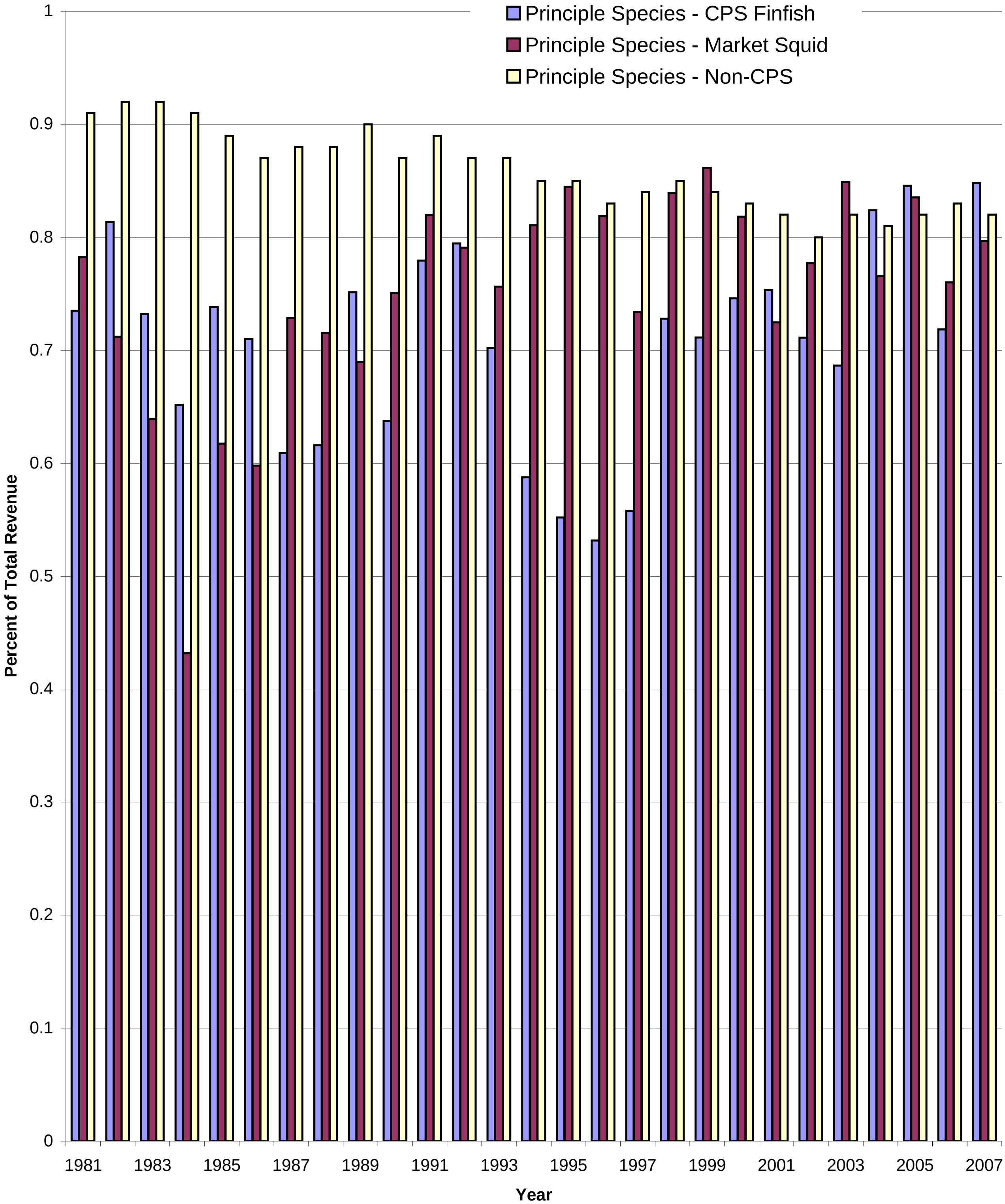


Figure 8. Average share principle species revenues of total revenues for vessels whose principle species was CPS finfish, market squid or non-CPS, 1981-2007.



Agenda Item G.1.b
Attachment 1
June 2008

PACIFIC MACKEREL (*Scomber japonicus*) STOCK ASSESSMENT FOR U.S. MANAGEMENT IN THE 2008-09 FISHING SEASON

by

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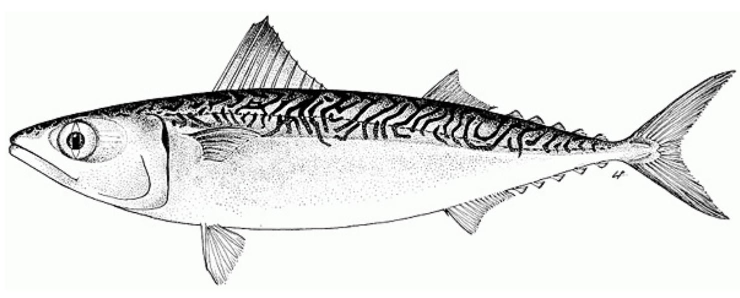
June 9, 2008



Dorval, E., K. T. Hill, N. C. Lo, and J. D. McDaniel. 2007. Pacific mackerel (*Scomber Japonicus*) stock assessment for U.S. management in the 2008-09 fishing season. Pacific Fishery Management Council, June 2007 Briefing Book, Agenda Item G.1.b, Attachement 1. 78 p.

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EXECUTIVE SUMMARY

Stock

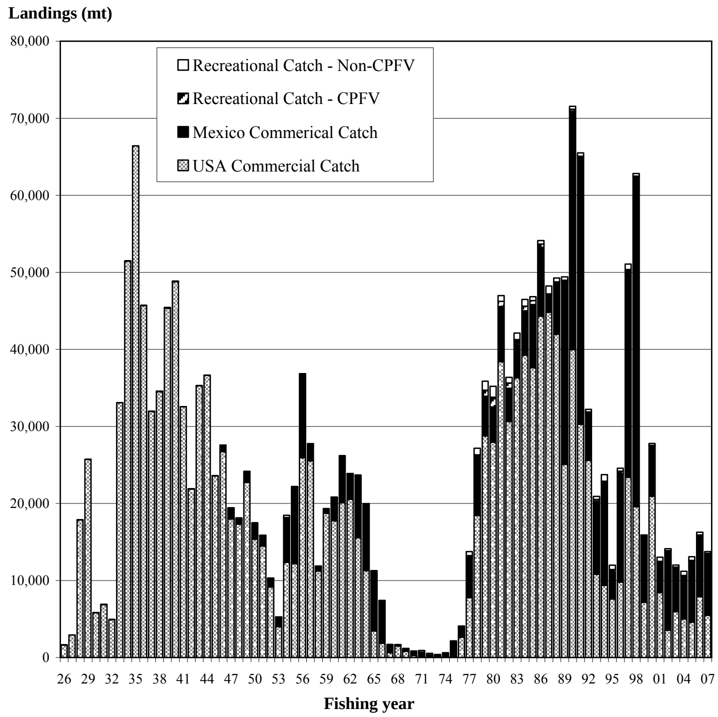
Pacific mackerel (*Scomber japonicus*), in the northeastern Pacific, range from southeastern Alaska to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California. They are common from Monterey Bay, California, to Cabo San Lucas, Baja California, but are most abundant south of Point Conception, 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. Most of the U.S. commercial catch is landed in southern California (Monterey and San Pedro). 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 1940s. 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. Pacific mackerel in Ensenada peaked twice, first in 1991-92 at 34,557 mt, and again in 1998-99 at 42,815 mt. The U.S. commercial landings peaked in 1935-36 (66,400 mt) and in 1990-91(39,974 mt), and were the lowest from 1970 to 1976, during the moratorium imposed by the State of California. The Ensenada fishery has been comparable in volume to the southern California fishery since 1990.

Table of catches (1992-2007).

Fishing Season	USA -Commercial Catch (mt)	Mexico-Commercial Catch (mt)	Recreational - CPFV Catch (mt)	Recreational - non-CPFV Catch (mt)	Total Catch (mt)
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	20	475	13,091
06	7,870	8,024	16	355	16,265
07	5,483	8,024	18	218	13,743



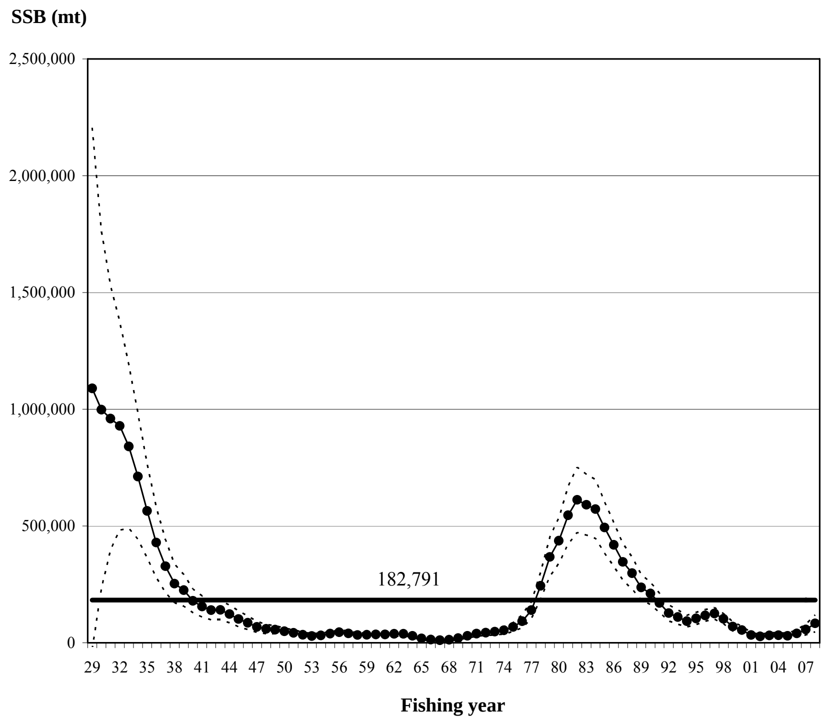
Plot of commercial and recreational landings (mt) of Pacific mackerel in California (USA) and Baja California (Mexico) used in the ASAP-E1 2008 model (1926-08).

Data and assessment:
The last assessment of Pacific mackerel was completed in 2007 for U.S. management in the 2007-08 fishing year. The current assessment is an update based on the Age-Structured-Assessment Program (ASAP)-E1 2007 model recommended by the 2007 Stock Assessment Review (STAR) Panel (La Jolla, May 2007). The assessment includes: catch data (1926-2007); Aerial spotter survey index data (1963-2001); California Passenger Fisheries Vessels (CPFV) recreational CPUE (1935-2007) index data; and California Cooperatives Fisheries Investigations (CalCOFI) larval production at hatching (1951-2006) index data. The final model integrates these data into the ASAP (V.1.3.2), and in this assessment we label this model, "ASAP-E1 2008 model."

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. The 2007 STAR Panels (May and September, La Jolla,) recommended that future stock assessments continue to examine the possibility of using Stock Synthesis2 (SS2) as an alternative to the ASAP platform. Although 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

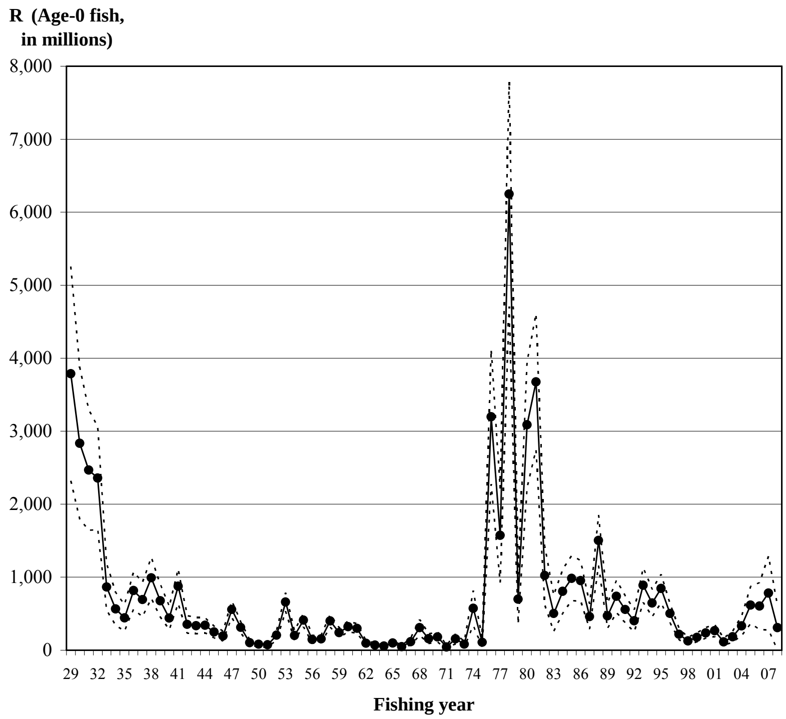
After a period of low abundance (1940-1977) spawning stock biomass (*SSB*) increased in the late 1970s reaching a peak of 611,964 mt in 1982. Since 1982 *SSB* has declined, reaching an estimate of 83,183 mt in 2008. A table of *SSB* estimated in the last 10 years is presented on page 6.



Plot of Pacific mackerel *SSB* (mt) estimated from the ASAP-E1 2008 model (1929-08). The confidence interval (± 2 STD) associated with this time series is also presented. Estimated 'virgin' *SSB* from stock-recruitment relationship is presented as bold horizontal line.

Recruitment

Recruitment was modeled following a standard Beverton & Holt stock-recruit relationship. Steepness was estimated to be 0.32 and Sigma-R (σ_R) was fixed to 0.7. Predicted recruits in the model showed large year classes in 1976, 1978, 1980 and 1981, but low level of recruitment throughout the 1990s and the early 2000s. The number of recruits estimated by the model is presented on page 6.



Plot of Pacific mackerel recruitment (age-0 fish in millions, R) estimated from the ASAP-E1 2008 model (1929-08). The confidence interval (± 2 STD) associated with this time series is also presented.

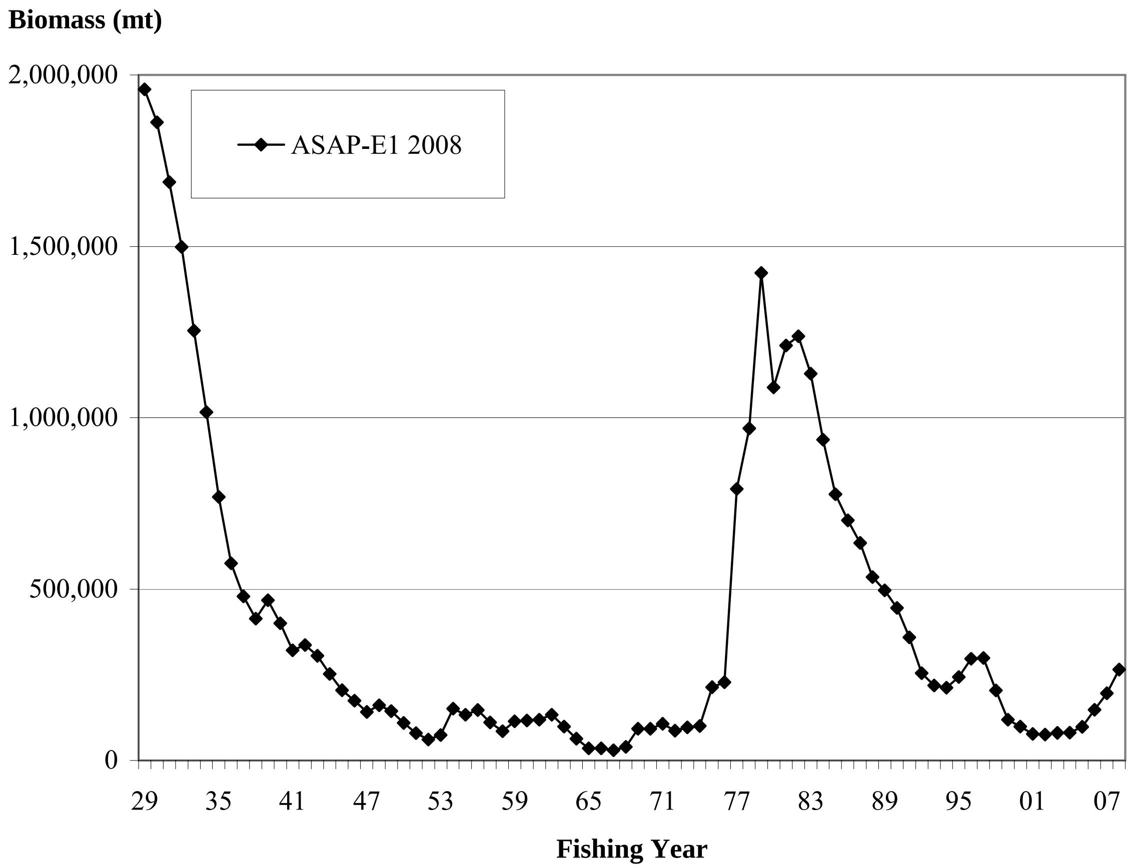
Management performance

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

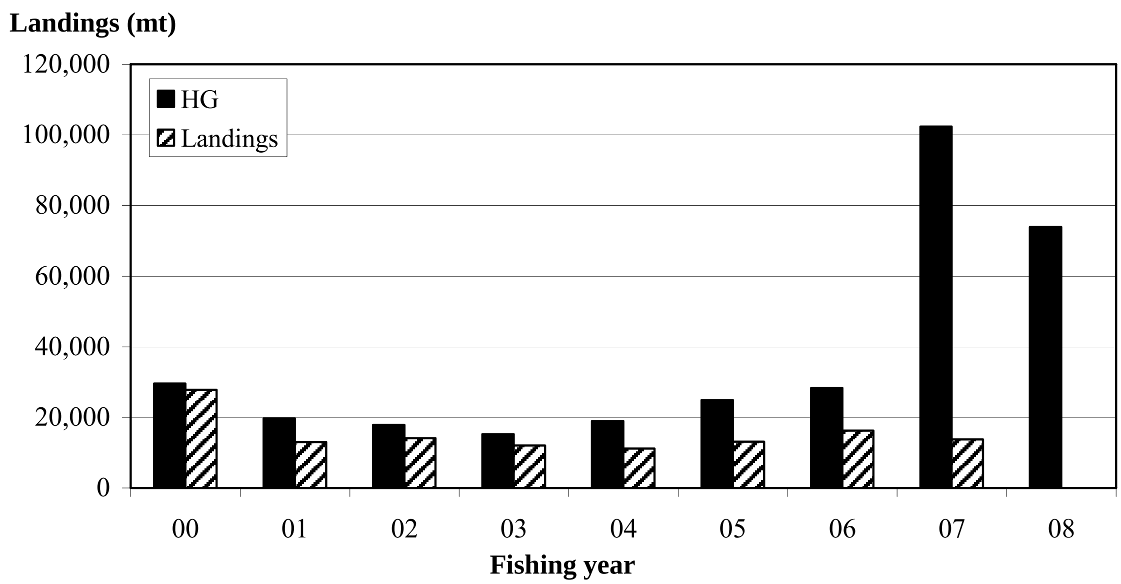
HARVEST = (BIOMASS-CUTOFF) x FRACTION x STOCK DISTRIBUTION,

where HARVEST is the HG, CUTOFF (18,200 mt) is the lowest level of estimated biomass (*B*) 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 year.

Age 1+ biomass was low from the late 1940s to the early 1970s, reaching a peak in 1982, and since then generally declined yielding 264,732 mt in 2008. However, landings of Pacific mackerel have been consistently below the HGs since 2001.



Plot of Age-1+ fish *B* (mt) of Pacific mackerel based on population biomass estimated from the ASAP-E1 2008 model (1929-08).



Total landings (mt) and Harvest Guidelines (HG) for Pacific mackerel based on no 'U.S. Distribution' parameter in the harvest control rule (*B*, 2000-08 Fishing years).

Table of estimated recruitment, Age 1+ biomass and spawning stock biomass (1998-2008).

Fishing Year	Recruits (Age-0)	Biomass (Age-1+)	SSB
98	124,650	203,657	102,820
99	175,250	119,155	69,737
00	235,520	98,641	54,266
01	265,960	76,872	32,721
02	113,010	75,701	27,250
03	183,750	79,973	31,670
04	331,430	81,406	32,063
05	615,780	97,727	29,420
06	603,760	147,833	40,167
07	781,550	195,806	56,688
08	307,250	264,732	83,183

Harvest Guideline for the 2008-09 Fishing Season

Biomass (Age-1+)	Cutoff (mt)	Fraction	Distribution	2008-09 Harvest Guideline (mt)
264,732	18,200	30%	70%	51,772

INTRODUCTION

Background

A Pacific mackerel (*Scomber japonicus*) stock assessment is conducted annually in support of the Pacific Fishery Management Council (PFMC) process, which ultimately establishes a harvest guideline (HG) or Optimal Yield (OY) for the Pacific mackerel fishery that operates off the U.S. Pacific coast. The HG for mackerel applies to a fishing year (management season) that begins in July 1st and ends on June 30th of the subsequent year. The main goal 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 Pacific mackerel' harvest control rule, see Amendment 8 of the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), section 4.0 (PFMC 1998).

The last assessment was completed in June 2007, setting an HG of 71,629 mt for the 2007-08 fishing year. However, as a precautionary measure the PFMC concurred with recommendations from the Coastal Pacific Species Management Team (CPSMT), and the Coastal Pacific Species Advisory SubPanel (CPSAS) to set an OY of 40,000 mt for the 2007-08 fishing year. The 2007-08 HG was based on biomass estimated from the ASAP-E1 model that was reviewed and recommended by the May 2007 STAR Panel (La Jolla, CA). This panel also reviewed several Stock Synthesis2 (SS2) model runs, but could not identify an acceptable SS2 model configuration (see STAR Panel report, May 2007). Thus, the STAR Panel recommended that future stock assessments continue to examine the possibility of using SS2 as an alternative to the ASAP platform, and proposed an SS2 methodology review in September 2007. Additional SS2 model runs were examined during the September 2007 STAR Panel in La Jolla, CA; but again the Panel was unable to identify an acceptable base model using SS2. The STAR Panel agreed that SS2 is an appropriate model for the assessment of Pacific mackerel, but further investigations were needed to determine a reliable and stable model configuration (see STAR Panel Report, September 2007).

The 2008-09 stock assessment presented here is an update based on the ASAP-E1 model that was reviewed in May 2007 (STAR Panel, La Jolla) and presented to the PFMC in June 2007 (Dorval et al. 2007). This updated assessment includes updated landings data (1929-06) and an additional year of data (2007) collected from ongoing fishery-dependent sampling programs conducted by the the California Department of Fish and Game (CDFG). Also, prior to adding updated catch and biological data, CDFG made minor updates to the California Commercial Passenger Fishing Vessel (CPFV) time series data, but those changes had no significant effect on the overall trajectory of this index. No new data were added to the aerial spotter index and to the CalCOFI larval production index, thus these input data are similar to the time series used in the 2007 assessment. Model parameterization replicates the ASAP-E1 2007 model, but we also conducted sensitivity analysis showing the performance of the model with and without the updated data stream. In this context we present an updated assessment that follows the "2007 CPS Term of Reference" for off year (i.e., years in which no STAR Panel is conducted). Readers interested in further details regarding the sample data and model parameterization used in this assessment should consult Dorval et al. (2007). Finally, electronic versions of model programs, input data, and displays (Table and Figures) can be obtained from the authors directly.

Distribution and Stock structure

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).

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).

Fisheries

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.

ASSESSMENT

Biological Data

Weight-at-age

A year-specific weight-at-age matrix based on fishery samples was developed for use in the ASAP-E1 model. As in the 2007 assessment this matrix was used to calculate spawning stock biomass (*SSB*) and Age 1+ biomass (*B*) from modeled population estimates. Weight-at-age data were updated for the years 2006 and 2007. 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. We assumed that fish that occur in the fisheries and in the overall population had similar growth.

Maturity Schedule

As in the 2007 assessment, normalized net fecundity-at-age (fraction mature x spawning frequency x batch fecundity) was used to interpret CalCOFI ichthyoplankton data and calculate *SSB*. Fraction mature was estimated by fitting a 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

As in the 2007 assessment, natural mortality rate (*M*) was assumed to be constant, 0.5 yr^{-1} for both sexes across all ages (0-8+) and years (1929-08). We refer readers to Dorval et al. (2007) for a review of method applied to derive mortality rate level used in this assessment.

Fishery Data

Landings

The assessment uses commercial and recreational landings in California and commercial landings in Baja California from 1926-27 through 2007-08. Landings were aggregated on a fishing year basis, and the updated time series data are presented in Figure 1. Landings for March-June 2008 were substituted with corresponding months from 2007.

Catch-at-age

As in the 2007 assessment, various sources were used to reconstruct a catch-at-age time series for Pacific mackerel (Dorval et al. 2007). 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.

Catch-at-age data (in proportion) compiled for the ASAP-E1 2008 model input are displayed in Figure 2. For years where age sampling was carried out (i.e. 1929-30 to

2007-08), an effective sample size (λ) of 45 was used, as in the 2007 assessment. Effective sample size was set to zero for cases with landings but no samples (i.e., 2008-09).

Indices of Relative Abundance

As in the 2007 assessment, survey data of relative abundance used in the ASAP-E1 2008 model include: 1) an aerial sightings by spotter pilots; 2) a larval production at hatching (P_h) from the CalCOFI program; and 3) a standardized, catch-per-unit-effort (CPUE) index developed from the CPFV logbooks (Figure 3).

In this assessment, the spotter index covers the fishing period 1962-63 through 2001-02 and is standardized using a Delta-GLM model as in the 2007 assessment (Dorval et al. 2007). Although data from 2004 through 2006 were available, the 2007 STAR Panel recommended that these data be dropped from the assessment. Therefore, data inputs for the spotter index are similar to inputs used in the 2007 assessment. Further, in 2007 no Pacific mackerel larvae were collected during the CalCOFI survey, consequently the Ph index could not be updated, and this assessment uses the same data inputs as derived in the 2007 assessment (Dorval et al. 2007).

Only the CPFV logbooks data were updated, including minor changes in the 1935-06 time series and new data collected in 2007. The new index was standardized using a Delta-GLM, following the same statistical procedures as in the 2007 assessment (Dorval et al. 2007). Figure 4 compares the 2007 and 2008 CPFV index developed using the Delta-GLM method, and shows that the changes made by CDFG had little effect on the overall trajectory of the index.

As in previous assessments, selectivity for the Spotter, CPFV and CalCOFI indices were fixed outside of the ASAP-E1 2008 model. Figure 5 presents selectivity curves assumed for each index, with time varying selectivity for the CPFV CPUE index.

Survey data for Pacific mackerel vary in quality 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 was thoroughly addressed during the 2007 STAR (May 2007 STAR Panel Report).

ASAP-E1 2008 Model

The ASAP model (Legault and Restrepo 1999) 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 ASAP-E1 2008 model is parameterized similarly to the ASAP-E1 2007 model recommended by the May 2007 STAR Panel. Only the catch, biological, and the CPFV data differ:

- Updated landing time series with additional year (i.e, 2007) of catch, catch-at-age, and weight-at-age data;
- Plus group for age data , 8+ years;
- Effective sample size for age comps iteratively adjusted to 45;
- Fishery selectivity estimated for three time blocks: 1929-69; 1970-77; 1978-08;
- Aerial spotter index, larval production index and updated CPFV index methods were included, with inverse-weighting of observations based on model CVs;
- Survey timings based on fishing year (July 1- June 30);
- Sigma-R for the spawner-recruit model was fixed to 0.7;
- As in the 2007 assessment, ASAP version 1.3.2 (compiled 14 September 2004) was used for all runs presented in this paper.

Results

Catch

The ASAP-E1 2008 model fit to catch data is displayed in Figure 6. 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 in the input data. Figure 7 presents estimates of Effective sample size from the ASAP-E1 2008 model. Further, Pearson residuals for the catch-at-age fits are displayed in Figure 8. Residual patterns were random, with no obvious trends over age or time. Catch-at-age proportions contributed to 44.8% of the total model likelihood (Table 2).

Fits to Indices

Model fits to the three indices of relative abundance are displayed in Figures 9-11. 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 45.6 % of the total model likelihood (Table 2).

Selectivity Estimates

Fishery selectivities (S_{age}) estimated for the three time blocks are displayed in Figure 12. Selectivities followed a dome-shaped pattern for the two periods of directed fishing (1929-1969 and 1978-2008), with the latter period selecting more fish of the youngest and oldest ages. This difference reflects changes in utilization among the two time periods; 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.

Fishing Mortality Rate

The fishing mortality multiplier (Fmult) is displayed in Figure 13, and fishing mortality-at-age is presented in Figure 14. Fmult increased steadily throughout the historic fishery, peaking at close to 0.7 by the mid-1960s. For the recent period, Fmult peaked at 0.62 in 1998 (an El Nino season) when the stock was relatively low but availability was high for the Ensenada fishery.

Spawning Stock Biomass

The time series of *SSB* is presented in Figure 15. *SSB* peaked at 611,964 mt in 1982, declining to 29, 420 mt in 2005 before increasing to the current level of 83,183 mt. B_0 is estimated to be 182,791 mt.

Recruitment

Recruitment time series (age-0 abundance) are displayed in Figure 16. The recruitment trend is closely similar in pattern to that of the 2007 assessment, with large year-classes occurring in 1976, 1978, 1980, and 1981.

Stock-Recruit Relationship

Fit to the stock-recruitment relationship is displayed in Figure 17. In general, estimated recruitment was 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=0.32 – a very low value for small pelagic species, but similar in range to past assessments for this stock.

Biomass of Age 1+ stock for PFMC Management

Stock biomass (Age 1+) peaked at 1.42 million mt in 1979, declined to a low of about 75,701 mt in 2002, 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 264,732 mt as of July 1, 2008.

Sensitivity Analyses to Last Year's Data

We performed sensitivity tests to investigate potential effects of updated data stream on parameter estimation and population abundance. In this section we present the results of these tests comparing results of four different model runs:

1) *ASAP-E1 2007 model* : similar input data and model parameterization (i.e., no updated data stream in the 2007 fishing year) as in the final ASAP model recommended by the 2007 STAR Panel.
2) *ASAP-E1a*: updated landings for the 2007 fishing year; no 2007 catch-at-age CPFV index estimates; same parameterization as in the ASAP-E1 2007 model.
3) *ASAP-E1b*: updated landing for 2007; updated catch-at-age for 2007; no 2007 CPFV index estimate; same parameterization as in the ASAP-E1 2007 model.

4) *ASAP-E1 2008 model*: all updated data streams were included; and same parameterization as in the 2007 model (see above).

Parameter estimation, spawning stock biomass and recruitment estimates for this model runs are summarized and compared in Table 1 and Figures 18-19.

Sensitivity Analyses to Years with CalCOFI Survey but no Larvae
We also performed a sentivity test to examine the effect of years where the CalCOFI survey was conducted, but no Pacific mackerel larvae were caught. In the ASAP-E1 model these years (i.e., 1964, 1967, 1968, 1975, 1990, 1999, 2000, 2002, 2004, 2007) were dropped from the CalCOFI larval production index. We performed this model run (ASAP-E1c) assuming that Ph for those years was equal to 0.015 (i.e., the lowest estimated value in the time series).

Parameter estimation, spawning stock biomass and recruitment estimates for this model run is also summarized in Table 1 and Figures 18-19.

Comparison of ASAP-E1 2008 Model Results to Previous Assessments

Age 1+ biomass and *SSB* estimated from the 2007 ASAP-E1 model and 2004 Virtual population model (VPA-ADEPT) are compared to 2008 ASAP-E1 2008 estimates in Figures 20 and 21.

HARVEST CONTROL RULE FOR U.S. MANAGEMENT IN 2008-09

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 PFMC's harvest policy for mackerel are based on analyses published by MacCall et al. (1985). BIOMASS (264,732 mt) is the estimated biomass of fish age 1 and older for the whole stock projected for July 1, 2008. Based on this formula, the 2008-09 HG is estimated to be 51,772 mt. Figure 22 presents commercial landings, HGs, and OYs for Pacific mackerel from 1992 to 2007. The recommended HG for the 2008-09 fishing season is 27% lower than the 2007-08' HG, but higher than the OY set by the PFMC for the 2007-08 fishing year and than the maximum yield since 1992-93.

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 (Instituto Nacional de la Pesca)-Ensenada has collected biological samples (size, sex, otoliths) since 1989, but the data have not been available for U.S. stock assessments. There is an urgent 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.

Weaknesses and strengths of the fishery-independent surveys used in this assessment are highlighted in the 2007 STAR Panel Reports. We summarize below (following bullets excerpted from the report) the most important recommendation of the 2007 Panels.

- 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 Panels in May and Sepetember 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. Further investigations should be undertaken in an attempt to identify an acceptable SS2 configuration that can form the basis of the 2009-10 harvest guideline

- 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 Southern California Bight can be used to provide information on the abundance of the coastwide stock.

ACKNOWLEDGEMENTS

This updated stock assessment depends in large part on the diligent efforts of many colleagues and the timely receipt of their data products. Port samples and age data were provided by CDFG Marine Region personnel in Los Alamitos and Monterey, and special thanks go to Leeanne Laughlin, Valerie Taylor, Kelly O'Reilly, Travis Tanaka, Dianna Porzio, Sonia Torres, and Kimberley Pentilla for long dockside and laboratory hours. Wendy Dunlap (CDFG, Los Alamitos) supplied logbook data from California's CPFV logbook program. Ron Dotson, Amy Hays, and Sue Manion (NMFS, La Jolla) provided aerial spotter logbook data. Susan Jacobson (NMFS, La Jolla) extracted CalCOFI larval data. Numerous staff from SIO, NMFS, and CDFG assisted in the ongoing collection and identification of CalCOFI ichthyoplankton samples. We are grateful to Christopher Legault (NMFS, Woods Hole) for providing the ASAP model. Finally we thank André Punt (SSC), Thomas Helser (SSC), and the CPSMT for reviewing an earlier draft of this report.

LITERATURE CITED

Allen, M. J., R. J. Wolotira, Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1990. West coast of North America coastal and oceanic zones strategic assessment: Data Atlas. NOAA. Seattle, WA. Invertebrate and fish 145:

Collette, B. B., and C. E. Nauen. 1983. Scombrids of the world. FAO Fish. Synop. 125. 137 p.

CPS Terms of Reference. 2007. Terms of reference for a coastal pelagic species stock assessment review process. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR, 97220.

Deriso, R. B., T. J. Quinn II, and P. R. Neal. 1985. Catch-age analysis with auxiliary information. Canadian Journal of Fisheries and Aquatic Sciences 42:815-824.

Dickerson, T. L., B. J. Macewicz and J. R. Hunter. 1992. Spawning frequency and batch fecundity of chub mackerel, *Scomber japonicus*, during 1995. Calif. Coop. Oceanic Fish. Invest. Rep. 33:130-140.

Dorval, E., K. T. Hill, N. C. H. Lo, and J. D. McDaniel. 2007. Pacific Mackerel (*Scomber japonicus*) Assessment for U.S. management in the 2007-2008 fishing season. Pacific Fishery Management Council June 2007 Briefing Book, Agenda Item F.2.b, Attachment 1. 175 p.

Fitch, J. E. 1969. Offshore fishes of California. 4th revision. Calif. Dep. Fish and Game, Sacramento, CA. 79 p.

Frey, H. W. [ed.] 1971. California's living marine resources and their utilization. Calif. Dept. Fish and Game 148 p.

Fournier, D., and C. P. Archibald. 1982. A general theory for analyzing catch at age data. Canadian Journal of Fisheries and Aquatic Sciences 39:1195-1207.

Hart, J. L. 1973. Pacific fishes of Canada. Fish. Res. Board Can., Bull. 180. 740 p.

Legault, C. M., and V. R. Restrepo. 1998. A flexible forward age-structured assessment program. ICCAT Working Document SCRS/98/58. 15 p.

MBC Applied Environmental Sciences. 1987. Ecology of important fisheries species offshore California. OCS-Study, MMS 86-0093. 252 p.

Otter Research Ltd. 2001. An introduction to AD Model Builder (Version 6.0.2) for use in nonlinear modeling and statistics. Otter Research Ltd., Sidney, B.C., Canada. 202 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. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR, 97220.

Table 1. List of estimated parameters.

Parameters	**Number**
log-sel_year1	9
log_sel_devs_vector:	18
log_Fmult_year1:	1
log_Fmult_devs:	79
log_recruit_devs:	80
log_N_year1_devs:	8
log_q_year1:	3
log_SRR_virgin:	1
SRR_steepness:	1
Total	**200**

Table 2. Comparison of likelihood function components for the ASAP-E1 2008, ASAP-E1a, ASAP-E1b, ASAP-E1c, and ASAP-E1 2007 model runs.

ASAP-E1 2008 Model Run

Component	***n***	***λ***	***RSS***	***L***	**% of Total**
Catch (weight) - fishery	80	100	0.02	2.36	0.2%
Catch-at-age (proportions) - fishery	720	na	na	530.93	44.8%
Fits - Survey indices					
Spotter	39	1	166.92	119.16	10.1%
CPFV	68	1	16.06	104.85	8.9%
CalCOFI	37	1	76.87	315.54	26.6%
All	144	3	259.85	539.55	45.6%
Recruitment (deviations)	80	1	57.65	57.65	4.9%
Stock-recruit fit	80	1	57.65	53.90	4.6%
F penalty	720	0.001	1.75	0.00	<1%
Number of estimated parameters (Total)	200	na	na	na	
Objective function (Total)	na	na	na	1184.38	100%

ASAP-E1a Model Run

Component	***n***	***λ***	***RSS***	***L***	**% of Total**
Catch (weight) - fishery	80	100	0.02298	2.298	0.2%
Catch-at-age (proportions) - fishery	720	see_below	na	523.466	44.7%
Fits - Survey indices					
Spotter	39	1	166.557	117.844	10.1%
CPFV	67	1	16.4706	101.298	8.6%
CalCOFI	37	1	76.7361	315.024	26.9%
All	143	3	259.7637	534.166	45.6%
Recruitment (deviations)	80	1	57.483	57.483	4.9%
Stock-recruit fit	80	1	57.483	53.6872	4.6%
F penalty	720	0.001	1.74535	0.001745	<1%
Number of estimated parameters (Total)	200	na	na	na	
Objective function (Total)	na	na	na	1171.1	100.0%

Table 2. cont.

ASAP-E1b Model Run

Component	*n*	*λ*	*RSS*	*L*	% of Total
Catch (weight) - fishery	80	100	0.0230254	2.30254	0.2%
Catch-at-age (proportions) - fishery	720	see_below	na	528.326	44.9%
Fits - Survey indices					
Spotter	39	1	166.509	117.804	10.0%
CPFV	67	1	16.5177	101.799	8.7%
CalCOFI	37	1	76.578	314.643	26.7%
All	143	3	259.604	534.246	45.4%
Recruitment (deviations)	80	1	57.7466	57.7466	4.9%
Stock-recruit fit	80	1	57.7466	54.0177	4.6%
F penalty	720	0.001	1.73547	0.001735	<1%
Number of estimated parameters (Total)	200	na	na	na	
Objective function (Total)	na	na	na	1176.64	100.0%

ASAP-E1c Model Run

Component	*n*	*λ*	*RSS*	*L*	% of Total
Catch (weight) - fishery	80	100	0.0311119	3.11119	0.2%
Catch-at-age (proportions) - fishery	720	see_below	na	532.796	40.3%
Fits - Survey indices					
Spotter	39	1	157.545	112.411	8.5%
CPFV	68	1	17.4904	114.048	8.6%
CalCOFI	47	1	164.818	445.81	33.7%
All	154	3	339.852	672.268	50.8%
Recruitment (deviations)	80	1	59.0798	59.0798	4.5%
Stock-recruit fit	80	1	59.0798	55.6894	4.2%
F penalty	720	0.001	1.3971	0.001397	<1%
Number of estimated parameters (Total)	200	na	na	na	
Objective function (Total)	na	na	na	1322.95	100.0%

Table 2. cont.

ASAP-E1 2007 Model Run					
Component	***n***	***λ***	***RSS***	***L***	**% of Total**
Catch (weight) - fishery	79	100	0.0200987	2.00987	0.2%
Catch-at-age (proportions) - fishery	711	see_below	N/A	524.626	39.7%
Fits - Survey indices					
Spotter	39	1	165.434	119.525	9.0%
CPFV	67	1	15.5464	107.834	8.2%
CalCOFI	37	1	78.0771	318.819	24.1%
All	143	3	259.057	546.179	41.3%
Recruitment (deviations)	79	1	58.803	58.803	4.4%
Stock-recruit fit	79	1	58.803	55.5721	4.2%
F penalty	711	0.001	1.9564	0.001956	<1%
Number of estimated parameters (Total)	198	na	na	na	
Objective function (Total)	na	na	na	1187.19	89.7%

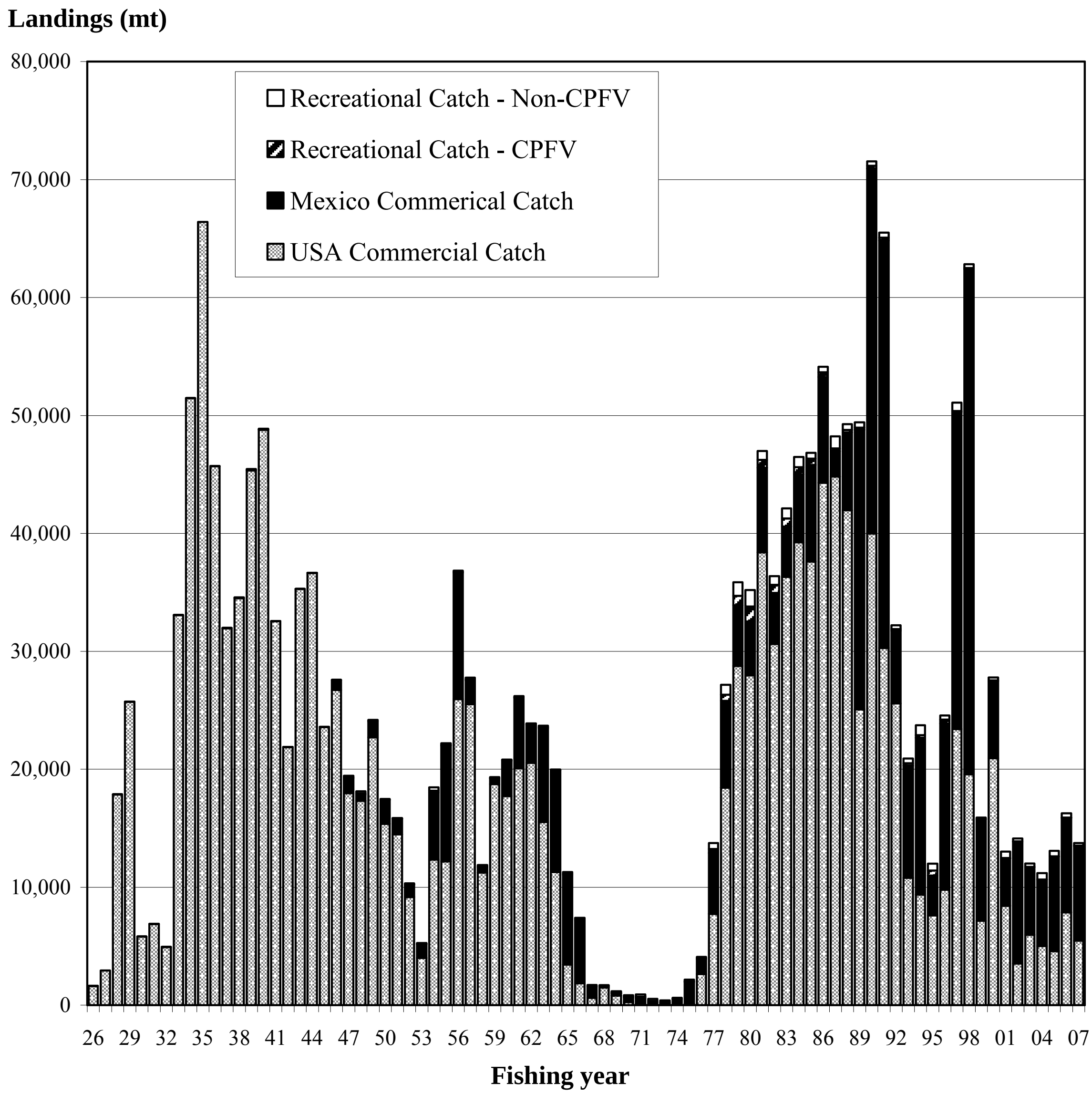


Figure 1. Commercial and recreational landings (mt) of Pacific mackerel in California (CA) and Baja California (MX) used in the ASAP-E1 2008 model (1926-08). See Fishery Data section for descriptions of fishing year.

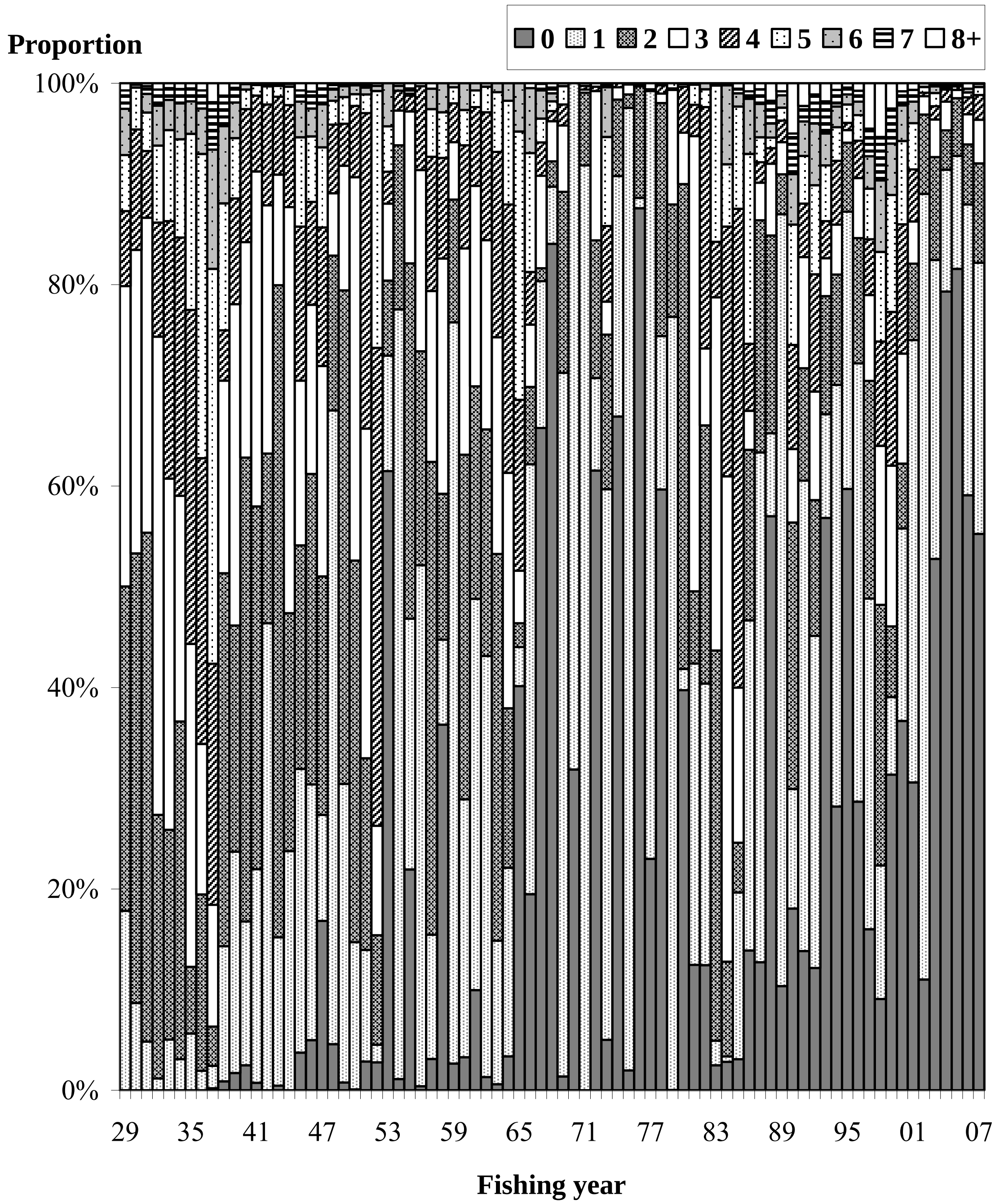


Figure 2. Pacific mackerel catch-at-age (in proportion) estimates used in the ASAP-E1 2008 model (1926-08).

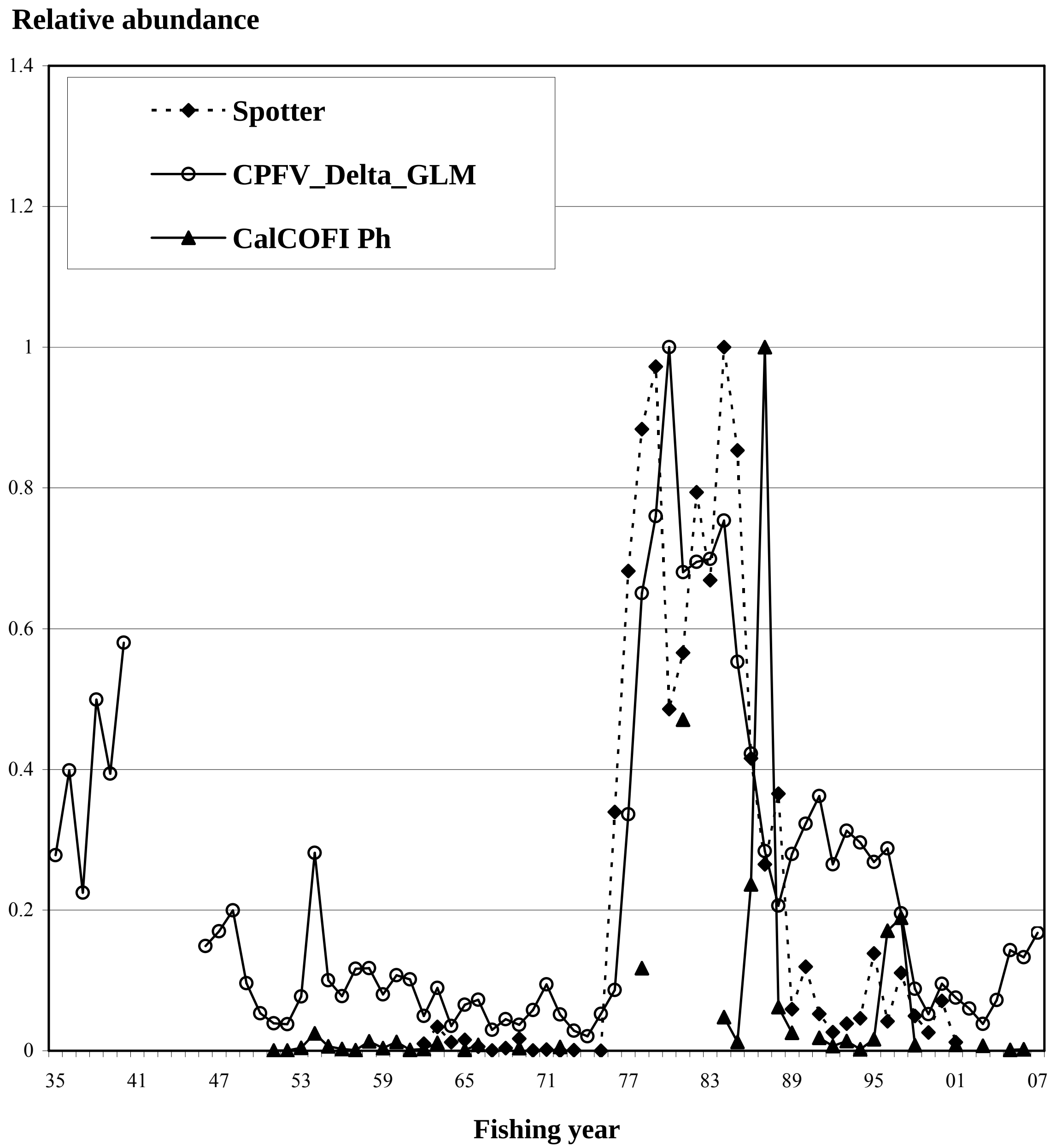


Figure 3. Indices of abundance time series for Pacific mackerel used in the ASAP-E1 2008 model (1926-08). Indices are rescaled (normalized) to a maximum of 1.

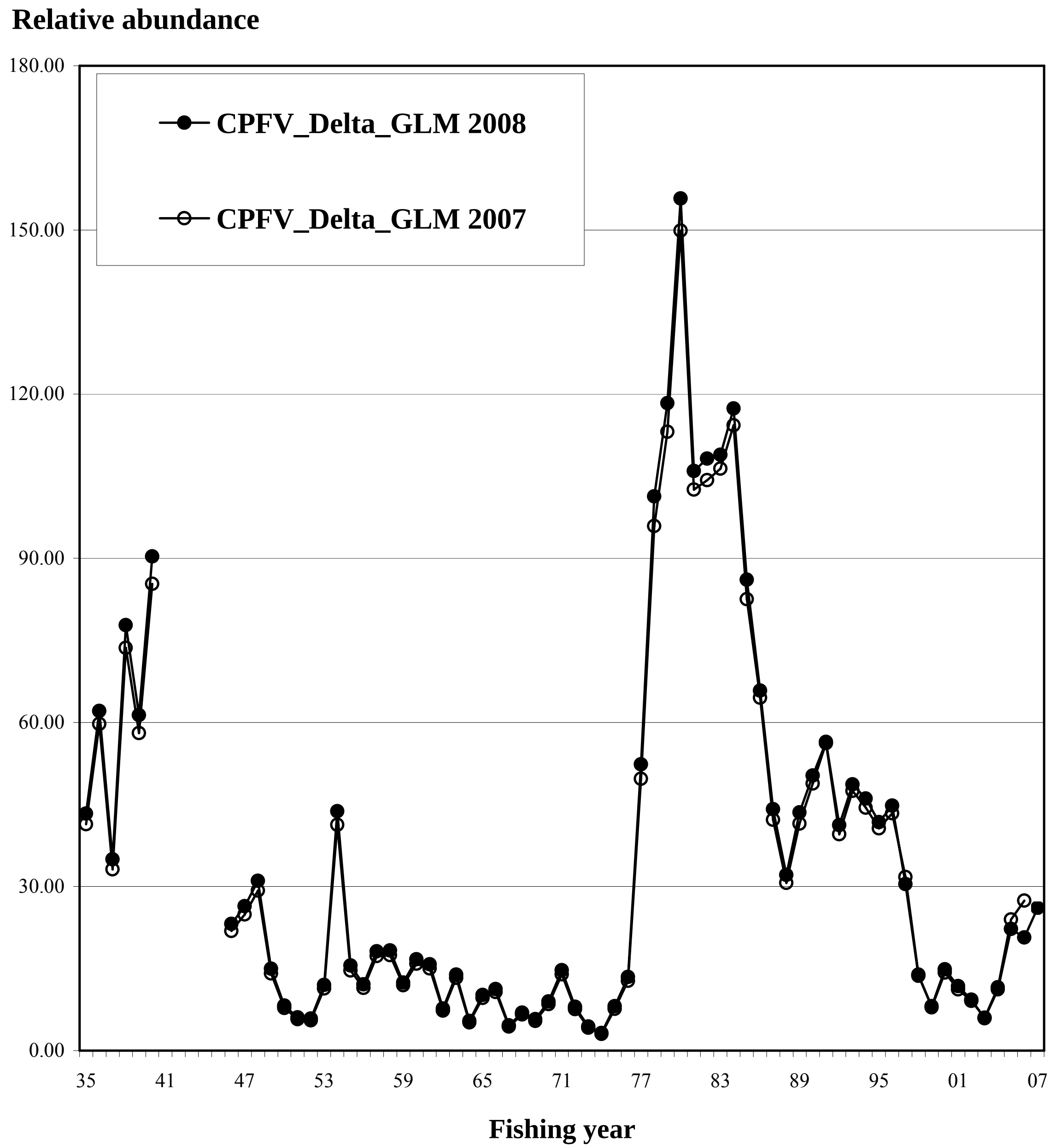


Figure 4. Indices of abundance time series for Pacific mackerel used in the ASAP-E1 and ASAP-E1 2008 models (1926-08) comparing GLM to Delta_GLM.

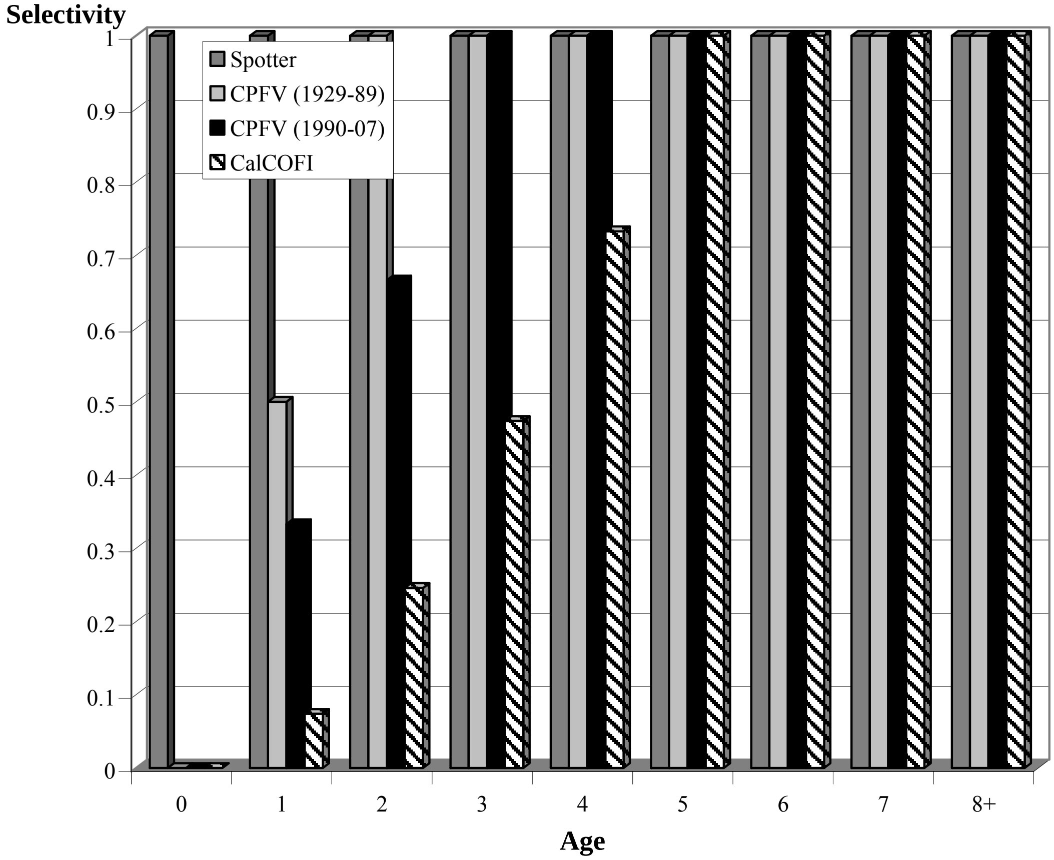


Figure 5. Assumed selectivity ogives for survey-related indices of abundance (Spotter, CPFV, and CalCOFI) from the ASAP-E1 2008 model (1926-08). Note that CPFV ogive represents (1990-07), with ogive for 1929-89 parameterized with slightly different probabilities for ages 1 and 2.

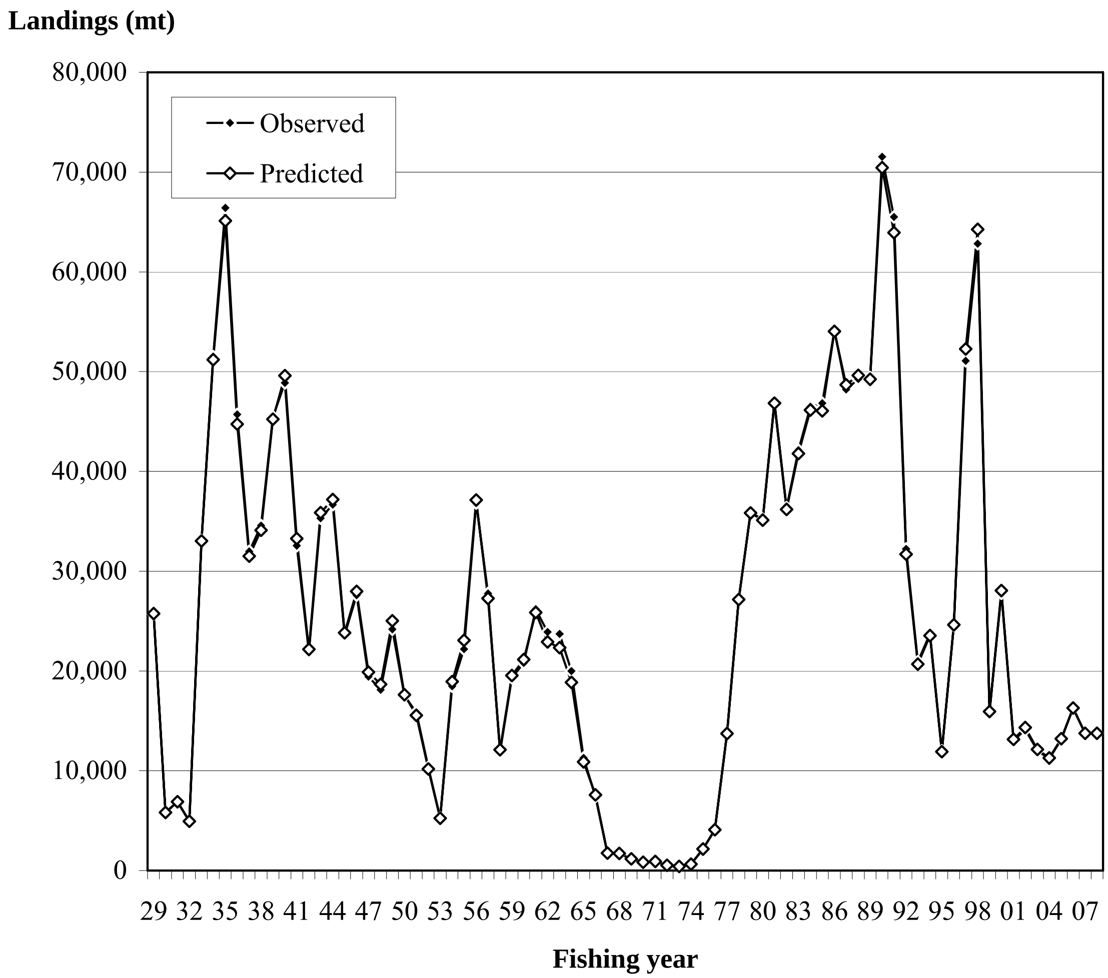


Figure 6. Observed and predicted estimates of total landings (mt) for Pacific mackerel generated from the ASAP-E1 2008 model (1929-08).

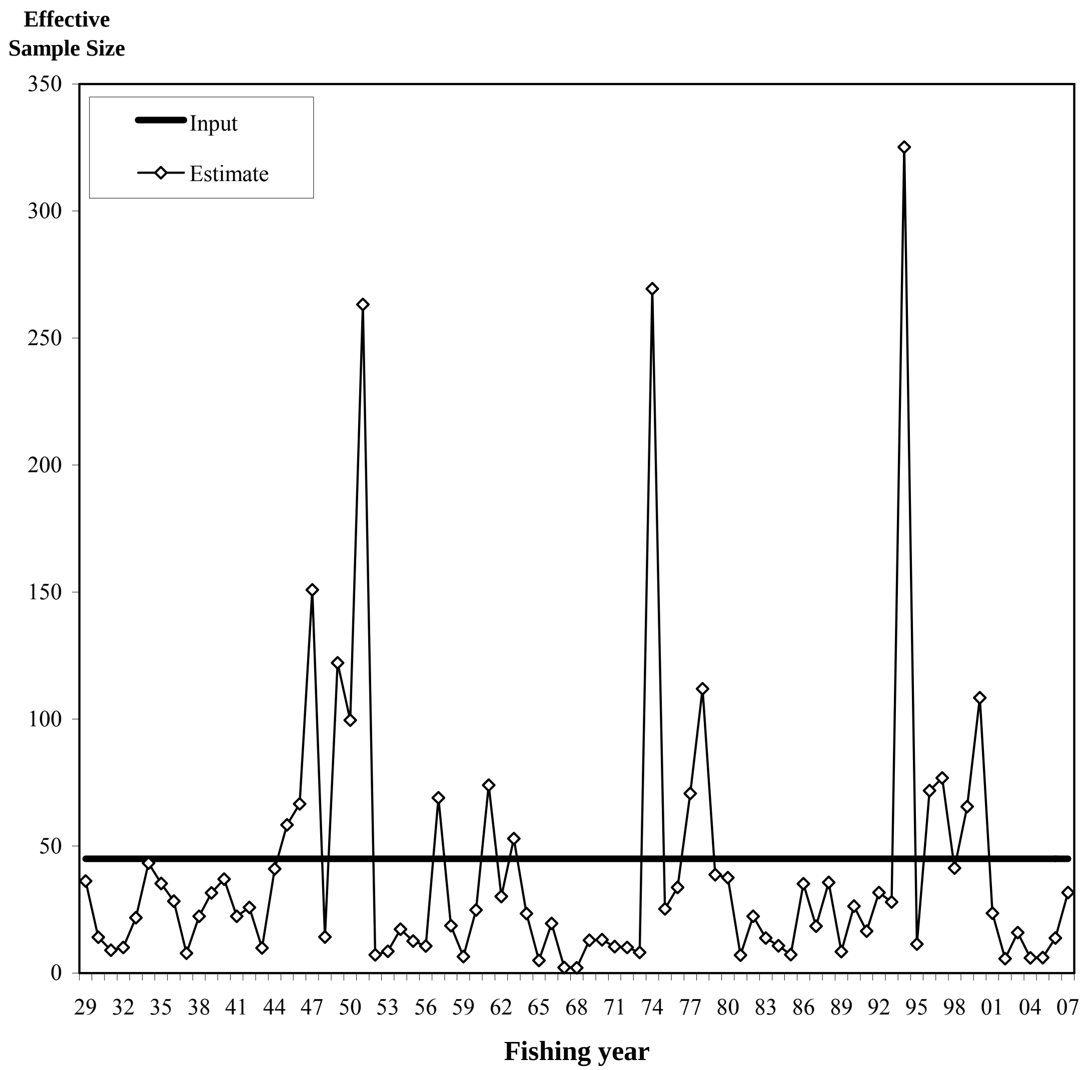


Figure 7. Effective sample sizes estimated for catch-at-age data generated from the ASAP-E1 2008 model (1929-08). Catch-at-age data were given a lamba weighting of '45' for all years.

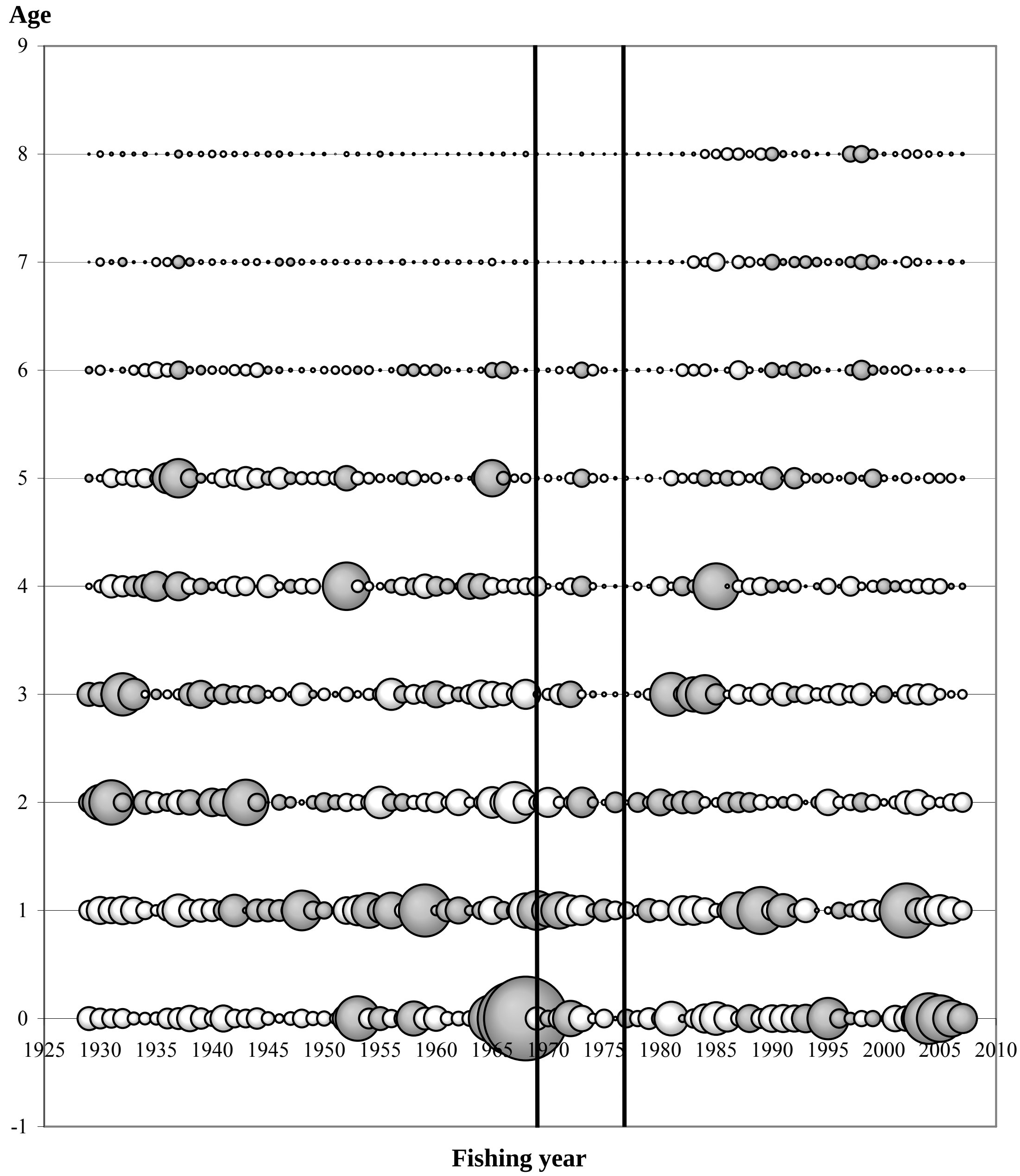


Figure 8. Pearson residual plot for Pacific mackerel catch-at-age fitted to the ASAP-E1 2008 model (1929-08). Dark gray bubbles indicate positive values and white bubbles indicated negative values. Vertical black lines represent periods of major change in fishery selectivity (1929-69, 1970-77, and 1978-07).

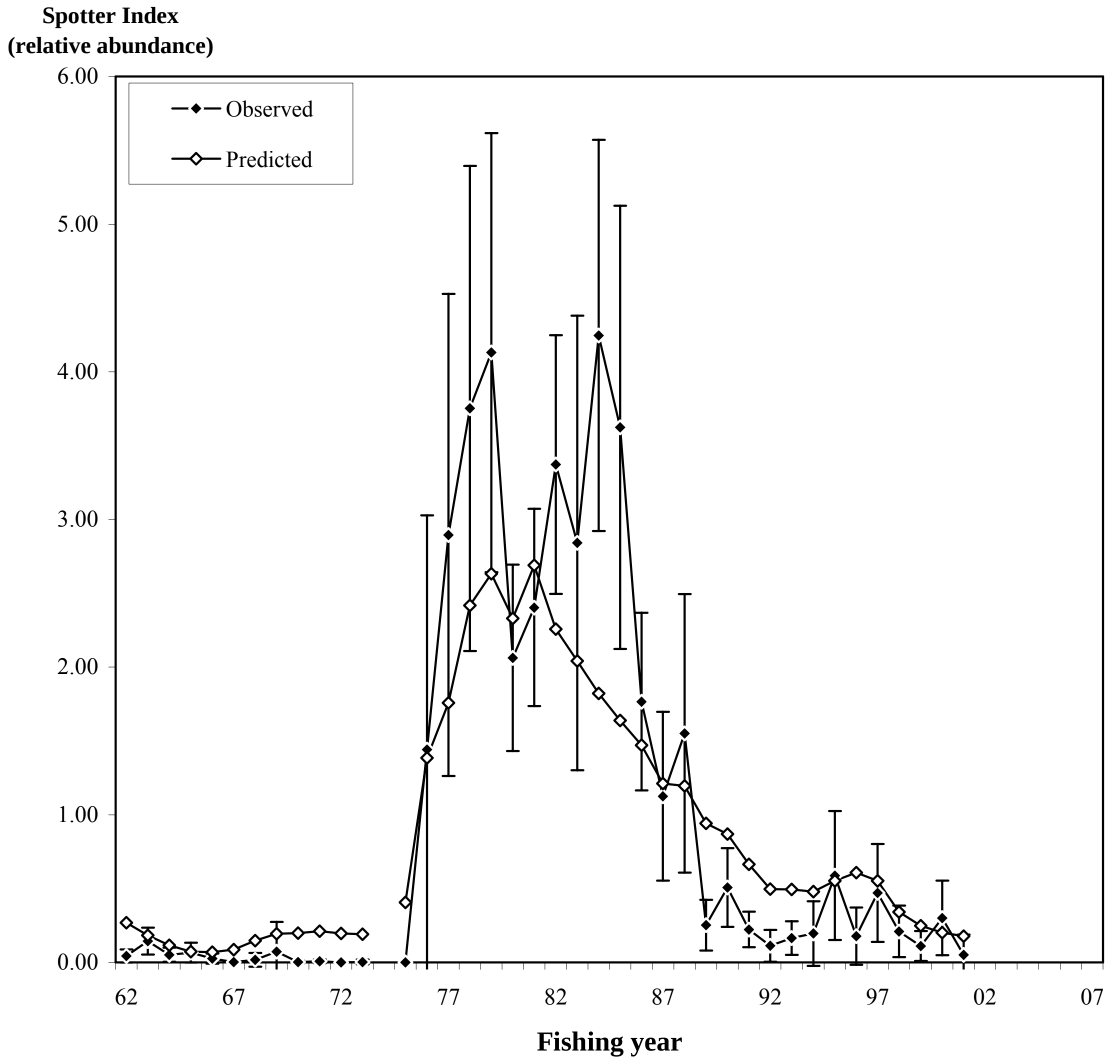


Figure 9. Observed and predicted estimates of the Spotter index of relative abundance for Pacific mackerel generated from the ASAP-E1 2008 model (1962-01). *Note: Observed values were internally re-scaled by ASAP.

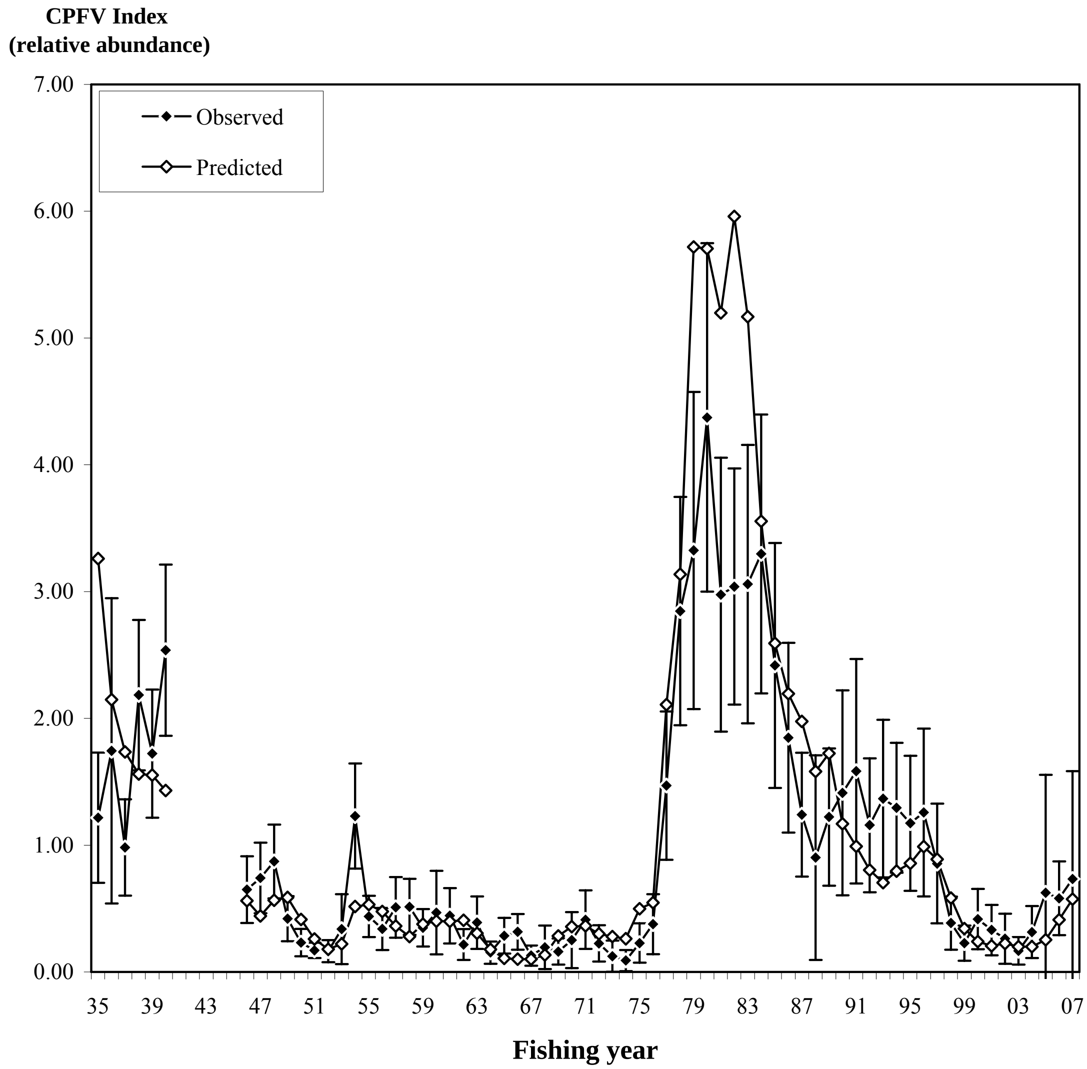


Figure 10. Observed and predicted estimates of the CPFV index of relative abundance for Pacific mackerel generated from the ASAP-E1 2008 model (1935-07). *Note: Observed values were internally re-scaled by ASAP.

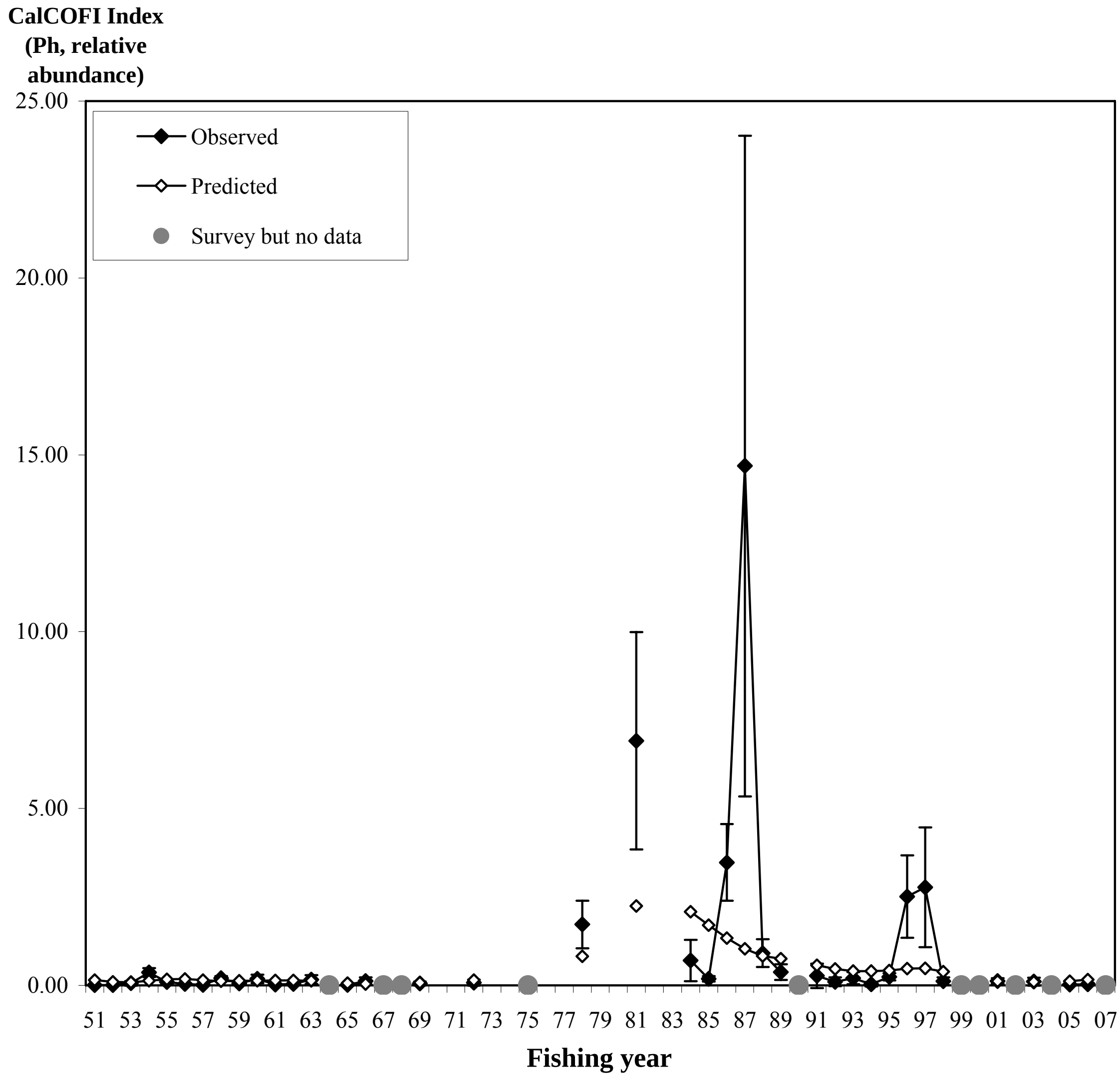


Figure 11. Observed and predicted estimates of the CalCOFI index of relative abundance for Pacific mackerel generated from the ASAP-E1 2008 model (1951-06). *Note: Observed values were internally re-scaled by ASAP.

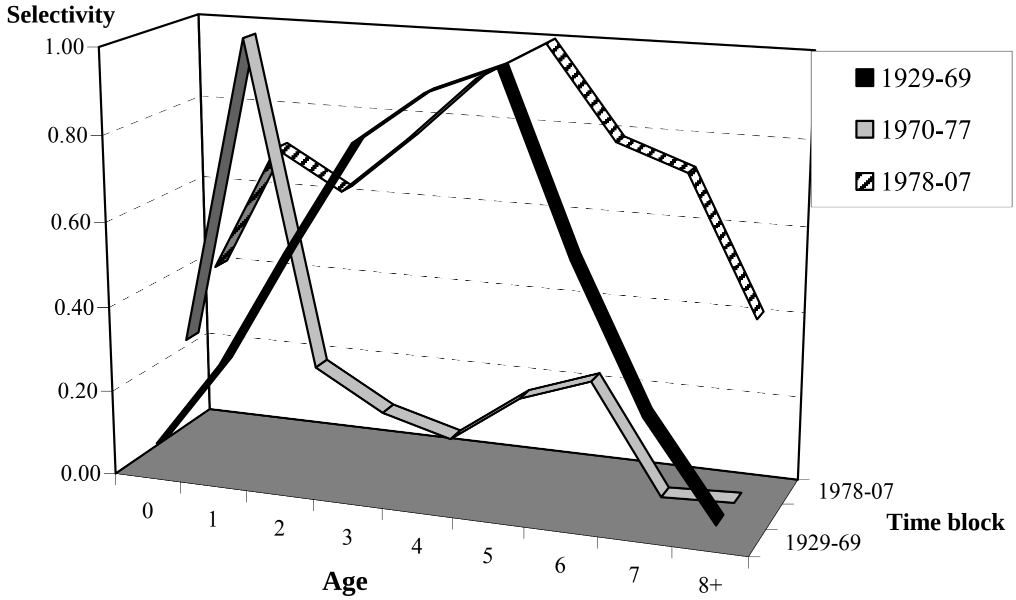


Figure 12. Estimated selectivity schedule for commercial fishery (catch-at-age) data from the ASAP-E1 2008 model (1926-08) based on three time blocks (1929-69, 1970-77, and 1978-07).

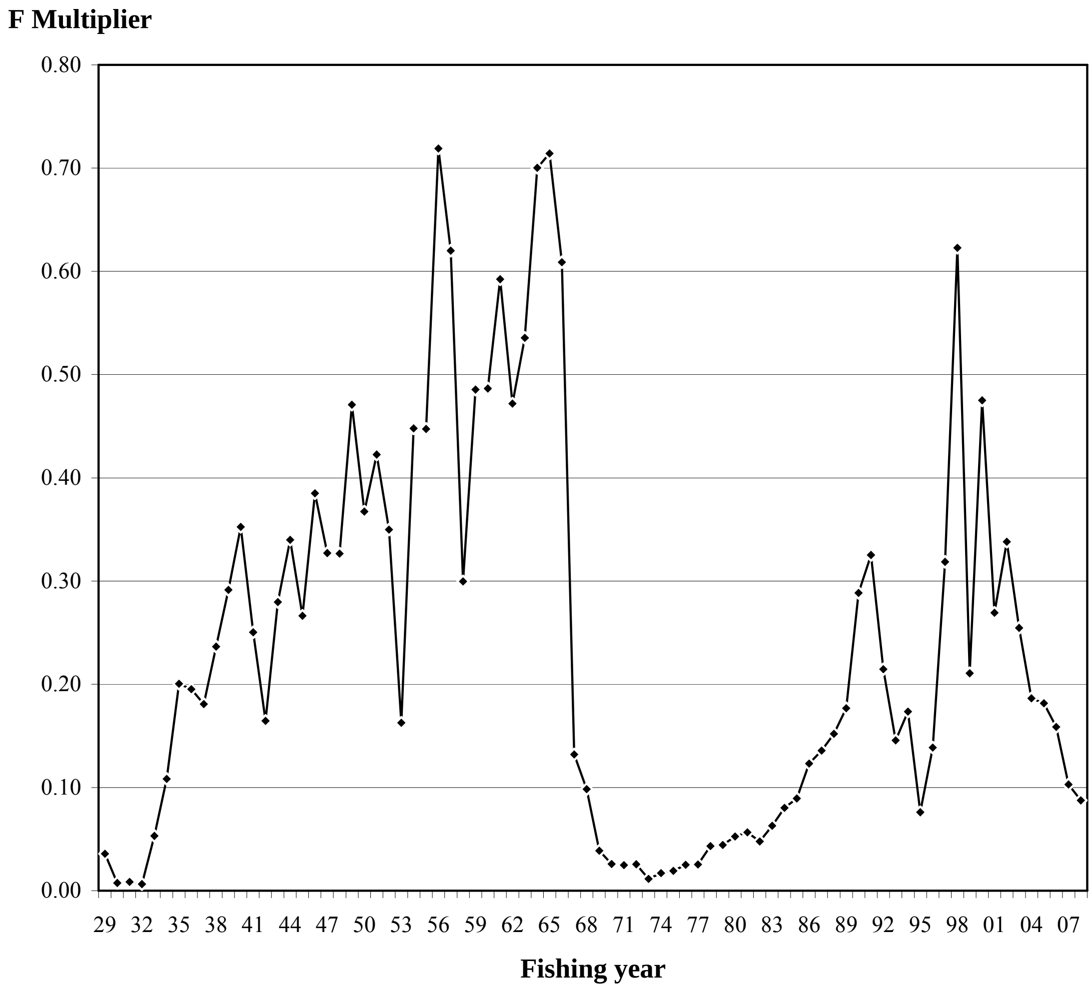


Figure 13. F multiplier for Pacific mackerel generated from the ASAP-E1 08 model (1929-08).

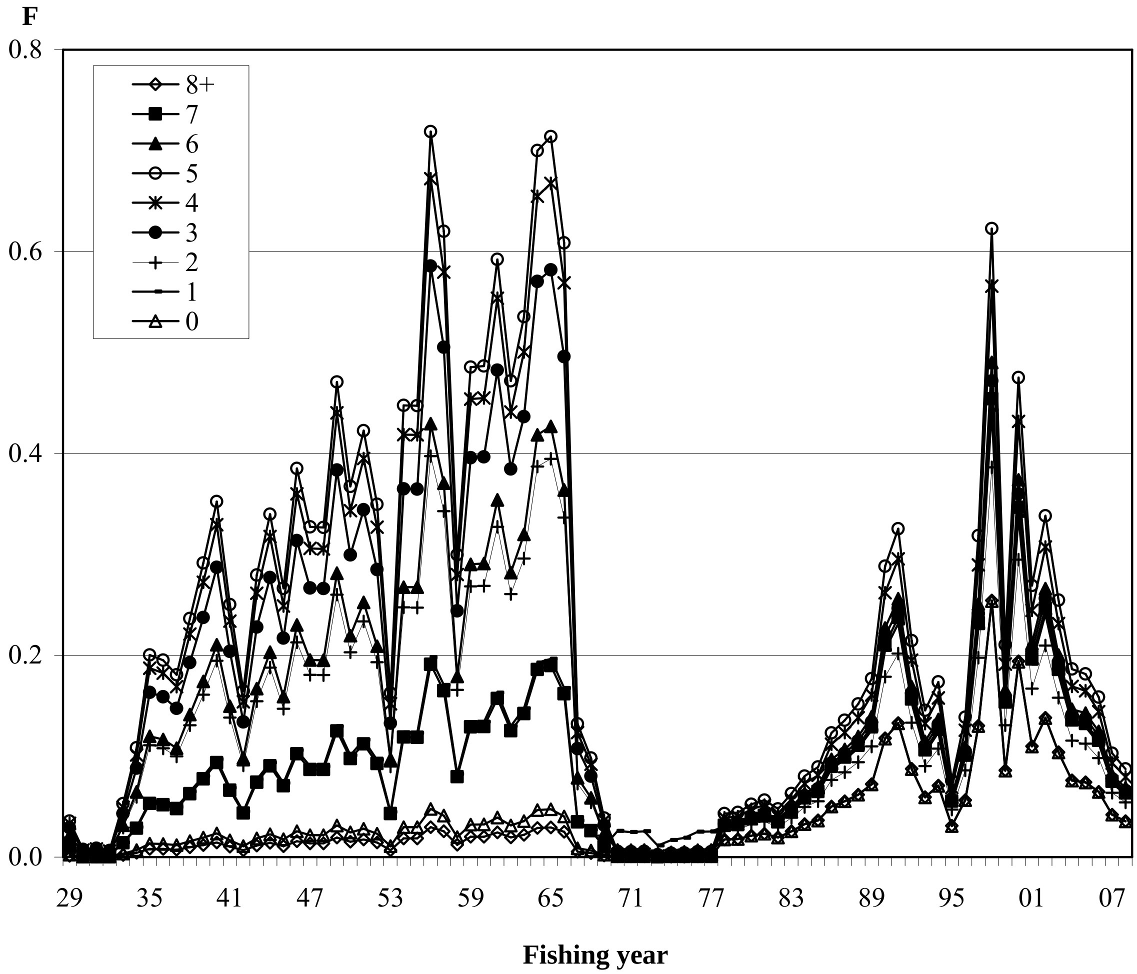


Figure 14. Estimated instantaneous fishing mortality (total) F-at-age for Pacific mackerel generated from the ASAP-E1 2008 model (1929-08).

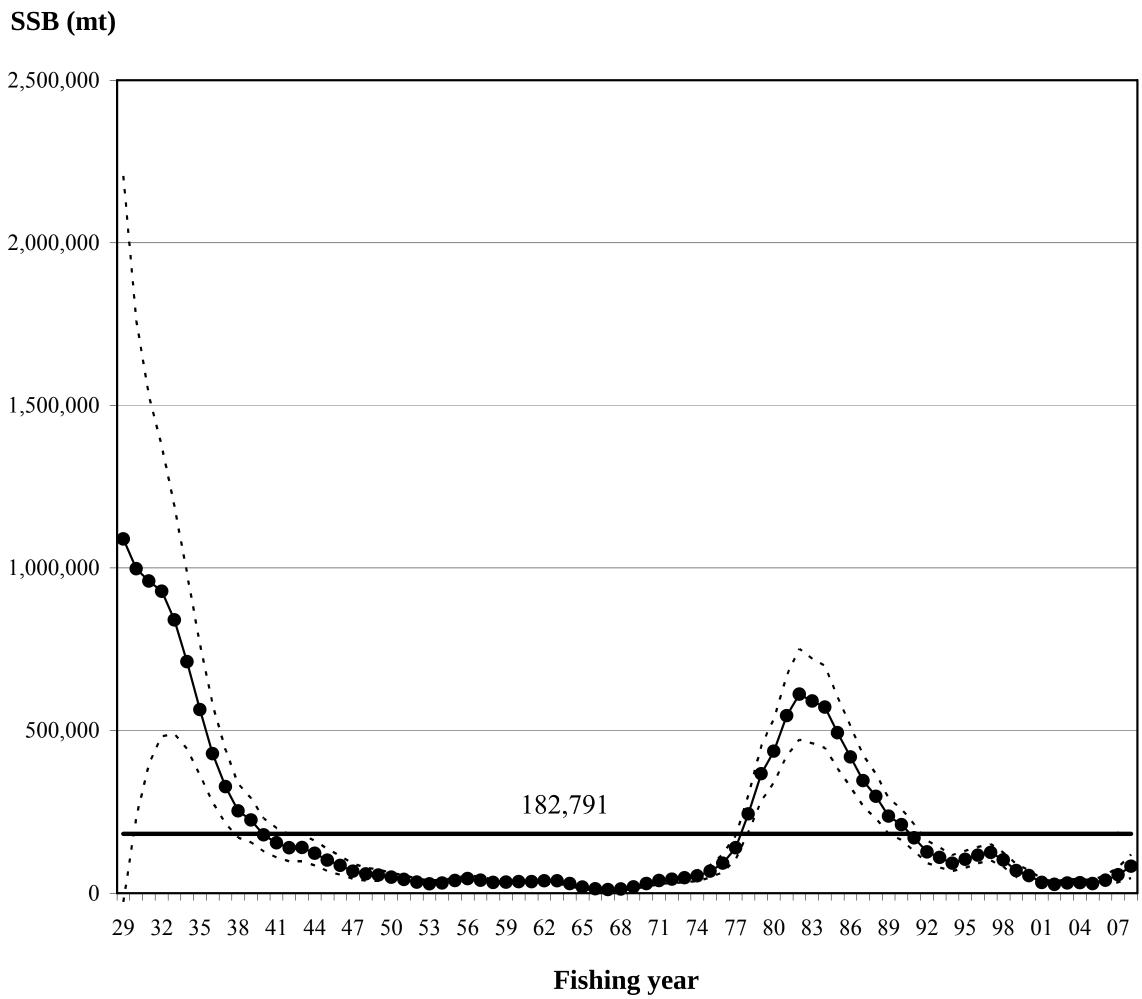


Figure 15. Estimated spawning stock biomass (*SSB*, in mt) of Pacific mackerel generated from the ASAP-E1 2008 model (1929-08). The confidence interval (± 2 STD) associated with this time series is also presented. Estimated 'virgin' *SSB* from stock-recruitment relationship is presented as solid horizontal line.

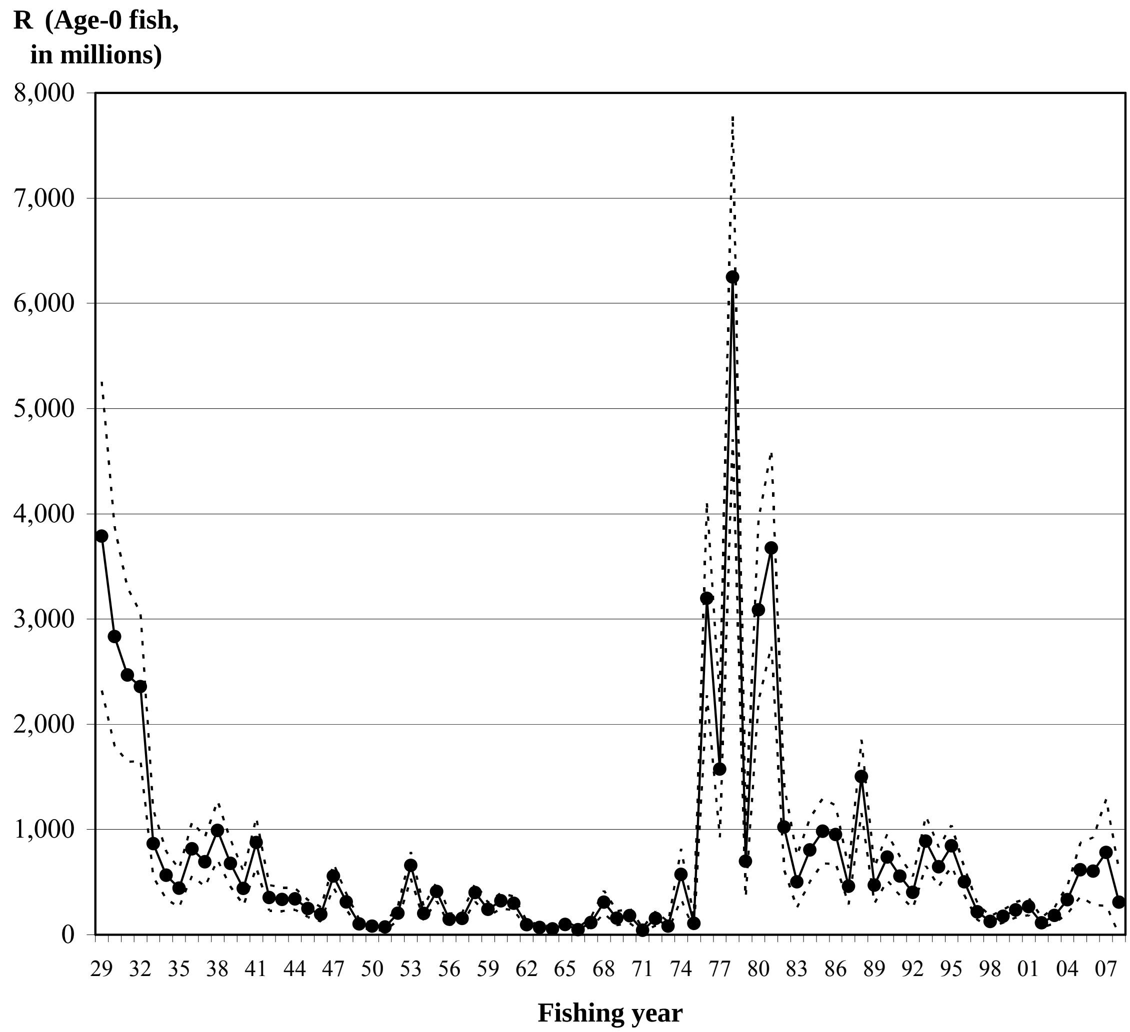


Figure 16. Estimated recruitment (age-0 fish in millions, R) of Pacific mackerel generated from the ASAP-E1 2008 model (1929-08). The confidence interval (± 2 STD) associated with this time series is also presented.

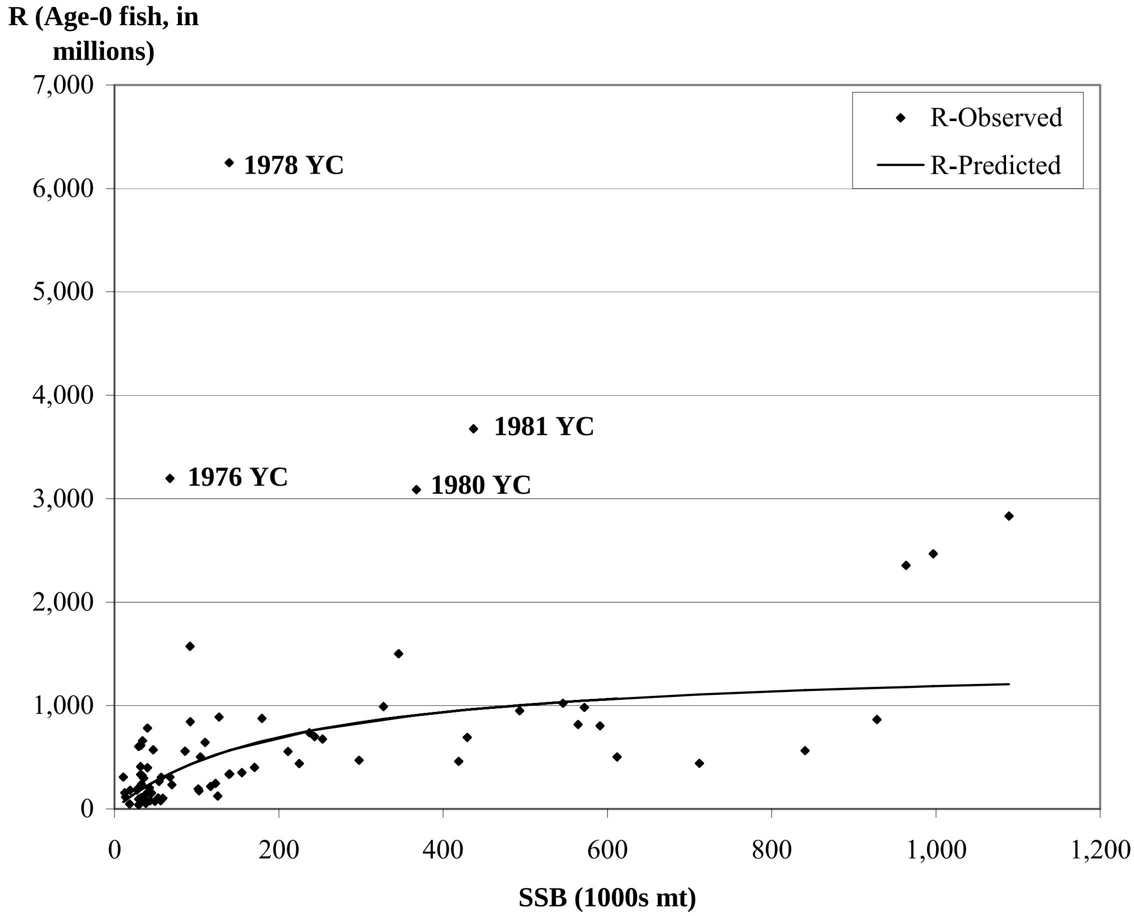


Figure 17. Beverton-Holt stock (*SSB*, in 1000s mt)-recruitment (Age-0 fish (R), in millions) relationship for Pacific mackerel estimated in the ASAP-E1 2008 model (1929-08). Recruitment estimates are presented as (year+1) values. Strong year classes are highlighted. Steepness= 0.32.

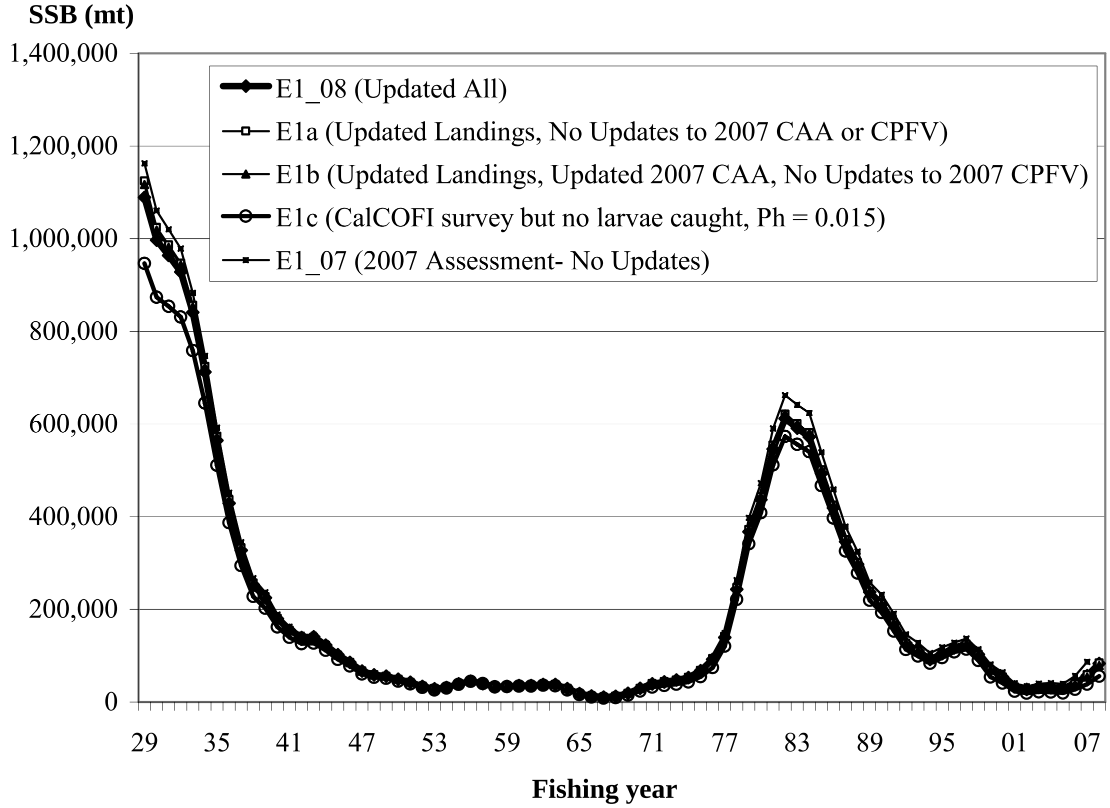


Figure 18. Comparison of spawning stock biomass estimated from sensitivity analyses. See Sensitivity Analysis section for description of each model run.

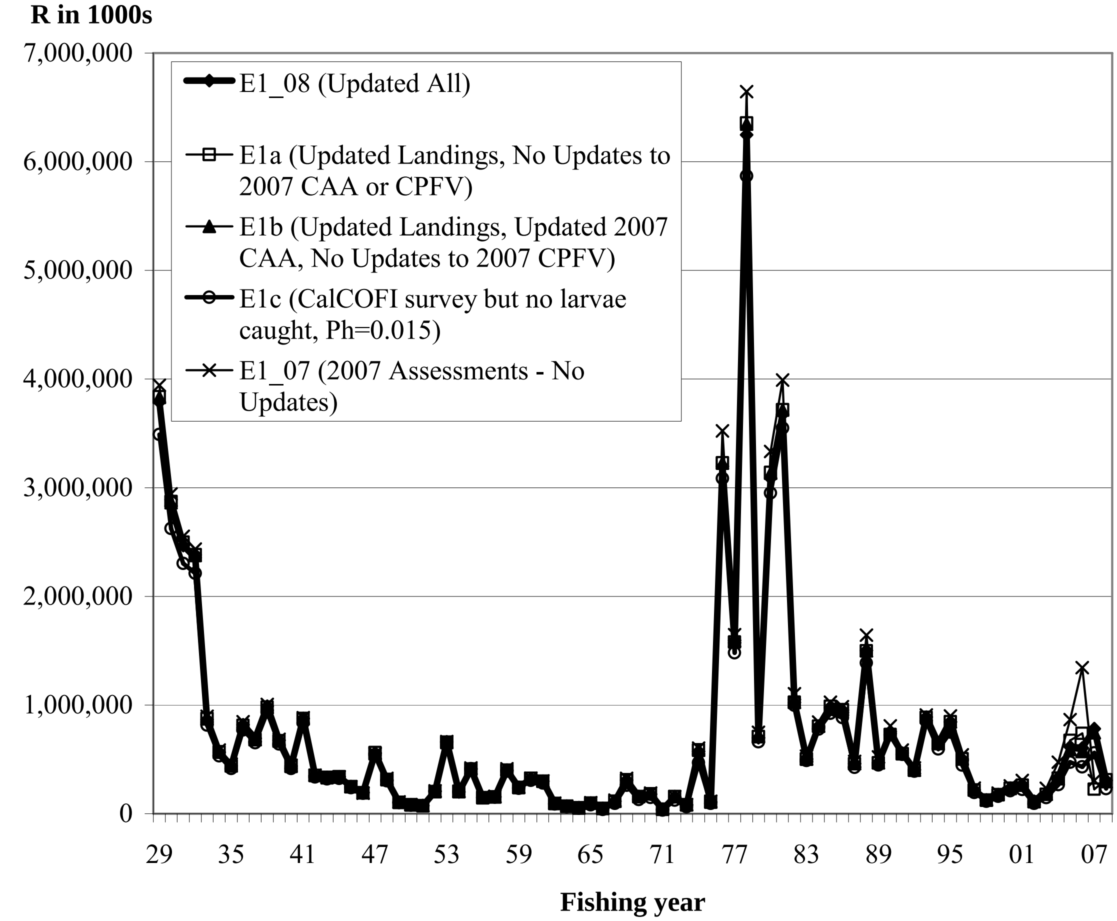


Figure 19. Comparison of recruitment (Age-0 fish) estimated from sensitivity analyses. See Sensitivity Analysis section for description of each model run.

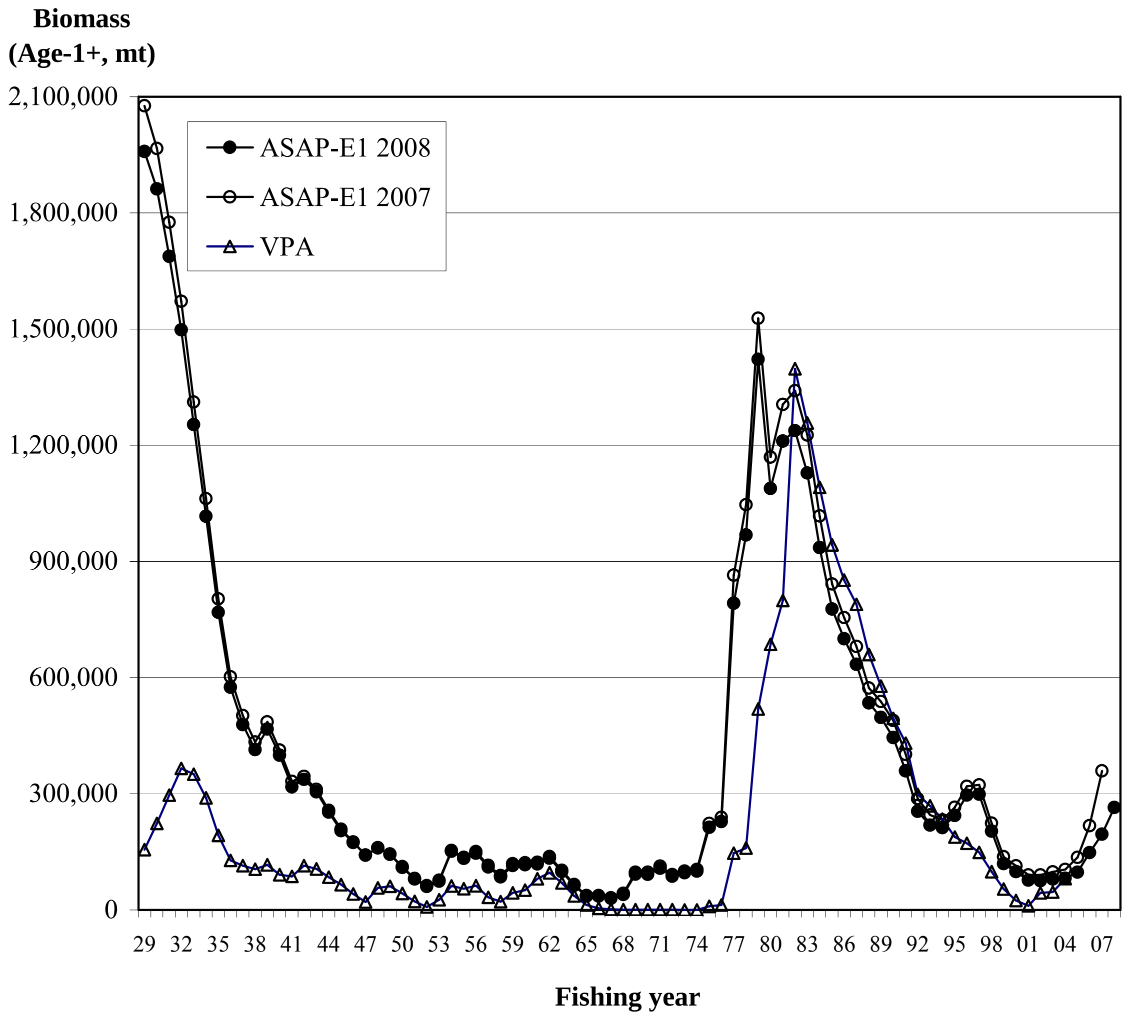


Figure 20. Estimated biomass (Age-1+ fish, in mt) of Pacific mackerel generated from the ASAP-E1 2008, ASAP-E1 2007, and VPA models (1929-08).

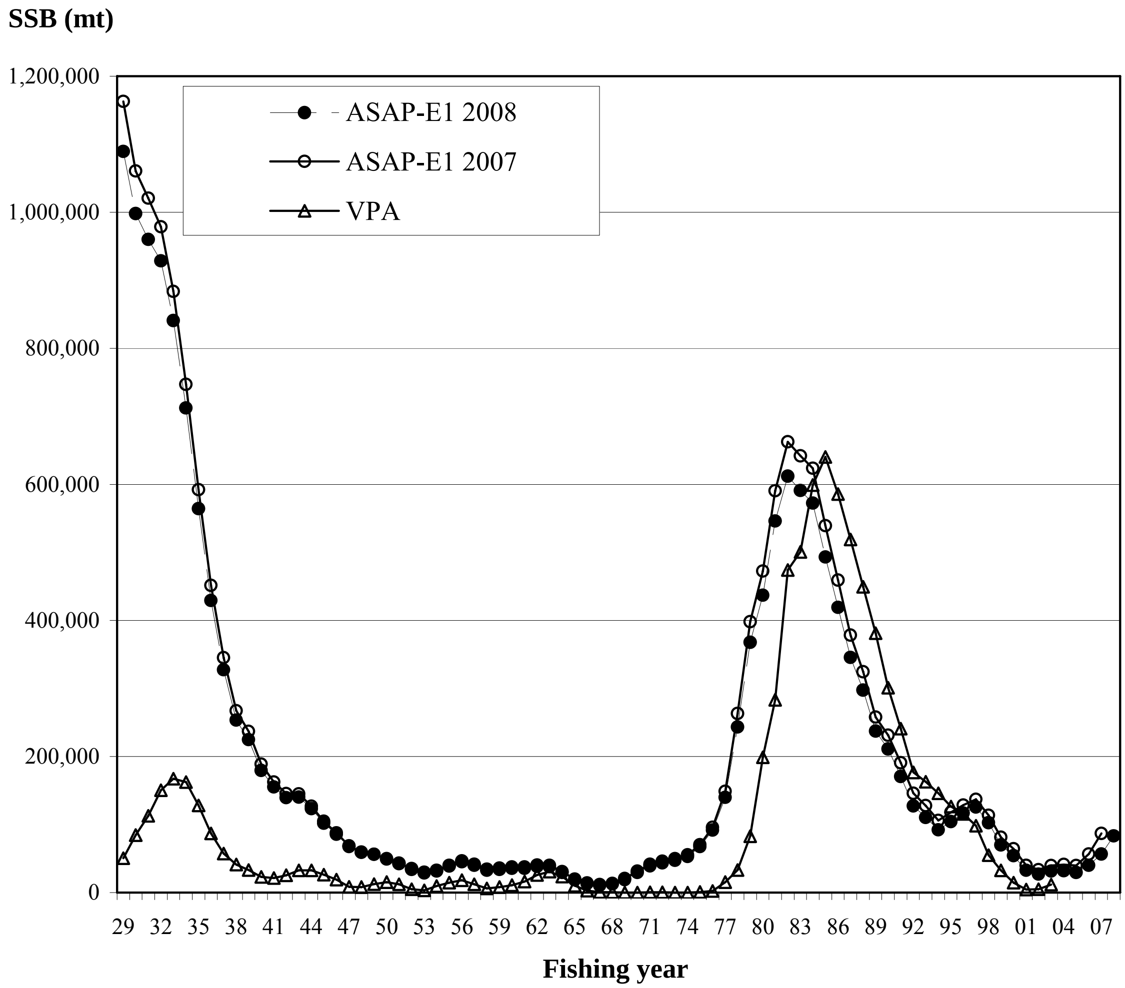


Figure 21. Estimated spawning stock biomass (*SSB*, in mt) of Pacific mackerel generated from the ASAP-E1 2008, ASAP-E1 2007, and VPA models (1929-08).

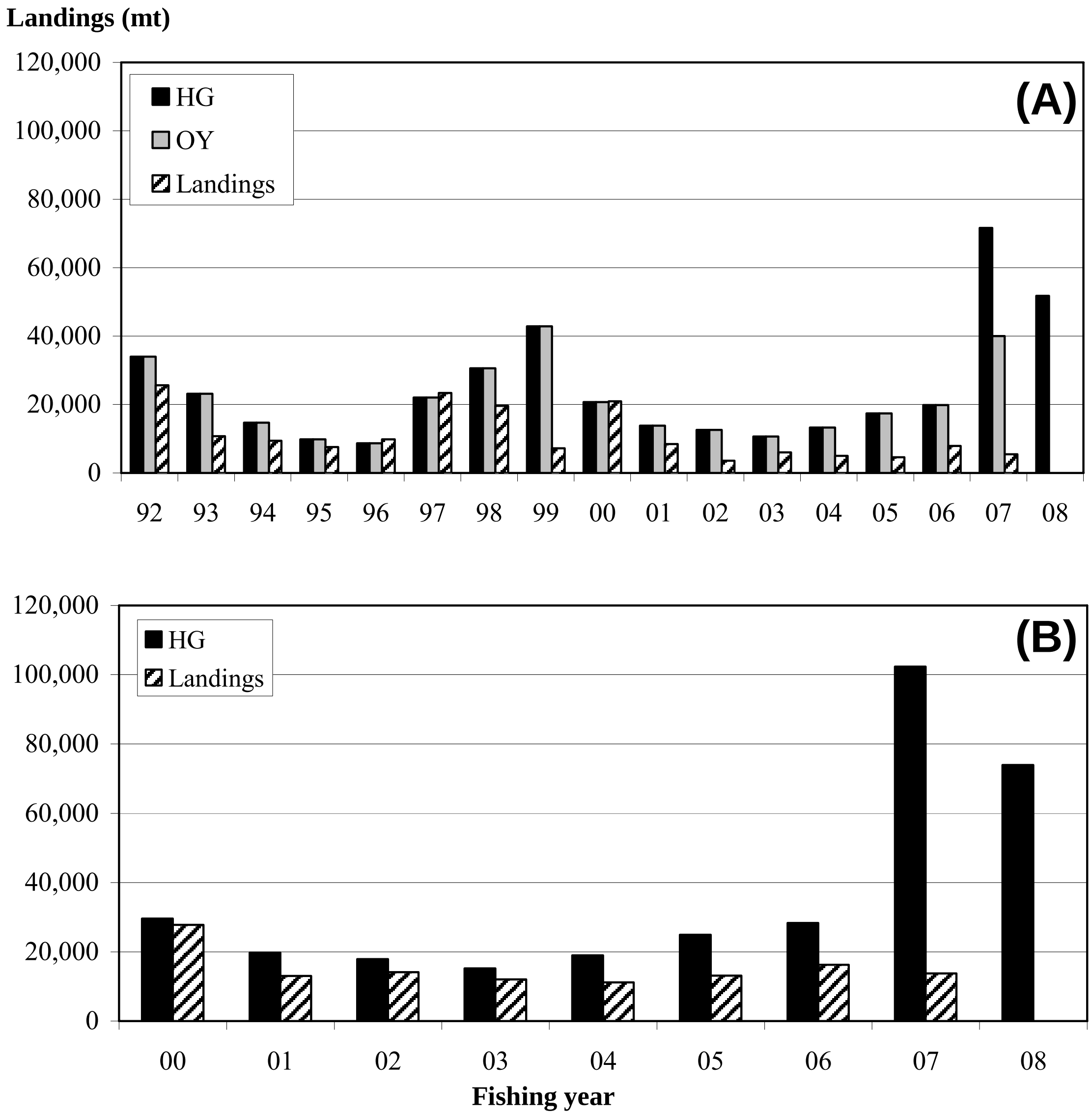


Figure 22. Commercial landings (California directed fishery in mt), Harvest Guidelines (HG in mt), and optimal yield (OY) for Pacific mackerel based on the harvest control rule, display (A, 1992-08 Fishing years). Total landings (mt) and Harvest Guidelines for Pacific mackerel based on no 'U.S. Distribution' parameter in the harvest control rule (B, 2000-08 Fishing years). Note that incidental landings from Pacific Northwest fisheries are not included, but typically range 100 to 300 mt per year.

APPENDIX A

```
# E1: SigR=0.7; M=0.5; update from 07
# Number of Years
   80
# 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
   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
   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
   0.126   0.222   0.353   0.522   0.752   0.824   0.848   0.918   0.935
   0.117   0.217   0.359   0.557   0.741   0.878   0.871   0.924   0.935
   0.117   0.217   0.359   0.557   0.741   0.878   0.871   0.924   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
48522.75	23717.95	4882.47	2454.61	1395.46	390.63	309.2	443.38	0	16265.15
34690.05	16917.34	6182.45	2734.26	1529.06	505.49	191.43	43.64	0	13743.29
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Fleet 1 Discards at Age - Last Column is Total Weight

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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

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0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0
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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
0	0	0	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
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        0         0         0         0         0         0         0         0         0
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        0         0         0         0         0         0         0         0         0
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        0         0         0         0         0         0         0         0         0
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        0         0         0         0         0         0         0         0         0
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        0         0         0         0         0         0         0         0         0
# 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
    1935      -999         1         1         1         1         1         1         1         1         1         1
    1936      -999         1         1         1         1         1         1         1         1         1         1
    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
1948	-999	1	1	1	1	1	1	1	1	1	1
1949	-999	1	1	1	1	1	1	1	1	1	1
1950	-999	1	1	1	1	1	1	1	1	1	1
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
1956	-999	1	1	1	1	1	1	1	1	1	1
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
2008	-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	43.31	0.21146	0	0.5	1	1	1	1	1	1	1
1936	62.06	0.34532	0	0.5	1	1	1	1	1	1	1
1937	34.99	0.19303	0	0.5	1	1	1	1	1	1	1
1938	77.75	0.1358	0	0.5	1	1	1	1	1	1	1
1939	61.33	0.14647	0	0.5	1	1	1	1	1	1	1
1940	90.34	0.13289	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	23.16	0.20273	0	0.5	1	1	1	1	1	1	1
1947	26.42	0.18721	0	0.5	1	1	1	1	1	1	1
1948	31.04	0.16684	0	0.5	1	1	1	1	1	1	1
1949	14.98	0.21146	0	0.5	1	1	1	1	1	1	1
1950	8.26	0.2328	0	0.5	1	1	1	1	1	1	1
1951	6.09	0.17654	0	0.5	1	1	1	1	1	1	1
1952	5.89	0.2619	0	0.5	1	1	1	1	1	1	1
1953	12.04	0.40643	0	0.5	1	1	1	1	1	1	1
1954	43.78	0.16878	0	0.5	1	1	1	1	1	1	1
1955	15.59	0.18624	0	0.5	1	1	1	1	1	1	1
1956	12.1	0.24347	0	0.5	1	1	1	1	1	1	1
1957	18.17	0.23377	0	0.5	1	1	1	1	1	1	1
1958	18.3	0.21437	0	0.5	1	1	1	1	1	1	1

1959	12.46	0.21049	0	0.5	1	1	1	1	1	1	1
1960	16.7	0.35114	0	0.5	1	1	1	1	1	1	1
1961	15.8	0.24541	0	0.5	1	1	1	1	1	1	1
1962	7.73	0.27839	0	0.5	1	1	1	1	1	1	1
1963	13.89	0.26578	0	0.5	1	1	1	1	1	1	1
1964	5.47	0.28615	0	0.5	1	1	1	1	1	1	1
1965	10.17	0.24638	0	0.5	1	1	1	1	1	1	1
1966	11.29	0.22213	0	0.5	1	1	1	1	1	1	1
1967	4.62	0.30361	0	0.5	1	1	1	1	1	1	1
1968	6.96	0.44038	0	0.5	1	1	1	1	1	1	1
1969	5.74	0.31913	0	0.5	1	1	1	1	1	1	1
1970	8.98	0.43941	0	0.5	1	1	1	1	1	1	1
1971	14.7	0.28033	0	0.5	1	1	1	1	1	1	1
1972	8.05	0.31719	0	0.5	1	1	1	1	1	1	1
1973	4.43	0.49179	0	0.5	1	1	1	1	1	1	1
1974	3.21	0.45881	0	0.5	1	1	1	1	1	1	1
1975	8.13	0.33853	0	0.5	1	1	1	1	1	1	1
1976	13.46	0.31234	0	0.5	1	1	1	1	1	1	1
1977	52.33	0.19885	0	0.5	1	1	1	1	1	1	1
1978	101.33	0.15811	0	0.5	1	1	1	1	1	1	1
1979	118.36	0.18818	0	0.5	1	1	1	1	1	1	1
1980	155.73	0.15714	0	0.5	1	1	1	1	1	1	1
1981	105.97	0.18139	0	0.5	1	1	1	1	1	1	1
1982	108.23	0.15326	0	0.5	1	1	1	1	1	1	1
1983	108.89	0.17945	0	0.5	1	1	1	1	1	1	1
1984	117.36	0.16684	0	0.5	1	1	1	1	1	1	1
1985	86.09	0.19982	0	0.5	1	1	1	1	1	1	1
1986	65.8	0.20273	0	0.5	1	1	1	1	1	1	1
1987	44.16	0.19691	0	0.5	1	1	1	1	1	1	1
1988	32.12	0.44717	0	0.5	1	1	1	1	1	1	1
1989	43.55	0.22116	0	0.5	1	1	1	1	1	1	1
1990	50.29	0.28615	0	0.333	0.666	1	1	1	1	1	1
1991	56.4	0.27936	0	0.333	0.666	1	1	1	1	1	1
1992	41.23	0.22795	0	0.333	0.666	1	1	1	1	1	1
1993	48.69	0.22698	0	0.333	0.666	1	1	1	1	1	1
1994	46.09	0.19788	0	0.333	0.666	1	1	1	1	1	1
1995	41.76	0.22698	0	0.333	0.666	1	1	1	1	1	1
1996	44.8	0.26287	0	0.333	0.666	1	1	1	1	1	1
1997	30.45	0.27548	0	0.333	0.666	1	1	1	1	1	1
1998	13.71	0.27257	0	0.333	0.666	1	1	1	1	1	1
1999	8.12	0.30555	0	0.333	0.666	1	1	1	1	1	1
2000	14.85	0.28421	0	0.333	0.666	1	1	1	1	1	1
2001	11.78	0.29973	0	0.333	0.666	1	1	1	1	1	1
2002	9.31	0.37733	0	0.333	0.666	1	1	1	1	1	1
2003	5.95	0.32204	0	0.333	0.666	1	1	1	1	1	1
2004	11.23	0.32495	0	0.333	0.666	1	1	1	1	1	1
2005	22.27	0.74399	0	0.333	0.666	1	1	1	1	1	1
2006	20.69	0.25026	0	0.333	0.666	1	1	1	1	1	1
2007	26.09	0.58006	0	0.333	0.666	1	1	1	1	1	1
2008	-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

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    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
    2008      -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
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#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
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         0
# Lambda for Discards at Age by Year & Fleet
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# 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
   2010
# Year Projected Recruits, What Projected, Target, non- directed F mult
      2009         2       0.3         1        -1
      2010         2       0.3         1        -1
# Test Value
   -23456
#####
# ---- FINIS ----
```

APPENDIX B

```
obj_fun        = 1184.38
Component          RSS      nobs  Lambda  Likelihood
  Catch_Fleet_1        0.0236194   80   100   2.36194
Catch_Fleet_Total     0.0236194   80   100   2.36194
  Discard_Fleet_1        0   80   0   0
Discard_Fleet_Total     0   80   0   0
CAA_proportions      N/A            720    see_below      530.926
Discard_proportions      N/A            720    see_below      0
  Index_Fit_1         166.917   39   1   119.157
  Index_Fit_2         16.057   68   1   104.852
  Index_Fit_3         76.8729   37   1   315.538
Index_Fit_Total     259.847   144   3   539.547
  Selectivity_devs_fleet_1   34.3354  2   0  0
Selectivity_devs_Total   34.3354  2   0  0
  Catchability_devs_index_1  0  39  1  0
  Catchability_devs_index_2  0  68  1  0
  Catchability_devs_index_3  0  37  1  0
Catchability_devs_Total  0  144  3  0
  Fmult_fleet_1     28.344   79   0  0
Fmult_fleet_Total   28.344   79   0  0
N_year_1            2.46086   8   0   0
Stock-Recruit_Fit   57.6502  80   1   53.8968
Recruit_devs        57.6502   80   1   57.6502
SRR_steepness       1.09899       1 0   0
SRR_virgin_stock    4.47778      1 0  0
Curvature_over_age  53.0086   14   0   0
Curvature_over_time 68.6708   702   0   0
F_penalty           1.74589    720     0.001     0.00174589
Mean_Sel_year1_pen  0   9      1000  0
Max_Sel_penalty     0.278802        1       100 0
Fmult_Max_penalty   0        ?       100 0

 Input and Estimated effective sample sizes for fleet 1
1929  45  36.2237
1930  45  14.0491
1931  45  9.04635
1932  45  10.0544
1933  45  21.7624
1934  45  43.2674
1935  45  35.2344
1936  45  28.2955
1937  45  7.80704
1938  45  22.3318
1939  45  31.5594
1940  45  37.0004
1941  45  22.3592
1942  45  25.8035
1943  45  9.88299
1944  45  41.0466
1945  45  58.3799
1946  45  66.6043
1947  45  150.869
1948  45  14.1723
1949  45  122.077
1950  45  99.5503
1951  45  263.272
1952  45  7.12822
1953  45  8.56774
1954  45  17.2541
1955  45  12.5785
1956  45  10.6006
1957  45  69.0312
1958  45  18.6191
1959  45  6.51177
1960  45  24.8915
1961  45  73.9718
1962  45  30.1446
1963  45  52.8996
1964  45  23.4466
1965  45  4.99631
1966  45  19.5674
1967  45  2.14204
1968  45  2.07588
1969  45  12.958
1970  45  13.1248
1971  45  10.4233
1972  45  10.0881
1973  45  8.08927
1974  45  269.388
1975  45  25.2922
1976  45  33.6836
1977  45  70.7012
1978  45  111.908
1979  45  38.7142
1980  45  37.5291
1981  45  7.06002
1982  45  22.3468
1983  45  13.7512
1984  45  10.7567
1985  45  7.2822
1986  45  35.1295
```

1987	45	18.4691
1988	45	35.7076
1989	45	8.48506
1990	45	26.341
1991	45	16.5076
1992	45	31.6193
1993	45	28.026
1994	45	325.181
1995	45	11.3491
1996	45	71.7909
1997	45	76.831
1998	45	41.3082
1999	45	65.4619
2000	45	108.359
2001	45	23.5083
2002	45	5.61202
2003	45	15.9449
2004	45	5.96139
2005	45	6.02485
2006	45	13.7905
2007	45	31.6195
2008	0	2.36347
Total	3555	3263.56

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
2008  0  1e+15
 Total  0  8e+16

Observed and predicted total fleet catch by year
 fleet 1 total catches
1929  25733.5  25741.8
1930  5825.88  5826.56
1931  6890.14  6890.57
1932  4938.95  4938.68
1933  33072.2  33026.1
1934  51483.8  51194.2
1935  66417.4  65125.2
1936  45714.2  44728.5
1937  31987.6  31502.6
1938  34561.8  34102
1939  45454  45249.7
1940  48868.2  49589.2
1941  32560.8  33263.3
1942  21885.7  22159.3
1943  35304.7  35855.2
1944  36657.1  37184.6
1945  23601.4  23810.9
1946  27582.5  27969.9
1947  19437  19872
1948  18124.7  18656.5
1949  24188.9  25021.8
1950  17493  17626
1951  15857.1  15540.8
1952  10325.8  10168.5
1953  5265.94  5236.22
1954  18464.7  18934.9
1955  22200.9  23068.4
1956  36835  37140.6
1957  27753.4  27262
1958  11874.8  12102.6
1959  19332.5  19554.3
1960  20822.5  21155.3
1961  26199.2  25858.5
1962  23901  22900
1963  23703  22335
1964  19987.9  18866.1
1965  11279.4  10898.5
1966  7405.18  7581.59
1967  1713.31  1732.8
1968  1695.04  1707.76
1969  1168.22  1171.32
1970  835.49  835.397
1971  911.26  911.794
1972  532  531.976
1973  400.94  401.036
1974  633.81  633.71
1975  2149.3  2148.38
1976  4091.65  4089.82
1977  13751.2  13730.3
1978  27172.6  27154.1
1979  35858.1  35846.7
1980  35203.1  35116.5
1981  46984.5  46846.3
1982  36371.4  36198.9
1983  42117.5  41802.2
1984  46468.3  46153.3
1985  46827.8  46075.7
1986  54122.6  54022.2
1987  48222.8  48682.2
1988  49264.6  49608.1
1989  49405.8  49245.7
1990  71550.6  70424.8
1991  65504.9  63934.7
1992  32217.5  31698.9
1993  20919.9  20683.5
1994  23737  23530.1
1995  11995.8  11919
1996  24562.7  24627.7
1997  51076.3  52266.2
1998  62822.7  64263.4
1999  15909.9  15928.7
2000  27791.9  28050.8
2001  13010.4  13141.7
2002  14122.8  14329.1
2003  12022.9  12128.3
2004  11195.4  11285.7
2005  13151.5  13206.2
2006  16265.1  16296.6
2007  13743.3  13746
2008  13743.3  13743.3
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
1955  0  0
1956  0  0
1957  0  0
1958  0  0
1959  0  0
1960  0  0
1961  0  0
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
1975  0  0
1976  0  0
1977  0  0
1978  0  0
1979  0  0
1980  0  0
1981  0  0
1982  0  0
1983  0  0
1984  0  0
1985  0  0
1986  0  0
1987  0  0
1988  0  0
1989  0  0
1990  0  0
1991  0  0
1992  0  0
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
2008  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  0.268188
1963  0.0974896  0.143439  0.182984
1964  0.190425  0.0511159  0.1149
1965  0.229574  0.0658689  0.0730904
1966  0.370805  0.0253169  0.0697859
1967  0.672149  0.00184983  0.0860493
```

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1968  1.10406  0.016614  0.146742
1969  1.07098  0.0728476  0.193622
1970  1.93856  0.00204988  0.197047
1971  0.583388  0.00713691  0.211389
1972  1.64914  0.000508051  0.195614
1973  2.22507  0.00269379  0.189564
1975  2.30918  0.000401044  0.406359
1976  0.264285  1.44157  1.38402
1977  0.0765202  2.89503  1.7583
1978  0.0468464  3.75184  2.41725
1979  0.0318862  4.12959  2.63254
1980  0.0231392  2.06239  2.32948
1981  0.0191367  2.40342  2.68956
1982  0.0167588  3.37185  2.25651
1983  0.0708694  2.84027  2.04102
1984  0.0240446  4.24635  1.82045
1985  0.0419564  3.62375  1.63859
1986  0.0284903  1.76601  1.47004
1987  0.0625202  1.12471  1.21239
1988  0.0883918  1.55145  1.19521
1989  0.110003  0.251322  0.942099
1990  0.0668817  0.506718  0.867667
1991  0.0703653  0.222483  0.664299
1992  0.207339  0.112365  0.495434
1993  0.112458  0.164169  0.493891
1994  0.273624  0.19519  0.478979
1995  0.12961  0.587796  0.551731
1996  0.260914  0.177525  0.60808
1997  0.117435  0.469986  0.552592
1998  0.160322  0.209194  0.341584
1999  0.191183  0.110532  0.248178
2000  0.162459  0.300632  0.202037
2001  1.02709  0.0510656  0.176915
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  0.0437444  1.21646  3.26014
1936  0.112655  1.7431  2.14752
1937  0.0365832  0.982776  1.73522
1938  0.0182737  2.18379  1.56086
1939  0.0212266  1.7226  1.55345
1940  0.0175056  2.53741  1.43095
1946  0.0402773  0.650503  0.562389
1947  0.0344474  0.742067  0.442904
1948  0.0274552  0.871831  0.565511
1949  0.0437444  0.420748  0.58799
1950  0.0527782  0.232001  0.413754
1951  0.0306906  0.171052  0.260908
1952  0.0663415  0.165434  0.18038
1953  0.15288  0.338172  0.221689
1954  0.0280885  1.22966  0.516462
1955  0.0340974  0.437882  0.531292
1956  0.0575872  0.339857  0.477769
1957  0.0532075  0.510347  0.363075
1958  0.0449299  0.513998  0.279651
1959  0.0433526  0.349968  0.378177
1960  0.11627  0.469058  0.401138
1961  0.0584822  0.44378  0.398097
1962  0.0746445  0.217115  0.407661
1963  0.0682557  0.390133  0.305671
1964  0.078702  0.153638  0.178806
1965  0.058932  0.285648  0.108565
1966  0.0481631  0.317106  0.103018
1967  0.0881748  0.129763  0.10114
1968  0.177254  0.195488  0.134086
1969  0.0969851  0.161221  0.285185
1970  0.176539  0.252224  0.358631
1971  0.0756499  0.412884  0.365455
1972  0.0958641  0.226103  0.301137
1973  0.216608  0.124427  0.279559
1974  0.191039  0.0901603  0.263493
1975  0.108498  0.22835  0.499596
1976  0.0930861  0.378056  0.545964
1977  0.0387796  1.46981  2.10855
1978  0.0246914  2.84609  3.13601
1979  0.0347991  3.32442  5.71703
1980  0.024393  4.37404  5.70554
1981  0.0323726  2.97641  5.19734
1982  0.023217  3.03989  5.95925
1983  0.0316947  3.05843  5.16684
1984  0.0274552  3.29633  3.55436
1985  0.0391515  2.41804  2.59132
1986  0.0402773  1.84815  2.1948
1987  0.0380407  1.24034  1.97627
1988  0.182289  0.902165  1.58064
1989  0.0477532  1.2232  1.72395
1990  0.078702  1.41251  1.17016
1991  0.0751464  1.58413  0.991806
1992  0.0506562  1.15804  0.805339
1993  0.0502367  1.36757  0.705475
1994  0.0384093  1.29455  0.795305
1995  0.0502367  1.17293  0.857487
```

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1996  0.0668178  1.25831  0.988486
1997  0.0731475  0.855259  0.888587
1998  0.0716641  0.385077  0.583458
1999  0.0892563  0.228069  0.343589
2000  0.0776787  0.417097  0.241661
2001  0.0860291  0.330869  0.206449
2002  0.133112  0.261493  0.225535
2003  0.098677  0.16712  0.19989
2004  0.100381  0.315421  0.199123
2005  0.440524  0.625505  0.253329
2006  0.060747  0.581127  0.412353
2007  0.290032  0.732799  0.574302
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  0.145789
1952  0.255882  0.00727985  0.1038
1953  0.25005  0.0591884  0.0872772
1954  0.0305059  0.36336  0.134718
1955  0.0911935  0.0908399  0.167498
1956  0.0957546  0.0357662  0.178822
1957  0.147043  0.0139267  0.14683
1958  0.0259055  0.199088  0.117815
1959  0.0456003  0.0582388  0.128421
1960  0.10159  0.185161  0.135326
1961  0.102774  0.0212065  0.140097
1962  0.166765  0.0395644  0.139418
1963  0.138889  0.163638  0.128509
1965  0.257556  0.0180414  0.0590616
1966  0.178451  0.120592  0.0415373
1969  0.217567  0.052858  0.0739768
1972  0.264285  0.0778628  0.14546
1978  0.0376965  1.72058  0.8242
1981  0.048108  6.91428  2.24777
1984  0.160322  0.703297  2.0794
1985  0.0443699  0.183262  1.6993
1986  0.0240446  3.47344  1.33724
1987  0.0963315  14.6828  1.03622
1988  0.0451884  0.910298  0.832714
1989  0.0812859  0.375704  0.756381
1991  0.347854  0.268405  0.568572
1992  0.339679  0.0997023  0.463394
1993  0.165325  0.203519  0.406943
1994  0.722143  0.0297524  0.401192
1995  0.0419564  0.239919  0.418104
1996  0.0524255  2.50743  0.473022
1997  0.0889491  2.77489  0.482144
1998  0.185152  0.117111  0.384828
2001  0.0906302  0.124707  0.118829
2003  0.263441  0.1054  0.102402
2005  0.179932  0.021523  0.115245
2006  0.26767  0.0326011  0.162069

Selectivity by age and year for each fleet rescaled so max=1.0
 fleet 1 selectivity at age
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
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 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.0665279 0.275275 0.552692 0.814848 0.934979 1 0.597672 0.265649 0.041441
 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
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 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
 0.270373 1 0.238174 0.146137 0.102386 0.218185 0.277213 0.0251064 0.0335359
 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864
 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864
 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864
 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864
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 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864
 0.407434 0.711699 0.620368 0.75767 0.908753 1 0.787272 0.729486 0.40864

Fmult by year for each fleet
1929   0.0357653
1930   0.00757934
1931   0.0086251
1932   0.00646769
1933   0.0529301
1934   0.108351
1935   0.20034
1936   0.195105
1937   0.180744
1938   0.236438
1939   0.291464
1940   0.352304
1941   0.250186
1942   0.164527
1943   0.279614
1944   0.33988
1945   0.266283
1946   0.385029
1947   0.327166
1948   0.326627
1949   0.470767
1950   0.367333
1951   0.422506
1952   0.349676
1953   0.16266
1954   0.447751
1955   0.447379
1956   0.718881
1957   0.620093
1958   0.299561
1959   0.485562
1960   0.486616
1961   0.592254
1962   0.471838
1963   0.535444
1964   0.700192
1965   0.714154
1966   0.608781
1967   0.132015
1968   0.0983321
1969   0.0386934
1970   0.025958
1971   0.0248188
1972   0.0257217
1973   0.0115938
1974   0.0169377
1975   0.0191575
1976   0.0250138
1977   0.0252685
1978   0.043068
```

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1979   0.0442698
1980   0.0524044
1981   0.0566203
1982   0.0478136
1983   0.0629856
1984   0.0802796
1985   0.0892204
1986   0.123188
1987   0.13567
1988   0.151864
1989   0.176843
1990   0.288319
1991   0.325335
1992   0.214636
1993   0.145579
1994   0.173498
1995   0.0759861
1996   0.138543
1997   0.318584
1998   0.622754
1999   0.210548
2000   0.475146
2001   0.26917
2002   0.338106
2003   0.254637
2004   0.18629
2005   0.181456
2006   0.158491
2007   0.102832
2008   0.0873431
```

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Directed F by age and year for each fleet
 fleet 1 directed F at age
 0.00237939 0.00984531 0.0197672 0.0291433 0.0334398 0.0357653 0.021376 0.00950101 0.00148215
 0.000504237 0.0020864 0.00418904 0.00617601 0.00708652 0.00757934 0.00452996 0.00201344 0.000314096
 0.00057381 0.00237427 0.00476702 0.00702815 0.00806428 0.0086251 0.00515498 0.00229124 0.000357433
 0.000430282 0.0017804 0.00357464 0.00527019 0.00604716 0.00646769 0.00386556 0.00171813 0.000268028
 0.00352133 0.0145703 0.029254 0.04313 0.0494885 0.0529301 0.0316349 0.0140608 0.00219348
 0.00720836 0.0298263 0.0598847 0.0882896 0.101306 0.108351 0.0647584 0.0287833 0.00449017
 0.0133282 0.0551486 0.110726 0.163247 0.187313 0.20034 0.119738 0.05322 0.00830229
 0.0129799 0.0537075 0.107833 0.158981 0.182419 0.195105 0.116609 0.0518293 0.00808534
 0.0120245 0.0497543 0.0998956 0.147279 0.168992 0.180744 0.108026 0.0480143 0.00749021
 0.0157297 0.0650854 0.130677 0.192661 0.221064 0.236438 0.141312 0.0628093 0.00979822
 0.0193905 0.0802328 0.16109 0.237499 0.272513 0.291464 0.1742 0.0774271 0.0120786
 0.023438 0.0969804 0.194715 0.287074 0.329396 0.352304 0.210562 0.0935889 0.0145998
 0.0166444 0.0688701 0.138276 0.203864 0.233919 0.250186 0.149529 0.0664617 0.010368
 0.0109457 0.0452902 0.0909328 0.134065 0.153829 0.164527 0.0983334 0.0437064 0.00681818
 0.0186022 0.0769709 0.154541 0.227843 0.261433 0.279614 0.167118 0.0742792 0.0115875
 0.0226115 0.0935605 0.187849 0.276951 0.31778 0.33988 0.203137 0.0902886 0.014085
 0.0177153 0.0733012 0.147173 0.216981 0.248969 0.266283 0.15915 0.0707378 0.011035
 0.0256152 0.105989 0.212802 0.31374 0.359994 0.385029 0.230121 0.102282 0.015956
 0.0217657 0.0900608 0.180822 0.266591 0.305894 0.327166 0.195538 0.0869113 0.0135581
 0.0217298 0.0899122 0.180524 0.266151 0.305389 0.326627 0.195216 0.0867679 0.0135357
 0.0313191 0.12959 0.260189 0.383604 0.440157 0.470767 0.281364 0.125059 0.0195091
 0.0244379 0.101118 0.203022 0.299321 0.343449 0.367333 0.219545 0.0975816 0.0152227
 0.0281084 0.116305 0.233515 0.344278 0.395034 0.422506 0.25252 0.112238 0.0175091
 0.0232632 0.0962572 0.193263 0.284933 0.32694 0.349676 0.208992 0.092891 0.0144909
 0.0108214 0.0447762 0.0899006 0.132543 0.152083 0.16266 0.0972172 0.0432103 0.00674078
 0.0297879 0.123255 0.247468 0.364849 0.418637 0.447751 0.267608 0.118944 0.0185552
 0.0297632 0.123152 0.247263 0.364546 0.41829 0.447379 0.267386 0.118846 0.0185398
 0.0478257 0.19789 0.39732 0.585779 0.672139 0.718881 0.429655 0.19097 0.0297912
 0.0412535 0.170696 0.34272 0.505282 0.579773 0.620093 0.370612 0.164727 0.0256973
 0.0199292 0.0824618 0.165565 0.244097 0.280083 0.299561 0.17904 0.079578 0.0124141
 0.0323034 0.133663 0.268366 0.39566 0.45399 0.485562 0.290207 0.128989 0.0201222
 0.0323736 0.133953 0.268949 0.396519 0.454976 0.486616 0.290837 0.129269 0.0201659
 0.0394014 0.163033 0.327334 0.482597 0.553745 0.592254 0.353974 0.157331 0.0245436
 0.0313904 0.129885 0.260781 0.384476 0.441158 0.471838 0.282004 0.125343 0.0195534
 0.035622 0.147394 0.295935 0.436306 0.500629 0.535444 0.32002 0.14224 0.0221893
 0.0465823 0.192745 0.38699 0.57055 0.654664 0.700192 0.418485 0.186005 0.0290167
 0.0475112 0.196589 0.394707 0.581927 0.667719 0.714154 0.42683 0.189714 0.0295953
 0.0405009 0.167582 0.336468 0.496064 0.569197 0.608781 0.363852 0.161722 0.0252285
 0.00878267 0.0363404 0.0729635 0.107572 0.123431 0.132015 0.0789016 0.0350696 0.00547083
 0.00654183 0.0270684 0.0543473 0.0801257 0.0919384 0.0983321 0.0587704 0.0261218 0.00407498
 0.00257419 0.0106513 0.0213855 0.0315292 0.0361775 0.0386934 0.023126 0.0102788 0.00160349
 0.00701834 0.025958 0.00618253 0.00379344 0.00265773 0.00566366 0.00719591 0.000651712 0.000870525
 0.00671034 0.0248188 0.0059112 0.00362696 0.0025411 0.0054151 0.00688011 0.000623111 0.000832321
 0.00695446 0.0257217 0.00612625 0.00375891 0.00263354 0.0056121 0.0071304 0.00064578 0.000862601
 0.00313465 0.0115938 0.00276135 0.00169429 0.00118704 0.0025296 0.00321396 0.000291079 0.000388809
 0.0045795 0.0169377 0.00403413 0.00247524 0.00173418 0.00369556 0.00469536 0.000425245 0.000568021
 0.00517967 0.0191575 0.00456282 0.00279963 0.00196146 0.00417988 0.00531071 0.000480976 0.000642463
 0.00676304 0.0250138 0.00595763 0.00365545 0.00256106 0.00545764 0.00693415 0.000628006 0.000838859
 0.00683191 0.0252685 0.00601829 0.00369267 0.00258713 0.00551321 0.00700475 0.0006344 0.0008474
 0.0175474 0.0306515 0.026718 0.0326313 0.0391382 0.043068 0.0339062 0.0314175 0.0175993
 0.018037 0.0315068 0.0274636 0.0335419 0.0402304 0.0442698 0.0348524 0.0322942 0.0180904
 0.0213513 0.0372962 0.03251 0.0397052 0.0476227 0.0524044 0.0412565 0.0382283 0.0214146
 0.023069 0.0402966 0.0351254 0.0428995 0.0514539 0.0566203 0.0445755 0.0413037 0.0231373
 0.0194809 0.0340289 0.029662 0.0362269 0.0434508 0.0478136 0.0376423 0.0348794 0.0195386
 0.0256624 0.0448268 0.0390743 0.0477223 0.0572384 0.0629856 0.0495868 0.0459471 0.0257385
 0.0327086 0.057135 0.0498029 0.0608254 0.0729544 0.0802796 0.0632019 0.0585629 0.0328055
 0.0363514 0.0634981 0.0553495 0.0675996 0.0810793 0.0892204 0.0702407 0.065085 0.0364591
 0.0501911 0.0876732 0.0764222 0.0933362 0.111948 0.123188 0.0969828 0.0898643 0.0503398
 0.0552763 0.096556 0.0841651 0.102793 0.12329 0.13567 0.106809 0.0989691 0.0554401
 0.0618746 0.108082 0.0942117 0.115063 0.138007 0.151864 0.119558 0.110783 0.0620578
 0.072052 0.125859 0.109708 0.133989 0.160707 0.176843 0.139224 0.129005 0.0722654
 0.117471 0.205197 0.178864 0.218451 0.262011 0.288319 0.226986 0.210325 0.117819
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 0.132553 0.231541 0.201828 0.246497 0.29565 0.325335 0.256127 0.237328 0.132945
 0.0874497 0.152756 0.133153 0.162623 0.195051 0.214636 0.168976 0.156574 0.0877088
 0.0593139 0.103609 0.0903127 0.110301 0.132296 0.145579 0.11461 0.106198 0.0594895
 0.070689 0.123479 0.107633 0.131454 0.157667 0.173498 0.13659 0.126564 0.0708984
 0.0309593 0.0540792 0.0471393 0.0575723 0.0690526 0.0759861 0.0598217 0.0554308 0.031051
 0.056447 0.0986008 0.0859475 0.10497 0.125901 0.138543 0.109071 0.101065 0.0566142
 0.129802 0.226736 0.197639 0.241381 0.289514 0.318584 0.250812 0.232402 0.130186
 0.253731 0.443214 0.386337 0.471842 0.56593 0.622754 0.490277 0.454291 0.254483
 0.0857843 0.149847 0.130617 0.159526 0.191336 0.210548 0.165758 0.153592 0.0860384
 0.193591 0.338161 0.294766 0.360004 0.431791 0.475146 0.374069 0.346613 0.194164
 0.109669 0.191568 0.166984 0.203942 0.244609 0.26917 0.21191 0.196356 0.109994
 0.137756 0.240629 0.20975 0.256172 0.307255 0.338106 0.266181 0.246643 0.138164
 0.103748 0.181225 0.157969 0.192931 0.231402 0.254637 0.200468 0.185754 0.104055
 0.0759006 0.132582 0.115568 0.141146 0.169291 0.18629 0.14666 0.135896 0.0761255
 0.0739312 0.129142 0.112569 0.137484 0.164899 0.181456 0.142855 0.13237 0.0741502
 0.0645745 0.112798 0.0983226 0.120084 0.144029 0.158491 0.124775 0.115617 0.0647657
 0.0418972 0.0731855 0.0637937 0.0779127 0.093449 0.102832 0.0809567 0.0750145 0.0420213
 0.0355865 0.062162 0.0541848 0.0661772 0.0793733 0.0873431 0.0687627 0.0637155 0.0356919
Discard F by age and year for each fleet
 fleet 1 Discard F at age
 0 0 0 0 0 0 0 0 0
 0 0 0 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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Total F
 0.00237939 0.00984531 0.0197672 0.0291433 0.0334398 0.0357653 0.021376 0.00950101 0.00148215
 0.000504237 0.0020864 0.00418904 0.00617601 0.00708652 0.00757934 0.00452996 0.00201344 0.000314096
 0.00057381 0.00237427 0.00476702 0.00702815 0.00806428 0.0086251 0.00515498 0.00229124 0.000357433
 0.000430282 0.0017804 0.00357464 0.00527019 0.00604716 0.00646769 0.00386556 0.00171813 0.000268028
 0.00352133 0.0145703 0.029254 0.04313 0.0494885 0.0529301 0.0316349 0.0140608 0.00219348
 0.00720836 0.0298263 0.0598847 0.0882896 0.101306 0.108351 0.0647584 0.0287833 0.00449017
 0.0133282 0.0551486 0.110726 0.163247 0.187313 0.20034 0.119738 0.05322 0.00830229
 0.0129799 0.0537075 0.107833 0.158981 0.182419 0.195105 0.116609 0.0518293 0.00808534
 0.0120245 0.0497543 0.0998956 0.147279 0.168992 0.180744 0.108026 0.0480143 0.00749021
 0.0157297 0.0650854 0.130677 0.192661 0.221064 0.236438 0.141312 0.0628093 0.00979822
 0.0193905 0.0802328 0.16109 0.237499 0.272513 0.291464 0.1742 0.0774271 0.0120786
 0.023438 0.0969804 0.194715 0.287074 0.329396 0.352304 0.210562 0.0935889 0.0145998
 0.0166444 0.0688701 0.138276 0.203864 0.233919 0.250186 0.149529 0.0664617 0.010368
 0.0109457 0.0452902 0.0909328 0.134065 0.153829 0.164527 0.0983334 0.0437064 0.00681818
 0.0186022 0.0769709 0.154541 0.227843 0.261433 0.279614 0.167118 0.0742792 0.0115875
 0.0226115 0.0935605 0.187849 0.276951 0.31778 0.33988 0.203137 0.0902886 0.014085
 0.0177153 0.0733012 0.147173 0.216981 0.248969 0.266283 0.15915 0.0707378 0.011035
 0.0256152 0.105989 0.212802 0.31374 0.359994 0.385029 0.230121 0.102282 0.015956
 0.0217657 0.0900608 0.180822 0.266591 0.305894 0.327166 0.195538 0.0869113 0.0135581
 0.0217298 0.0899122 0.180524 0.266151 0.305389 0.326627 0.195216 0.0867679 0.0135357
 0.0313191 0.12959 0.260189 0.383604 0.440157 0.470767 0.281364 0.125059 0.0195091
 0.0244379 0.101118 0.203022 0.299321 0.343449 0.367333 0.219545 0.0975816 0.0152227
 0.0281084 0.116305 0.233515 0.344278 0.395034 0.422506 0.25252 0.112238 0.0175091
 0.0232632 0.0962572 0.193263 0.284933 0.32694 0.349676 0.208992 0.092891 0.0144909
 0.0108214 0.0447762 0.0899006 0.132543 0.152083 0.16266 0.0972172 0.0432103 0.00674078
 0.0297879 0.123255 0.247468 0.364849 0.418637 0.447751 0.267608 0.118944 0.0185552
 0.0297632 0.123152 0.247263 0.364546 0.41829 0.447379 0.267386 0.118846 0.0185398
 0.0478257 0.19789 0.39732 0.585779 0.672139 0.718881 0.429655 0.19097 0.0297912
 0.0412535 0.170696 0.34272 0.505282 0.579773 0.620093 0.370612 0.164727 0.0256973
 0.0199292 0.0824618 0.165565 0.244097 0.280083 0.299561 0.17904 0.079578 0.0124141
 0.0323034 0.133663 0.268366 0.39566 0.45399 0.485562 0.290207 0.128989 0.0201222
 0.0323736 0.133953 0.268949 0.396519 0.454976 0.486616 0.290837 0.129269 0.0201659
 0.0394014 0.163033 0.327334 0.482597 0.553745 0.592254 0.353974 0.157331 0.0245436
 0.0313904 0.129885 0.260781 0.384476 0.441158 0.471838 0.282004 0.125343 0.0195534
 0.035622 0.147394 0.295935 0.436306 0.500629 0.535444 0.32002 0.14224 0.0221893
 0.0465823 0.192745 0.38699 0.57055 0.654664 0.700192 0.418485 0.186005 0.0290167
 0.0475112 0.196589 0.394707 0.581927 0.667719 0.714154 0.42683 0.189714 0.0295953
 0.0405009 0.167582 0.336468 0.496064 0.569197 0.608781 0.363852 0.161722 0.0252285
 0.00878267 0.0363404 0.0729635 0.107572 0.123431 0.132015 0.0789016 0.0350696 0.00547083
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Population Numbers at the Start of the Year
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 2.46669e+06 1.71715e+06 1.38731e+06 886065 474069 268802 84754.4 46190.6 296824
 2.3567e+06 1.49526e+06 1.03904e+06 837444 533662 285228 161636 51141.8 207920
 866344 1.42879e+06 905310 627959 505266 321731 171884 97659.2 157042
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2005  1.96511e-06
2006  1.96511e-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 =  0.0906126 0.240943 0.26074 0.219281 0.0795583 0.0462915 0.0380178 0.0178877 0.00666753
Year 2 Obs  =  0 0.0867775 0.446367 0.301453 0.11939 0.0417583 0.00273329 0.00108783 0.000433015
Year 2 Pred =  0.0646768 0.216395 0.277812 0.219375 0.142797 0.0481684 0.0156639 0.00965308 0.00545888
Year 3 Obs  =  0 0.048402 0.505194 0.313014 0.0660961 0.0380708 0.0187757 0.00747368 0.0029743
Year 3 Pred =  0.0564665 0.162514 0.263326 0.247703 0.151994 0.0921516 0.0173935 0.00421883 0.00423296
Year 4 Obs  =  0 0.0117399 0.261808 0.474939 0.113249 0.0764021 0.0397449 0.0158206 0.00629655
Year 4 Pred =  0.0575737 0.151054 0.210574 0.250026 0.182754 0.10445 0.0354189 0.0049859 0.00316428
Year 5 Obs  =  0 0.0505403 0.20803 0.348817 0.255576 0.0905435 0.0298707 0.0118901 0.00473207
Year 5 Pred =  0.0244541 0.166034 0.209811 0.213212 0.196277 0.133463 0.0430305 0.0109543 0.00276292
Year 6 Obs  =  0 0.0307845 0.335587 0.223908 0.256675 0.0975438 0.0356587 0.0141941 0.00564898
Year 6 Pred =  0.0207999 0.0789924 0.255179 0.231904 0.180964 0.154256 0.0596663 0.0147119 0.00352555
Year 7 Obs  =  0 0.0564975 0.0661942 0.320666 0.33166 0.174786 0.03225 0.0128372 0.00510896
Year 7 Pred =  0.0240764 0.075284 0.133642 0.304622 0.209874 0.150698 0.074119 0.0225022 0.00518217
Year 8 Obs  =  0 0.0193028 0.17522 0.149419 0.283927 0.301928 0.0451043 0.0179539 0.00714533
Year 8 Pred =  0.0681446 0.0895891 0.129662 0.160234 0.273257 0.172183 0.0710308 0.0279749 0.00792517
Year 9 Obs  =  0.001935 0.022218 0.0390255 0.120969 0.239529 0.392018 0.118413 0.0471347 0.0187587
Year 9 Pred =  0.0772983 0.221881 0.135338 0.136692 0.126573 0.197566 0.0713566 0.0234936 0.00980242
Year 10 Obs  =  0.00893818 0.134115 0.370324 0.191463 0.0499225 0.126082 0.0765549 0.0304729 0.0121276
Year 10 Pred =  0.124849 0.211736 0.280511 0.11891 0.0899232 0.0761695 0.0688465 0.0199437 0.00911099
Year 11 Obs  =  0.0170716 0.219961 0.224557 0.319107 0.105056 0.0597505 0.0354563 0.0144452 0.00459618
Year 11 Pred =  0.0865955 0.304538 0.235274 0.213442 0.0670021 0.0461046 0.0227803 0.0168611 0.00740191
Year 12 Obs  =  0.0248007 0.143047 0.460585 0.213906 0.131975 0.0194862 0.00531445 0.000885742 0
Year 12 Pred =  0.0605785 0.222418 0.351478 0.183123 0.121648 0.0345582 0.0139842 0.00578146 0.00643085
Year 13 Obs  =  0.007362 0.21227 0.360327 0.332515 0.0752556 0.010634 0.000817962 0.000817962 0
Year 13 Pred =  0.129227 0.154797 0.256772 0.274159 0.104164 0.0625228 0.0102427 0.00346617 0.00464877
Year 14 Obs  =  0 0.463869 0.168609 0.246309 0.100233 0.017871 0.00233102 0.000776952 0
Year 14 Pred =  0.0531001 0.321198 0.177743 0.204392 0.162327 0.0562612 0.0192619 0.00254438 0.00317336
Year 15 Obs  =  0.00444443 0.147556 0.647556 0.109778 0.0773333 0.0106666 0.00177775 0.000888928 0
Year 15 Pred =  0.0559236 0.142486 0.396427 0.152097 0.130981 0.0951509 0.0192499 0.00529986 0.0023853
Year 16 Obs  =  0 0.2375 0.236184 0.403289 0.101316 0.0184211 0.00263156 0 0.000657919
Year 16 Pred =  0.0700839 0.164766 0.189176 0.356096 0.100281 0.0782427 0.0333716 0.00562346 0.00235966
Year 17 Obs  =  0.0373743 0.281744 0.22185 0.163872 0.152851 0.0886441 0.0354577 0.0110205 0.00718732
Year 17 Pred =  0.0638592 0.208358 0.221187 0.17161 0.23582 0.0600318 0.0270983 0.00965993 0.00237713
Year 18 Obs  =  0.0500569 0.253697 0.308305 0.167994 0.10201 0.0652256 0.027683 0.0166857 0.00834285
Year 18 Pred =  0.0612544 0.186876 0.273694 0.196008 0.111599 0.138909 0.0209279 0.00789534 0.00283618
Year 19 Obs  =  0.168217 0.105226 0.236936 0.209019 0.137437 0.079456 0.0429492 0.0157481 0.00501085
Year 19 Pred =  0.194433 0.160077 0.217758 0.212541 0.11002 0.0563518 0.0409274 0.00525523 0.00263673
Year 20 Obs  =  0.0459588 0.62916 0.153724 0.0618066 0.0681458 0.0237718 0.0110936 0.00475437 0.00158485
Year 20 Pred =  0.0991772 0.424994 0.15707 0.143701 0.10228 0.0478261 0.0143243 0.00874555 0.0018812
Year 21 Obs  =  0.00763357 0.296619 0.490185 0.123773 0.0414394 0.0267176 0.0109052 0.00163574 0.00109049
Year 21 Pred =  0.0345807 0.245411 0.464031 0.113559 0.0752425 0.0481992 0.0134941 0.00346777 0.00201535
Year 22 Obs  =  0.000981302 0.146222 0.378803 0.380766 0.0706575 0.0117763 0.00883216 0.000981302 0.000981302
Year 22 Pred =  0.0346458 0.104347 0.325356 0.402676 0.0701528 0.0415131 0.0155679 0.0038139 0.00192761
Year 23 Obs  =  0.0285714 0.110989 0.19011 0.327473 0.313187 0.0186814 0.00659342 0.00219771 0.00219771
Year 23 Pred =  0.0464092 0.117685 0.156563 0.322856 0.288262 0.0451229 0.0158381 0.00511028 0.00215395
Year 24 Obs  =  0.0277779 0.0176766 0.108586 0.108586 0.474747 0.25505 0.00505068 0.00252507 0
Year 24 Pred =  0.164843 0.141642 0.159029 0.139815 0.206972 0.165695 0.0151687 0.00459343 0.00224116
Year 25 Obs  =  0.614865 0.114865 0.0743242 0.0765767 0.0315314 0.0450448 0.0427928 0 0
Year 25 Pred =  0.37005 0.27644 0.108511 0.0831772 0.0535899 0.071868 0.0326819 0.00246845 0.00121312
Year 26 Obs  =  0.0110974 0.764488 0.162762 0.0345253 0.0197287 0 0.00493225 0.00246605 0
Year 26 Pred =  0.0766298 0.598614 0.201607 0.0538811 0.0306855 0.0180069 0.0144945 0.00542789 0.00065349
Year 27 Obs  =  0.219298 0.249123 0.352632 0.150877 0.0157895 0.00175435 0.00350883 0.00175435 0.00526318
Year 27 Pred =  0.139081 0.158883 0.541561 0.118788 0.0225942 0.0114875 0.00400195 0.00283542 0.000769116
Year 28 Obs  =  0.00395652 0.51731 0.212661 0.18002 0.083086 0.00296739 0 0 0
Year 28 Pred =  0.0546912 0.346652 0.167429 0.361414 0.0557328 0.00940273 0.00295962 0.000942265 0.000776345
Year 29 Obs  =  0.0311493 0.123523 0.469388 0.16971 0.13319 0.0472609 0.0204082 0.00537054 0
Year 29 Pred =  0.0750568 0.161901 0.425151 0.125723 0.183539 0.0246558 0.0025092 0.000761687 0.000702505
Year 30 Obs  =  0.363234 0.084164 0.145072 0.233666 0.0996677 0.0454042 0.0287929 0 0
Year 30 Pred =  0.203812 0.184476 0.173237 0.292904 0.060428 0.0780565 0.00603268 0.000551911 0.000502533
Year 31 Obs  =  0.0265252 0.736074 0.122016 0.0570292 0.0384615 0.0159151 0.00397886 0 0
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Year 31 Pred =  0.110379 0.431757 0.172671 0.107656 0.132273 0.0245978 0.0190887 0.00126046 0.000316861
Year 32 Obs  =  0.0327868 0.256148 0.342213 0.204918 0.102459 0.034836 0.0266393 0 0
Year 32 Pred =  0.139608 0.24101 0.407653 0.105101 0.0462767 0.0505713 0.00560976 0.00388857 0.000280807
Year 33 Obs  =  0.099526 0.388626 0.2109 0.199052 0.078199 0.0165877 0.00710899 0 0
Year 33 Pred =  0.126536 0.31476 0.23205 0.250209 0.0453292 0.0177046 0.011733 0.00118013 0.000497582
Year 34 Obs  =  0.0132497 0.417966 0.225209 0.187863 0.12687 0.0254956 0.00334697 0 0
Year 34 Pred =  0.0433132 0.316927 0.337289 0.157832 0.118265 0.018913 0.00437701 0.00265427 0.00042897
Year 35 Obs  =  0.00592527 0.142545 0.383941 0.215353 0.184199 0.0591923 0.00884417 0 0
Year 35 Pred =  0.0399375 0.127109 0.400509 0.273972 0.0905277 0.0603199 0.00580192 0.0012036 0.000619175
Year 36 Obs  =  0.0337332 0.187382 0.158354 0.233831 0.266371 0.102963 0.0173653 0 0
Year 36 Pred =  0.0496149 0.140863 0.188022 0.370649 0.17596 0.0512609 0.0210127 0.00188229 0.000734742
Year 37 Obs  =  0.401408 0.0388331 0.0235413 0.0522133 0.169618 0.266398 0.047988 0 0
Year 37 Pred =  0.135911 0.171766 0.20031 0.16265 0.216606 0.0895126 0.0159664 0.00636334 0.000914247
Year 38 Obs  =  0.194677 0.427054 0.0769113 0.0616409 0.0523264 0.118213 0.0643685 0.00480818 0
Year 38 Pred =  0.0819762 0.379495 0.199074 0.142415 0.0783066 0.090902 0.0226254 0.00388133 0.00132468
Year 39 Obs  =  0.657835 0.145684 0.0128271 0.0917297 0.0331728 0.0237318 0.0278497 0.00660377 0.000566287
Year 39 Pred =  0.186824 0.182798 0.376588 0.129881 0.0655013 0.0320428 0.020798 0.00452744 0.00103967
Year 40 Obs  =  0.840647 0.0566066 0.0250615 0.0400243 0.0101157 0.00970434 0.00771655 0.00588063 0.00424303
Year 40 Pred =  0.309816 0.283399 0.130917 0.191872 0.0502639 0.0233554 0.00646907 0.00326329 0.000643827
Year 41 Obs  =  0.0137492 0.69875 0.179811 0.0656796 0.0209859 0.0182135 0.00281098 0 0
Year 41 Pred =  0.101385 0.499766 0.218294 0.0726195 0.0814997 0.0197498 0.00514655 0.00108972 0.000449556
Year 42 Obs  =  0.318667 0.681333 0 0 0 0 0 0 0
Year 42 Pred =  0.27978 0.535362 0.152615 0.0202754 0.0031893 0.0066216 0.00190221 7.59802e-05 0.000178028
Year 43 Obs  =  0 0.918346 0.0721092 0.00318711 0.00381488 0.00254325 0 0 0
Year 43 Pred =  0.0759693 0.74302 0.0914067 0.0679231 0.0103224 0.00493523 0.00609506 0.000125067 0.000203605
Year 44 Obs  =  0.615382 0.0919161 0.136717 0.148312 0.00432343 0.00334868 0 0 0
Year 44 Pred =  0.447104 0.262351 0.165091 0.0529178 0.0449795 0.0207752 0.0059088 0.000521311 0.000351179
Year 45 Obs  =  0.050081 0.546991 0.153253 0.0329207 0.0749215 0.0883818 0.049331 0.00206004 0.00206004
Year 45 Pred =  0.163443 0.698865 0.0262456 0.0430231 0.0157707 0.0407724 0.0112063 0.000227313 0.000446484
Year 46 Obs  =  0.669105 0.23874 0.0758828 0.0122035 0.00406887 0 0 0 0
Year 46 Pred =  0.683062 0.211584 0.0583367 0.00567501 0.0106322 0.0118469 0.0182394 0.000357915 0.000264923
Year 47 Obs  =  0.0195705 0.955894 0.0135269 0.00990975 0.000285205 0.000541739 0.000271624 0 0
Year 47 Pred =  0.0733956 0.88096 0.0175722 0.012579 0.00139899 0.00796731 0.0052846 0.000580932 0.000261877
Year 48 Obs  =  0.875994 0.010291 0.11054 4.70167e-05 0.00144059 0 0.00168696 0 0
Year 48 Pred =  0.877649 0.0643564 0.0497996 0.00258205 0.00211363 0.000714376 0.00242108 0.000114731 0.000249414
Year 49 Obs  =  0.229832 0.762596 0.00161824 0.00595355 0 0 0 0 0
Year 49 Pred =  0.179712 0.806837 0.00380569 0.00767353 0.0004551 0.00113228 0.000227655 5.5114e-05 0.00010154
Year 50 Obs  =  0.596692 0.152357 0.231306 0.00942713 0.00813682 0.00208085 0 0 0
Year 50 Pred =  0.633317 0.166713 0.174955 0.00426459 0.0167802 0.00156124 0.00143873 0.000211031 0.00075917
Year 51 Obs  =  0.000203985 0.767831 0.111662 0.113603 0.0016599 0.00504044 0 0 0
Year 51 Pred =  0.0742972 0.687368 0.0898171 0.131983 0.00313968 0.0112735 0.000752022 0.000820695 0.000547934
Year 52 Obs  =  0.397376 0.0209664 0.481455 0.0510616 0.0458306 0.00252993 0.000779936 0 0
Year 52 Pred =  0.355795 0.0831943 0.382112 0.0698827 0.100153 0.00217317 0.00559863 0.000442435 0.000648343
Year 53 Obs  =  0.12455 0.29922 0.0716614 0.451951 0.0312945 0.0200249 0.000493155 0.000804903 0
Year 53 Pred =  0.346695 0.299654 0.0347443 0.223385 0.0398087 0.0519958 0.00080949 0.00247317 0.000434377
Year 54 Obs  =  0.124414 0.279434 0.25634 0.0765293 0.239475 0.0178835 0.00592472 0 0
Year 54 Pred =  0.115233 0.426448 0.182577 0.0296559 0.185844 0.0301837 0.0282565 0.000521832 0.00128024
Year 55 Obs  =  0.0248154 0.0245617 0.387195 0.350854 0.0551877 0.155191 0.00219528 0 0
Year 55 Pred =  0.0818168 0.17135 0.314767 0.188525 0.0298361 0.170422 0.019876 0.0220581 0.00134824
Year 56 Obs  =  0.0282877 0.00524412 0.0943585 0.481844 0.248019 0.0617107 0.0785911 0.0019442 0
Year 56 Pred =  0.170747 0.108831 0.112934 0.290131 0.168919 0.0243188 0.099837 0.0138342 0.0104477
Year 57 Obs  =  0.0308318 0.165781 0.0492178 0.154192 0.475344 0.101534 0.0131711 0.00992887 0
Year 57 Pred =  0.234165 0.194207 0.0611788 0.0888127 0.22137 0.117034 0.0121096 0.0591998 0.0119235
Year 58 Obs  =  0.138839 0.327844 0.169457 0.0388448 0.0662747 0.188477 0.0547372 0.00753582 0.0079909
Year 58 Pred =  0.25801 0.267768 0.109746 0.048286 0.0678086 0.153151 0.0583524 0.00720371 0.0296739
Year 59 Obs  =  0.127165 0.506432 0.230247 0.0375036 0.0201527 0.0247659 0.0332249 0.0145325 0.00597554
Year 59 Pred =  0.161614 0.331053 0.16891 0.0967817 0.0410519 0.0520633 0.084697 0.03867 0.0251592
Year 60 Obs  =  0.570154 0.0823816 0.196302 0.0713299 0.0154715 0.0105521 0.0139787 0.0225674 0.0172625
Year 60 Pred =  0.464115 0.139384 0.140164 0.0999424 0.0550956 0.0210695 0.0192633 0.0376235 0.0233432
Year 61 Obs  =  0.10365 0.76615 0.0397887 0.0318993 0.0214395 0.0129103 0.0120773 0.00411792 0.00796741
Year 61 Pred =  0.162549 0.50405 0.0741851 0.104184 0.0712669 0.0353368 0.00975626 0.0107366 0.0279349
Year 62 Obs  =  0.180593 0.118733 0.264447 0.0731527 0.103116 0.119672 0.0502753 0.0399953 0.0500162
Year 62 Pred =  0.305728 0.185388 0.281775 0.0576084 0.0769107 0.0470173 0.0169796 0.00567543 0.0229173
Year 63 Obs  =  0.138341 0.467133 0.111522 0.110364 0.0529952 0.0474732 0.0341453 0.0153868 0.0226398
Year 63 Pred =  0.266308 0.3175 0.0927166 0.196467 0.0377663 0.0445649 0.0197906 0.00877931 0.0161068
Year 64 Obs  =  0.121609 0.329654 0.134973 0.107747 0.116311 0.0885753 0.0611695 0.0287533 0.0112088
Year 64 Pred =  0.24343 0.302993 0.172103 0.0706617 0.141365 0.0240411 0.0203651 0.0111303 0.0139106
Year 65 Obs  =  0.568585 0.102906 0.117101 0.0377232 0.0369103 0.0553067 0.0316353 0.0317291 0.0181029
Year 65 Pred =  0.458158 0.197623 0.119117 0.094975 0.0373052 0.0668501 0.00815757 0.00837436 0.00943972
Year 66 Obs  =  0.281886 0.418543 0.109505 0.0498703 0.0633214 0.0332717 0.020579 0.016348 0.006675
Year 66 Pred =  0.308944 0.415399 0.0878915 0.0739759 0.0566246 0.0200182 0.0258991 0.00380091 0.00744671
Year 67 Obs  =  0.597211 0.275366 0.0682615 0.0127006 0.00713895 0.0183222 0.00981228 0.00684189 0.00434565
Year 67 Pred =  0.378087 0.282233 0.184535 0.0549251 0.0445745 0.0307558 0.00776751 0.0120965 0.0050263
Year 68 Obs  =  0.286794 0.435129 0.124389 0.0595121 0.0370643 0.0254399 0.0135528 0.0106332 0.00748687
Year 68 Pred =  0.233417 0.395107 0.146167 0.133266 0.0383701 0.0282301 0.0140674 0.00423391 0.00714125
Year 69 Obs  =  0.160104 0.328173 0.216088 0.0853181 0.0553272 0.0501796 0.0322665 0.0274253 0.0451183
Year 69 Pred =  0.137557 0.303888 0.25407 0.130081 0.112863 0.0291024 0.0156674 0.00941532 0.0073556
Year 70 Obs  =  0.0907195 0.132568 0.258606 0.158071 0.103525 0.0889858 0.0711439 0.0431607 0.0532205
Year 70 Pred =  0.128678 0.193053 0.206587 0.237219 0.111918 0.0847067 0.0162372 0.0108527 0.010749
Year 71 Obs  =  0.313482 0.077059 0.0700383 0.159918 0.15245 0.116195 0.0508593 0.0347571 0.0252423
Year 71 Pred =  0.275547 0.156542 0.10611 0.162278 0.171753 0.0697766 0.0372712 0.0091375 0.0115864
Year 72 Obs  =  0.366854 0.191166 0.0644712 0.109169 0.128236 0.0826361 0.0354184 0.0142007 0.00784852
Year 72 Pred =  0.373315 0.253577 0.0707096 0.0659878 0.0945942 0.088609 0.0265958 0.0173458 0.00926581
Year 73 Obs  =  0.305678 0.439405 0.0756729 0.0419842 0.0518005 0.0459145 0.0211745 0.0119458 0.00642483
Year 73 Pred =  0.422165 0.314667 0.0993975 0.0391559 0.0339662 0.0424114 0.0284244 0.0107167 0.00909615
Year 74 Obs  =  0.110228 0.780057 0.0787162 0.0181348 0.0034718 0.00554983 0.00384275 0 0
Year 74 Pred =  0.214219 0.45734 0.164787 0.0724443 0.0268513 0.0206122 0.0187363 0.0153931 0.00961547
Year 75 Obs  =  0.527677 0.296787 0.102162 0.0375274 0.0131551 0.0129358 0.00656773 0.00189719 0.00129092
Year 75 Pred =  0.382544 0.209787 0.213244 0.107846 0.0446015 0.0145864 0.00806157 0.0090419 0.0102879
Year 76 Obs  =  0.79319 0.120929 0.039149 0.0283708 0.0120824 0.00242117 0.00161412 0.000629423 0.00161412
Year 76 Pred =  0.499839 0.258007 0.0681617 0.097219 0.0467655 0.0172362 0.0040514 0.00272966 0.00599075
Year 77 Obs  =  0.815607 0.112104 0.0574635 0.00831505 0.00325068 0.00198288 0.00102078 0.000256591 0
Year 77 Pred =  0.555274 0.286291 0.072013 0.0266087 0.0363017 0.0156574 0.0041607 0.00118219 0.0025106
Year 78 Obs  =  0.590902 0.288833 0.0594579 0.0298918 0.0169937 0.00475702 0.00376538 0.00539941 0
Year 78 Pred =  0.416196 0.408692 0.102673 0.0361622 0.012805 0.0156846 0.00486837 0.00156201 0.00135704
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Year 79 Obs  =  0.552445 0.269411 0.0984565 0.0435435 0.0243505 0.00805001 0.00304855 0.000694974 0
Year 79 Pred =  0.430467 0.325631 0.15606 0.0550187 0.0186723 0.00596115 0.00523359 0.00195319 0.00100294
Year 80 Obs  =  0 0 0 0 0 0 0 0 0
Year 80 Pred =  0.182935 0.467104 0.173965 0.116782 0.0398823 0.0122685 0.00281127 0.00294679 0.0013061

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
Year 80 Obs  =  0 0 0 0 0 0 0 0 0
Year 80 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     0.546603     11.8214
  Fmax     9.99999     6364.79
  F30%SPR  0.43591     9.24096
  F40%SPR  0.316978     6.93074
  Fmsy     0.138133     4.26029    SSmsy    122357     MSY   23048.2
  Foy      0.1036     xxxxxx    SSoy    158998     OY   21792
  Fcurrent 0.0873431     3.65958

Stock-Recruitment Relationship Parameters
 alpha     = 1.44455e+06
 beta      = 216717
 virgin    = 182787
 steepness = 0.315471
Spawning Stock, Obs Recruits(year+1), Pred Recruits(year+1)
1929  1.08911e+06  2.83254e+06  1.20481e+06
1930  996757  2.46669e+06  1.18656e+06
1931  963593  2.3567e+06  1.17932e+06
1932  928197  866344  1.17112e+06
1933  840657  564630  1.14848e+06
1934  712147  441430  1.10752e+06
```

1935	564283	816214	1.04371e+06
1936	429301	692408	959953
1937	327346	989893	869141
1938	253329	676424	778533
1939	224774	438609	735457
1940	179607	876571	654644
1941	155143	352122	602678
1942	139479	334084	565656
1943	140357	338972	567817
1944	123104	248540	523304
1945	101881	193681	461936
1946	85730.5	557898	409466
1947	67354.4	309960	342508
1948	58863.8	102598	308555
1949	55983.5	80024.9	296556
1950	49164.6	74263.5	267114
1951	42537	204026	237014
1952	33991	659370	195852
1953	28592.7	200881	168373
1954	31721.9	410646	184447
1955	38991.7	147555	220272
1956	45090.2	154403	248790
1957	40031.8	399309	225232
1958	32676.7	239901	189272
1959	33843.3	322528	195116
1960	35366	297979	202663
1961	35607.8	93976.6	203853
1962	38256.4	68283.6	216741
1963	38083	54550.1	215906
1964	29331	96708	172203
1965	18498.5	47216.3	113607
1966	13217.8	114845	83039.7
1967	10701.7	309418	67976.6
1968	12437.3	155927	78402.4
1969	19114.7	180759	117084
1970	29403.1	40830.5	172575
1971	39319.3	153731	221838
1972	43519.9	79784.9	241575
1973	47194.4	572756	258324
1974	52977.2	105878	283759
1975	67411.2	3.19561e+06	342729
1976	91854.8	1.57267e+06	430010
1977	139675	6.24907e+06	566140
1978	243480	698876	764279
1979	367600	3.0875e+06	908782
1980	437089	3.67572e+06	965725
1981	546112	1.02151e+06	1.03416e+06
1982	611964	502391	1.06677e+06
1983	591001	804937	1.05697e+06
1984	572172	982993	1.04772e+06
1985	493089	951396	1.0035e+06
1986	419170	459336	952232
1987	345766	1.50165e+06	887985
1988	297606	470734	835869
1989	237230	735979	754913
1990	211149	556558	712876
1991	170401	402952	635859
1992	127154	888898	534153
1993	110197	644569	486934
1994	92115.1	843485	430865
1995	104429	502186	469732
1996	116908	218035	506196
1997	125597	124645	530013
1998	102816	175248	464812
1999	69736.9	235521	351674
2000	54266.5	265956	289282
2001	32720.8	113006	189493
2002	27249.5	183753	161347
2003	31670.1	331431	184185
2004	32062.8	615782	186174
2005	29420.1	603758	172663
2006	40167.2	781553	225874
2007	56688.2	307250	299515
2008	83183.3	xxxx	400675

```
average F (ages 4 to 8 unweighted) by year
Projection into Future
Projected NAA
 2 179842 259103 111189 60715.2 17163.2 4777.02 1404.64 2873.52
 2 1.14668 98866.2 144248 60738 32481.3 9066.94 2598.85 2417.52
Projected Directed FAA
 0.05628 0.0983092 0.0856933 0.104659 0.125529 0.138133 0.108748 0.100766 0.0564468
 0.05628 0.0983092 0.0856933 0.104659 0.125529 0.138133 0.108748 0.100766 0.0564468
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
 0.0863326 13305.2 16804.6 8732.4 5665.87 1752.55 389.114 106.399 124.397
 0.0863326 0.0848344 6412.14 11328.7 5668 3316.7 738.55 196.858 104.657
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
 0.0101009 2887.23 6032.83 4863.95 4198.41 1538.74 338.918 98.3125 116.312
 0.0101009 0.0184091 2301.96 6310.11 4199.99 2912.06 643.277 181.897 97.8539
Year, Total Yield (in weight), Total Discards (in weight), SSB, proj_what, SS/SSmsy
2009  20074.7  0  111152  0  0.908424
2010  16647.2  0  120568  0  0.985386

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
 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
 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
 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
 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
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 0 0.01519 0.08975 0.26179 0.54093 0.878 0.871 0.924 0.935

SSmsy_ratio = 0.983427
Fmsy_ratio =  0.632311
that's all
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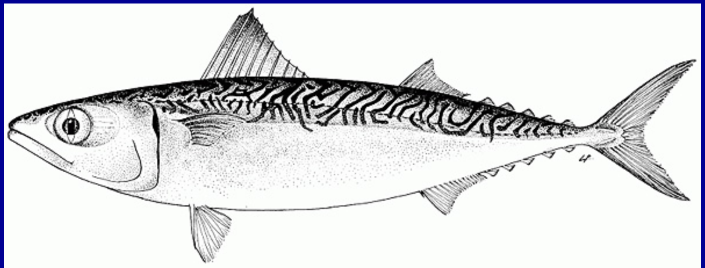
Agenda Item G.1.b
Supplemental NMFS PowerPoint
June 2008

Pacific Mackerel Stock Assessment For U.S. Management In The 2008-09 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

Background

Distribution

Spawning Area

Fisheries

MANAGEMENT HISTORY

- No formal management prior to 1970; Canneries imposed minimum size limits and paid lower prices for fish <30 cm;

- State of California imposed moratorium 1970-1977;

- 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;

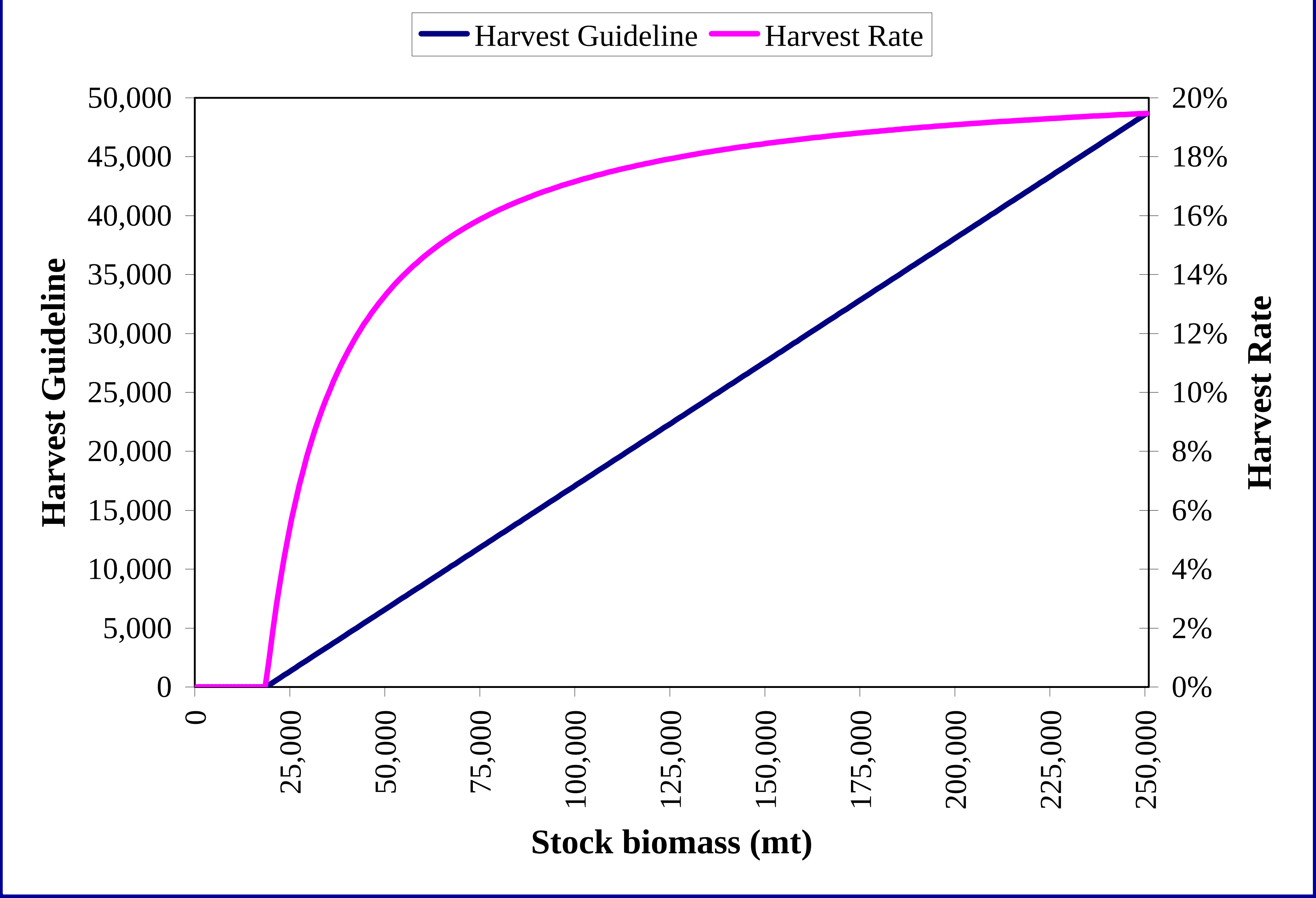
- No catch limitations by Mexico; min size=25.5 cm; limited entry;

- No international management agreements.

MSY CONTROL RULE – FEDERAL FMP:

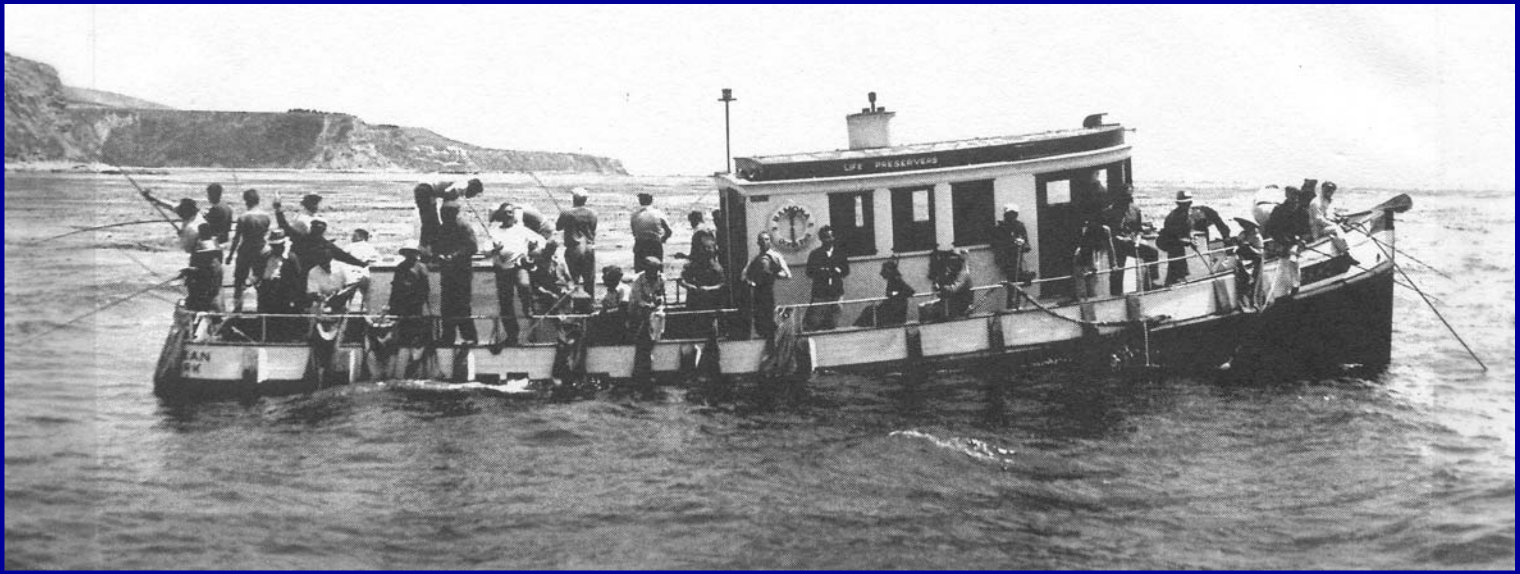
Harvest Guideline = (Biomass$_{1+}$ – Cutoff) x Fraction x Distribution

Harvest Guideline = (Biomass$_{1+}$ – 18,200) x 0.30 x 0.70

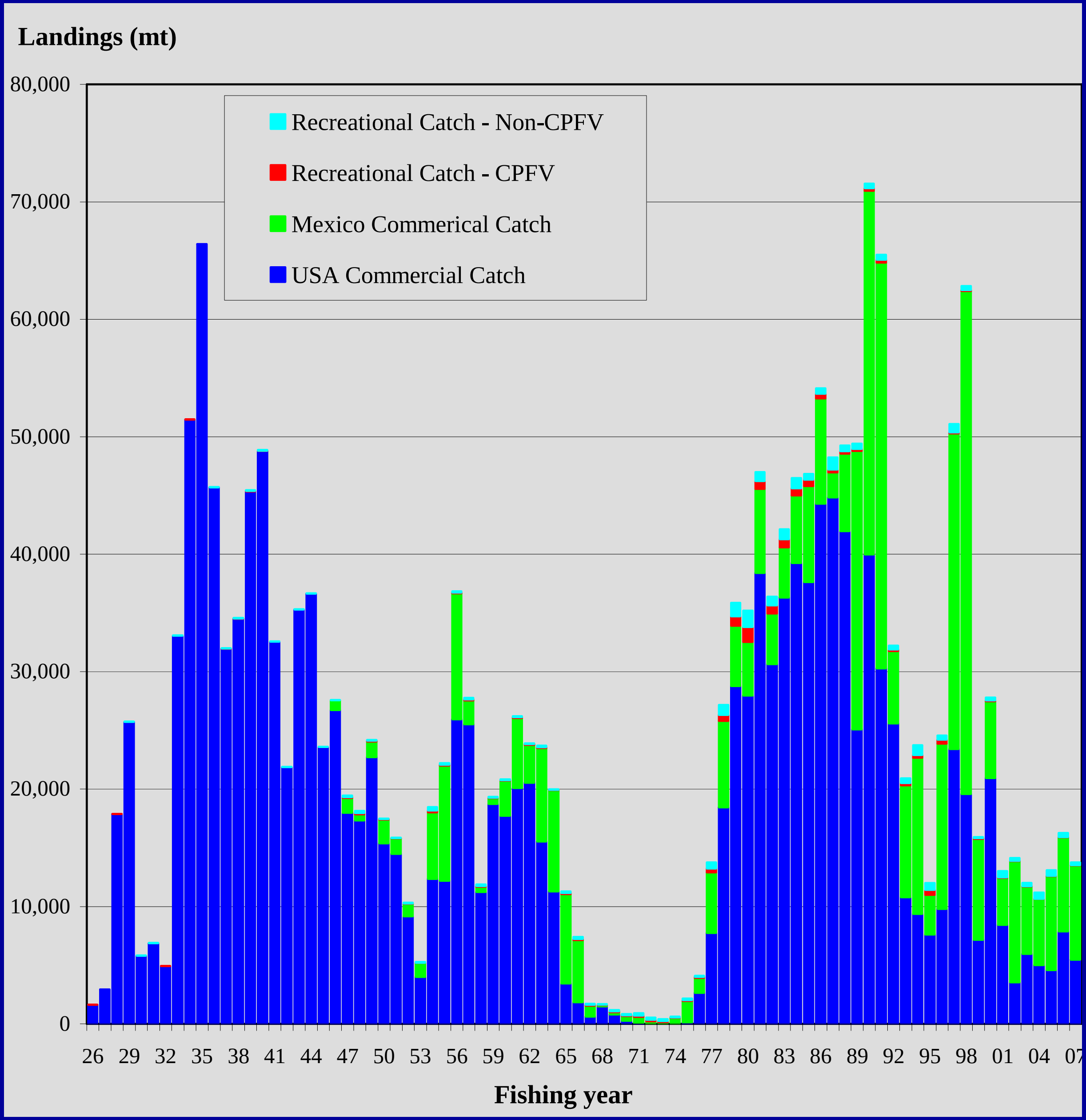


Landings

- 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

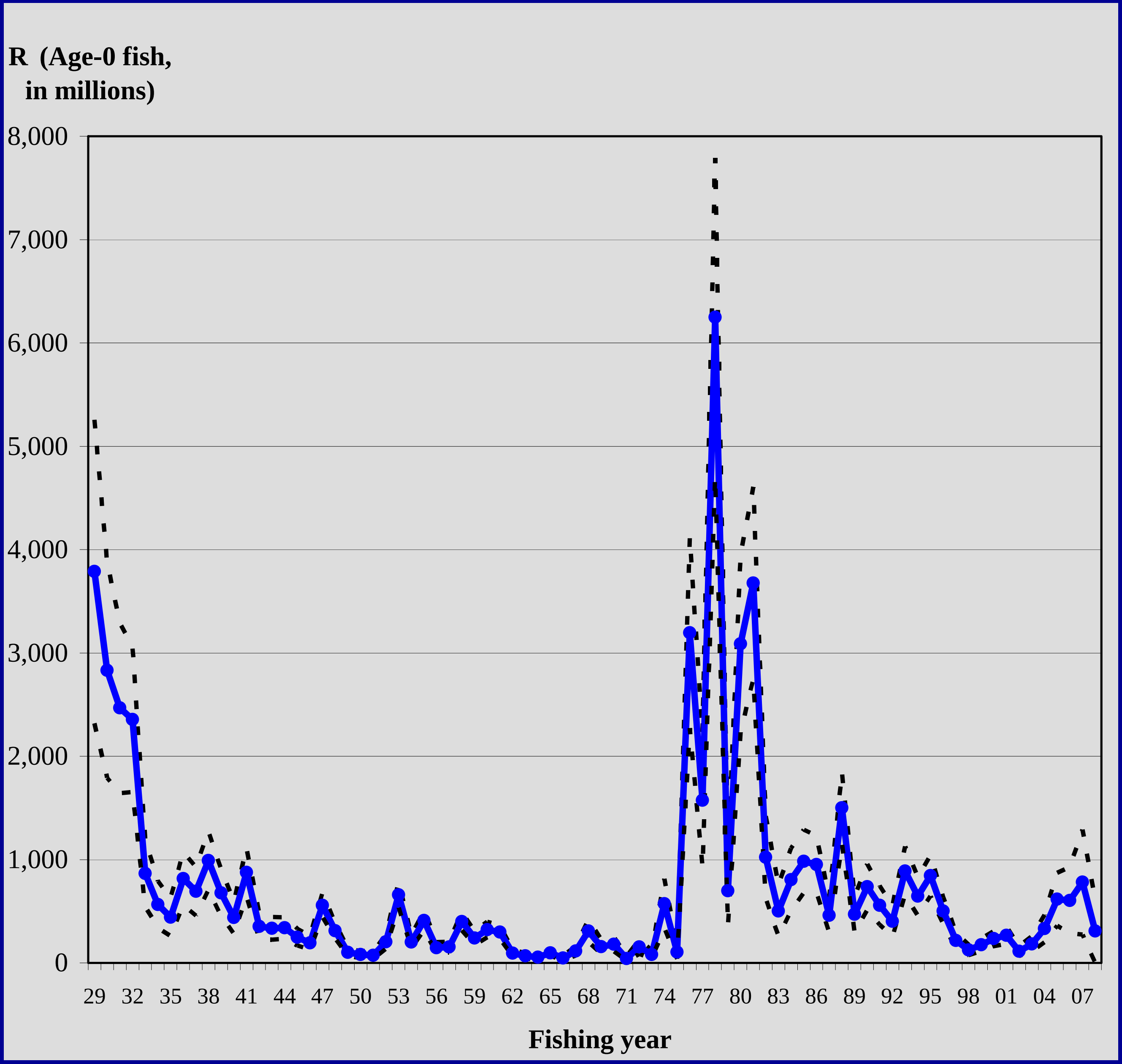

Landings (mt)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Recreational Catch - Non-CPFV
Recreational Catch - CPFV
Mexico Commerical Catch
USA Commercial Catch
26 29 32 35 38 41 44 47 50 53 56 59 62 65 68 71 74 77 80 83 86 89 92 95 98 01 04 07
Fishing year

ASAP-E1 Model

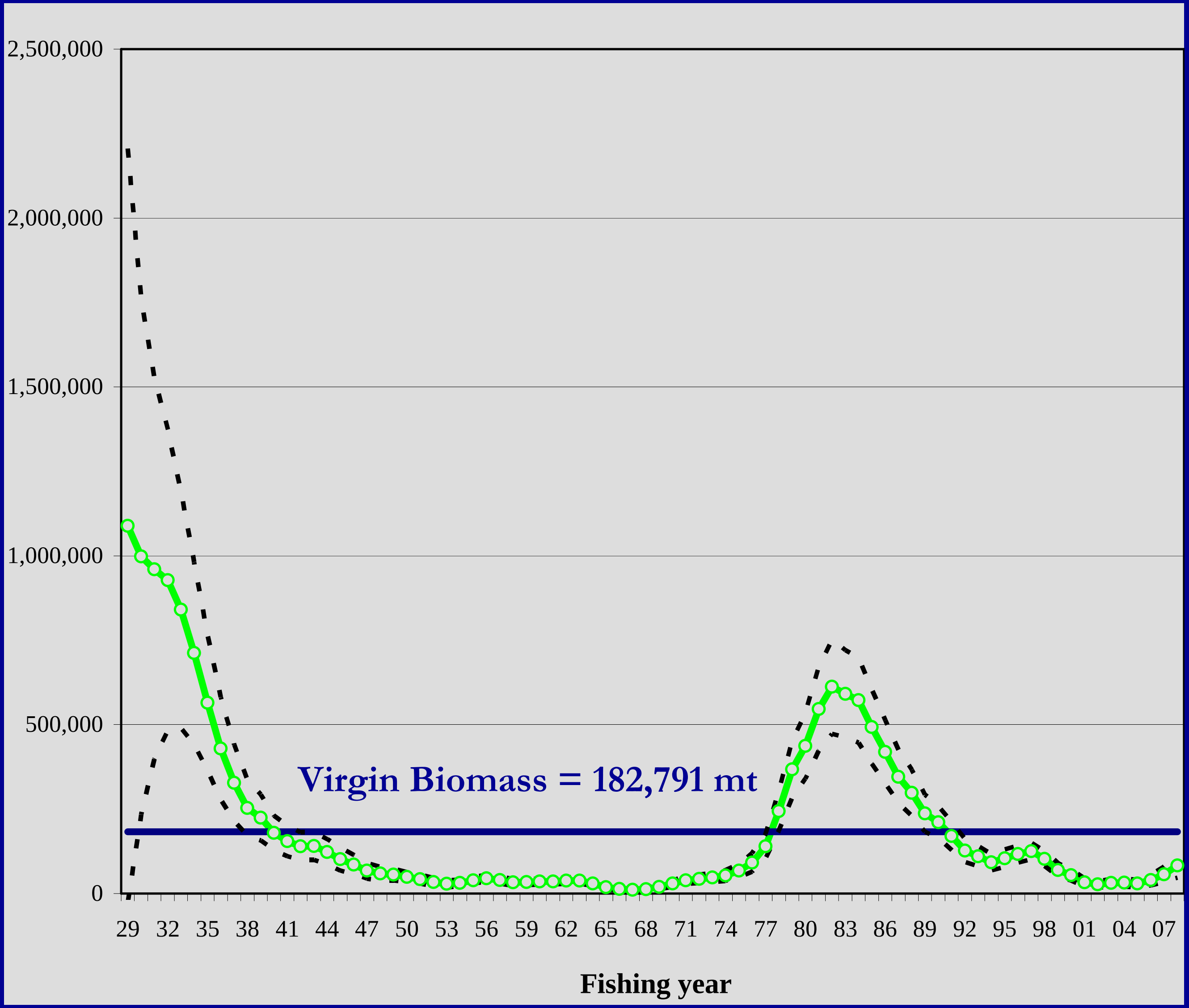
- ASAP Version 1.3.2 (Legault and Restrepo 1998)

- Model Structure
  - Natural Mortality, M = 0.5
  - Sigma R =0.7
  - Age 3 : Maturity ~ 50%
  - Year-specific weight-at-age
  - Spawner-Recruit curve: Standard Beverton & Holt

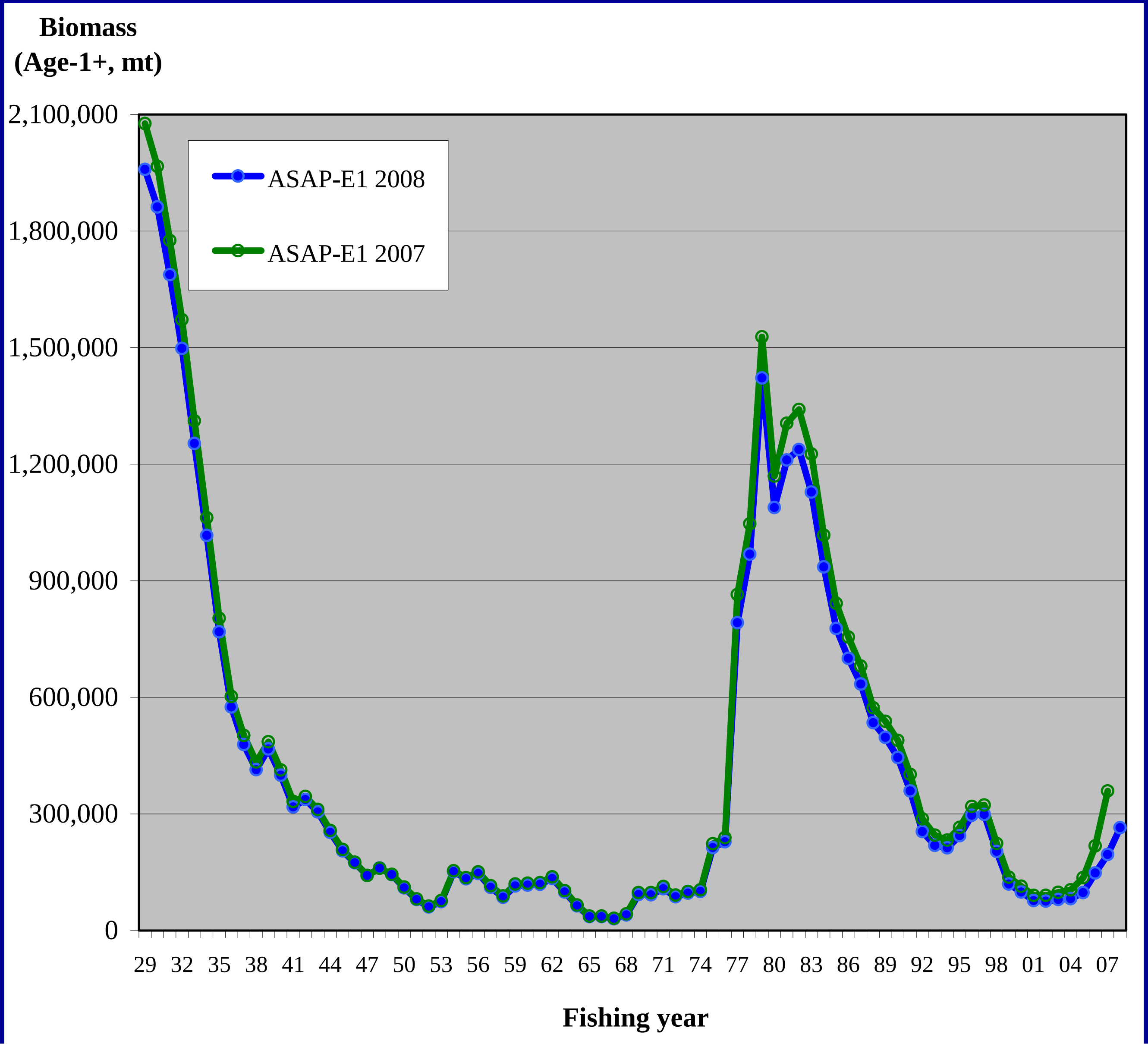
Recruitment



Spawning Stock Biomass



Age 1+ Biomass



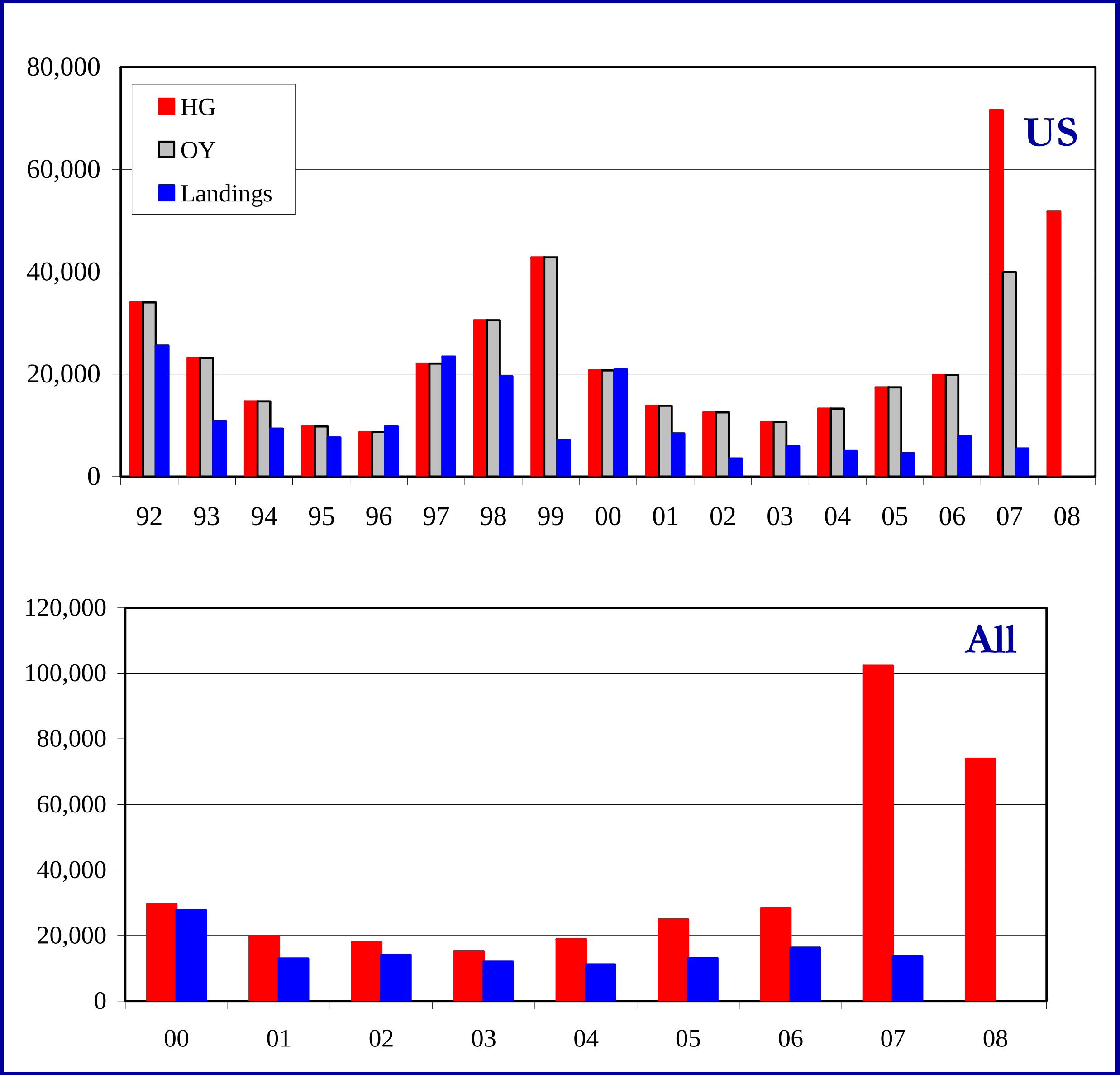
Harvest Guideline (HG_{08}) for 2008-09

HG_{08} = (BIOMASS$_{08}$ - CUTOFF) * FRACTION * DISTRIBUTION

HG_{08} = (264,732 – 18,200) * 0.30 * 0.70

HG_{08} = **51,772 mt**

Landings, OY and HGs



Future Research and Data Needs

- Continuation of effort to obtain from Mexico:
  - Biological data
  - Fishery-independent survey data
  - CPFV logbook data from Mexico

- Age-reading studies will be conducted to construct an age-reading error matrix.

- Continue to examine the possibility of using SS2 as an alternative platform to ASAP.

Agenda Item G.1.c
CPSAS Report
June 2008

COASTAL PELAGIC SPECIES ADVISORY SUBPANEL REPORT ON PACIFIC MACKEREL MANAGEMENT FOR 2008-2009

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 for the 2008-2009 season.

Based on the current assessment update and the harvest control rule for Pacific mackerel, the acceptable biological catch (ABC) for the 2008-2009 is estimated to be 51,772 metric tons (mt). The CPSAS again concurs with the Coastal Pelagic Species Management Team (CPSMT) recommendation to establish a harvest guideline for the directed fishery at 40,000 mt, providing an 11,772 mt set-aside for incidental landings in other fisheries. The CPSAS 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 with a 45 percent incidental landing 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 2008-2009 Pacific mackerel fishery at the nearest feasible Council meeting, if needed, with the possibility of either releasing a portion of the incidental set-aside to the directed fishery or further constraining incidental landings to ensure total harvest remains below the ABC.

PFMC
05/21/08

COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON PACIFIC MACKEREL MANAGEMENT FOR 2008-2009

In 2008, an updated assessment for Pacific mackerel was completed by Southwest Fisheries Science Center of the National Marine Fisheries Service. The Coastal Pelagic Species Management Team (CPSMT) and the Scientific and Statistical Committee's Coastal Pelagic Species (CPS) Subcommittee met May 13, 2008 in Long Beach, California to review the latest stock assessment of Pacific mackerel. The CPSMT heard a presentation by Dr. Emmanis Dorval of the Stock Assessment Team. The CPSMT supported conclusions from the most recent Pacific mackerel stock assessment update and 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 2008-2009 management season (i.e., July 1, 2008 through June 30, 2009). Based on a total stock biomass estimate of 264,732 mt, the ABC for U.S. fisheries is 51,772 mt.

Due to uncertainty associated with changes to modeling parameters recommended by the 2007 Stock Assessment Review Panel and the fact that the U.S. fishery is assumed to be market limited to roughly 40,000 mt, the CPSMT recommends setting the 2008-2009 harvest guideline (HG) no higher than 40,000 mt. This HG recommendation is the same as the HG adopted by the Council for the 2007-2008 fishery.

Recent U.S. annual landings have been well below the established HGs for the directed fishery. 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
05/19/08

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON PACIFIC MACKEREL MANAGEMENT FOR 2008-2009

The Scientific and Statistical Committee (SSC) received a presentation on the 2008 Pacific mackerel stock assessment by Dr. Emmanis Dorval. In addition, Dr. Tom Helser briefed the SSC on the results of an assessment review that was sponsored by the Council on May 13, 2008, in Long Beach, CA. The review was conducted by two members of the Coastal Pelagic Species (CPS) sub-committee of the SSC, and several members of the CPS Management Team.

The last full assessment of Pacific Mackerel occurred during May 2007 and the current assessment was prepared as an update assessment. The SSC considers that the assessment has satisfied the Terms of Reference for a CPS Stock Assessment update because (a) the base model that was selected and approved at the 2007 Stock Assessment Review (STAR) Panel formed the basis for the update assessment, (b) this assessment used the same model structure and estimation framework (ASAP) as the last full assessment, and (c) only updates to the data used during the 2007 full assessment were included in the updated assessment. The updated assessment included revised catch landings, catch-at-age and weight-at-age data for 2006-07, and new 2007-08 data. The assessment was based on three indices of abundance (California Cooperative Oceanic Fisheries Investigations [CalCOFI], commercial passenger fishing vessel [CPFV] and spotter). Only one of the indices of abundance (CPFV) was updated to include data for 2007-08. The CPFV index is now the primary index of abundance for Pacific mackerel, but is based on fishery-dependent sampling and is therefore subject to the concerns associated with such data. In addition, the CPFV index may not reflect trends in abundance for the southern portion of the range.

Dr. Dorval indicated that the stock assessment team (STAT) intends to continue to investigate an SS2-based Pacific mackerel assessment. If completed, an SS2-based assessment should be reviewed at a May 2009 STAR Panel. The SSC also notes that the ASAP model has been updated and that some of its new features may be useful for the Pacific mackerel assessment. Should the work on SS2 modelling for Pacific mackerel prove problematic, the updated ASAP model should be considered as a possible alternative modelling platform.

The SSC endorses the update assessment as the best available science and its use in Council management decisions. Based on the Council's harvest control rule, the acceptable biological catch (ABC) and maximum allowable harvest guideline for Pacific mackerel from the update assessment is 51,772 mt.

PFMC
6/9/08

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Portland, OR 97202 USA www.oceana.org

May 6, 2008

Dr. Samuel Herrick, Chair
Coastal Pelagic Species Management Team
P.O. Box 271
La Jolla, CA 92037-0271

Mr. John Royal, Chair
Coastal Pelagic Species Advisory Subpanel
P.O. Box 1162
San Pedro, CA 90733

RE: Ecosystem Considerations in Coastal Pelagic Species Stock Assessment and Fishery Evaluation (SAFE) Reports and Harvest Guidelines

Dear Chairmen Herrick and Royal:

We are writing to recommend information and analysis that the Pacific Fishery Management Council Coastal Pelagic Species Management Team (CPSMT) should include in the 2008 Coastal Pelagic Species Stock Assessment and Fishery Evaluation (SAFE) reports in order to meet its obligation to incorporate and evaluate ecosystem information. It is imperative that this ecosystem information be used in setting optimum yields for Pacific mackerel and sardines. Given the importance of these and other forage species to the California Current food web, they cannot be managed by single species fisheries management alone but, instead, must be considered in the broader ecosystem context.

Forage species, including those managed under the Coastal Pelagic Species Fishery Management Plan (CPS FMP), play a crucial role in marine ecosystems as they transfer energy from plankton to the larger fishes, seabirds, and marine mammals (Alder & Pauly 2006). The impacts of forage species removals on marine mammals and seabird populations both globally (Tasker et al. 2000, Furness 2003) and on the U.S. West Coast (Baraff & Loughlin 2000; Becker and Beissinger 2006) have been well documented. In fact, fisheries targeting forage species can even reduce the productivity of other commercial fisheries targeting fish that consume forage species as prey (Walters et al. 2006). Maintaining a healthy abundance of forage in our coastal marine systems is critical to the resilience of these systems in the face of the global climate and oceanographic changes we will face in coming decades (IPCC 2006). CPS fisheries management clearly requires a precautionary approach given the multiple sources of uncertainty regarding these species' population sizes and the important role forage species play in the productivity of marine wildlife and commercial and recreational fisheries (i.e. NRC 2006).

The CPS FMP requires that the CPSMT prepare an annual SAFE report and, "in particular, the SAFE report shall include…ecosystem information" (CPS FMP, at 4-6). Currently, SAFE documents lack any meaningful information about the role of CPS in the marine ecosystem or the ecological effects of harvesting CPS. In order to fulfill its obligations under the CPS FMP, we recommend that the CPSMT add an ecosystem chapter to the SAFE document that includes:

- A description of the California Current Large Marine Ecosystem,
- An explanation of the influence of oceanographic conditions on CPS, and

- Food web analyses including information such as
  - The role of CPS in the food web, including analysis of the relative interaction strengths between predators and CPS,
  - Consumption levels of CPS by other species including marine mammals, seabirds, and fish,
  - Shared prey analysis that will help provide an understanding of relative competition for CPS between predators and fisheries,
  - Species sensitivity analysis to determine how impacts to one species might transmit to other species through food web relationships, and
  - Spatial and temporal interactions.

In addition, we request that the CPSMT develop recommendations for setting appropriate levels of allocation of CPS to their predators prior to setting optimum yield in the current harvest guidelines. We recommend that the CPSMT review and utilize the results and methods presented in the ecosystem research currently being conducted by NOAA Fisheries, for example Field & Francis (2006), Field et al. (2006) and Fowler (1999). As such, working with seabird and marine mammal experts can be useful in obtaining initial estimates of quantities of CPS consumed by their predators.

We appreciate the hard work of the National Marine Fisheries Service stock assessment teams, the CPSMT and CPSAS to provide scientific estimates of the abundance of actively managed CPS (Pacific mackerel and sardine) and recommended harvest guidelines. Stock assessments, harvest control rules and management measures are the first step to sustainable fishery management. It is now time to include ecosystem information into the SAFE documents and in the harvest guidelines. The availability of forage species to provide a source of food for salmon, other fish, birds and marine mammals must be a priority consideration. A precautionary approach is necessary, especially for those fisheries targeting species lacking stock assessments and when ensuring abundant populations of forage for ecosystem needs.

Thank you for your time and consideration. We look forward to continuing to work with you.

Sincerely,

Ben Enticknap
Pacific Project Manager
CPS Advisory Subpanel Member

cc: Dr. Donald McIsaac, Executive Director, Pacific Fishery Management Council

References:

Alder, J. and Pauly, D. 2006. On the Multiple Uses of Forage Fish: From Ecosystems to Markets. Fisheries Centre Research Reports 14(3). *The Fisheries Centre, University of British Columbia. 120pp.*

Baraff, L.S. and Loughlin, T.R. 2000. Trends and Potential Interactions Between Pinnipeds and Fisheries of New England and the U.S. West Coast. Marine Fisheries Review 62(4): 1-39.

Becker, B.H., and S.R. Beissinger. 2006. Centennial decline in the trophic level of an endangered seabird after fisheries decline. Conservation Biology. 20(2): 470-479.

Coastal Pelagic Species Fishery Management Plan. December 1998. NMFS and PFMC, at 4-6.

Field, J.C. and Francis, R.C. 2006. Considering ecosystem-based fisheries management in the California Current. Marine Policy 30:552-569.

Field, J.C., Francis, R.C., Aydin, K. 2006. Top-down modeling and bottom-up dynamics: Linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68:238-270.

Fowler, C.W. 1999. Nature's Monte Carlo Experiments in Sustainability. Proceedings, 5th NMFS NSAW. 1999. NOAA Tech. Memo. NMFS-F/SPO-40.

Furness, R. 2003. Impacts of fisheries on seabird communities. Sci. Mar. 67(2): 33-45.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report: Climate Change 2007: Synthesis Report. United Nations Environment Programme.

National Research Council, Committee on Ecosystem Effects of Fishing, Phase II. Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options. National Academies Press, Washington, D.C. (2006). 160 pp.

Tasker, M. L., Camphuysen, C. J., Cooper, J., Garthe, S., Montevecchi, W. A., and Blaber, S. J. M. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science, 57: 531–547.

Walters, C. J., Christensen, V., Martell, S. J., and Kitchell, J. F. 2005. Possible ecosystem impacts of applying MSY policies from single-species assessment. ICES Journal of Marine Science, 62: 558-568.

Dr. Samuel Herrick, Chair
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May 11, 2008

Mr. John Royal, Chair
Coastal Pelagic Species Advisory Subpanel
P.O. Box 1162
San Pedro, CA 90733

RE: Oceana's letter of May 6, 2008 "Ecosystem Considerations in Coastal Pelagic Species Stock Assessment and Fishery Evaluation (SAFE) Reports and Harvest Guidelines"

Dear Chairmen Herrick and Royal.

I am writing this letter in response to Oceana's concerns about the importance of the sardine stock as forage for other species. The existing sardine control rule was developed using a model designed by Larry Jacobson, and I did the evaluations of model output that resulted in the original CPS Management Team's recommended harvest rule that was accepted by the Pacific Council. I believe Sam Herrick is the only original member of the CPSMT who is a member of the current CPSMT.

Unfortunately, Larry Jacobson transferred to the Northeast Fisheries Research Center shortly after the sardine harvest rule was enacted and I was unable to secure the travel budget needed for me to travel to the east coast to organize a paper, with Larry, describing the modeling work. Therefore the basis and results for the sardine harvest rule were never published.

I will briefly describe the concepts used in the development of the present sardine harvest rule later, but at the outset it needs to be recognized that the sardine harvest rule is clearly ecosystem-based management. The figures shown below are the same figures I presented to the Pacific Council. The rationale for the CPSMTs recommended harvest rule was dominated by a concern for maintaining the sardine stock at population levels well above that which would occur with a single-species, MSY-based management strategy. In fact, the principal basis for the present sardine rule was to maintain a large population of sardine due to their importance as forage. I personally testified to the Pacific Council concerning the ecosystem value of sardine. During my presentation I noted that many of the fish stocks that were then in trouble (bocaccio, cowcod, lingcod and salmon) were fish eaters and I suggested that maintaining high sardine population levels could be a major factor in the recovery of these depressed stocks. In addition, the modeling included a published relationship between sea surface temperature and recruitment success in sardine as it was realized that bottom up ecosystem forcing needed to be included in any fishery management plan. The present sardine harvest rule therefore is clearly ecosystem-based management and it includes both physical environmental factors and trophic level concerns.

The sardine model management assessment model is briefly described in the 1998 CPS Management Plan which is available on the Council's website. The table below describing the then proposed management options is taken from that management document.

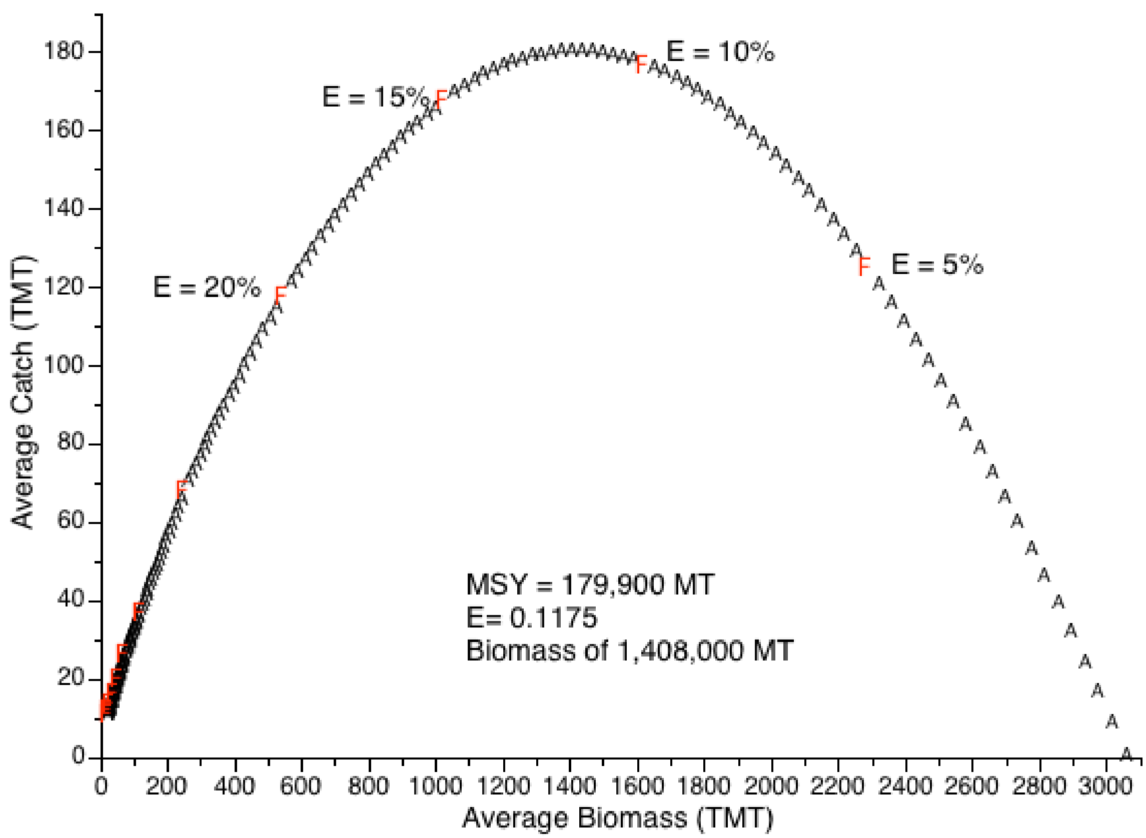
TABLE 4.2.5-1. MSY control rule options for Pacific Sardine. All options evaluated in a stochastic model.

	Option A (Status Quo)	Option B	Option C	Option D	Option E	Option F	Option G	Option H	Option I	Option J	Option K	Option L (Stochastic F_{MSY})	Option M (Determ. Equil. F_{MSY} in a Stochastic Model)
Overfishing Definitions													
Overfishing Rate	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC	Catch> ABC
Overfished Threshold (mt)	50	50	50	50	50	50	50	50	50	50	50	50	50
Control Rule Parameters													
FRACTION	20%	F_{MSY} (10-30%)	20%	F_{MSY} (10-30%)	F_{MSY} (10-30%)	F_{MSY} (5-25%)	F_{MSY} (5-15%)	F_{MSY} (5-15%)	F_{MSY} (5-25%)	F_{MSY} (5-15%)	F_{MSY} (10-30%)	12%	8.8%
CUTOFF	50	50	100	100	100	100	100	100	100	150	50	0	0
MAXCAT	400	400	400	400	300	400	400	300	300	200	200	Infinite	Infinite
Performance Measure													
Average Catch	151	159	165	171	165	177	179	169	169	145	141	180	170
Std. Dev. Catch	137	140	140	143	113	143	133	105	112	67	72	180	153
Mean Biomass	936	964	1,073	1,091	1,280	1,216	1,543	1,665	1,400	1,952	1,516	1,408	1,784
StdDev Biomass	27	27	29	28	34	32	39	42	37	49	43	39	43
Mean Log Catch	4.33	4.46	4.44	4.54	4.64	4.62	4.77	4.80	4.70	4.76	4.65	4.72	4.77
Mean Log Biom	6.24	6.37	6.50	6.59	6.75	6.74	7.06	7.15	6.89	7.34	6.87	6.89	7.24
Percent Years Biomass>400	61%	64%	70%	73%	79%	81%	90%	92%	84%	96%	79%	84%	93%
Percent Years No Catch	5%	2%	7%	4%	3%	2%	1%	0%	1%	0.5%	1%	0%	0%
Median Catch	103	104	119	121	148	131	140	156	158	182	188	128	127
Median Biomass	598	600	700	748	898	850	1,248	1,349	1,048	1,648	1,099	1,500	1,049

The following figures were used to demonstrate to the Pacific Council the relationship between increasing exploitation and average catch in the stochastic sardine simulations and the effect of increasing catch on the value of sardine as forage for other species. The first shows the average catch and average biomass with increasing exploitation rates. The bell shaped curve shows that at low exploitation rates catch rises rapidly in relation to the decline in biomass, at about E=0.10 the curve has flattened markedly and as the exploitation rate continues to increase the catch increases only slightly while biomass continues to decline. The catch reaches a maximum at E=0.1175 and at higher exploitation rates both catch and biomass decline.

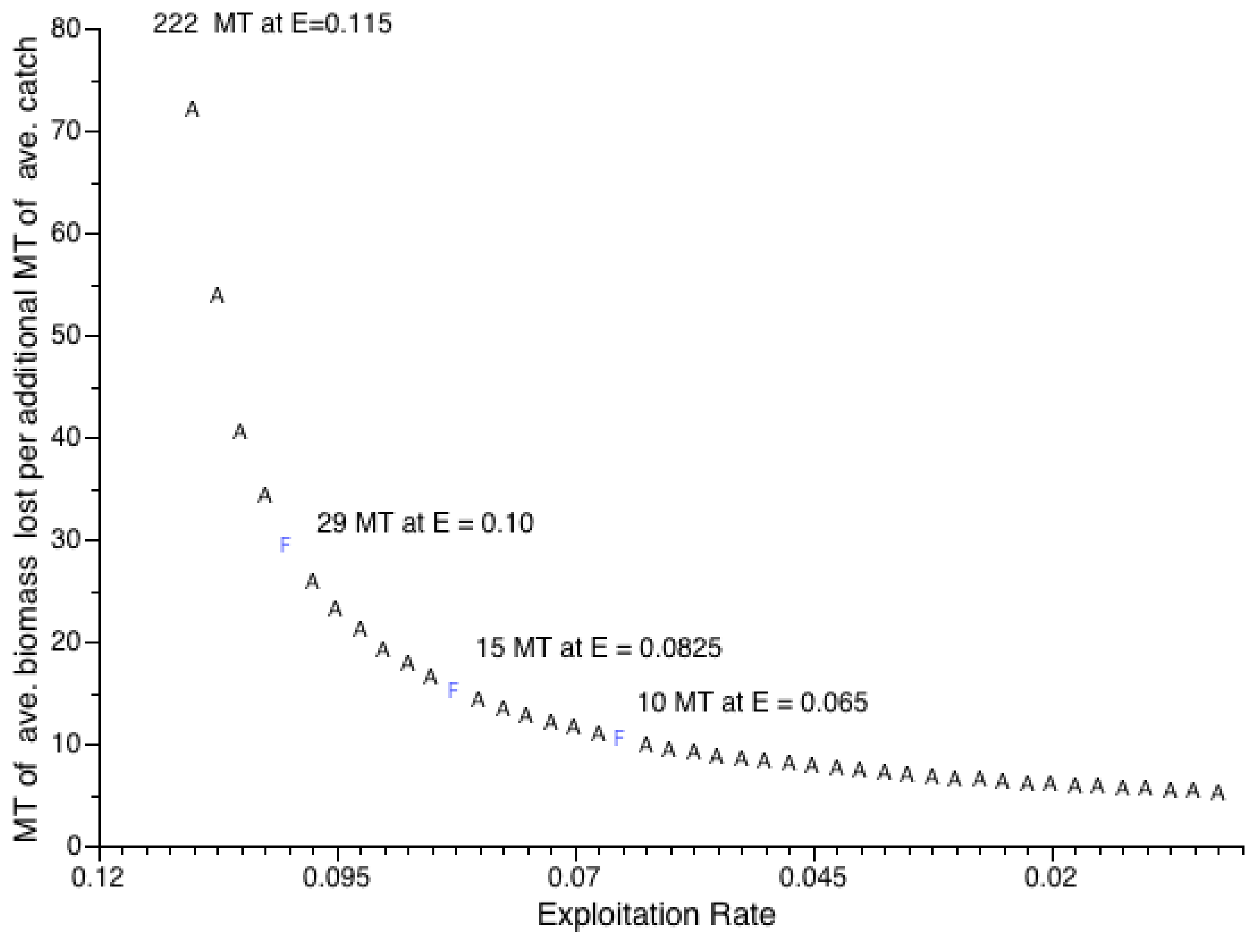
Sardine 1000 year simulations with exploitation rates from 0.0025 to 0.6

(no cutoff or maxcat)

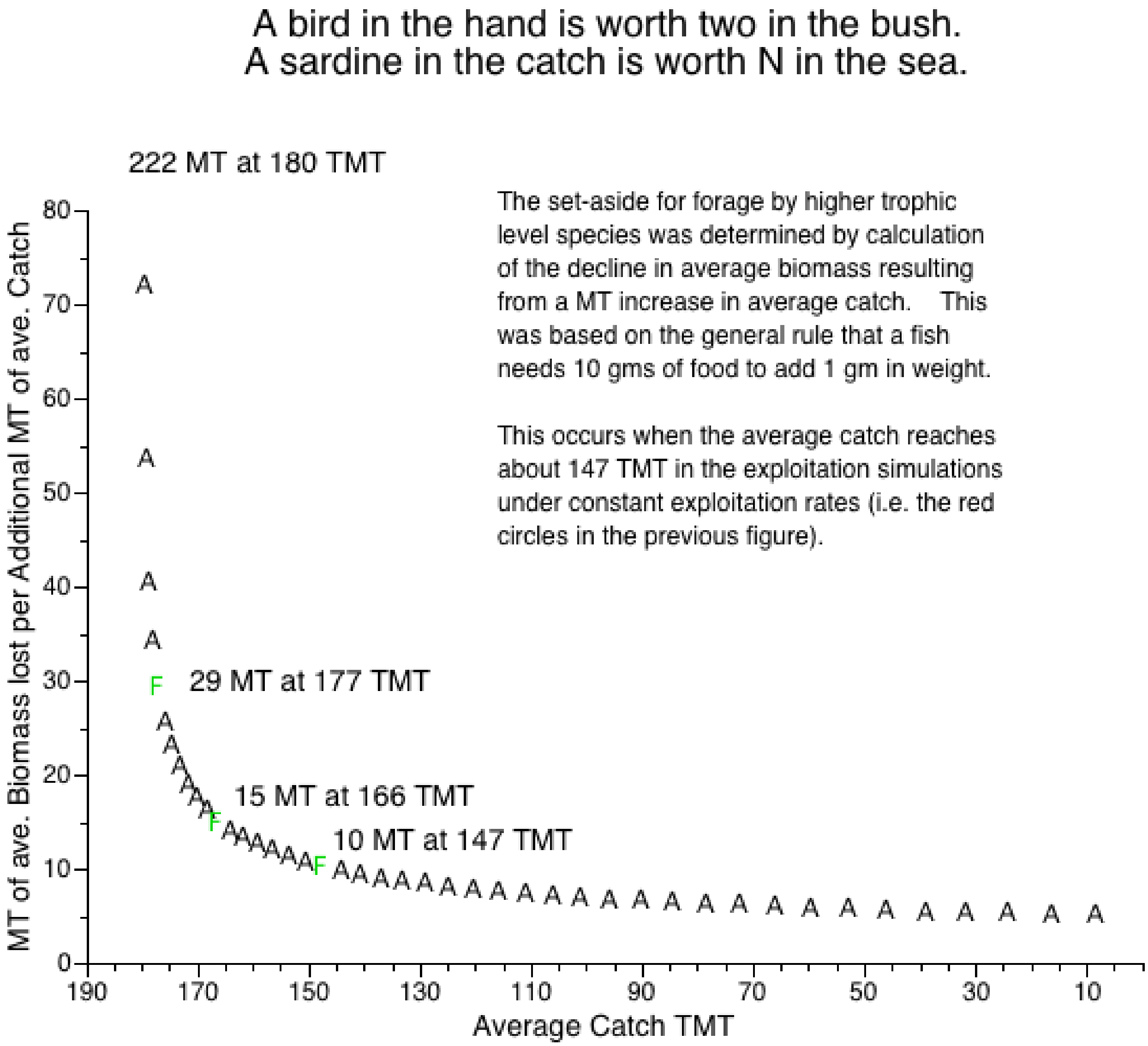


The second figure, below, shows the rate of decline in average biomass versus the exploitation rate at levels below that producing the maximum sustainable yield. This relationship shows the drop in average biomass that occurs with each additional average metric ton of annual catch over the range of exploitation rates below the MSY rate. For example at E=0.10 each additional metric ton of annual catch results in a loss of 29 metric tons of average biomass; at E=0.065 the result is 10 metric tons.

A sardine in the catch is worth N sardines in the sea.



The third figure shows a similar relationship to that in the second figure except that the exploitation rate is replaced with the average catch that occurs at the given exploitation rate. Note that the non-linear relationships in the three figures offer little information on where the optimum exploitation rate (or average catch) and average biomass occurs. The approach taken by the CPSMT was to use the general ecological rule that it takes ten gms. of food to produce one gm. of weight. This point occurs at an annual average catch of 147 thousand tons or an exploitation rate of 0.065. Using this approach the exploitation rate should not exceed the rate where an increase in catch results in a tenfold decrease in average biomass. In other words the set aside for forage by other species was determined by setting the exploitation rate at the level where the weight of the last mt of catch equaled the increase in biomass that would occur if the resulting ten mt. average biomass were left in the ocean. Note that this is a quite conservative estimate because 10 metric tons of average biomass would produce less than half of this weight in natural mortality or forage for other species in any given year.

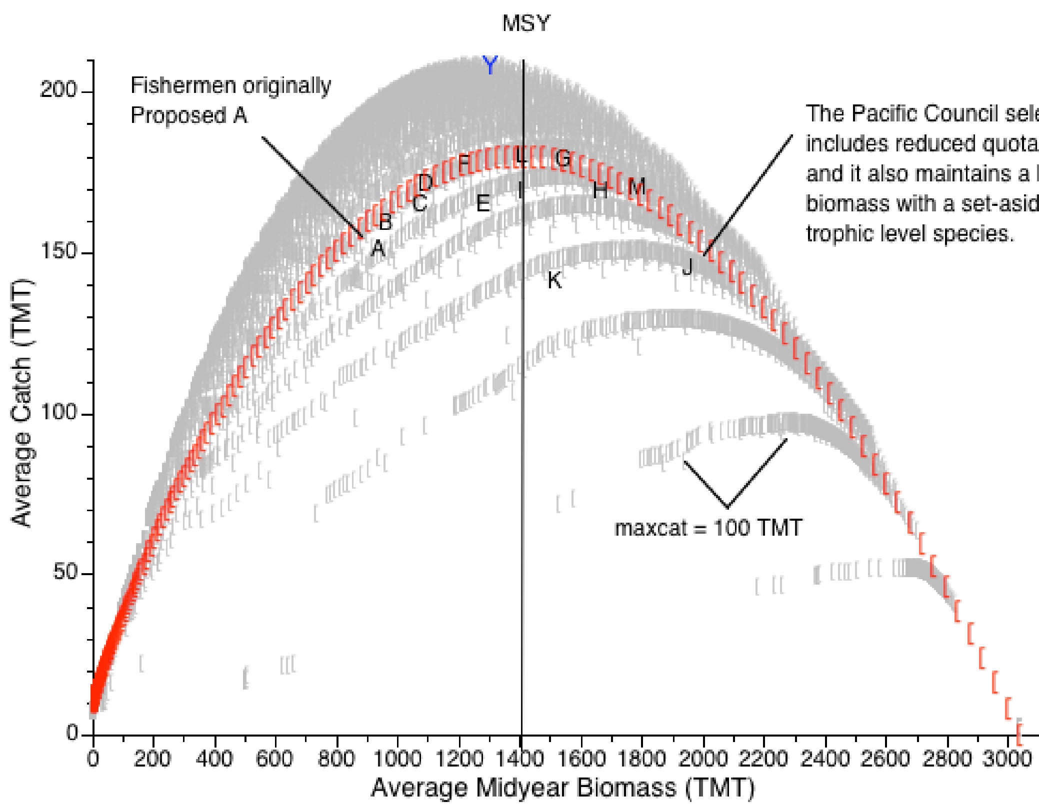


Given the above assumptions for a forage allocation, analyses of the sardine model output were made to establish a harvest rule that achieved a mix of the following characteristics.

1. High average biomass.
2. High median biomass
3. High standard deviation in biomass (it was found that low standard deviation in biomass was associated with low biomass)
4. Low percentage of years with biomass below 400 thousand mt. (this is the population level where the sardine population became restricted to the area south of Point Conception in the historical fishery).
5. Average catch near 147 thousand tons
6. High median catch
7. Low standard deviation of catch (to achieve a stable fishery)
8. Low percentage of years with no fishery.

An extremely wide range of harvest rules was used in the population simulations. The following figure shows the resulting average catch and average biomass from the harvest rule policies examined. The maximum average catch was from a policy with a cutoff of 1 million mt, a high fraction, and maximum catch of 1 million mt (Y in the figure). This harvest rule produced a pulse fishery with no fishery in nearly half of the years. The simulation with stochastic MSY (L) had an average catch of 180 thousand mt and an average biomass of 1408 mt. The council selected the CPSMT's preferred option (option J) that had an average catch of 145 thousand mt and an average biomass of 1,952 mt. The MSY option would result in an average depletion of 46% and option J would have 64%. Option J would have an average biomass 544 thousand mt greater than the stochastic MSY option.

Sardine Fishery Simulation Results: Average biomass vs average catch for 13 proposed management policies, 240 exploitation rates (0.0025-0.6) and 9260 policies with a wide range of cutoffs (0-1000 TMT), constant fractions (0.05-1.0) and maxcats.(50-1000 TMT).



The Oceana letter includes the following statement "In addition, we request that the CPSMT develop recommendations for setting appropriate levels of allocation of CPS to their predators prior to setting optimum yield in the current harvest guidelines". Oceana apparently failed to realize that the current harvest guidelines include a large "allocation" for forage. However, having been closely involved in the development of the current harvest guidelines, I note that the term "allocation" is difficult to define. One way to define an "allocation" would be to use the CUTOFF portion of a harvest guideline as the definition of "allocation". Under this definition the harvest policy with the maximum average catch (CUTOFF = 1 million mt) would have a much higher "allocation" than the current harvest policy (CUTOFF = 150 thousand mt) but it would have an average depletion of 42% (option J has 64%). Using the current harvest rule, the forage allocation could be considered to be the difference (i.e 544 thousand mt) between the average biomass with the current rule and the MSY option.

To do what Oceana suggests (i.e. have the Council determine the forage allocation resulting in optimum yield) the present harvest rule would have to be abandoned and the harvest policy would probably revert to an ABC established by the MSY exploitation rate (E=0.12) with the addition of the 25% overfishing definition and 40% point of concern. The Council would then develop some criteria for establishing OY based on the ABC. If this sort of approach is followed it will be necessary to evaluate the performance of the resulting policy in comparison to the current policy.

Obviously the sophisticated analyses suggested by Oceana would need to be carried out before altering the present harvest rule, which already has a large allocation for forage. This allocation was assessed in a model that uses stochastic environmental variability that was based on the variance, auto correlation and 60 year cycle observed in the California Current System. I note that ecosystem analyses such as the Field et al model are not presently capable of incorporating the complex temporal patterns observed in the California Current System.

If the analyses suggested by Oceana are carried out the discussion between the relative accuracy of the present harvest policy (which includes realistic temporal resolution but no trophic level interaction) versus a model with poor temporal resolution and extensive trophic level interaction should be very interesting.

Richard Parrish
Fisheries Biologist (ancient)

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June 6, 2008

Mr. Donald K. Hansen
Chair, Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220

RE: G.1 Coastal Pelagic Species Management

Dear Chairman Hansen

The Pacific Fishery Management Council (PFMC) must manage forage species using an ecosystem-based approach that recognizes and accounts for the important role forage species play in the California Current Large Marine Ecosystem. Forage species, including those managed under the Coastal Pelagic Species Fishery Management Plan (CPS FMP), play a crucial role in marine ecosystems by transferring energy from plankton to larger fishes, seabirds, and marine mammals.[1] The PFMC has the responsibility under the Magnuson-Stevens Fishery Conservation and Management Act and CPS FMP to consider ecosystem needs and minimize adverse effects on prey species and their habitat. As demonstrated by their recent actions prohibiting fishing for krill, the PFMC and National Marine Fisheries Service also have the ability to set policies and take actions that protect the functional role of forage species in the food web. As such, the Council should adopt a policy that protects populations of forage species and their functional role in the ecosystem by managing forage with an ecosystem-based approach and utilizing a precautionary, conservative approach to fisheries management.

Specifically, we recommend the PFMC take the following actions:

1. Include ecosystem information in annual SAFE reports

The CPS FMP requires that the Coastal Pelagic Species Management Team (CPSMT) prepare an annual SAFE report, and, "in particular, the SAFE report shall include…ecosystem information."[2] Previous SAFE reports lacked meaningful information about the role of CPS in the marine ecosystem or the ecological effects of harvesting coastal pelagic species (CPS). Therefore, in our May 6, 2008 letter to the CPSMT and Advisory Subpanel (CPSAS) (Agenda Item G.1.d, Public Comment) we provided a detailed request for analyses of ecosystem information in Stock Assessment and Fishery Evaluation (SAFE) reports. We are pleased that the CPSMT recognized the importance of ecosystem information and has taken an initial step to include ecosystem information in the draft 2008 SAFE report by including a section on 'ecosystem-based fishery management' and one on 'sardines as forage'.[3] Clearly this will require additional discussion and analysis, but we applaud the CPSMT for taking a first step toward providing ecosystem information as specified in the CPS FMP.

In addition, we support the Council's past and current research recommendations to "[e]valuate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and define predator prey relationships."[4] Specifically, we request that the SAFE report comply with the CPS FMP as stated above and include the analyses recommended in our May 6, 2008 letter.

2. Account for the needs of the ecosystem when setting catch levels

One of the CPS FMP goals is to "[p]rovide adequate forage for dependent species."[5] This is a critical goal with sound scientific basis as forage species are important for other commercially and recreationally important species[6] as well as the wider ecosystem.[7] There has been no showing, however, that the Maximum Sustainable Yield (MSY) control rules for the two actively managed CPS (Pacific sardine and Pacific mackerel) adequately account for ecosystem needs. Including ecosystem information in SAFE documents would help provide an answer to this question.

The PFMC must reevaluate the MSY control rules to ensure that ecosystem needs are directly incorporated into the process by which catch levels are set. For example, the 'CUTOFF' values in the control rules for both Pacific sardine and Pacific mackerel should be re-examined. Currently, the CUTOFF values for Pacific sardine and Pacific mackerel are as low as 10-15% and 5-20% respectively, of recent biomass estimates. Targeted fishing for these species should be stopped at a considerably higher biomass unless or until there is strong scientific evidence showing that commercial take, up to these very low biomass levels, does not harm dependent species.

The Council's own 'Current and past Research and Data Needs' documents have identified the priority need to "re-evaluate the harvest control rules for both Pacific sardine and Pacific mackerel."[8] We support such a re-evaluation of the MSY control rules for these species and note that, as it undertakes that re-evaluation, the PFMC must ensure that adequate forage for ecosystem needs are provided.

We also are concerned about directed fishing for monitored species that do not have recent stock assessments. Under the default MSY control rule used for monitored species, Allowable Biological Catch (ABC) is set at 25% of MSY, and overfishing is considered to be occurring when catches are higher than the ABC level. The threshold for moving monitored CPS to actively managed status is unclear; the FMP states only that "[a]ny stock approaching the ABC or MSY levels should be Actively managed unless there is too little information available or other practical problems."[9] Without accurate stock assessments, however, and a thorough evaluation of ecosystem needs, there is no reliable information to evaluate whether or not current catch levels of 'monitored' CPS are sustainable.

3. Prohibit new fisheries for forage species unless or until research shows it can happen without negatively impacting dependent species.

As the PFMC has already done with krill and as the North Pacific Fishery Management Council has done with many other forage species[10], precautionary action must be taken to prevent the development of fisheries on non-managed forage species unless or until research demonstrates there will not be adverse effects on the ecosystem. Given the mounting pressures on forage species from increasing aquaculture, global climate change, and a burgeoning population, it is imperative that the Council continue to take precautionary actions to protect the marine food web. Specifically, we recommend that directed take of any species not currently managed by the PFMC or states (*e.g.*, Pacific sauries and sand lance) be prohibited unless and until necessary ecosystem research and evaluation has been conducted.

4. Prioritize the role of forage species in the ecosystem

To ensure the use of forage fish best serves the public interest, we recommend the Council prioritize utilization in the following order: (1) ecosystem needs, (2) direct human consumption, (3) bait and aquaria, and (4) all other uses. We also support the Council's own recommendation of additional research on the role of CPS in the ecosystem,[11] consistent with moving the fishery towards an ecosystem-based and precautionary management regime.

Again, please see our May 6, 2008 letter for specific recommendations on the type of information we think needs to be incorporated into SAFE documents and control rules for forage species. We applaud the CPSMT for taking an initial step in the right direction by including a discussion on how to include ecosystem information, but much more must be done in order to protect CPS species and their role in the ecosystem. We look forward to continuing to work with the Council on this issue in order to protect the base of the marine food web that will provide long-term benefits to the diverse and productive California Current Large Marine Ecosystem, users of ocean resources, and current and future generations.

Sincerely,

Jim Ayers
Vice President, Oceana

Attached: Oceana – CPSMT letter, May6 2008

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[1] Alder, J. and Pauly, D. (2006). On the Multiple Uses of Forage Fish: From Ecosystems to Markets. Fisheries Centre Research Reports 14(3). *The Fisheries Centre, University of British Columbia. 120pp.*
[2] PFMC. CPS FMP, at 4-6
[3] PFMC. June 2008, Agenda Item G.1.a, Attachment 1, Draft CPS SAFE, at 45-47
[4] PFMC, 2007. CPS SAFE, at 47
[5] PFMC, 2006 (as amended). CPS FMP at 1-4
[6] Walters, C. J., Christensen, V., Martell, S. J., and Kitchell, J. F. 2005. Possible ecosystem impacts of applying MSY policies from single-species assessment. ICES Journal of Marine Science, 62: 558-568; National Research Council, Committee on Ecosystem Effects of Fishing, Phase II. Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options. National Academies Press, Washington, D.C. (2006). 160 pp.
[7] Furness, Robert W. 2003. Impacts of Fisheries on Seabird Communities. Sci. Mar., 67 (Suppl.2): 33-45; Baraff, L.S. and Loughlin, T.R. 2000. Trends and Potential Interactions Between Pinnipeds and Fisheries of New England and the U.S. West Coast. Marine Fisheries Review 62(4): 1-39; Becker, Benjamin H. & Beissinger, Steven R. 2006. Centennial Decline in the Trophic Level of an Endangered Seabird after Fisheries Decline. Conservation Biology, 20 (2): 470-490; Tasker, M. L., Camphuysen, C. J., Cooper, J., Garthe, S., Montevecchi, W. A., and Blaber, S. J. M. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science, 57: 531–547.
[8] PFMC. 2008 Research and Data Needs, at 23
[9] PFMC. CPS FMP, at 4-2
[10] NPFMC, 1998. Amendment 36 to the BSAI Groundfish FMP and Amendment 39 to GOA Groundfish FMP to Create and Manage a Forage Fish Species Category.
[11] PFMC. 2007 CPS SAFE, at 47

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May 6, 2008

Dr. Samuel Herrick, Chair
Coastal Pelagic Species Management Team
P.O. Box 271
La Jolla, CA 92037-0271

Mr. John Royal, Chair
Coastal Pelagic Species Advisory Subpanel
P.O. Box 1162
San Pedro, CA 90733

RE: Ecosystem Considerations in Coastal Pelagic Species Stock Assessment and Fishery Evaluation (SAFE) Reports and Harvest Guidelines

Dear Chairmen Herrick and Royal:

We are writing to recommend information and analysis that the Pacific Fishery Management Council Coastal Pelagic Species Management Team (CPSMT) should include in the 2008 Coastal Pelagic Species Stock Assessment and Fishery Evaluation (SAFE) reports in order to meet its obligation to incorporate and evaluate ecosystem information. It is imperative that this ecosystem information be used in setting optimum yields for Pacific mackerel and sardines. Given the importance of these and other forage species to the California Current food web, they cannot be managed by single species fisheries management alone but, instead, must be considered in the broader ecosystem context.

Forage species, including those managed under the Coastal Pelagic Species Fishery Management Plan (CPS FMP), play a crucial role in marine ecosystems as they transfer energy from plankton to the larger fishes, seabirds, and marine mammals (Alder & Pauly 2006). The impacts of forage species removals on marine mammals and seabird populations both globally (Tasker et al. 2000, Furness 2003) and on the U.S. West Coast (Baraff & Loughlin 2000; Becker and Beissinger 2006) have been well documented. In fact, fisheries targeting forage species can even reduce the productivity of other commercial fisheries targeting fish that consume forage species as prey (Walters et al. 2006). Maintaining a healthy abundance of forage in our coastal marine systems is critical to the resilience of these systems in the face of the global climate and oceanographic changes we will face in coming decades (IPCC 2006). CPS fisheries management clearly requires a precautionary approach given the multiple sources of uncertainty regarding these species' population sizes and the important role forage species play in the productivity of marine wildlife and commercial and recreational fisheries (i.e. NRC 2006).

The CPS FMP requires that the CPSMT prepare an annual SAFE report and, "in particular, the SAFE report shall include…ecosystem information" (CPS FMP, at 4-6). Currently, SAFE documents lack any meaningful information about the role of CPS in the marine ecosystem or the ecological effects of harvesting CPS. In order to fulfill its obligations under the CPS FMP, we recommend that the CPSMT add an ecosystem chapter to the SAFE document that includes:

- A description of the California Current Large Marine Ecosystem,
- An explanation of the influence of oceanographic conditions on CPS, and

- Food web analyses including information such as
    - The role of CPS in the food web, including analysis of the relative interaction strengths between predators and CPS,
    - Consumption levels of CPS by other species including marine mammals, seabirds, and fish,
    - Shared prey analysis that will help provide an understanding of relative competition for CPS between predators and fisheries,
    - Species sensitivity analysis to determine how impacts to one species might transmit to other species through food web relationships, and
    - Spatial and temporal interactions.

In addition, we request that the CPSMT develop recommendations for setting appropriate levels of allocation of CPS to their predators prior to setting optimum yield in the current harvest guidelines. We recommend that the CPSMT review and utilize the results and methods presented in the ecosystem research currently being conducted by NOAA Fisheries, for example Field & Francis (2006), Field et al. (2006) and Fowler (1999). As such, working with seabird and marine mammal experts can be useful in obtaining initial estimates of quantities of CPS consumed by their predators.

We appreciate the hard work of the National Marine Fisheries Service stock assessment teams, the CPSMT and CPSAS to provide scientific estimates of the abundance of actively managed CPS (Pacific mackerel and sardine) and recommended harvest guidelines. Stock assessments, harvest control rules and management measures are the first step to sustainable fishery management. It is now time to include ecosystem information into the SAFE documents and in the harvest guidelines. The availability of forage species to provide a source of food for salmon, other fish, birds and marine mammals must be a priority consideration. A precautionary approach is necessary, especially for those fisheries targeting species lacking stock assessments and when ensuring abundant populations of forage for ecosystem needs.

Thank you for your time and consideration. We look forward to continuing to work with you.

Sincerely,

Ben Enticknap
Pacific Project Manager
CPS Advisory Subpanel Member

cc: Dr. Donald McIsaac, Executive Director, Pacific Fishery Management Council

References:

Alder, J. and Pauly, D. 2006. On the Multiple Uses of Forage Fish: From Ecosystems to Markets. Fisheries Centre Research Reports 14(3). *The Fisheries Centre, University of British Columbia. 120pp.*

Baraff, L.S. and Loughlin, T.R. 2000. Trends and Potential Interactions Between Pinnipeds and Fisheries of New England and the U.S. West Coast. Marine Fisheries Review 62(4): 1-39.

Becker, B.H., and S.R. Beissinger. 2006. Centennial decline in the trophic level of an endangered seabird after fisheries decline. Conservation Biology. 20(2): 470-479.

Coastal Pelagic Species Fishery Management Plan. December 1998. NMFS and PFMC, at 4-6.

Field, J.C. and Francis, R.C. 2006. Considering ecosystem-based fisheries management in the California Current. Marine Policy 30:552-569.

Field, J.C., Francis, R.C., Aydin, K. 2006. Top-down modeling and bottom-up dynamics: Linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68:238-270.

Fowler, C.W. 1999. Nature's Monte Carlo Experiments in Sustainability. Proceedings, 5th NMFS NSAW. 1999. NOAA Tech. Memo. NMFS-F/SPO-40.

Furness, R. 2003. Impacts of fisheries on seabird communities. Sci. Mar. 67(2): 33-45.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report: Climate Change 2007: Synthesis Report. United Nations Environment Programme.

National Research Council, Committee on Ecosystem Effects of Fishing, Phase II. Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options. National Academies Press, Washington, D.C. (2006). 160 pp.

Tasker, M. L., Camphuysen, C. J., Cooper, J., Garthe, S., Montevecchi, W. A., and Blaber, S. J. M. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science, 57: 531–547.

Walters, C. J., Christensen, V., Martell, S. J., and Kitchell, J. F. 2005. Possible ecosystem impacts of applying MSY policies from single-species assessment. ICES Journal of Marine Science, 62: 558-568.