NATIONAL MARINE FISHERIES SERVICE REPORT ON COASTAL PELAGIC SPECIES MANAGEMENT

Situation: National Marine Fisheries Service (NMFS) will briefly report on recent developments in the coastal pelagic species fishery and other issues of relevance to the Council.

Council Task:

1. Council discussion.

Reference Materials: None.

Agenda Order:

a. Informational Update — Svein Fougner
b. Reports and Comments of Advisory Bodies
c. Public Comment
d. Council Discussion

PFMC
05/28/03

PACIFIC MACKEREL HARVEST GUIDELINE FOR 2003 THROUGH 2004

Situation: The Council is scheduled to review the current Pacific mackerel stock assessment and adopt a harvest guideline for the 2003-2004 Pacific mackerel fishing season.

In 2002, a harvest guideline of 12,535 mt was established based on a biomass estimate of 77,892 mt. Because this relatively small harvest guideline could have interfered with the harvest of other coastal pelagic species (CPS), the fishery for Pacific mackerel was conducted as follows.

1. A directed fishery was allotted 9,500 mt, with 3,035 mt of the harvest guideline utilized for incidental landings following the closure of the directed fishery.

2. If necessary, National Marine Fisheries Service (NMFS) was to close the directed fishery, after which no more than 40% by weight of a landing of CPS could consist of Pacific mackerel, except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS.

3. If a sufficient amount of the harvest guideline remained before the end of the fishing season, the directed fishery would be reopened.

However, as of May 21, only 3,755 mt of Pacific mackerel has been harvested, and the directed fishery remains open.

The 2003-2004 fishery opens July 1, 2003. The current stock assessment and management recommendations are summarized in Attachment 1, Appendix 2.

The Coastal Pelagic Species Management Team (CPSMT) and the Coastal Pelagic Species Advisory Subpanel (CPSAS) have reviewed the assessment and the recommended harvest guideline. They will present their respective advice to the Council.

The CPSMT has completed the fourth annual *Status of the Pacific Coast Coastal Pelagic Species (CPS) Fishery and Recommended Harvest Guidelines – Stock Assessment and Fishery Evaluation (SAFE) – 2003* document. This is included in the briefing book.

Council Action:

1. Adopt Pacific Mackerel Harvest Guideline for the 2003 through 2004 Season.

Reference Materials:

1. Exhibit E.2, Attachment 1, *Status of the Pacific Coast Coastal Pelagic Species (CPS) Fishery and Recommended Harvest Guidelines – Stock Assessment and Fishery Evaluation (SAFE) – 2003.*
2. Exhibit E.2.b, CPSMT Report.
3. Exhibit E.2.b, CPSAS Report.

Agenda Order:

a. Agendum Overview — Dan Waldeck
b. Reports and Comments of Advisory Bodies
c. Public Comment
d. **Council Action**: Adopt Pacific Mackerel Harvest Guideline for the 2003 through 2004 Season

PFMC
05/30/03

COASTAL PELAGIC SPECIES ADVISORY SUBPANEL STATEMENT ON PACIFIC MACKEREL STOCK ASSESSMENT AND HARVEST GUIDELINE FOR 2003 THROUGH 2004

The Coastal Pelagic Species Advisory Subpanel (CPSAS) heard a report from Dr. Kevin Hill of the Coastal Pelagic Species Management Team (CPSMT) regarding the Pacific mackerel stock assessment and proposed harvest guideline for the 2003-2004 season.

Based on the most recent information, the CPSMT is recommending a harvest guideline of 10,652 mt for the 2003-2004 season.

Based on this harvest guideline, the CPSAS is recommending a directed fishery for 7,500 mt to begin on July 1, 2003. After the directed fishery quota is reached, the fishery will revert to an incidental-catch-only fishery. There will be 3,152 mt as a set aside for the incidental fishery. The CPSAS recommends a 40% incidental catch rate when 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 inseason review of the mackerel season for the March 2004 Council meeting, with the possibility of re-opening the directed fishery as an automatic action if a sufficient amount of the harvest guideline remains.

PFMC
05/30/03

COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON PACIFIC MACKEREL HARVEST GUIDELINE FOR 2003 THROUGH 2004

For the 2003 Pacific mackerel assessment, the Coastal Pelagic Species Management Team (CPSMT) agreed that the mackerel biomass estimate from the ADEPT model was appropriate, because it is consistent with the approach used in recent years, and the resulting biomass estimate is reasonable relative to what is known about recent recruitment. The CPSMT notes that several improvements for future assessments are anticipated in the near future. These include pooling of the southern and northern California party boat logbook information into a single index, increased and enhanced fishery dependent data from aerial surveys, and new research surveys. These changes are scheduled for review at the CPS stock assessment review (STAR) meeting in 2004 and incorporation into the 2005-2006 fishery.

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 fishery management plan (FMP), there is, currently, not a concern related to overfishing of Pacific mackerel. Historically, intermittent periods of high recruitment have supported relatively high amounts of fishing pressure. However, more recently, protracted periods of generally lower recruitment have contributed to lower levels of spawning stock and total biomass. Fishing pressure is largely influenced by availability of the resource to the fishery, as well as market factors. The U.S. West Coast Pacific mackerel fishery targets the mackerel in the northern parts of its overall range and in inshore waters. It is possible that mackerel abundance could be strong south of the U.S. border and/or in offshore waters beyond the range of the U.S. West Coast CPS fleet. Also, as in other CPS fisheries, market dynamics greatly influence total harvest. While mackerel is desirable it is not as important to the CPS fishery as Pacific sardine and market squid. In addition, most commercial harvest of Pacific mackerel occurs within the area under limited entry as defined by the CPS FMP. Under the limited entry 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 acceptable biological catch (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, 68,924 mt is well above the cut off value.

PFMC
05/30/03

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON PACIFIC MACKEREL HARVEST GUIDELINE FOR 2003 THROUGH 2004

Dr. Kevin Hill discussed the 2003-2004 Pacific mackerel harvest guideline (HG) with the Scientific and Statistical Committee (SSC). The recommended HG is 10,652 mt based on the maximum sustainable yield control rule in Amendment 8 to the Coastal Pelagic Species (CPS) fishery management plan. The SSC notes that the HG is based on the same stock assessment methodology and harvest control rule used in 2002, with the addition of one additional year of catch data and new data for four of the six indices of abundance. Compared with the 2002 assessment, the biomass time series for the 2003 assessment is 10% lower over the last decade. The estimate of the July 1, 2002 biomass from the assessment is 30% lower than the projection of this biomass from last year's assessment.

The methodology on which this assessment is based is not fully documented in the Stock Assessment and Fishery Evaluation (SAFE) report precluding a detailed review by the SSC at this time. However, this assessment will be reviewed along with the sardine assessment during a STAR Panel meeting in May 2004. Dr. Hill outlined some planned changes to the assessment methodology and the data used when fitting the model. The SSC suggested that the possibility of using data on bycatch in the whiting fishery be explored to develop an abundance index for the component of the population off Oregon and Washington.

PFMC
06/17/03

Exhibit E.2
Attachment 1
June 2003

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

STOCK ASSESSMENT AND FISHERY EVALUATION – 2003

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, OR 97220
(503) 820-2280
www.pcouncil.org

JUNE 2003

ACKNOWLEDGMENTS

COASTAL PELAGIC SPECIES MANAGEMENT TEAM

Dr. Paul Crone, National Marine Fisheries Service, Southwest Fisheries Science Center
Mr. Brian Culver, Washington Department of Fish and Wildlife
Dr. Samuel Herrick, National Marine Fisheries Service, Southwest Fisheries Science Center
Dr. Kevin Hill, Team Chair, California Department of Fish and Game
Ms. Jean McCrae, Oregon Department of Fish and Wildlife
Dr. Paul Smith, National Marine Fisheries Service, Southwest Fisheries Science Center

ADDITIONAL INFORMATION FOR THIS REPORT PROVIDED BY:

Mr. Darrin Bergen, California Department of Fish and Game
Ms. Annette Henry, California Department of Fish and Game
Mr. Walterio Garcia-Franco, Instituto Nacional de la Pesca, Ensenada, Baja California, Mexico
Mr. Jim Morgan, National Marine Fisheries Service
Ms. Heather Munro, Munro Consulting
Ms. Michele Robinson, Washington Department of Fish and Wildlife
Mr. Dan Waldeck, Staff, Pacific Fishery Management Council

DOCUMENT PRODUCTION AND EDITORIAL SUPPORT PROVIDED BY:

Ms. Kerry Aden, Staff, Pacific Fishery Management Council
Ms. Renee Dorval, Staff, Pacific Fishery Management Council
Ms. Donde Hayes, Staff, Pacific Fishery Management Council

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LIST OF ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
C-B	cost benefit
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
CPSMT	Coastal Pelagic Species Management Team
CPSPDT	Coastal Pelagic Species Plan Development Team
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
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MAXCAT	maximum harvest level parameter
MSY	maximum sustainable yield
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	Recreation Fishery Information Network
RFA	Regulatory Flexibility Act
RIR	regulatory impact review
ROV	remotely operated vehicle
SAFE	stock assessment and fishery evaluation
Secretary	U.S. Secretary of Commerce
SSC	Scientific and Statistical Committee
SST	Sea surface temperature
STAR	Stock Assessment Review (Panel)
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center (NMFS)
VPA	virtual population analysis
WDFW	Washington Department of Fish and Wildlife

1.0 Introduction

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

This is the fourth *Status of the Pacific Coast Coastal Pelagic Species (CPS) 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 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 a description of landings, fishing patterns, estimates of the status of stocks (including stocks assessments for Pacific mackerel and Pacific sardine, Appendix 2), and acceptable biological catches (ABC).

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).

Members of the CPSMT are: Dr. Kevin Hill, Chair (CDFG); Dr. Paul Crone (NMFS); Mr. Brian Culver (WDFW); Dr. Sam Herrick (NMFS); Ms. Jean McCrae (ODFW); and Dr. Paul Smith (NMFS). Mr. Jim Morgan (NMFS), Mr. Dan Waldeck (Council staff), Mr. Darrin Bergen (CDFG), Ms. Annette Henry (CDFG), Ms. Michele Robinson (WDFW), and Ms. Heather Munro also provided information for this report.

2.0 The CPS Fishery

2.1 Management History

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

1. Drop the anchovy FMP (which would have resulted 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, 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

Amendment 8

Development of Amendment 8 to the northern anchovy FMP[1/] 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 include the management unit species; CPS fishery management areas, consisting of a limited entry zone and two subareas; a procedure for setting annual specifications including harvest guidelines, quotas, and allocations; provisions for closing directed fisheries when the directed portion of a harvest guideline or quota is taken; fishing seasons for Pacific sardine and Pacific mackerel; catch restrictions in the limited entry zone and, when the directed fishery for a CPS is closed, limited harvest of that species to an incidental limit; a limited entry program; authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited; and a framework process to make management decisions without amending the FMP.

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

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

Amendment 9

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

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

Amendment 10

In April 2001, the Council adopted a capacity goal for the CPS limited entry finfish fishery and asked the CPSMT to begin work on a 10th amendment to the FMP. Amendment 10 included the capacity goal,

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1/ This document was subsequently re-titled the Coastal Pelagic Species Fishery Management Plan. References to Amendment 8 and CPS FMP refer to the same document.

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 limited entry fishery, the amendment established a capacity goal, provided for limited entry permit transferability to achieve and maintain the capacity goal, and established a process for considering new limited entry permits. The purpose of this action was to ensure fishing capacity in the CPS limited entry 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 of Commerce approved Amendment 10. On January 27, 2003, NMFS issued the final rule and regulations implementing Amendment 10.

Sardine Allocation Regulatory Amendment

In 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. 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. 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% to both subareas to 20% to Subarea A and 80 % 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 harvest guideline were at least 90% of the 2003 harvest guideline. The regulatory amendment was transmitted to NMFS in April 2003.

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

2.3 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.

Other vessels target CPS finfish in small quantities, typically selling their catch to specialty markets for relatively high prices. During the period 1993 through 1997, 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.

- 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

In June 2002, the Council approved Amendment 10 to the CPS FMP, which established capacity goal and permit transferability provisions for the CPS finfish limited entry (LE) fleet. NMFS approved Amendment 10 in 2002 and implemented regulations on January 27, 2003. NMFS Southwest Region office manages the permit system and will review all permit transfer applications. No transfer applications have been received to date.

The CPS LE fleet currently consists of 65 permitted vessels (Tables 3 and 4). Forty-four of these vessels are original permit holders, and the other 21 vessels gained entry to the fishery through permit transfers in 2000. Fifty-five of these vessels currently hold California state permits to fish for market squid in California waters, and at least four vessels have been active in the CPS live-bait fishery since 1996. CPS LE vessels range in age from 2 to 66 years, with an average age of 32 years (Table 3). Sixteen vessels are constructed from wood.

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 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 Coast Guard database, and each vessel's calculated GT was attached to the permit. GT values for the current fleet range from 23.8 GT to 340.2 GT, with an average of 88.8 GT (Tables 3 and 4). Total fleet GT increased from 5,650.9 GT to 5,775.2 GT during 2002. The increase was due to corrections to Coast Guard measurements and updated documentation for two vessels: Heavy Duty (GT increased from 75.6 to 84.4), and Caitlin Ann (GT increased from 224.7 to 340.2).

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 limited entry fleet is 5,775.2 GT, well within the bounds of the capacity goal.

2.3.2 Northern Fisheries

In Oregon, Pacific sardine is managed as a developmental fishery. In 2002, all 20 developmental fishery permits were issued. Permit stipulations include: permit is not transferable; logbook is required; observers are allowed on board; a grate must be placed over the hold to sort out larger fish; renewal of the permit is subject to meeting minimum annual landing requirements of 5 landings of sardines of at least 500 pounds each, or one landing of at least 5,000 pounds.

Washington's trial fishery was managed to a state harvest guideline of 15,000 mt. WDFW issued a total of 45 permits, and 19 permit holders participated in the fishery. As part of the trial fishery regulations, WDFW requires fishers to carry at-sea observers, primarily to collect bycatch information. Bycatch has been recorded in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether the fish were alive, dead, or in poor condition.

2.3.3 Treaty Tribe Fisheries

As of June 2002, no treaty tribe fisheries for CPS have occurred.

3.0 Stock Assessment Models

3.1 Pacific Sardine

Conser *et al.* (2002) summarized the status of the Pacific sardine resource in California and Baja California, Mexico. An age-structured stock assessment model (CANSAR-TAM, Catch-at-age ANalysis for SARdine - Two Area Model; see Hill *et al.* 1999) is applied to fishery-dependent and fishery-independent data to derive estimates of population abundance and age-specific fishing mortality rates. In 1998, the original CANSAR model (Deriso *et al.* 1996) was modified to account for the expansion of the population northward to waters off the Pacific northwest. The model is based on a "forward-simulation" approach (see Megrey 1989) for a description of the general modeling approach), whereby parameters (e.g., population sizes, recruitments, fishing mortality rates, gear selectivities, and catchability coefficients) are estimated after log transformation using the method of nonlinear least squares. The terms in the objective function (to be minimized) include the sum of squared differences in ($\log_e$) observed and ($\log_e$) predicted estimates from the catch-at-age and various sources of auxiliary data used for "tuning" the model; e.g., indices of abundance from survey (fishery-independent) data. Bootstrap procedures are used to calculate variance and bias (95% confidence intervals) of sardine biomass and recruitment estimates generated from the assessment model. The CANSAR-TAM model is based on two fisheries (California, U.S., and Ensenada, Mexico); and semesters within a year are used as time steps, with ages being incremented between semesters on July 1 and spawning that is assumed to occur on April 1 (middle of the first semester).

Fishery-dependent data from the California and Ensenada fisheries (1983 through the first semester of the most recent year) are used to develop the following time series, (1) catch (in mt); (2) age distributions (catch-at-age in numbers of fish); and (3) estimates of weight-at-age (fishery- and population-specific). Fishery-independent data (time series) from research surveys included the following indices, which were developed from data collected from Area 1 (*Inside Area*, primarily waters off southern California) and used as relative abundance measures; (1) index (proportion-positive stations) of sardine egg abundance from California Cooperative Oceanic and Fisheries Investigations (CalCOFI) survey data (*CalCOFI Index*; see Deriso *et al.* 1996); (2) index of spawning biomass (mt) based on the Daily Egg Production Method survey data (*DEPM Index*; see Lo *et al.* (1996); (3) index of spawning area (Nmi^2) from CalCOFI and DEPM survey data (*Spawning Area Index)*; and (4) index of pre-adult biomass (mt) from aerial spotter plane survey data (*Aerial Spotter Index*; see Lo *et al.* 1992). Time series of sea-surface temperatures recorded at Scripps Pier, La Jolla, California were used to determine appropriate harvest guidelines (*Sea-surface Temperature Index*), see the Coastal Pelagic Species Fishery Management Plan, Option J, Table 4.2.5-1, PFMC (1998).

3.2 Pacific Mackerel

A modified virtual population analysis (VPA) stock assessment model ("ADEPT," Jacobson 1993), based on Gavaris' (1988) procedure, is used to estimate biomass of Pacific mackerel. ADEPT employs both fishery-dependent and fishery-independent data to estimate abundance. ADEPT adjusts population abundance estimates using the fishery-independent indices of relative abundance. ADEPT has been used to assess Pacific mackerel for the past nine years (Jacobson *et al.* 1994, Hill *et al.* 1999). A conventional VPA back-calculates age-structured biomass estimates utilizing catch-at-age data, weight-at-age data, natural mortality estimates, and fishing mortality (F) estimates for the most recent year (referred to as "terminal F"). ADEPT improves upon a conventional VPA by choosing terminal F and other parameters to obtain the best statistical fit (lowest log-scale sums of squares) between VPA output and survey indices of relative abundance, including spotter pilot sightings, CalCOFI larval data from southern California, recreational fishery catch-per-unit-effort, power plant impingement rates, and triennial trawl survey data. The crux of the estimate lies in the models' ability to estimate terminal F based upon the survey indices, essentially using them to adjust the conventional VPA output.

The assessment model is based on an annual time increment and now incorporates 75 years (1929 to 2002) of fishery data, including landings, age composition, and mean weights-at-age. Abundance estimates are adjusted by the model to better match the fishery-independent (survey) indices of relative abundance, including aerial spotter sightings (Lo *et al.* 1992), CalCOFI larval data, recreational fishery catch-per-unit-effort, triennial shelf survey, and power plant impingement rates. Component likelihoods for most surveys are weighted equally to a value of 1.0. The power plant impingement index (age-0 Pacific mackerel caught in cooling water at San Onofre Nuclear Generating Station, California) represents a relatively small portion of the coastline and is down-weighted to 0.1. ADEPT also has the ability to weight influence of annual survey observations using the coefficient of variation (CV; a measure of relative variation in any sample). Coefficients of variation are calculated for each survey and re-scaled to the median value. Re-scaling CVs of each survey to a value of 1.0 maintains equal weighting among surveys while down-weighting annual observations within surveys for poorly-sampled or highly-variable years.

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4.0 Optimum Yield, Maximum Sustainable Yield, and Maximum Sustainable Yield Control Rules

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

4.1 Optimum Yield

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

- Will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.
- Is prescribed on the basis of the maximum sustainable yield 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 maximum sustainable yield in such fishery [50 CFR §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} 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.

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:

$$H = (BIOMASS-CUTOFF) \times FRACTION$$

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 CVs 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. 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:

$$F_{MSY} = 0.248649805\,T^2 - 8.190043975\,T + 67.4558326$$

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 (chub) 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

The MSY Control Rule for market squid is defined within the framework of the Egg Escapement method, which serves as the assessment-related tool for this species and was formally adopted by the Council in 2002. 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 gauge the need for "active" management. 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 that supports catches approaching the ABC or MSY levels should come under active management, unless there is too little information available or other practical problems. Overfishing of a monitored CPS stock is "approached" whenever current estimates or projections indicate that a minimum stock threshold will be realized within two years.

The Egg Escapement method is founded on conventional spawning biomass "per recruit" model 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 believed to represent a minimum level that is considered necessary to allow the population to maintain its level of abundance into the future (i.e., allow for "sustainable" reproduction year after year). The threshold proposed currently (i.e., 30%) necessarily represents a "baseline" statistic (i.e., preliminary, but intended to be precautionary), given that such biological reference points have not been definitively determined for coastal pelagic stocks specifically, as well as numerous fish stocks in general. Rather, the relationship between reproductive-related thresholds and sustainable population levels for this species will receive further scrutiny in the near future as much needed data accumulate and simulation modeling research gets underway (see section 9.2.3). Finally, further discussion concerning specific details involved in this assessment approach, as well as review-related discussion can be found in the Appendix 3 of the 2002 SAFE document.

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 U.S. Secretary of Commerce 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 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 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. Incidental harvest of non-prohibited larger fish are often taken home for personal use or processed. CPS finfish landings are sold as relatively high volume/low value products (e.g., mackerel canned for pet food, sardine frozen and shipped to Australia to feed penned tuna, and anchovy reduced to meal and oil). In addition to fishing for CPS finfish, many of the vessels fish for market squid, Pacific bonito, bluefin tuna, and Pacific herring.

Historically, market squid have been fished at night with the use of powerful lights, which aggregate squid, so they can be pumped directly from the sea or encircled with a net.

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 limited entry permits under the FMP should reduce any regulatory discard, because those fish can be landed.

5 From 1996 to 2002, bycatch from the live bait logs was reported with an incidence of 10%. The primary species taken as incidental catch was barracuda. Virtually all fish caught incidentally in this fishery are either used for bait, for personal use, or released alive. See Tables 13, 14, and 15.

6 CDFG has implemented a logbook program for the squid fishery. The data to be collected includes bycatch. See table 8a and 8b.

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 2000, 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.

In Oregon, Pacific sardine is managed as a developmental fishery. In 2001, the number of permits was increased from 15 to 20. Permit stipulations include: permit is not transferable; logbook is required; observers are allowed on board; a grate must be place over the hold to sort out larger fish; renewal of the permit is subject to meeting minimum annual landing requirements of five landings of sardines of at least 500 pounds each, or one landing of at least 5,000 pounds.

In Washington, sardines are currently managed under Emerging Commercial Fishery provisions as a trial commercial fishery. The Washington Fish and Wildlife Commission first approved a trial ocean purse seine sardine fishery in 2000, and the fishery has occurred for the last three years. As part of the trial fishery regulations, WDFW requires fishers to pay for, and carry at-sea observers, primarily to collect bycatch information. Bycatch has been recorded in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether the fish were alive, dead, or in poor condition. Permits in a trial emerging fishery, by law, may not be limited. However, WDFW is currently pursuing moving the fishery to limited entry. In 2002, WDFW issued 35 permits and 19 vessels made landings. The majority of the catch was landed by 13 vessels. In 2002, Washington's trial fishery was managed to a state harvest guideline of 15,000 mt.

Bycatch in the Oregon and Washington-based fisheries is reported to be low. See Section 6.2 for more information on these 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 Fishery South of Pigeon Point

Information from at-sea observations of the CDFG and conversations with CPS fishers suggest that bycatch is not significant in these fisheries. However, some individuals have expressed concern that game fish and salmon might constitute significant bycatch in this fishery. This is a reasonable concern, because anchovy and sardine are forage for virtually all predators, but there are no data to confirm significant bycatch of these species. CDFG port samples indicate minimal bycatch in the California fishery (Tables 5, 6, 7a, and 7b). The behavior of predators, which tend to dart through a school of prey rather than linger in the school, and can more easily avoid encirclement with a purse seine, may help to minimize bycatch.

CDFG port samples collect information from CPS landings in Monterey and ports to the south. Biological samples are taken to monitor the fish stocks, and port samplers report incidentally caught fish. Reports of bycatch by CDFG port samplers confirm small and insignificant landings of bycatch at California off-loading sites (Tables 5, 6, 7a, and 7b). These data are likely representative of actual bycatch, because (as noted) fish are pumped from the sea into fish holds aboard the fishing vessel. Fishers do not sort catch at sea that pass through the pump. Generally, whatever is caught is pumped into the hold and landed. Unloading of fish also occurs with pumps. The fish is either pumped into ice bins and ferried away to processors or to a conveyor belt leading into a processing facility.

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 was reported. Earlier incidents of bycatch may not have been noted, because the harvest of anchovy and sardine was small, and only in recent years has the harvest of sardine increased. The incidental catch reported are primarily those species that are marketable and do not meet the definition of bycatch in the Magnuson-Stevens Act. During this period, unless an incidental species represented a significant portion of the load, at least a whole percentage point, the amount of the incidental catch was not recorded. Of the incidental catch reported from 1992 to 1999, the two most prevalent species were market squid at 79%, and northern anchovy at 12% incidence within samples (not by load composition). CDFG port sample information provides a useful database for determining the significance of bycatch in the CPS fishery off California (south of Pigeon Point).

In 2001, California wetfish port samplers were directed to tally bycatch observed during landings in greater detail, and recorded 343 fish, items or animals that were not the targeted species (Table 7a). These included 210 finfish (61%), 44 elasmobranchs (sharks or rays) (13%), and 89 incidents of vegetation, invertebrates, and various debris (26%). Seventy three incidents (21% of total) represented other CPS finfish that were not the target species of that trip.

In 2002, there was a similar result to 2001 observations, with 181 non-targeted finfish, 37 elasmobranchs, and 150 incidents of invertebrates, vegetation, or other non-fish items noted by CDFG port samplers in CPS landings (Table 7b). Of incidental catches observed, finfish comprised 49%, sharks and rays 10%, and invertebrates, vegetation, or other items occurred as 41% of non-targeted catches.

Kelp (specifically holdfasts), flatfish, and elasmobranchs can serve as an indication of shallow set depth. Larger fish and animals are typically sorted either for market, personal consumption, or nutrient recycling in the harbor. As the collection of bycatch information in the CPS fishery is not a funded portion of the project, further study will require additional support from outside of CDFG.

6.1.1 Incidental Catch Associated with the Market Squid Fishery

In 2002, less than 9% of squid landings included "incidental" catch (Table 8a). Because squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur occasionally (e.g., in 2002, roughly 7% of squid landings included CPS finfish).

Another type of incidental catch is defined here as "bycatch" (i.e., species that are landed along with squid that are not recorded through landing receipt processes [i.e., not sold] as is typically done for incidentally-caught species). Although non-target catch in market squid landings is considered minimal, the presence of bycatch has been documented through CDFG's port sampling program. The port sampling program records bycatch observed (i.e., presence or absence evaluations), but actual amounts of bycatch have not been quantified to date. During 2002, bycatch was present in slightly more than half of squid landings observed (Table 8b). Similar to previous years, most of this catch was other pelagic species, including Pacific sardine, Pacific mackerel, northern anchovy, jack mackerel, and squid egg cases.

Finally, the extent that squid egg beds and bottom substrate are damaged by recent purse seine operations and subsequently, contribute to significant mortality of early life stages is not definitively known at this time. However, information regarding bycatch of squid eggs determined from squid landings port-side generally indicate that egg bed-related impacts have increased over the last several years. For example, from October 1998 through September 2001, bycatch of squid eggs had a 1.8% frequency of occurrence. In 2002, squid egg bycatch was 6.7%, which represents more than a three-fold increase in the amount of squid egg cases taken as bycatch in this fishery. If bycatch of squid eggs continues to increase, some gear regulations may need to be implemented in the future (e.g., restrictions to the depth at which nets could be set, spatio-temporal closures of some shallow water habitats). In this context, further investigations regarding potential damage to squid spawning beds from fishery-related operations would likely benefit status-based analyses concerning the overall squid population off California, given eggs-per-recruit theory underlies the recently adopted squid assessment method. Such investigations should involve collaborative research efforts between the CPSMT, CDFG, and NMFS-Southwest Fisheries Science Center.

6.2 Fishery North of Pigeon Point

Since 2000, limited fisheries for Pacific sardine occurred off the Pacific Northwest. Oregon and Washington closely monitor these fisheries and collect information about landings and the environmental effects of these fisheries. Information on salmon bycatch from Oregon and Washington (2000 through 2002) is summarized in Table 9.

During 2002, in Oregon, landings of Pacific sardine began in early June and continued through mid October. Seventeen vessels made 657 landings for a total of 22,711 mt, averaging over 34 mt per trip, with 8 vessels making over 85% of the landings. Based on logbook data, 90% of the pounds landed were taken off Oregon and 10% off Washington.

Oregon's permit stipulations include allowing observers when requested and requiring a grate over the hold opening to sort out larger species of fish. Due to budget restriction, Oregon did not hire a seasonal employee in 2002 to ride along on sardine vessels and observe bycatch of non-target species. However, permanent staff was able to observe seven trips. Vessel skippers were also required to submit logbooks, which record all species caught. Logbooks submitted accounted for 98% of the landings.

Based on both observer and logbook data, bycatch continues to be low. Bycatch included salmon, sharks, hake, and cod (Table 10). Salmon were the major species of concern. Based on logbooks, salmon catch averaged 0.4 salmon per trip, with 71% being released alive. The estimated total catch of salmon for the fishery, based on logbook data, is 280 salmon (0.012 salmon/mt) (Table 11).

Incidental catch recorded on fishtickets consisted of 126.3 mt of Pacific mackerel, 0.3 mt of jack mackerel, 3.3 mt of Pacific herring, 0.2 mt of anchovy, and 0.3 mt of shad, for a total of 0.6% of the total catch.

Washington's trial purse seine fishery opened on May 15 and continued through October 31, 2002. However, the first landing into Washington occurred on June 10. The fishery was managed to a state harvest guideline of 15,000 mt. WDFW issued a total of 45 permits and 19 permit holders participated in the fishery.

A total of 15,212 mt of sardines were landed into Washington, which is a 40% increase over the previous year (10,837 mt) and more than three times the amount landed in 2000 (4,791 mt). A total of 424 landings were made and the majority of the landings (91%) were made into the port of Ilwaco.

As part of the trial fishery regulations, WDFW requires fishers to carry at-sea observers primarily to collect bycatch information. Bycatch has been recorded in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether the fish were alive, dead, or in poor condition. WDFW was aiming for 30% coverage and averaged about 24% overall. Based on observer data, the bycatch of non-targeted species was fairly low. Bycatch included chinook and coho salmon, spiny dogfish, blue shark, and other species (Table 12a). Expanded observer data indicates a bycatch rate of 0.100 salmon/mt (with a salmon mortality rate of 0.074 salmon/mt). A complete list of non-targeted species and the amounts observed (numbers of individuals) compared with amounts reported in logbooks is contained in Table 12b.

7.0 Live Bait Fishery (California)

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 Commercial Passenger Fishing Vessel (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, 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 62 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 1990's 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 (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 13). Estimates of ancillary catch data has been documented in earlier reports, and in CPS FMP Amendment 9.

The CDFG Pelagic Fisheries Assessment Unit (PFAU) at the Southwest Fisheries Science Center (SWFSC) in La Jolla presently archives the CDFG Live Bait Logs. Preliminary estimates of the reported total live bait harvest in California through 2002 have been appended to previously reported estimates from Thomson *et al.* (1991, 1992, 1994).

7.4 Species Composition

The ratio of anchovy to sardine in the southern California live bait harvests shifts significantly as the populations of these two fish expand and contract over periods of years or decades. Much of the early reported harvest consisted of anchovy, following the collapse of the sardine fishery in the 1940s (Table 14).

Through the years 1994 to 2002 the proportion of anchovy in the total reported harvest ranged from a low of 13% in 1998, to a high of 58% in 1994. The proportion of sardine ranged from a low of 42% in 1994, to a high of 87% in 1998 (Table 15).

References for Section 7:

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.

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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.

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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 limited entry fishery is 30 years and 16 of the 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 has published final regulations to implement Amendment 10 to the CPS FMP, which allows limited entry permits to be transferred to another vessel and/or individual.

As discussed in Section 2.2, the Council recently adopted a regulatory amendment related to the CPS FMP. Under the regulatory amendment, the proposed action is not expected to have a substantial adverse impact on public health or safety. However, for Pacific Northwest fisheries, the proposed action is anticipated to enhance safety at sea by advancing the reallocation date from October 1 to September 1. 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, fishing seasons, and other management controls are used. Other CPS species (northern anchovy, jack mackerel, 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. For information on commercial harvest of CPS finfish landed into Ensenada, Mexico (1978-2001) (Table 16, García 2002).

9.1 Actively Managed Species

9.1.1 Pacific Sardine

The CDFG Code Section 8150.7 states that it was the intent of the Legislature that the Pacific sardine resource off California be rehabilitated, and that once the spawning population was estimated to reach 18,144 mt, a 907 mt directed fishery would be established. This happened in the 1980s and the quota was expanded as the population increased. The Pacific sardine has made a strong recovery in waters off the U.S. Pacific Coast since the late 1980s. The sardine biomass increase approximately 30% annually through the late 1990s, with a leveling off at approximately 1 million mt observed in recent years. Estimates of sardine biomass in waters off Oregon were greater than 50,000 mt in 1994 (Bentley *et al.* 1996), and greater than 100,000 mt in waters around Vancouver Island, B.C. in 1998 (S. McFarlane, Canada Department of Fisheries and Oceans, personal communication).

Conser *et al.* (2002) summarized the status of the Pacific sardine resource off California and Baja California, Mexico. Total landings of Pacific sardine for the directed fisheries off California, U.S. and Ensenada, Mexico were generally similar to levels observed in the previous year, with a total harvest of approximately 81,000 mt in 2002. Note that landing values presented here differ slightly than those presented in Conser *et al.* (2001), given semester 2 landings from 2001 used in the previous analysis were projected estimates based on landing patterns observed in the fisheries over the last decade. Total landings in California in 2002 (53,703 mt) declined slightly from the previous year (54,903 mt), whereas landings in northern Mexico in 2002 (27,422) increased nearly 25% from last year (22,246). Currently, the U.S. fishery (California landings) is regulated using a quota-based (e.g., harvest guideline) management scheme, whereas the Mexico fishery (Ensenada landings) remains largely unregulated. Since the mid 1990s, actual landings from the California fishery have been less than the recommended harvest guidelines. Further, as was the case generally observed in recent years, landings from the U.S. coastwide (i.e., California, Oregon, and Washington) sardine fishery composed just under 75% (roughly, 87,000 mt) of the harvest guideline recommended for 2002 (118,000 mt).

Estimated stock biomass (≥1-yr old fish on July 1, 2002) from the assessment conducted in 2002 indicated the sardine population has remained at a relatively high abundance level, with a bias-corrected estimate of nearly 1 million mt. Estimated recruitment (age-0 fish on July 1, 2002) over the last several years has declined considerably from that estimated for the strong 1998 year class. However, it should be noted that recent recruitment (i.e., approximately 4-22 billion recruits) is not estimated precisely and thus, definitive determinations regarding the apparent "plateau" reached by the sardine population should be interpreted accordingly, given the inherent uncertainty surrounding estimated recruitment (see below). See Table 17 for biomass and recruitment time series, 1983-2002.

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 derived in the 2002 analysis once again showed a downward trend in recruits per spawner, which may be indicative of a stock that has reached a threshold under current environmental conditions.

9.1.1.1 Harvest Guideline for 2003

The harvest guideline recommended for the U.S. Pacific Coast fishery for 2002 was 110,908 mt. Statistics used to determine this harvest guideline are discussed below. The harvest guideline for 2003 is based on the MSY control rule defined in the CPS FMP. This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over a long-term horizon. The CPS FMP harvest formula for sardine is:

$$HG_{2003} = (\text{TOTAL STOCK BIOMASS}_{2002} - \text{CUTOFF}) \bullet \text{FRACTION} \bullet \text{U.S. DISTRIBUTION},$$

where HG_{2003} is the total U.S. (California, Oregon, and Washington) harvest guideline recommended for 2003, TOTAL STOCK $BIOMASS_{2002}$ is the estimated stock biomass ($\geq$1-yr old fish) from the assessment conducted in 2002, 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 (see below), and U.S. DISTRIBUTION is the percentage of TOTAL STOCK $BIOMASS_{2002}$ 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 MSY under "equilibrium" assumptions). Given F_{MSY} and the productivity of the sardine stock have been shown to increase when relatively warm-water 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 years. Ultimately, FRACTION is constrained and ranges between 5% and 15%.

Based on the T values observed throughout the period covered by this stock assessment (1983-2002), the appropriate F_{MSY} exploitation fraction (FRACTION) has consistently been 15% and this remains the case under current oceanographic conditions (T_{2002} = 17.31 °C). However, it should be noted that the decline in T generally observed in recent years (1998-2002) may invoke an environment-based reduction in the FRACTION value in the near future if sea-surface temperatures off the southern extreme of the U.S. Pacific Coast continue to decline from those observed in the latter part of the 1990s.

Although the U.S. harvest guideline in 2003 (110,908 mt) was less than the 2002 harvest guideline (118,442 mt), recent fishery practices indicate that the recommended yield may not be constraining to U.S.-based fisheries in 2003 (see above). However, should the recent declining recruitment trend estimated in this assessment be confirmed with future work and should the sea-surface temperature decline further, it is likely that harvest guidelines in the future will constrain fishery operations and removals to some degree.

Further, when viewed on a larger spatial scale and considering the landings of Mexico and Canada as well as the U.S., adherence to an implied "population-wide" harvest guideline may constrain fisheries even without potential declines in water temperature. See the current sardine assessment (Conser *et al.* 2002) in Appendix 2 for comparisons concerning recent international-based landings with the annual harvest guidelines that would have resulted from applying the CPS FMP harvest formula (see above) without the "U.S. Distribution" term. Finally, should Oregon and Washington landings continue to increase at rates comparable to those observed over the past few years and/or Mexico landings return to levels observed from 1997-2000, the implied population-wide harvest guideline may be exceeded as early as next year (2003).

See Tables 18 and 19 for a retrospective of U.S. West Coast Pacific sardine landings, 1981-2002.

9.1.2 Pacific Mackerel

The coast-wide harvest of Pacific mackerel increased slightly (+3%) in calendar year 2002. The directed fisheries off California and northern Baja California (Ensenada, Mexico) had a combined yield of 12,775 mt, compared to 12,424 mt in 2001 (García and Sánchez 2003). California's directed fishery for calendar year 2002 landed 4,536 mt – a drop of about 42% from the 2001 yield. The Ensenada fishery experienced a 95% increase in yield, from 4,078 mt in 2001 to 7,963 mt in 2002. The RecFIN estimate of recreational take was 276 mt in 2002, down from 561 mt in 2001.

The U.S. commercial fishery was provided a 12,535 mt harvest guideline for the 2002-2003 (July through June) season based on a July 1, 2002 biomass forecast of 77,892 mt (Hill *et al.* 2002). Through the Council management process it was determined that, in order to stay within the harvest guideline, there would be an initial directed fishery of 9,500 mt, with 3,035 mt set aside for incidental catch in other CPS fisheries. The 2002-2003 season has progressed slowly, with only 3,378 mt of the directed HG allocation being landed from July 2002 through April 2003. The directed fishery will likely remain open through June 30, 2003.

Some members of southern California's fishing industry attribute the slow season to poor availability rather than market demand. The same has been stated for the Ensenada fishery (Walterio Garcia-Franco, INP Ensenada, pers comm), which typically harvests larger yields when the fish are available. Little is known about mackerel abundance south of Ensenada, but spawning activity has historically been centered off the central and northern Baja California coast. Pacific mackerel have been present as incidental catch in whiting and salmon fisheries off Oregon and Washington since 1992. Mackerel catches in northern waters usually increase during El Niño events, and the presence of older and larger mackerel in the region may explain the relative paucity of older mackerel (ages 3+) in the southern California catch. Sardine fishermen in the Pacific northwest encountered "catchable" quantities (i.e., pure schools) of mackerel through the summer of 2002.

A modified VPA stock assessment model (ADEPT, Jacobson 1993), based on Gavaris' (1988) ADAPT procedure, was used to estimate biomass of Pacific mackerel. A complete executive summary of the latest assessment (Hill *et al.* 2003), including methods, tables, and figures, may be found in Appendix 2 of this SAFE document. ADEPT has been used to assess Pacific mackerel for the past ten years and is described in detail by Jacobson (1993), Jacobson *et al.* (1994), and Hill *et al.* (1999a,b). ADEPT recalculates biomass and recruitment for all years in the 74-year time series. Differences in biomass estimates among assessment years can be caused by changes in landings, shifts in fishery age composition, trends in fishery-independent surveys, and assumptions of terminal year fishing selectivity. As is true for all age-structured population models, abundance-at-age estimates are the least certain for the most recent years when the youngest year classes have not yet become fully vulnerable to, or utilized by, the fishery. Compounding this uncertainty is the general lack of fishery or survey data for Pacific mackerel outside the Southern California Bight and the lack of fishery-independent information on recruitment. Catch-at-age and weight-at-age data have not yet been made available from the Ensenada fishery, which is comparable in volume to California's commercial fishery.

Pacific mackerel biomass peaked in 1982 at approximately 1.4 million mt, declining steadily to a low of 22,252 mt in 2000. The peak biomass observed twenty years ago was primarily built by exceptional year classes in 1978, 1980, and 1981. These recruitment pulses occurred after a decade of extremely low biomass from the mid-1960s to mid-1970s. The decline in biomass since 1982 has resulted from a steadily decline in year class strength, and relatively low reproductive success (recruits per spawning stock biomass) since that time. Modeled estimates of 2000 and 2001 year class abundance are slightly higher than for the previous few years, and recent reproductive success (recruits per spawning stock biomass) is more optimistic relative to the past 18 years.

The overall trend in age 1+ biomass for current assessment was similar to that estimated during the 2002 stock assessment (Hill *et al.* 2002). Compared to Hill *et al.* (2002), the biomass time series for the current assessment is 10% lower over the most recent decade. The current estimate of July 1, 2002 biomass is estimated to be 30% lower than last years' projection for that same time. A more precipitous decline in biomass was observed from 1997 to 2000. This decrease is attributed to relatively weak year classes in 1998 and 1999, combined with high fishing mortality during the 1998 fishery. The 1998 fishery was the second largest on record (71,355 mt), with the majority (50,726 mt) being landed in Ensenada, Mexico. Despite the lower overall estimates of biomass compared with Hill *et al.* (2002), the current time series indicates a stabilization in biomass in the past two years. This may be attributed to what appears to be a relatively strong 2000 year class which contributes substantially to the exploitable biomass in 2002.

The July 1, 2003 biomass projection, used to calculate the 2003-2004 harvest guideline (HG), was based on ADEPT outputs and certain assumptions about recruitment and fishing mortality during the first half of 2002.

Estimates of year class strength (age-0 abundance) for the terminal year (2002) are included in the forecast. Various approaches may be used to address uncertainty in model estimates of age-0 abundance, (1) use a model-derived estimate, (2) use an average of model-derived estimates, or (3) rely strictly on a stock-recruit relationship. Decisions concerning the best approach necessarily depend on assumptions regarding the accuracy of the hypothesized stock-recruit relationship and in particular, the existence of compensatory responses by the stock (i.e., relatively speaking, increased recruitment at low spawning biomass levels).

Reliance on the stock-recruit relationship seems reasonable when model estimates are considerably higher or lower than recently observed values and when no ancillary information exists to suggest that recruitment is atypically high (e.g., year class failure or a compensatory increase in juvenile production and/or survival). Modeled age-0 abundance for January 2002 was 337 million fish, well-within the range of recruitments observed for the past seven years. Some evidence exists to suggest relatively strong year classes in 2000 and 2001. The 2001 fishery contained the highest proportion of age-0 fish (2000 year class) in recent history (33%) in spite of market orders to not land smaller fish due to low oil content. The 2000 year class comprised the largest proportion (63%) of the 2002 catch. Length data from recreational angler surveys indicated increased catches of young mackerel by "shore mode" anglers in 2000 and 2001. Based on the above evidence for stronger 2000 and 2001 year classes, we applied the model estimate of 2002 age-0 abundance in the forecast. From this, we estimate the July 1, 2003 age 1+ biomass will be approximately 68,934 mt.

9.1.2.1 Harvest Guideline for 2001-2002

In Amendment 8 to the CPS FMP, the recommended maximum sustainable yield control rule for Pacific mackerel was:

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

where HARVEST is the U.S. harvest guideline, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS in U.S. waters. CUTOFF and FRACTION values applied in the Council's harvest policy for mackerel are based on analyses published by MacCall *et al.* (1985). BIOMASS (68,924 mt) is the estimated biomass of fish age 1 and older for the whole stock as of July 1, 2003. Based on this formula, the 2003-2004 season harvest guideline would be 10,652 mt. The recommended harvest guideline is 1,883 mt lower (-15%) than the 2002-2003 HG, and lower than the average yield (~13,500 mt) realized by the fishery since the 1992-1993 season.

HARVEST GUIDELINE = (BIOMASS - CUTOFF) x FRACTION x STOCK DISTRIBUTION
= (68,924 mt - 18,200 mt) x 0.30 x 0.70
= 10,652 mt of HG for 2003-2004

9.2 Monitored Species

Figure 1 illustrates distribution of northern anchovy and jack mackerel eggs for areas surveyed off of Southern California, April 2003.

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; and 4,650 mt in 2002. There are no reported landings of northern anchovy into Oregon from 1981 through 2001, with 3.1 mt reported in 2002 and about 42 mt reported in Washington in 1988. Through the 1970s and early 1980s, Mexican landings increased, peaking at 258,700 mt in 1981. Mexican landings decreased to less than 2,324 mt per year during the early 1990s. There was an increase in Mexican landings to 21,168 mt in 1995, primarily during the months of September through November.

Catches in Ensenada were 4,168; 1,823; 972; 3,482; 1,562; and 76 mt in 1996-2001, respectively. There have been no catches reported for 2002.

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

Total age 1+ biomass of northern anchovy rose in the early 1970s to a maximum estimate of 1,598,000 mt in 1973, and decreased to 392,000 mt in 1994. Further estimates of spawning biomass (age 1+) peaked in 1975 at 1,069,000 mt, and declined to 388,000 mt in 1994. Fishing mortality estimates in 1990 to 1994 did not exceed 0.03%, and declined to zero in 1993 and 1994.

9.2.2 Jack Mackerel

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

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

In California, CDFG landing receipts for jack mackerel totaled 1,269 mt in 2000; 3,624 mt in 2001; and 1,006 mt in 2002. Oregon reported 161 mt in 2000 and 183 mt in 2001, and 8.9 mt in 2002. 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.

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.

9.2.3 Market Squid

Currently, only limited information is available regarding market squid population dynamics and further, data concerning historical and current levels of absolute biomass are unavailable. A Stock Assessment Review (STAR) Panel was convened in May 2001 to evaluate assessment methods for use in the management of the squid fishery and ultimately, to assess the appropriateness of defining MSY for this species. Preliminary attempts to estimate biological references 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 concepts. Egg escapement is defined here as the number (or proportion) of a female squid's potential lifetime fecundity that she is able to spawn, on average, before being harvested in the fishery. An Egg Escapement Method (see Appendix 3 in the 2002 SAFE document) based on conventional yield and spawning biomass "per recruit" models was fully developed by the Stock Assessment Team (STAT) 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 candidate proxies for the fishing mortality that results in MSY (F_{MSY}). However, it is important to note that this approach does not provide estimates of historical or current total biomass and thus, a definitive yield (i.e., quota or ABC) cannot be determined at this time. Ultimately, the Egg Escapement Method can be used to assess whether the fleet is fishing above or below an a priori-determined sustainable level of exploitation and in this context, can be used as an effective management tool.

The STAR Panel provided general recommendations regarding analytical methods (i.e., the Egg Escapement Method) and left determination of specific model configurations and other management-related parameters to the CPSMT. In this context, the CPSMT provided guidance concerning four critical areas of the Egg Escapement Method, which was 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) necessary 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 2002 SAFE.

Finally, data collection programs and subsequent laboratory analysis continued throughout 2002 in attempts to complement baseline sample information that served as the foundation for developing the Egg Escapement Method described above. That is, as discussed generally in CPS-related documents presented in Appendix 3 of the 2002 SAFE, further work surrounding the Egg Escapement assessment approach continued in 2002 to the present, including collection of additional sample data, as well as further analysis-related research that addressed statistical uncertainty associated with important model parameters (e.g., mean standing stock of eggs per female and estimated threshold levels). Specifically, the recent work has consisted of, (1) collecting much needed reproductive sample information from the fisheries to bolster the original source of data that was relied upon initially when developing the overall Egg Escapement Method from 2000-2001; (2) critically evaluating spatial/temporal patterns of the overall fishery through stratified sampling and subsequent analysis; (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 (see also Section 6.1.1); and (4) beginning simulation modeling research efforts to further examine the relationship between critical biological reference points (i.e., "threshold" levels) and absolute levels of squid population abundance off southern California.

9.2.3.1 California's Market Squid Fishery

The California market squid fishery is separated at Point Conception into northern and southern fisheries. Historically, the northern fishery accounted for the majority of the catch. Since the early 1980s, the southern fishery has continually increased its landings and has been dominant since the mid-1980s. Typically, the northern fishery occurs during the summer months and the southern fishery in the winter months. In 1999, the southern California fishery began operating nearly year-round, because market squid was readily available during most of the year in southern California. This trend has continued to date, although landings generally decrease in the summer months as compared to the rest of the year.

A mild El Niño event in 2002 likely contributed, to some degree, to an overall decrease in landings coastwide (72,878 mt). However, this oceanographic phenomenon brought record landings to the northern market squid fishery, while hampering the southern fishery. In the 1990s, landings for the northern fishery have averaged just under 7,000 mt. Since 1999, the northern fishery has continually landed higher amounts of squid each year, with the 2002 landing estimate of 26,292 mt the highest to date. This increase in landings for the northern fishery has been largely an outcome of expanding market opportunities and subsequently, increases in the size of the purse seine fleet itself, as well as the fleet's fishing grounds, both north and south of Monterey Bay.

During ENSO events, the availability of squid to the fishery is greatly reduced and this was evident in landings for the southern fishery, where only 46,586 mt of squid were harvested in 2002. The previous ENSO event that occurred in 1998 resulted in landings that plummeted to 2,894 mt. It is generally believed that movement out of established spawning grounds into favorable habitat and reduced reproduction by the population are responsible for the changes in availability. Further, there is no clear indication of short-term detrimental effects to the squid population (i.e., as evident in the relatively high landing amounts that have immediately followed ENSO-related events observed over the last decade or so).

La Niña conditions in 1999 contributed to record-high market squid landings of 91,517 mt for California, surpassing the previous high in 1996 of 80,402 mt. This record took place primarily in the southern California fishery, which accounted for 99.7% of all landings that year. Landings for the northern California fishery were only 289 mt during this time period.

In 2000, an abundance of squid and somewhat favorable market conditions contributed to another record-high for market squid landings (117,962 mt). New landing records were set six times since 1990, reflecting a continued expansion of the southern California fishery and increased international demand for this marine resource.

In 2001, market squid landings were 86,186 mt, a 27% decrease from 2000. The immediate reason for the decline in landings is not known, but anecdotal information suggests that squid were not as available at typical spawning sites, and fishers had to go to alternate areas to locate good quality squid. The lower harvest might be reflective of pre-El Niño conditions, when the abundance of market squid at known fishing areas is likely strongly affected by environmental conditions.

In 2001, legislation transferred the authority for management of the market squid fishery to the California Fish and Game Commission (Commission). Legislation requires that the Commission adopt a market squid fishery management plan and regulations to protect and manage the squid resource. CDFG has prepared a draft market squid fishery management plan (April 11, 2003) with management recommendations for the market squid fishery which should be in place for the April 1, 2004 squid fishing season. The management plan takes into account the level of fishing effort and ecological factors, including, but not limited to, the species' role in the marine ecosystem and oceanic conditions. The plan includes a limited entry program geared to maintain the long-term economic viability of the fishery and seeks to match the level of fishing effort to the health of the resource. The management alternatives recommended by CDFG are intended to provide sustainability of the market squid resource both as a forage item and for those that rely upon squid for their livelihood. The management alternatives are based on precautionary principles and utilize the best science available. Starting in 1998, vessels participating in the squid fishery must have one of two permits: the first requires a commercial market squid vessel permit to land more than two short tons daily; the second permit is to operate a light boat for the purpose of attracting market squid by light. Participants must have purchased a permit the previous year to renew their permit. A moratorium placed on the number of vessels in the squid fishery (starting in 1998) continues until adoption of the management plan. Originally, there were 248 vessel permits and 54 light boat permits during the 1998-1999 season. For the 2002-2003 season, 184 market squid vessel permits and 41 light boat permits were sold. Permit fees were set at $2,500 for three years beginning with the 1998-1999 fishing season after which time they were dropped to $400 annually. The sale of market squid permits during the initial three years provided funds for biological assessment of the resource and development of management recommendations, which were provided by the CDFG to the State Legislature in April 2001.

In developing a restricted access program, the CDFG supports a "moderately productive and specialized" fleet capacity goal of 52 round-haul vessels, 52 light boats, and 18 brail boats. These goals are within the range of the number of vessels actively participating in the fishery in a given year. The recommendations include establishing limited entry permit criteria based on prior catch or fishing history and provide for full transferability of vessel permits only between vessels of comparable capacity.

Additionally, CDFG recommends enacting catch limits to prevent increases in the volume of the current fishery and limit future participation by vessels of a significantly larger size. The proposed project recommends a statewide seasonal catch limitation of 107,047 mt (118,000 short tons) and restricts transferability of permits to vessels of similar capacity (within 10%). A seasonal landings catch limit of 113,400 mt (125,000 short tons) was adopted in 2001 and was in place for the 2002-2003 season.

In response to potential negative effects on nesting seabirds on several of the Channel Islands of vessels using lights to attract squid and to reduce potential light impacts on coastal communities, interim regulations went into effect May 2000 restricting lights to a maximum of 30,000 watts and requiring that lights be shielded. However, in April 2002, a petition was filed with the U.S. Fish and Wildlife Service and Commission to consider listing of Xantus's murrelets under the Endangered Species Act, citing high predation on nesting birds in 1999 "almost certainly resulted, in part, from high light levels caused by squid fishing boats." Xantus's murrelets are small nocturnal seabirds, 80% of the U.S. breeding population nest in the Channel Islands, primarily at Santa Barbara Island (also found at San Miguel, Santa Cruz, and Anacapa islands). On

October 23, 2002, the Commission designated the Xantus's murrelet as a candidate species under the California Endangered Species Act (CESA). Emergency regulations became effective November 7, 2002 and extend through the candidacy period. These regulations are necessary to allow economic and recreational activities to continue during the candidacy period, while ensuring appropriate interim protection regulations for the species during the 12-month candidacy period. As a result, incidental take of Xantus's murrelet during the candidacy period is authorized, as long as it occurs in a manner consistent with conditions specified in the regulations. The proposed project in the market squid management plan includes a recommendation by CDFG to close Anacapa and Santa Barbara islands to squid fishing using attracting lights from February 1 through September 30 to mitigate potential fishery impacts on the nesting seabirds while recommending that the existing interim wattage and shielding regulations be maintained. The Commission will consider whether to designate the Xantus's murrelet as a threatened species under CESA in 2003, following a 12-month status review of the species by the CDFG.

In the State of California's preliminary draft management plan, CDFG does not recommend any specific closure areas for squid replenishment at this time, but supports continued evaluation and identification of squid harvest replenishment areas as a future resource protection tool. In 2003, a network of marine reserves at the Channel Islands went into effect. A total 132 square nautical miles of the Channel Islands National Marine Sanctuary have been set aside; the area closed was determined to have a maximum potential loss of 12% to the squid fishery.

Maintaining the closure of the fishery on weekends statewide in the spirit of precautionary management is the preferred alternative in the management plan. In the absence of conclusive biological information upon which to base a quota or other management approach, a two-day, per week period provides assurance that there is some uninterrupted spawning in areas where squid are present. Unlike a seasonal quota or seasonal closure, this measure spreads escapement of squid throughout the year, rather than concentrating it at the beginning or end.

Continuing squid research and fishery monitoring is also strongly encouraged. This includes sampling efforts conducted at ports statewide, requiring logbooks for all permitted vessels participating in commercial squid fishing, monitoring of catch information and continuation of independent research contracts, especially those focused on developing population models useful for management. Finally, in their draft plan, CDFG recommends the permit fee be increased to offset the costs of squid research and monitoring programs.

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10.0 Emerging Issues

10.1 Long-Term Allocation Framework for Optimal Use of the Annual Pacific Sardine Harvest Guideline

In April, 2003 the Council adopted an interim[2/] allocation framework that seeks optimal use of the annual Pacific sardine harvest guideline with minimal impacts on any sector of the West Coast sardine fishing industry and fishing communities. This action addresses recent problems which have occurred as a result of the current allocation framework.

The CPSMT generally agreed that the impacts of the interim allocation scheme used to partition the Pacific sardine harvest guideline 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 effect the dynamics of the sardine population at large. To this end, while coastwide the species is genetically homogenous, as pertains to a long time scale, it is divided into habitat groups which may be important to the contemporary management time horizon. Therefore, a more comprehensive analysis of alternative allocation frameworks in terms of long-term socioeconomic and biological impacts is warranted.

The biological questions relating to allocation and differential impacts on the coastwide resource from the Southern California, Northern California, and Pacific Northwest fishery sectors generally include:

- Impacts to the coastwide sardine resource from a fishery that targets older, mature fish.
- Impacts to the coastwide sardine resource from a fishery that targets younger, immature fish.
- Recent indications of changes in maturity rates (i.e., delayed maturity) in the southern fishery resulting from density-dependent factors.
- Potential refinements to the Pacific sardine assessment and/or harvest control rule in response to new biological information

To address these issues, future biological information will include NMFS research surveys off the Pacific Northwest scheduled for summer 2003 and winter 2004, and a stock assessment review scheduled for spring 2004.

NMFS-Southwest Fisheries Science Center will conduct sardine acoustic trawl and Continuous Underway Fish Egg Sampler (CUFES) surveys off the coast of Oregon and Washington in July 2003 and January-February 2004 (acoustic-trawl only). These surveys are designed to fill major gaps in knowledge of sardine populations, by measuring the age structure and reproductive rates, and assessing the extent the fishery is dependent on migration and on local production of sardine. The objective of the surveys is to estimate the biomass present at these two times of the year, with the ratio of the two values providing an estimation of the relative proportion and size and age structure of the sardine stock that over-winters off the coast of Oregon and Washington.

A CPS STAR workshop is scheduled for May 2004. The goals and objectives for the CPS assessment and review process are: ensure that CPS stock assessments provide the kinds and quality of information required by all members of the Council family; satisfy the Magnuson-Stevens Act and other legal requirements; provide a well-defined, Council oriented process that helps make CPS stock assessments the "best available" scientific information and facilitates use of the information by the Council. In this context, "well-defined" means with a detailed calendar, explicit responsibilities for all participants, and specified outcomes and reports; emphasize external, independent review of CPS stock assessment work; increase understanding and acceptance of CPS stock assessment and review work by all members of the Council family; identify research needed to improve assessments, reviews, and fishery management in the future; and use assessment and review resources effectively and efficiently. The CPS STAR process will provide information for Pacific sardine that will be used to craft alternatives for a longer-term allocation framework.

As data become available, this information, along with more robust economic information on producer profit and surplus, will be considered in crafting longer-term management alternatives for annual allocation of the Pacific sardine harvest guideline.

2/ The interim measure will be in place for the current fishing year (2003), 2004, and conditionally for 2005.

10.2 Development of Long-Term Monitoring/Analysis Schedule for Market Squid off California

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

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.

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

11.1 Pacific Sardine

The Trinational Sardine Forum (Mexico, U.S., and Canada) met again in 2002 to discuss issues related to the rapidly recovered sardine population and fishery along the West Coast of North America. The Forum has identified several issues for priority work. Issue 1 is developing cooperative relationships with the fishing industry to provide fishing vessel platforms for critical studies of the life history of sardine. Issue 2 is to standardize fishery-dependent data collection among agencies, particularly age and size data, and improve exchange of this data in summarized form to stock assessment scientists. Issue 3 is the need to assemble mutually compatible fishery assessments off of the West Coast of Mexico, U.S., and Canada to form a baseline of stock status and variability of possibly more than one interbreeding stock of sardines, or a temperature-derived phenotype with radically heterogeneous population parameters influencing harvest guidelines. Coastwide sea surveys which include egg and adult samples are viewed as a top priority. Otolith microchemistry and DNA analyses are promising tools to improve our knowledge of sardine stock structure. The final report of the Trinational Forum 2002 is now available online.

http://swfsc.ucsd.edu/frd/Trinational/text/lj-03-05.pdf

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 this data would enable us to continue the historical CalCOFI time series, which begins in 1951. This information could be directly incorporated into the assessment model. Night-light surveys for newly recruited Pacific mackerel should be re-instituted in the Southern California Bight. Surveys following protocols employed during CDFG Sea Survey cruises (1950-1988) could allow splining the new recruitment data set to the historical time series. The new time series would represent the only recruitment index in the mackerel stock assessment and would strengthen the ability to accurately forecast age zero and total stock abundance for each coming fishing season.

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

11.3 Market Squid

Currently, there exists only limited understanding of market squid population dynamics, which necessarily 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 6 to 7 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 and oceanographic conditions associated with the population. Furthermore, information describing mechanisms and patterns of dispersal of adults (as well as paralarvae) along the coast is required to clarify how local impacts might be mitigated by recruitment from other areas inhabited by this short-lived species.

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

Potential impacts to essential fish habitat (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.

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

11.4 Live Bait Fishery

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

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

11.5 Cost-Earnings Data

Measuring the economic effects of prescribed allocations in the sardine fishery in terms of net economic benefits that accrue from utilization of the resource, entails estimating the changes in net national benefits associated with each allocation option within a cost-benefit (C-B) framework regulatory impact review [RIR] requirement. In the quantitative evaluation of north-south sardine long term allocation options the focus will be on the economic values of the incremental production of sardine products, under each allocation option as measured by changes in short-run profits or producer surplus. The problem is to determine, for each fishery sector (Southern California, Northern California, and Pacific Northwest), the relative harvests of sardine, the quantities of the different processed products, the revenue received for these products and the costs of producing the products under each allocation alternative, and calculate the change in producer surplus from the status quo (no action alternative). This type of analysis will obviously require detailed, representative cost and earnings data for the sardine harvesters and processors making up each fishery sector.

In addition to the social welfare considerations, the impact of allocation alternatives on the profitability of harvesting and processing operations (Regulatory Flexibility Act [RFA] requirement) and CPS fishing communities will also be taken into account (community impacts, National Standard 8 requirement). Estimating the impacts on firm profitability entails a financial analysis based on the concept of private financial profit, which may differ from the net economic benefits defined by C-B economic analysis. The financial analysis would nonetheless rely on the same cost-earnings data required of the C-B analysis.

Community impacts will be evaluated using various economic impact "multipliers" to gauge the affects of allocation options on the level of economic activity within a particular area; i.e., if you increase/decrease sardine landings in a particular area, how much does the level of economic activity increase/decrease in that area. Some of the applicable multipliers are available in the Council's "Draft Communities Document" and from the West Coast Fisheries Economic Assessment Model. Others will have to be researched or drawn from other sources.

12.0 Economic Status of Washington, Oregon, and California CPS Fisheries in 2001

This section briefly summarizes economic data presented in the Economic Appendix – Economic Status of Washington, Oregon, and California CPS Fisheries in 2002. Pacific Coast landings of CPS amounted to 178,781 mt in 2002, 7% less than total CPS landings in 2001. Market squid landings were 72,317 mt in 2002, down 16% from 2001. Pacific sardine landings continued to increase in 2002, with further expansion of the northwest fishery, reaching 96,824 mt, up 28% from 2001. The exvessel value of 2002 CPS landings was just under $30 million in 2002, down 1% from 2001 (2001 converted to 2002 dollars). Market squid accounted for 40%, and Pacific sardine 54% of total landings in 2002. Landings of Pacific mackerel fell 51%, and landings of northern anchovy fell 75% from 2001 to 2002. Real exvessel market squid revenues (2002 $) increased 2% from 2001; the decrease in landings was accompanied by a 21% increase in exvessel price from $207 per mt to $250 per mt (2002 $). Aggregate CPS finfish real exvessel revenues decreased 5% from 2001; total landings remained virtually unchanged, while the overall finfish exvessel price fell 5%. In 2002, market squid made up almost 7% of the exvessel value of total Pacific Coast landings, and CPS finfish accounted for slightly less than 5%. Market squid ranked first in exvessel value among California commercial fisheries in 2002, with exvessel revenue of, $18,067,636, 51% greater than that for Dungeness crab, the next most valuable California fishery in 2002.

Pacific sardine ranked fifth highest in California exvessel value in 2002 at $5,806,215. California accounted for 77% of coastwide CPS landings in 2002, down from 87% in 2001. Pacific sardine landings in Oregon almost doubled from 12,780 mt in 2001 to 23,126 mt in 2002. Washington landings of Pacific sardine increased from 11,127 mt in 2001 to 15,833 mt in 2002. Oregon landings of Pacific mackerel fell from 371 mt in 2001 to 248 mt in 2002. Washington landings of Pacific mackerel decreased from 371 mt to 248 mt; and anchovy landings rose from 68 mt to 229 mt from 2001 to 2002.

In 2002, the number of vessels with Pacific Coast landings of CPS finfish was 198, down from 231 in 2001. With the decrease in vessels and no change in total CPS finfish landings, finfish landings per vessel increased 17% from 2001. Of the CPS finfish vessels active in 2002, 24% depended on CPS finfish for the largest share of their 2002 exvessel revenues. From 2001 to 2002, the number of vessels with Pacific Coast landings of market squid increased from 168 to 207, with 34% of these vessels dependent on market squid for the largest share of their total 2002 exvessel revenues. Market squid landings were 350 mt per vessel in 2002, down 32% from 2001. Market squid total revenue shares for vessels that depend mainly on market squid have been higher on average than average finfish total revenue shares for vessels that depend primarily on CPS finfish over the period 1981-2002, 74% vis a vis 63%, suggesting that market squid vessels tend to be more specialized than CPS finfish vessels. Roundhaul gear accounted by far for the largest share of total CPS landings in 2002, 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 2002, 66,611 mt of market squid were exported through West Coast customs districts with an export value of $53 million; a 33% decrease in quantity, and a 27% decrease in the real value of West Coast market squid exports from 2001. The primary country of export was China, 45% of the total, which received 30,074 mt, 30% less than the quantity exported to China in 2001. Eighty percent of market squid exports went to China and four additional countries: the Philippines (9,542 mt), Japan (7,602 mt), Spain (3,589 mt), and Venezuela (2,360 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or packaged for use as frozen bait.

Sixty-one percent, 58,802 mt, of Pacific sardine landings were exported in 2002, up 24% from 2001; most of the remaining landings were consumed domestically as canned Pacific sardine. Pacific sardine exports were valued at $36.3 million in 2002, up 35% from 2001. Almost 73% of Pacific sardine exports were in the frozen form, the balance was in the preserved form. Japan was the primary export market in 2002, receiving 30,731 mt, 52% of total exports. Australia was second with 16,783 mt, 29% of the total. Japanese demand for large frozen Pacific sardine continues to grow for both human consumption and use as bait in its longline fisheries – exports to Japan were up 58% from 2001. West Coast Pacific sardine exports to Australia are primarily for feed in Australia's bluefin tuna farming operations. Concern over Viral Hemorrhagic Septicemia found in West Coast Pacific sardine was a factor in the 10% drop in exports to Australia from 2001.

In 2002, approximately 90% of the sardine landed into Oregon and Washington were exported to Japan for human consumption or for longline bait. Only the highest quality sardine is eligible for use in the longline fishery. Approximately 30% of the fish delivered to Japan in 2002 went into the human consumption market, up to 10% more than in 2001. The amount destined for human consumption is expected to grow as additional food markets are developed, and the longline bait market becomes saturated. All refuse type fish (about 10% in 2002 compared to 20% in 2001) was sold to Australian tuna farmers in the form of 50 pound frozen blocks for feed. The amount of Pacific northwest refuse type sardine is expected to decrease to negligible amounts in 2003. A very small amount of sardine was sold for the domestic human consumption market (i.e., restaurants in Portland).

In Monterey in 2002, 10% to 20% of the sardine landed was sold to Australia, either to tuna farms for feed or in 2 kilogram packs for sportfishing bait. Eighty-ninety percent of sardine landings were sold to Japan for either human consumption or for small longline bait (albacore and yellowtail), depending on the size of the fish.

The sardine landed in San Pedro are generally smaller than those landed in Monterey. The smaller fish are suitable for the Australian tuna farms while the larger fish (small percentage of landings) are used for bait and consumption. Of the sardine landed in San Pedro during 2002, 85% was exported to tuna farmers in Australia and 5% to Japan for human consumption and sportfishing bait. The remaining 10% went elsewhere, including Guam, Fiji, and Hawaii.

Pacific mackerel caught off Oregon and Washington are generally large in size and high in oil content, and most of the landings were exported to Japan for human consumption in 2002. In Monterey all mackerel landed during 2002 were sold to Japan for human consumption. The majority of mackerel landings in San Pedro during 2002 were exported to overseas canneries such as in the Philippines and Malta. Some mackerel was utilized as bait for domestic lobster fishermen and a small amount was utilized for human consumption.

In California approximately 50% of anchovy landings in 2002 were reduced for fish meal, and 40% were sold to Australia for tuna farms. Another 10% was utilized as domestic sportfishing bait.

Table 1. History of Council Actions

- The Council initiated development of the FMP for Northern anchovy in January of 1977. The FMP was submitted to the U.S. Secretary of Commerce (Secretary) in June of 1978. Regulations implementing the FMP for Northern anchovy were published in the *Federal Register* on September 13, 1978 (43*FR*40868). Subsequently, the Council has considered seven amendments.

- The first amendment changed the method of specifying the domestic annual harvest for Northern anchovy and added a requirement for an estimate of domestic processing capacity and expected annual level of domestic processing. Approval for this amendment was published in the *Federal Register* on July 18, 1979 (44*FR*41806).

- The second amendment, which became effective on February 5, 1982, was published in the *Federal Register* on January 6, 1982 (47*FR*629). The purpose of this amendment was to increase the domestic fishing fleet's opportunity to harvest the entire optimum yield (OY) of Northern anchovy from the U.S. EEZ by releasing, inseason, unutilized portions of the Northern quota.

- During the spring of 1982, the Council considered a third amendment that divided the quota for Northern anchovy into two halves and made release of the second half conditional on the results of a mid-season review of the status of the stock. The methods proposed for the mid-season assessment were considered too complex to implement, and the amendment was not approved.

- The fourth amendment, which had two parts, was published in the *Federal Register* on August 2, 1983 (48*FR*34963) and became effective on August 13, 1983. The first part abolished the five-inch size limit in the commercial fishery and established a minimum mesh size of 5/8 inch for Northern anchovy. The mesh size requirement did not become effective until April 1986 in order to give the fleet additional time to comply without undue economic hardship. The second part established a mid-season quota evaluation that was simpler in design than the method proposed in Amendment 3.

- The fifth amendment in 1983 incorporated advances in scientific information concerning the size and potential yield of the central subpopulation of Northern anchovy. In addition, the fifth amendment included changes to a variety of other management measures. Two or more alternative actions were considered in each of seven general categories; (1) OY and harvest quotas; (2) season closures; (3) area closures; (4) quota allocation between areas; (5) the reduction quota reserve; (6) minimum fish size or mesh size; and (7) foreign fishing and joint venture regulations. The alternatives for the fifth amendment were reviewed by the Council during 1983. The final rule was published in the *Federal Register* on March 14, 1984 (49*FR*9572).

- In 1990, the sixth amendment implemented a definition of overfishing for Northern anchovy consistent with National Standard 7, and addresses vessel safety (56*FR*15299, April 16, 1991).

- The Council began developing the seventh amendment as a new FMP for CPS on a motion from NMFS and California in 1990. A complete draft was available in November of 1993, but the Council suspended further work, because NMFS withdrew support due to budget constraints. In July of 1994, the Council decided to proceed with the plan through the public comment period. NMFS agreed with the decision on the condition that the Council also consider the options of dropping or amending the anchovy FMP. Thus, four principal options were considered for managing CPS (1) drop the anchovy FMP (no federal or Council involvement in CPS); (2) continue with the existing FMP for anchovy (status quo); (3) amend the FMP for Northern anchovy; and (4) implement an FMP for the entire CPS fishery. In March of 1995, after considering all four principal options, 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 US Secretary of Commerce, but rejected by NMFS, Southwest Region, as being inconsistent with National Standard 7. NMFS announced its intention to drop the FMP for Northern anchovy (in addition to FMP's other species) in the *Federal Register* on March 26, 1996 (61*FR*13148), but the action was never completed.

- Development of Amendment 8 began in June, 1997 when the Council directed the CPSPDT to amend the FMP for Northern anchovy to conform to the recently revised Magnuson-Stevens Fishery Conservation and Management Act and to expand the scope of the FMP to include the entire CPS fishery. Amendment 8 was partially approved by the U.S. Secretary of Commerce on June 10, 1999, and final regulations were published on December 15, 1999 (64 *FR* 69888). The FMP was implemented on January 1, 2000.

- At its meeting in June 1999, the Council directed its Coastal Pelagic Species Management Team (CPSMT) to recommend appropriate revisions to the FMP and report to the Council the following September. A public meeting of the CPSMT was held in La Jolla, CA, on August 3 and 4, 1999, and August 24, 1999, and a meeting was held between the CPSMT and the Coastal Pelagic Species Advisory Subpanel on August 24, 1999. At its September 1999 meeting, the Council gave further direction to the CPSMT regarding MSY for squid. At its March 2000 meeting, the Council asked the CPSMT for a more thorough analysis of the alternatives proposed for establishing MSY for squid and for bycatch. At a public meeting in La Jolla, CA, on April 20 and 21, 2000, the CPSMT reviewed comments from the Council, the Council's Scientific and Statistical Committee (SSC) and prepared additional material for establishing MSY for squid based on spawning area.

- The Council distributed Amendment 9 for public review on July 27, 2000. At its September 2000 meeting, the Council reviewed written comments, received comments from its advisory bodies, and heard public comments, and decided to submit only two provisions for Secretarial review. Based on testimony concerning MSY for squid, the Council decided to include in Amendment 9 only the bycatch provision and a provision providing a framework to ensure that Indian fishing rights are implemented according to treaties between the U.S. and the specific tribes. Since implementation of the FMP, the CPS fishery has expanded to Oregon and Washington. As a result, the FMP must discuss Indian fishing rights in these areas. These rights were not included in the FMP; and the Council decided to address this issue in Amendment 9. The Council decided to conduct further analysis of the squid resource and will prepare a separate amendment that addresses OY and MSY for squid.

- The Secretary of Commerce approved Amendment 9 on March 22, 2001.

- In April 2001, the Council adopted the capacity goal and transferability provisions recommended by the CPSMT for inclusion in Amendment 10. The Council directed the CPSMT to develop an amendment to the CPS FMP that will include the capacity goal, provisions for permit transferability, a process for monitoring fleet capacity relative to the goal, and a framework for modifying transferability provisions as warranted by increases or decreases in fleet capacity. The amendment will also address determination of OY and MSY for market squid.

- In November 2001, the Council reviewed the findings of the market squid stock assessment review (STAR) workshop and endorsed the egg escapement approach as a proxy for squid MSY, as recommended by the market squid STAR Panel and CPSMT.

- In March 2002, the Council adopted draft Amendment 10 to the CPS FMP for public review.

- In June 2002, the Council adopted Amendment 10 to the CPS FMP.

- December 30, 2002, the Secretary of Commerce approved Amendment 10. On January 27, 2003 NMFS issued the final rule and regulations for implementing Amendment 10.

- September 2002, the Council requested NMFS take emergency action to reallocate the unharvested portion of the harvest guideline prior to October 1. The Council believed this action would minimize negative economic impacts in the northern fishery without causing market disruptions in the southern fishery. On September 26, 2002, through an emergency rule, NMFS reallocated the remaining Pacific sardine harvest guideline and reopened the northern subarea fishery, which had been closed on September 14, 2002.

- September 2002, the CPSAS recommended the Council initiate a regulatory or FMP amendment and direct the CPSMT to prepare management alternatives for revising the sardine allocation framework. The Council directed the CPSMT to review CPSAS recommendations for revising the allocation framework. A public meeting of the CPSMT was held on October 8, 2002. The CPSMT discussed information needs and prospective analyses for developing allocation management alternatives.

- On October 30, 2002, the Council initiated a regulatory amendment to address allocation problems.

- The CPSMT met January 30-31, 2003 to analyze various alternatives for revising the allocation framework and developed recommendations for Council consideration.

- At the March 2003 Council meeting, the SSC and CPSAS reviewed analyses of the proposed management alternatives for sardine allocation. Based on the advisory body recommendations and public comment, the Council adopted five allocation management alternatives for public review.

- At the April 2003 Council meeting, the CPSAS reviewed the five management alternatives and developed recommendations for the Council. The Council took final action on the regulatory amendment. The proposed action adopted by the Council would (1) change the definition of subarea A and subarea B by moving the geographic boundary between the two areas from 35° 40' N latitude to 39° N latitude, (2) move the date when Pacific sardine that remains unharvested is reallocated to Subarea A and Subarea B from October 1 to September 1, (3) change the percentage of the unharvested sardine that is reallocated to Subarea A and Subarea B from 50 percent to both subareas to 20 percent to Subarea A and 80 percent to Subarea B, and (4) reallocate all unharvested sardine that remains on December 1 coast wide. The Council's intent is for this interim revision to the allocation framework be in effect for the 2003 and 2004 seasons. The allocation regime could be extended to 2005 if the 2005 harvest guideline were at least 90% of the 2003 harvest guideline.

Table 2. Regulatory Actions

January 25, 2000. NMFS published harvest guidelines for Pacific sardine and Pacific mackerel for the fishing year beginning January 1, 2000. A harvest guideline of 186,791 mt was established for Pacific sardine, based on a biomass estimate of 1,581,346 mt. The harvest guideline was allocated for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation was 62,264 mt; the southern allocation was 124,527 mt. The sardine harvest guideline was in effect until December 31, 2000, or until it was reached and the fishery closed. A harvest guideline of 42,819 mt was established for Pacific mackerel based on a biomass estimate of 239,286 mt. The harvest guideline for Pacific mackerel was in effect until June 30, 2000, or until it was reached and the fishery closed. (65*FR*3890)

September 11, 2000. NMFS announced the annual harvest guideline for Pacific mackerel in the exclusive economic zone (EEZ) off the Pacific Coast. Based on the estimated biomass of 116,967 mt and the formula in the FMP, a harvest guideline of 20,740 mt was calculated for the fishery beginning on July 1, 2000. This harvest guideline is available for harvest for the fishing season July 1, 2000, through June 30, 2001. (65*FR*54817)

November 1, 2000. NMFS announced the closure of the directed fishery for Pacific mackerel in the EEZ off the Pacific Coast on October 27, 2000. The FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on a formula in the FMP and to close the fishery when the harvest guideline is reached. The harvest guideline of 20,740 mt is projected to be reached before the end of the fishing season on June 30, 2001, which requires closing the directed fishery and setting an incidental harvest limit for Pacific mackerel so that the harvest of other coastal pelagic species will not be further restricted. The intended effect of this action is to ensure conservation of the Pacific mackerel resource. For the reasons stated here and in accordance with the FMP and its implementing regulations at 50 CFR 660.509, the directed fishery for Pacific mackerel will be closed October 27, 2000, after which time no more than 20% by weight of any landing of Pacific sardine may be Pacific mackerel. (65*FR*65272)

November 17, 2000. NMFS published a correction to the Pacific mackerel closure which was published on November 1, 2000. In 65*FR*65272, make the following correction: On page 65272, in the third column, under the heading SUPPLEMENTARY INFORMATION, the last sentence is corrected to read as follows: "For the reasons stated here and in accordance with the FMP and its implementing regulations at 50 CFR 660.509, the directed fishery for Pacific mackerel will be closed October 27, 2000, after which time no more than 20% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid may consist of Pacific mackerel." (65*FR*69483)

December 27, 2000. NMFS announced the annual harvest guideline for Pacific sardine in the EEZ off the Pacific Coast for the January 1, 2001, through December 31, 2001, fishing season. This harvest guideline has been calculated according to the regulations implementing the FMP. The intended effect of this action is to establish allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 1,182,465 mt and the formula in the FMP, a harvest guideline of 134,737 mt was calculated for the fishery beginning January 1, 2001. The harvest guideline is allocated one-third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and two-thirds for Subarea B, which is south of 35° 40' N latitude to the Mexican border. Any unused resource in either area will be reallocated between areas to help ensure that the optimum yield will be achieved. The northern allocation is 44,912 mt; the southern allocation is 89,825 mt. (65*FR*81766)

February 22, 2001. NMFS announced changes to the restriction on landings of Pacific mackerel for individuals participating in the CPS fishery and for individuals involved in other fisheries who harvest small amounts of Pacific mackerel. The incidental limit on landings of 20% by weight of Pacific mackerel in landings of Pacific sardine, northern anchovy, jack mackerel, and market squid remains in effect; however, CPS fishermen may land up to 1 mt of Pacific mackerel even if they land no other species from the trip. Non-CPS fisherman may land no more than 1 mt of Pacific mackerel per trip. After the harvest guideline of 20,740 mt is reached, all landings of Pacific mackerel will be restricted to 1 mt per trip. This action is authorized by the FMP and is intended to ensure that the fishery achieves, but does not exceed, the harvest guideline while minimizing the economic impact on small businesses. For the reasons stated here, no fishing vessel may land more than 1 mt of Pacific mackerel per fishing trip, except that fishing vessels with other CPS on board may land more than 1 mt of Pacific mackerel in a fishing trip if the total amount of Pacific mackerel on board the vessel does not exceed 20% by weight of the combined weight of all CPS on board the vessel. (66*FR*11119)

March 30, 2001. NMFS announced the closure of the fishery for Pacific mackerel in the EEZ off the Pacific Coast at 12:00 a.m. on March 27, 2001. The FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on a formula in the FMP and to close the fishery when the harvest guideline is reached. The harvest guideline of 20,740 mt has been reached. Following this date no more than 1 mt of Pacific mackerel may be landed from any fishing trip. The effect of this action is to ensure conservation of the Pacific mackerel resource. (66*FR*17373)

July 25, 2001. NMFS announced a harvest guideline of 13,837 mt for Pacific mackerel for the fishing season July 1, 2001 through June 30, 2002. A directed fishery of 6,000 mt was established, which, when attained, would be followed by an incidental allowance of 45% of Pacific mackerel in a landing of any coastal pelagic species. If a significant amount of the harvest guideline remained unused before the end of the fishing season on June 30, 2002, the directed fishery would be reopened. This approach was taken because of concern about the low harvest guideline's potential negative effect on the harvest of Pacific sardine if the fishery for Pacific mackerel had to be closed. The two species occur together often and could present incidental catch problems. (66*FR*38571)

November 27, 2001. NMFS announced the closure of the directed fishery for Pacific mackerel in the EEZ off the Pacific Coast at 12:00 noon on November 21, 2001. For the fishing season beginning July 1, 2001, 6,000 mt of the 13,837 mt harvest guideline was established for a directed fishery. More than 6,000 mt has been landed. Therefore, the directed fishery for Pacific mackerel was closed on November 21, 2001, after which time no more than 45% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid could consist of Pacific mackerel. The intended effect of this action was to ensure that the harvest guideline was achieved, but not exceeded, and to minimize bycatch of Pacific mackerel while other CPS were being harvested. (66*FR*59173)

December 27, 2001. NMFS published the harvest guideline for Pacific sardine for the fishing season beginning January 1, 2002. A harvest guideline of 118,442 mt was established for Pacific sardine based on a biomass estimate of 1,057,599 mt. The harvest guideline is allocated for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation is 39,481 mt; the southern allocation is 78,961 mt. The sardine harvest guideline is in effect until December 31, 2002, or until it is reached and the fishery closed. (66*FR*66811)

April 5, 2002. NMFS announced the reopening of the directed fishery for Pacific mackerel in the U.S. EEZ off the Pacific Coast on April 1, 2002. A significant portion of the Pacific mackerel harvest guideline remains unharvested (6,585 mt). Therefore, the incidental catch allowance that has been in effect since November 21, 2001 is removed, and any landing of Pacific mackerel may consist of 100% Pacific mackerel. This action was taken to help ensure that the harvest guideline is attained. If the harvest guideline is projected to be reached before June 30, 2002, the directed fishery will be closed and an appropriate incidental landing restriction imposed. (67*FR*16322)

July 11, 2002. NMFS proposed a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. This action proposes allowable harvest levels for Pacific mackerel off the Pacific Coast. Based on the estimated biomass of 77,516 mt and the formula in the FMP, a harvest guideline of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the harvest guideline is attained and the fishery closed before June 30. (67*FR*45952)

September 18, 2002. NMFS announced the closure of the fishery for Pacific sardine in the U.S. EEZ off the Pacific Coast north of Point Piedras Blancas, CA, (35° 40' N latitude) at 0001 hrs local time on September 14, 2002. The closure will remain in effect until the reallocation of the remaining portion of the coast wide harvest guideline is required by the CPS FMP. That reallocation is expected to occur on or about October 1, 2002. The purpose of this action is to comply with the allocation procedures mandated by the FMP. (67*FR*58733)

September 26, 2002. Emergency rule. NMFS announced the reallocation of the remaining Pacific sardine harvest guideline in the U.S. EEZ off the Pacific Coast. The CPS FMP requires that NMFS conduct a review of the fishery 9 months after the beginning of the fishing season on January 1, and reallocate any unharvested portion of the harvest guideline, with 50% allocated north and south of Point Piedras Blancas, California. The allocation north of Point Piedras Blancas was reached on September 14, 2002, and the fishery was closed until the scheduled time for reallocation on October 1, 2002. This action reallocates the remainder of the harvest guideline earlier than the date specified in the FMP in order to minimize the negative economic effects on fishing and processing, primarily in the Pacific Northwest, that would result from delaying the reallocation. (67*FR*60601)

October 3, 2002. NMFS issued a regulation to implement the annual harvest guideline for Pacific mackerel in the EEZ off the Pacific Coast. The CPS FMP and its implementing regulations require NMFS to set an annual harvest guideline for Pacific mackerel based on the formula in the FMP. This action is to conserve Pacific mackerel off the Pacific Coast. Based on the estimated biomass of 77,516 mt and the formula in the FMP, a harvest guideline of 12,456 is proposed for the fishery beginning on July 1, 2002, and continue through June 30, 2003, unless the harvest guideline is attained and the fishery closed before June 30. There will be a directed fishery of at least 9,500 mt, and 3,035 mt of the harvest guideline will be utilized for incidental landings following the closure of the directed fishery. After closure of the directed fishery, no more than 40% by weight of a landing of Pacific sardine, northern anchovy, jack mackerel, or market squid may consist of Pacific mackerel, except that up to 1 mt of Pacific mackerel may be landed without landing any other CPS. The fishery will be monitored, and if a sufficient amount of the harvest guideline remains before June 30, 2003, the directed fishery will be reopened. The goal is to achieve the harvest guideline and minimize the impact on other coastal pelagic fisheries. 67*FR*61994)

October 30, 2002. NMFS proposed a regulation to implement Amendment 10 to the CPS FMP, which was submitted by the Council for review and approval by the Secretary of Commerce. Amendment 10 addresses the two unrelated subjects of the transferability of limited entry permits and maximum sustainable yield for market squid. Only the provisions regarding limited entry permits require regulatory action. The purpose of this proposed rule is to establish the procedures by which limited entry permits can be transferred to other vessels and/or individuals so that the holders of the permits have maximum flexibility in their fishing operations while the goals of the FMP are achieved. (67*FR*66103)

November 25, 2002. NMFS proposed a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This harvest guideline has been calculated according to the CPS FMP and establishes allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 999,871 mt and the formula in the FMP, a harvest guideline of 110,908 mt was determined for the fishery beginning January 1, 2003. The harvest guideline is allocated one-third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas) to the Canadian border, and two-thirds for Subarea B, which is south of 35° 40' N latitude to the Mexican border. The northern allocation is 36,969 mt; the southern allocation is 73,939 mt. (67*FR*70573)

December 31, 2002. NMFS issued a regulation to implement the annual harvest guideline for Pacific sardine in the U.S. EEZ off the Pacific Coast for the fishing season January 1, 2003, through December 31, 2003. This harvest guideline has been calculated according to the CPS FMP and establishes allowable harvest levels for Pacific sardine off the Pacific Coast. Based on the estimated biomass of 999,871 mt and the formula in the FMP, a harvest guideline of 110,908 mt was determined for the fishery beginning January 1, 2003. The harvest guideline is allocated one-third for Subarea A, which is north of 35° 40' N latitude (Point Piedras Blancas, CA) to the Canadian border, and two-thirds for Subarea B, which is south of 35° 40' North latitude to the Mexican border. The northern allocation is 36,969 mt; the southern allocation is 73,939 mt. If an allocation or the harvest guideline is reached, up to 45% by weight of Pacific sardine may be landed in any landing of Pacific mackerel, jack mackerel, northern anchovy, or market squid. (67*FR*79889).

January 27, 2003. NMFS issued a regulation to implement Amendment 10 to the CPS FMP, which was submitted by the Council for review and approval by the Secretary of Commerce. Amendment 10 addresses the two unrelated subjects of the transferability of limited entry permits and maximum sustainable yield for market squid. Only the provisions regarding limited entry permits require regulatory action. The primary purpose of this final rule is to establish the procedures by which limited entry permits can be transferred to other vessels and/or individuals so that the holders of the permits have maximum flexibility in their fishing operations while the goals of the FMP are achieved. (68*FR*3819)

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

	Initial Fleet	Current Fleet
Number of Permitted Vessels	65	65
Average Vessel Age	35 yrs	32 yrs
Range of Ages	12 - 66 yrs	2 - 66 yrs
Average GT	71.3	88.8
Range of GT	12.8 - 206.9	23.8 - 340.2
Sum of Fleet GT	4,635.9	5,775.2
Capacity Goal (GT)/1	---	5,650.9
Transferability Trigger (Goal+5%)/1	---	5,933.5

1/ Established by Amendment 10 to the CPS FMP.

Table 4. 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	CG Number	Permit Number	Year Built	Vessel Age	CG Measurements (ft.)[1/] Length	Breadth	Depth	Calculated GT Endorsement[2/]	Max. Transfer Allowance[3/]
Misty Moon	D578511	1	1976	27	49.60	19.00	10.10	63.8	70.1
Paloma	D280452	2	1960	43	47.40	16.50	8.30	43.5	47.8
St. George II	D238969	3	1939	64	71.40	21.20	9.70	98.4	108.2
Barbara H	D643518	4	1981	22	64.90	24.00	11.60	121.1	133.2
San Antonio	D236947	5	1937	66	72.10	19.50	8.70	82.0	90.1
Annie D	D246533	6	1944	59	73.20	21.50	9.30	98.1	107.9
San Pedro Pride	D549506	7	1973	30	79.60	24.50	12.30	160.7	176.8
Ferrigno Boy	D602455	8	1978	25	69.60	23.70	12.60	139.3	153.2
King Philip	D1061827	9	1997	6	79.00	26.00	11.40	156.9	172.6
Sea Wave	D951443	10	1989	14	78.00	22.00	18.00	206.9	227.6
Mary Louise	D247128	11	1944	59	58.30	18.00	8.00	56.2	61.9
Bainbridge	D236505	12	1937	66	78.60	22.70	9.60	114.8	126.2
Pioneer	D246212	13	1944	59	77.80	24.30	11.20	141.9	156.1
Maria	D236760	14	1937	66	70.70	20.50	9.20	89.3	98.3
St. Joseph	D633570	15	1981	22	62.90	22.00	9.10	84.4	92.8
Sea Scout	D248454	16	1945	58	81.50	23.10	10.90	137.5	151.2
Retriever	D582022	17	1977	26	54.20	19.60	8.70	61.9	68.1
Atlantis	D649333	18	1982	21	49.60	19.00	10.10	63.8	70.1
G. Nazzareno	D246518	19	1944	59	78.00	22.70	10.50	124.6	137.0
Sea Queen	D582167	20	1974	29	68.40	22.00	11.10	111.9	123.1
Pacific Leader	D643138	21	1981	22	59.50	21.00	9.20	77.0	84.7
Chovie Clipper	D524626	22	1970	33	51.10	18.00	10.30	63.5	69.8
Pacific Journey[4/]	OR 661 ZK	23	2001	2	64.30	22.01	10.30	97.7	107.4
Ocean Angel I	D584336	24	1977	26	49.60	19.00	10.10	63.8	70.1
Maria T	D509632	25	1967	36	57.30	18.10	9.80	68.1	74.9
Manana	D253321	26	1947	56	40.10	13.20	6.70	23.8	26.1
Miss Juli	D548223	27	1973	30	49.50	17.80	9.40	55.5	61.0
Mineo Bros.	D939449	28	1989	14	58.00	21.00	9.00	73.4	80.8
Sea Queen	D583781	29	1977	26	49.00	16.00	8.00	42.0	46.2
Little Joe II	D531019	30	1971	32	50.10	16.00	7.60	40.8	44.9
Caitlin Ann	D960836	31	1990	13	98.00	33.00	15.70	340.2	374.2
Eldorado	D690849	32	1985	18	56.00	17.00	8.60	54.9	60.3
Kristen Gail	D618791	33	1980	23	87.00	26.00	12.80	194.0	213.4
Fiore D'Mare	D550564	34	1973	30	71.50	23.00	11.40	125.6	138.2
Endurance	D613302	35	1979	24	49.00	16.00	8.00	42.0	46.2
New Sunbeam	D284470	36	1961	42	50.30	20.00	4.00	27.0	29.7
Calogera A	D984694	37	1992	11	57.75	21.00	10.50	85.3	93.8
Eileen	D252749	38	1947	56	79.40	22.10	10.20	119.9	131.9
Pamela Rose	D693271	39	1985	18	54.00	19.00	9.00	61.9	68.1
New Stella	D598813	40	1978	25	58.00	22.00	8.40	71.8	79.0
Traveler	D661936	41	1983	20	56.00	17.00	6.90	44.0	48.4
Lucky Star	D295673	42	1964	39	49.90	17.00	7.30	41.5	45.6
Ocean Angel II	D622522	43	1980	23	74.50	28.00	10.70	149.5	164.5
Mello Boy	D1061917	44	1997	6	66.00	26.00	12.00	138.0	151.8
Trionfo	D625449	45	1980	23	63.80	19.30	9.60	79.2	87.1
Jenny Lynn	D541444	46	1972	31	66.00	21.60	8.90	85.0	93.5
Heavy Duty	D655523	47	1983	20	58.00	21.30	10.20	84.4	92.9
Aliotti Bros	D685870	48	1985	18	67.60	26.00	9.10	107.2	117.9
Lady J	D647528	49	1982	21	50.30	17.00	7.10	40.7	44.7
Anna S	D253402	50	1947	56	50.80	16.20	9.10	50.2	55.2
Endeavor	D971540	51	1990	13	57.40	19.00	9.90	72.3	79.6
Antoinette W	D606156	52	1978	25	45.40	16.00	7.60	37.0	40.7
Donna B	D648720	53	1982	21	73.20	25.00	12.90	158.2	174.0
Papa George	D549243	54	1973	30	72.00	22.80	11.50	126.5	139.1
Mercurio Bros	D650376	55	1982	21	42.00	16.70	8.60	40.4	44.5
Kathy Jeanne	D507798	56	1967	36	65.90	22.20	8.80	86.3	94.9

Vessel Name	CG Number	Permit Number	Year Built	Vessel Age	CG Measurements (ft.)[1/] Length	Breadth	Depth	Calculated GT Endorsement[2/]	Max. Transfer Allowance[3/]
Merva W	D532023	57	1971	32	56.70	17.90	8.00	54.4	59.8
Santa Maria	D236806	58	1937	66	79.20	19.50	8.80	91.1	100.2
Buccaneer	D592177	59	1978	25	62.10	19.90	9.00	74.5	82.0
Midnight Hour	D276920	60	1958	45	61.10	18.00	8.60	63.4	69.7
Nancy B II	D542513	61	1972	31	56.40	18.00	8.80	59.9	65.8
Miss Kristina	D580843	62	1977	26	50.00	16.00	7.40	39.7	43.6
Emerald Sea	D626289	63	1980	23	62.70	26.00	7.90	86.3	94.9
Connie Marie	D624240	64	1980	23	49.90	17.90	9.10	54.5	59.9
Theresa Marie	D629721	65	1980	23	40.60	14.70	6.60	26.4	29.0

1/ Vessel dimension data were obtained from the U.S. Coast Guard web site http://psix.uscg.mil

2/ Vessel calculated gross tonnage is GT=0.67(length*breadth*depth)/100. See 46 CFR 69.209.

3/ Maximum transfer allowance is based on vessel GT + 10%.

4/ Pacific Journey was built in Canada and is not currently registered with the U.S. Coast Guard. Measurements by marine surveyor Det Norske Veritas.

Table 5. Number of commercial landings sampled per year by the CDFG port sampling program, 1985-2002.

Year	Sardine Landings	Mackerel Landings	Total Landings
2002	137	94	231
2001	172	89	261
2000	110	85	195
1999	157	70	227
1998	97	97	194
1997	113	116	229
1996	96	85	181
1995	254	215	469
1994	119	167	286
1993	85	183	268
1992	231	113	344
1991	169	42	211
1990	99	233	332
1989	149	451	600
1988	190	385	575
1987	128	510	638
1986	105	440	545
1985	40	333	373

Table 6. Incidental catch from landings sampled by the CDFG port sampling program, 1992-1999. (Information represents **occurrence** of incidental catch, not numbers or weights of fish.)

Yr	Anchovy	Jacksmelt	Herring	White Croaker	M. Squid	Lingcod	Pac Mack	Y-tail	Jack Mackerel	Y-fin Tuna	Skipjack Tuna	Total
99	5	1	1									7
98	3		2	1	4							10
97	1		1		44							46
96	8			1	22	1						32
95	5		1		71		1	1	1			80
94			1									1
93												--
92					1					1	1	3

Table 7a. Incidental catch recorded by CDFG CPS port samplers in Los Angeles County, California, 2001.

Fishes	Incidents	Elasmobranchs	Incidents	Invertebrates, Vegetation and Garbage	Incidents
Halibut	8	Pacific electric ray	2	Kelp	50
Bonito	1	"Sand shark"	1	Crab	7
Sablefish	3	Spiny dogfish	1	Sea cucumber	2
Cusk eel	4	Smoothhound	1	"Debris"	1
Kelp bass	1	"Shark"	1	Kelp fronds	1
Sand bass	2	Sevengill shark	1	Lobster	3
Flyingfish	1	Bat ray	22	Plastic bottle	1
Lizardfish	6	"Skates"	4	Sea star	2
Tonguefish	3	Thornback	4	"Sea weed"	4
Sardine	13	Horn shark	4	Snail	1
"Flatfish"	33	Swell shark	1	Squid	16
Butterfish	5	Stingray	2	Squid eggs	1
Pompano	1				
Barracuda	5				
Midshipman	13				
Senorita	1				
"Bass"	1				
Anchovy	10				
Jacksmelt	4				
White croaker	19				
Pacific mackerel	21				
Jack mackerel	29				
California Scorpionfish	26				
Total	210	Total	44	Total	89

Table 7b. Incidental catch recorded by CDFG CPS port samplers in Los Angeles County, California, 2002.

Fishes	Incidents	Elasmobranchs	Incidents	Invertebrates, Vegetation and Garbage	Incidents
Anchovy, northern	13	Guitarfish, shovelnose	1	Crab, pelagic red	6
Barracuda, California	2	Ray, bat	20	Crab, shells	1
Bass, barred sand	5	Ray, CA butterfly	1	Crab, unsp. Rock	3
Bass, kelp	2	Ray, Pacific electric	3	Cucumber, sea	3
Bonito, Pacific	1	Ray, round stingray	1	Eelgrass	3
Butterfish	11	Shark, brown smoothhound	1	Gorgonians	1
Corbina, California	5	Shark, gray smoothhound	1	Jellyfish	1
Croaker, white	24	Shark, Pacific angel	1	Kelp	67
Croaker, yellowfin	1	Shark, unspecified	1	Lobster, California spiny	3
Cusk-eel	9	Skate, thornback	5	Octopus, unspecified	3
Eel, Yellow Snake	1	Skate, unspecified	2	Pleurobranch	1
Flatfish, unspecified	29			Prawn, spot	1
Flyingfish	2			Salps	19
Halibut, California	6			Sea stars	2
Herring, round	1			Squid egg cases	1
Jacksmelt	3			Squid, market	35
Lizardfish, California	9				
Midshipman, plainfin	13				
Sanddab	1				
Scorpionfish, California	26				
Seabass, giant (black)	1				
Senorita	1				
Sole, bigmouth	1				
Sole, fantail	1				
Surfperch, pink	2				
Surfperch, unspecified	1				
Tonguefish	3				
Topsmelt	1				
Turbot, curlfin	1				
Turbot, diamond	1				
Turbot, hornyhead	3				
Whitefish, ocean	1				
Total incidents	181	Total incidents	37	Total incidents	150

Table 8a. Observed market squid incidental catch for 2002. Incidental catch includes species landed with market squid and recorded on landing receipts.

Species Name	Number of Landings	Tons (mt)
Pacific sardine	162	2079.1
Northern anchovy	80	339.5
Pacific mackerel	56	66.3
Jack mackerel	47	15.0
Ridgeback prawn	39	13.8
Dover sole	29	4.7
Sea cucumber	20	2.2
Jacksmelt	15	1.7
Sablefish	12	0.9
Bank rockfish	8	0.7
Albacore	7	0.5
Spot prawn	7	0.5
California halibut	6	0.3
Pacific butterfish	6	0.3
Sole	4	0.2
Skate	3	0.2
Pacific ocean shrimp	3	0.1
California sheephead	3	0.1
Bluefin tuna	2	0.1
Sand sole	2	0.1
Rockfish	2	0.1
Surfperch	2	0.1
Gray smoothound shark	2	0.1
26 other species	61	4.2

Table 8b. Observed market squid bycatch by percent frequency of occurrence (n = 496; January 2002 through December 2002). Bycatch is discriminated from incidental catch as catch landed but not recorded on landing receipts.

Species name	Percent frequency of occurrence
Pacific sardine	17.3
Colonial invertebrates	10.9
Kelp	9.5
Market squid eggs	6.7
Pacific mackerel	6
Northern anchovy	3.8
Jack mackerel	3
Pacific butterfish	3
Jacksmelt	2.6
Bat ray	2.4
Dungeness crab	2
Miscellaneous fish	2
Pacific electric ray	1.4
Pelagic red crab	1.4
Sanddab	1.2
King salmon	1
Rock crab	0.8
Sculpin	0.8
Sea star	0.8
White croaker	0.6
Bocaccio	0.4
Cabezon	0.4
Pacific herring	0.4
Pacific saury	0.4
Rockfish	0.4
Bigmouth sole	0.2
Curlfin turbot	0.2
Diamond turbot	0.2
English sole	0.2
Greenspotted rockfish	0.2
Horn shark	0.2
Hornyhead turbot	0.2
Midshipman	0.2
Mussel	0.2
Olive rockfish	0.2
Pacific sanddab	0.2
Pink surfperch	0.2
Queenfish	0.2
Ray	0.2
Sea urchins	0.2
Shovelnose guitarfish	0.2
Sole	0.2
Stingray	0.2
Surfperch	0.2
Trigger fish	0.2
Turbot	0.2

Table 9. Expanded salmonid bycatch in Pacific sardine fisheries in Oregon and Washington, 2000- 2002.

	Chinook (live)	Chinook (dead)	Coho (live)	Coho (dead)	Pink (live)	Unid Sal (live)	Unid Sal (dead)	Total (live)	Total (dead)	Grand Total
2002										
Oregon								199	81	280
Washington	150	356	61	765	0	200	0	411	1,121	1,532
2001										
Oregon	45	45	201	134	22	45	0	313	179	492
Washington	449	170	571	504	0	80	0	1100	674	1774
2000										
Oregon	43	72	159	43	0	303	43	505	158	663
Washington	38	3	276	116	0	7	0	321	119	440

Table 10. Observed and reported catches of non-target species caught in the Pacific sardine fishery off of Oregon, 2002.

Species	Logbook Data # Caught	Observer Data # Caught
Blue shark	1	2
Thresher shark	1	
Unknown	450 lb	1
Salmon (unknown)	274	8
	(71% alive; 29%	(50% alive; 50%
Herring	55,000 lb	
Mackerel	133,430 lb	2,500 lb
Anchovy	22,550 lb	
Shad	200 lb	300 lb
Hake		15 lb
Cod		4 lb

Table 11. Observed and expanded total number of salmon caught in the Pacific sardine fishery off of Oregon, 2000 - 2002. (Expanded total is based on salmon per trip).

	Chinook		Coho		Pink	Unknown		Total		Grand Total
	alive	dead	alive	dead	alive	alive	dead	alive	dead	
2002 expanded total								199	81	280
2001 expanded total	45	45	201	134	22	45	0	313	179	492
2000 expanded total	43	72	159	43	0	303	43	504	159	663

Table 12a. Expanded observed bycatch data for the 2000 - 2002 Washington trial sardine fisheries. Expanded data based upon salmon and shark per mt sardines landed.

Year	Chinook (live)	Chinook (dead)	Coho (live)	Coho (dead)	Unkn. Salmon (live)	Shark (live)	Shark (dead)
2002	150	356	61	765	200	37	22
2001	449	170	571	504	80	150	50
2000	38	3	276	116	7	169	31

Table 12b. List of the observed and reported logbook catches of non-targeted species caught in the 2002 Washington sardine fishery (non-expanded numbers of individuals, unless otherwise noted).

	Observer Data		Logbook Data	
Species	# Released Alive	# Dead	# Released Alive	# Dead
Anchovy	1 lbs	0	4 mt	0
Blackcod	0	1	0	0
Blue Shark	9	10	4	0
Cabezon	1	0	0	0
Chinook salmon	17	42	65	56
Chum salmon	0	4	11	3
Coho salmon	13	55	73	75
Dogfish	353	172	3	0
Dungeness crab	0	9	0	0
Hake	0	216	351	0
Herring	1 mt	0	9 mt	0
Pink salmon	0	0	0	0
Pollock	0	0	100	0
Salmon species	23	11	24	11
Sanddab	236	100	0	0
Sea lion	0	0	0	0
Shad	45	3,360	50	0
Skate	4	5	0	0
Smelt	24	0	0	0
Soupfin shark	3	0	0	0

Species	Observer Data # Released Alive	# Dead	Logbook Data # Released Alive	# Dead
Squid	0	1	0	0
Starry flounder	3	15	0	0
Steelhead	0	0	0	0
Sunfish	2	0	0	0
Thresher shark	2	0	2	0
Wolf-eel	0	1	0	0
Yellowtail rockfish	0	1	0	0

Table 13. Species noted as encountered on CDFG Live Bait Logs, 1996-2002.

Year	Days Fished	Grunion	Smelts	Barracuda	Herring	Stickle-back	Shiner Surfperch	Sea Star	Queenfish
2002	1,073			1					1
2001	1,052	1		56					
2000	488	1		34					
1999	449		1	7	1				
1998	809			69	1		1		
1997	773			104			3	1	
1996	522		5	27	3	1			

Table 14. Estimates of Pacific sardine and Northern anchovy live bait harvest in California (mt). Data for 1939-1992 from Thomson et al. (1994), and 1993-2002 from CDFG logs.

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

Table 15. Ratio of N. anchovy to P. sardine in preliminary reported live bait catch in California, 1994-2002.

Year	Anchovy	Sardine	Total	% Anchovy	% Sardine
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 16. Commercial harvest (metric tons) of CPS finfish in Ensenada, Northern Baja California, Mexico, 1978-2001[1/]. Market squid are not commercially fished off Ensenada.

Year	Sardine	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	31,392	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

1/ Source: Data provided by Biol. Walterio Garcia-Franco, Instituto Nacional de la Pesca, Ensenada.

Table 17. 1983-2002, Pacific sardine time series of stock biomass (age-1 fish in mt) and recruitment (age-0 fish in 1,000s) estimated at the beginning of semester 2 of each year. Stock biomass estimates are presented for Area 1 (Inside) and the Total Area of the stock. The 95% confidence intervals (CI) for Total Area biomass and recruitment estimates are also presented. See Conser *et al.* (2002) for details regarding methods used to derive estimates.

Year	Area 1	Total Area	Lower CI	Upper CI	Total Area	Lower CI	Upper CI
1983	5,145	5,145	2,988	10,237	149,689	89,658	270,675
1984	13,409	13,473	9,132	23,233	224,302	147,543	392,307
1985	21,173	21,675	15,754	36,295	217,919	147,483	370,813
1986	29,917	31,546	24,369	49,475	866,710	623,621	1,366,185
1987	73,715	77,313	60,204	115,178	839,143	605,890	1,256,424
1988	107,013	116,721	95,152	162,348	1,465,991	1,032,887	2,389,804
1989	162,381	181,604	148,898	254,547	1,157,082	791,458	1,975,840
1990	176,794	210,440	173,500	301,142	4,792,851	3,130,855	8,333,861
1991	226,334	263,632	203,648	413,259	5,889,816	3,719,993	10,548,967
1992	353,005	421,519	323,045	659,025	4,170,058	2,597,005	7,521,409
1993	335,486	447,224	344,253	681,348	9,244,272	6,537,849	15,455,594
1994	494,524	654,337	535,996	955,097	10,755,601	7,664,169	17,160,261
1995	508,294	726,690	598,227	1,029,945	6,607,815	4,604,385	10,396,623
1996	531,651	791,496	667,663	1,094,850	5,550,420	4,069,965	8,823,371
1997	482,595	770,613	659,886	1,030,390	9,424,984	6,870,295	14,799,898
1998	457,126	775,882	668,011	1,056,753	15,082,296	10,943,898	23,682,041
1999	610,828	992,323	833,745	1,384,818	8,217,217	5,254,279	14,563,581
2000	586,710	1,000,871	827,203	1,404,431	9,386,310	5,567,436	17,800,084
2001	510,877	928,578	728,391	1,405,681	10,773,256	5,945,732	22,997,633
2002	570,306	999,871	704,161	1,668,985	8,362,928	3,677,163	21,765,966

Table 18. Annual U.S. West Coast Pacific sardine landings and harvest guidelines (metric tons) by state and management subarea, 1981-2002.

						Management Area Landings			Harvest Guidelines		
						Southern	Northern	WOC	Southern	Northern	
Year	So. Calif.	No. Calif.	Calif. Total	Oregon	Washington	Subarea	Subarea	Total	Subarea	Subarea	Total HG
1981	34.4	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	1.8	0.0	0.0	1.8	0.0	1.8	n/a	n/a	n/a
1983	0.6	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	1.2	0.0	0.0	0.9	0.3	1.2	n/a	n/a	n/a
1985	3.7	2.2	5.8	0.0	0.0	3.7	2.2	5.8	n/a	n/a	n/a
1986	304.0	84.4	388.5	0.0	0.0	304.0	84.4	388.5	n/a	n/a	n/a
1987	391.6	47.8	439.4	0.0	0.0	391.6	47.8	439.4	n/a	n/a	n/a
1988	1,185.4	3.0	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	836.7	0.0	0.0	598.7	238.0	836.7	n/a	n/a	n/a
1990	1,537.1	127.1	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	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	17,949.5	0.0	0.0	14,821.9	3,127.6	17,949.5	n/a	n/a	n/a
1993	14,669.6	675.6	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	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	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	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	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	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	59,263.5	775.5	0.0	42,017.2	18,021.8	60,039.0	n/a	n/a	n/a
2000	42,296.9	11,367.4	53,664.2	9,527.9	0.0	42,296.9	25,686.7	67,983.6	124,527.3	62,263.7	186,791.0
2001	44,708.9	7,102.5	51,811.4	12,780.3	11,127.1	44,708.9	31,009.9	75,718.8	89,824.7	44,912.3	134,737.0
2002	49,366.7	14,078.1	63,444.8	23,125.8	15,832.4	49,366.7	53,036.3	102,403.0	78,961.3	39,480.7	118,442.0

Table 19. West Coast Pacific sardine landings by country. Mexican landings are for Ensenada, Northern Baja California, 1981-2002.

Year	Mexico	United States	Canada	Total
1981	0.0	34.4	0.0	34.4
1982	0.0	1.8	0.0	1.8
1983	273.6	0.6	0.0	274.2
1984	0.2	1.2	0.0	1.4
1985	3,722.3	5.9	0.0	3,728.2
1986	242.6	388.5	0.0	631.1
1987	2,431.6	439.4	0.0	2,871.0
1988	2,034.9	1,188.4	0.0	3,223.3
1989	6,224.2	836.7	0.0	7,060.9
1990	11,375.3	1,664.2	0.0	13,039.5
1991	31,391.8	7,587.3	0.0	38,979.1
1992	34,568.2	17,949.5	0.0	52,517.7
1993	32,045.0	15,345.4	0.0	47,390.4
1994	20,876.9	11,643.5	0.0	32,520.4
1995	35,396.2	40,326.9	25.0	75,748.1
1996	39,064.7	32,553.1	88.0	71,705.8
1997	68,439.1	43,245.1	34.0	111,718.2
1998	47,812.2	42,965.4	745.0	91,513.6
1999	58,569.4	60,039.0	1,250.0	119,858.4
2000	51,172.9	67,983.6	1,718.0	120,874.5
2001	22,246.0	75,718.8	1,600.0	99,564.8
2002	43,436.4	102,403.0	703.0	146,542.4

Table 20. RecFIN estimated recreational harvest of Pacific (chub) mackerel in California by fishing mode (metric tons), 1980-2002.

Year	Man Made Structures	Beach/Bank	Shore Modes	Party/Charter	Private/Rental	Calif Total
1980	349.9	74.9	-	1320.5	1,009.2	2,754.4
1981	224.6	63.4	-	590.7	515.7	1,394.5
1982	271.5	3.2	-	865.1	527.6	1,667.5
1983	358.5	3.4	-	702.6	404.3	1,468.9
1984	257.9	24.0	-	577.9	585.5	1,445.4
1985	141.4	0.6	-	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
1993	88.3	0.5	-	172.2	362.1	623.0
1994	200.9	5.0	-	245.1	496.3	947.3
1995	119.4	1.8	-	373.4	531.8	1,026.3
1996	92.5	0.9	-	319.4	281.1	693.9
1997	145.0	3.3	-	169.0	650.5	967.8
1998	96.4	0.4	-	131.3	221.4	449.4
1999	57.3	5.1	-	60.7	73.3	196.4
2000	34.4	16.9	-	76.9	121.9	250.1
2001	138.3	208.8	-	52.2	162.2	561.4
2002	71.8	20.2		24.4	159.5	276.0

Notes from RecFIN query:
1. No data in from 1990 to 1992.
2. No data in wave 1 1995.
3. Data in 2002 are preliminary and may be incomplete.
4. Northern California charter boats were not fully sampled due to refusals.
5. Northern California charter boat tuna trips were not fully sampled.
6. Year 2002 California Party Charter (PC) estimates from PC Phone Survey.

Table 21. RecFIN estimated recreational harvest of Pacific (chub) mackerel by subarea (metric tons), 1980-2002.

Year	Southern California	Northern California	Oregon	Washington	Total
1980	2,745.3	9.1	-	-	2,754.4
1981	1,225.6	168.8	-	-	1,394.5
1982	1,554.7	112.8	-	-	1,667.5
1983	1,341.3	126.0	1.5	-	1,468.9
1984	1,257.4	187.7	0.2	-	1,445.4
1985	1,028.0	48.6	0.0	-	1,076.6
1986	968.2	34.3	-	-	1,002.6
1987	1,257.7	13.5	-	-	1,271.2
1988	778.9	21.2	-	-	800.1
1989	605.6	5.0	-	-	610.6
1990	N/A	N/A	N/A	N/A	N/A
1991	N/A	N/A	N/A	N/A	N/A
1992	N/A	N/A	N/A	N/A	N/A
1993	591.0	30.9	1.1	-	623.0
1994	933.4	13.8	0.2	-	947.3
1995	1,022.9	3.4	0.0	-	1,026.3
1996	664.0	29.8	0.1	-	693.9
1997	568.6	398.4	0.8	-	967.8
1998	425.6	22.6	0.1	1.0	449.4
1999	193.0	3.0	-	0.3	196.4
2000	248.6	1.4	0.1	-	250.1
2001	557.5	3.9	-	-	561.4
2002	275.9	0.0	-	-	276.0

Notes from RecFIN query:
1. No data in from 1990 to 1992.
2. No data in wave 1 1995.
3. Data in 2001 are preliminary and may be incomplete.
4. Northern California charter boats were not fully sampled due to refusals.

Table 22. West coast landings (mt) and real[1] exvessel revenues ($ 2002) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2002.

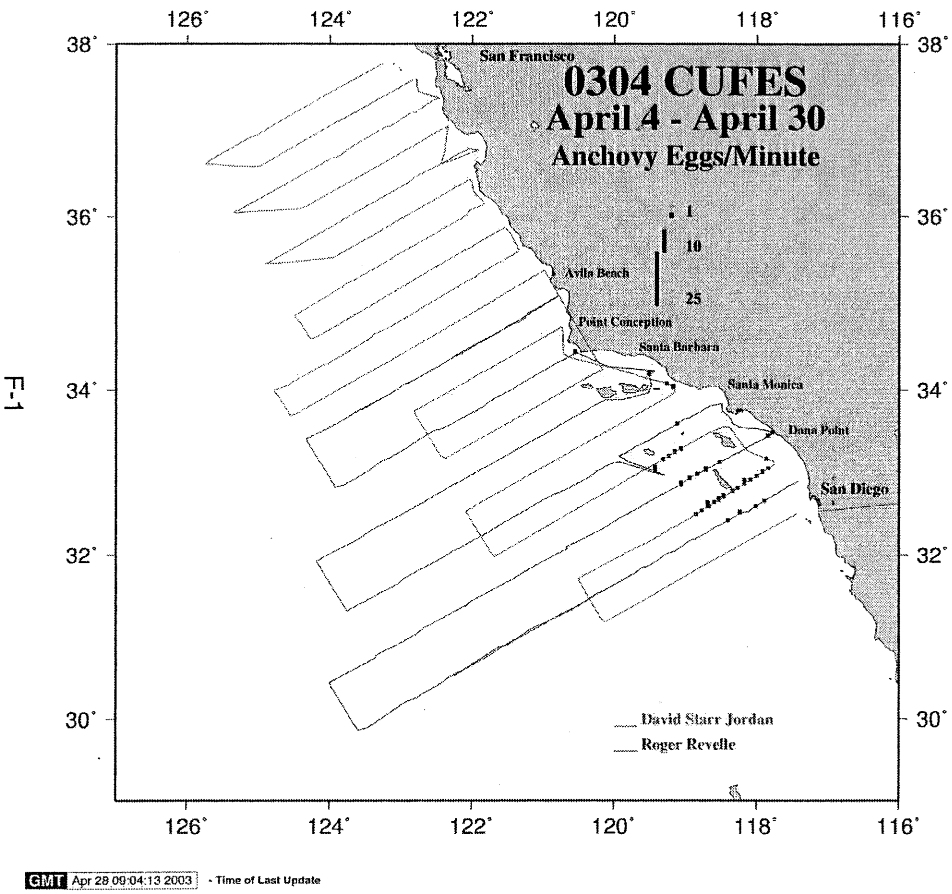
Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
1981	15	$5,355	35,388	$12,920,673	17,778	$6,482,366	52,309	$5,808,068	23,510	$9,012,896
1982	2	$899	36,065	$12,142,186	19,617	$6,655,295	42,155	$3,629,837	16,308	$5,966,853
1983	1	$281	41,479	$12,939,111	9,829	$2,883,549	4,430	$674,171	1,824	$1,217,719
1984	1	$1,346	44,084	$12,885,145	9,149	$2,115,521	2,899	$643,750	564	$463,595
1985	6	$2,123	37,772	$9,958,375	6,876	$1,937,405	1,638	$347,575	10,276	$5,625,463
1986	388	$120,140	48,089	$11,706,260	4,777	$1,242,854	1,557	$484,451	21,278	$6,647,506
1987	439	$89,183	46,725	$9,545,117	8,020	$1,688,696	1,467	$442,002	19,984	$5,647,446
1988	1,188	$219,728	50,864	$11,690,368	5,068	$1,097,825	1,518	$552,899	37,232	$10,854,819
1989	837	$243,796	47,713	$9,508,221	10,745	$2,082,516	2,511	$1,321,197	40,893	$9,241,830
1990	1,664	$254,207	40,092	$6,842,426	3,223	$556,634	3,259	$812,439	28,447	$6,073,399
1991	7,587	$1,105,183	32,019	$6,594,127	1,712	$307,124	4,068	$819,737	37,389	$7,512,415
1992	17,954	$2,203,084	19,045	$4,782,266	1,526	$287,231	1,166	$288,530	13,110	$3,006,019
1993	15,347	$1,811,677	12,129	$1,777,597	1,950	$336,908	2,003	$577,955	42,830	$11,956,914
1994	11,644	$2,087,651	10,293	$1,657,295	2,906	$448,654	1,859	$637,657	55,892	$20,294,448
1995	40,256	$4,157,745	8,823	$1,280,169	1,877	$314,754	2,016	$489,760	70,252	$25,460,763
1996	32,553	$3,391,813	9,725	$1,452,215	2,438	$335,695	4,505	$1,066,213	80,320	$35,361,701
1997	42,839	$4,420,752	20,162	$3,019,192	1,534	$305,930	5,778	$897,852	70,247	$23,721,838
1998	42,581	$3,873,059	20,405	$2,722,544	1,563	$330,526	1,553	$256,584	2,709	$1,629,804
1999	60,130	$5,448,175	9,094	$1,154,812	1,579	$212,488	5,311	$1,013,305	91,519	$35,146,611
2000	68,034	$7,532,323	22,042	$3,025,684	1,450	$283,212	11,831	$1,493,894	117,953	$27,986,222
2001	75,720	$9,221,652	7,618	$1,314,806	3,839	$621,322	19,256	$1,436,955	85,829	$17,756,115
2002	96,824	$10,582,225	3,733	$523,943	1,025	$206,634	4,882	$623,366	72,317	$18,067,636

Source: PacFIN data extracted May, 2003.

[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 2002.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

Figure . Distribution of northern anchovy and jack mackerel eggs collected during CalCOFI cruise 0304 (April 2003) using the Continuous Underway Fish Egg Sampler (CUFES). Maps provided by SWFSC: http://swfsc.nmfs.noaa.gov/frd/CalCOFI/CurrentCruise/currentcruise.htm.



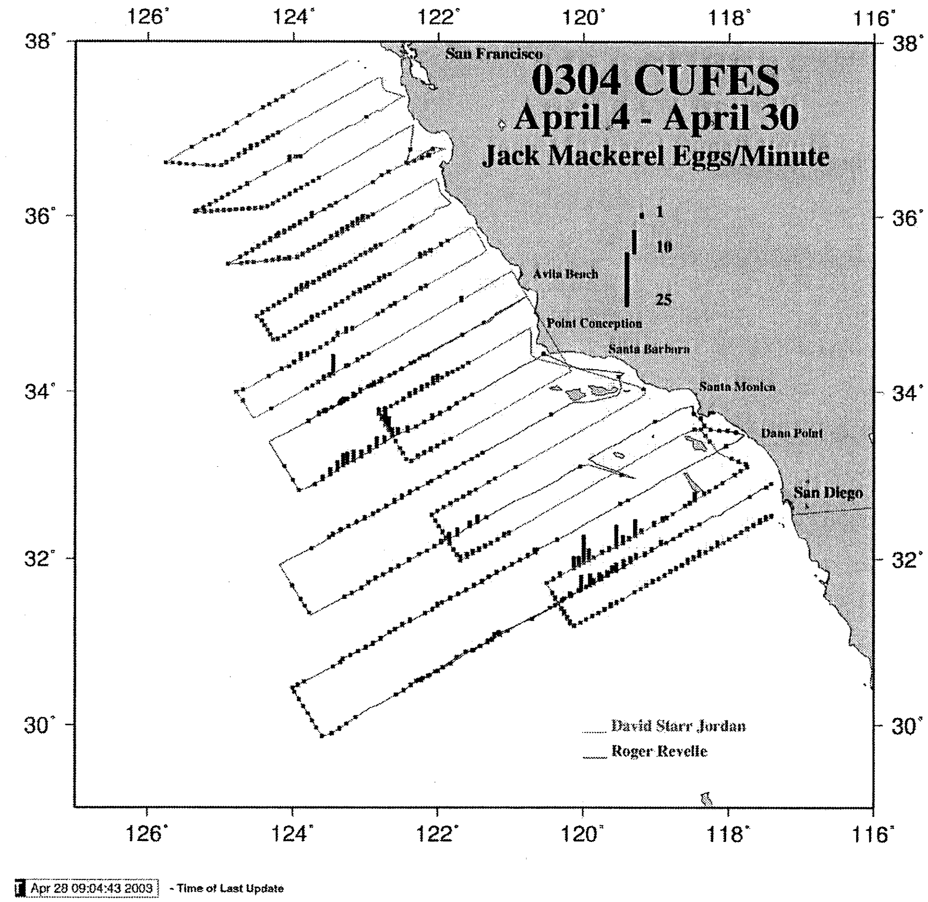
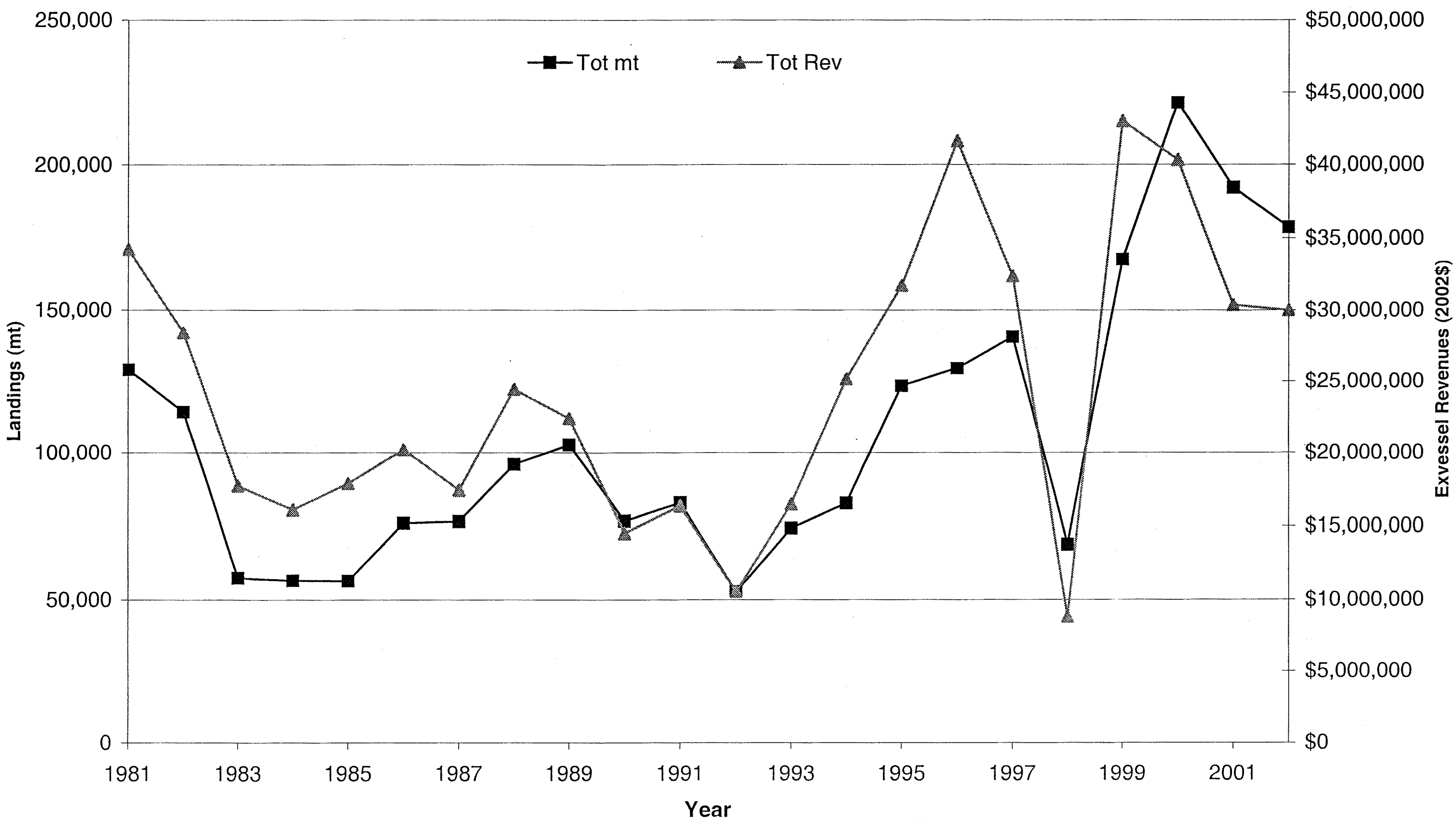


Figure 2. Annual Pacific coast landings and real exvessel revenues for all CPS species, 1981-2002.



APPENDIX 1

ECONOMIC STATUS

OF

WASHINGTON, OREGON, AND CALIFORNIA

CPS FISHERIES

IN 2002

Samuel F. Herrick, Jr. National Marine Fisheries Service, Southwest Fisheries Science Center

June 2003

Table 1. Pacific coast landings (mt) and real[1] exvessel revenues ($ 200[illegible] Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by landing area, 1981-2002.

	Landings (mt)					Exvessel Revenues (2002 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
San Diego										
1981		13	12	2	4		$16,340	$7,209	$1,161	$3,199
1982		30	<1		<1		$22,176	$217		$36
1983		18	<1	2	1		$15,310	$856	$1,102	$1,148
1984	<1	27	<1			$408	$20,101	$637		$38
1985		19	<1		<1		$26,996	$131		$216
1986		9	<1				$8,819	$308		$17
1987	<1	10	<1	<1	3	$48	$10,974	$1,379	$16	$2,047
1988	<1	17	<1	6	19	$76	$16,522	$1	$4,456	$9,750
1989	<1	8	<1	94	2	$208	$8,556	$19	$221,762	$2,944
1990	<1	8	<1	18	1	$248	$7,297	$79	$51,360	$1,383
1991		11	<1	400			$9,517	$97	$121,482	
1992	<1	17	1	121	16	$213	$16,861	$1,152	$24,486	$4,352
1993	<1	16	3	4	<1	$624	$15,578	$3,031	$1,041	$101
1994	2	21	5	28	<1	$1,001	$15,682	$2,952	$11,153	$249
1995	5	31	<1	38	<1	$4,625	$19,589	$494	$42,733	$653
1996	1	26		145	2	$1,233	$17,171		$75,305	$581
1997	3	16	<1	12	3	$3,214	$10,718	$2	$5,986	$781
1998	215	52		2	2	$21,493	$9,228		$1,093	$1,409
1999	592	15	<1	2	4	$63,221	$4,821	$132	$702	$4,753
2000	19	2	<1	4	35	$7,581	$2,212	$235	$1,792	$10,918
2001	<1	3	<1	2	11	$100	$2,570	$112	$751	$14,798
2002	90	<1	<1	5	1	$59,190	$897	$113	$3,098	$1,138
Orange/LA										
1981	15	29,140	14,706	38,384	8,291	$5,341	$10,723,739	$5,356,698	$4,210,196	$1,706,731
1982	2	29,875	18,141	32,632	4,293	$827	$10,026,283	$6,170,677	$2,598,561	$964,128
1983	<1	33,904	6,788	1,023	854	$259	$10,875,500	$2,218,225	$209,583	$523,618
1984	<1	35,574	3,567	264	66	$525	$11,205,567	$1,086,387	$143,956	$56,945
1985	3	32,013	5,860	68	3,097	$1,223	$8,622,630	$1,643,164	$28,195	$1,536,058
1986	287	41,072	4,289	161	8,125	$88,807	$10,159,610	$1,080,736	$38,318	$2,706,508
1987	317	39,865	7,801	115	5,422	$65,839	$8,182,064	$1,637,514	$30,896	$1,586,122
1988	1,172	47,659	4,939	94	15,090	$214,511	$10,655,144	$1,055,017	$24,576	$4,279,135
1989	505	41,722	10,704	503	16,354	$77,720	$8,522,192	$2,069,322	$78,281	$3,554,337
1990	1,180	37,139	2,936	201	9,798	$186,355	$6,352,407	$497,049	$43,689	$1,764,679
1991	6,415	31,567	1,640	434	12,307	$942,129	$6,490,513	$282,628	$66,606	$1,996,555
1992	13,849	18,078	1,096	137	1,701	$1,657,047	$4,647,373	$262,477	$25,027	$313,440
1993	13,978	11,724	1,269	119	12,890	$1,656,472	$1,733,541	$216,128	$18,453	$3,175,088
1994	9,032	9,844	2,460	137	11,231	$1,137,028	$1,574,928	$335,768	$19,012	$2,752,924
1995	34,137	7,864	1,596	298	18,415	$3,382,247	$1,161,277	$218,906	$32,099	$5,821,511
1996	23,923	8,761	2,054	239	14,768	$2,410,586	$1,255,939	$302,342	$27,089	$4,795,945
1997	26,083	13,997	823	1,121	17,697	$2,710,173	$2,396,412	$195,679	$103,521	$6,305,180
1998	30,781	16,987	798	338	238	$2,972,616	$2,322,714	$262,236	$44,015	$145,569
1999	39,084	8,551	927	1,418	27,574	$3,707,940	$1,094,990	$195,647	$230,339	$9,629,424
2000	39,181	21,631	1,210	1,279	44,840	$4,334,988	$2,985,561	$233,536	$151,262	$11,743,120
2001	40,682	6,677	3,624	3,658	39,055	$4,522,838	$1,078,843	$568,287	$326,018	$8,892,050
2002	38,821	3,358	1,003	1,206	27,981	$3,785,987	$486,522	$202,162	$101,621	$6,372,819

Year	Landings (mt)					Exvessel Revenues (2002 $)				
	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
Ventura/Santa Barbara										
1981	<1	4,873	2,847	9,077	2,390	$13	$1,782,321	$1,036,626	$1,011,410	$382,054
1982		4,096	1,195	6,514	1,403		$1,458,516	$390,304	$589,016	$248,934
1983	<1	4,083	583	2,749	7	$2	$1,205,483	$164,123	$261,050	$6,509
1984		1,310	101	192	10		$370,963	$28,095	$90,435	$15,371
1985		3,002	787	114	3,289		$716,253	$211,834	$47,348	$1,318,219
1986	18	5,007	297	162	6,832	$4,415	$1,178,672	$76,750	$62,691	$1,664,061
1987	74	5,885	8	172	8,606	$15,693	$1,177,648	$2,344	$64,876	$2,211,792
1988	13	3,122	7	190	16,898	$4,080	$987,894	$1,546	$77,236	$4,872,684
1989	93	5,908	<1	168	17,369	$16,306	$950,657	$30	$59,986	$3,583,006
1990	236	421	76	144	10,601	$27,311	$65,563	$8,821	$58,577	$2,473,434
1991	186	138	9	194	16,905	$26,419	$19,044	$1,175	$74,147	$3,092,050
1992	973	94	<1	93	2,834	$83,750	$10,556	$98	$36,142	$552,502
1993	692	39	<1	306	20,847	$61,456	$5,734	$10	$101,388	$5,141,235
1994	315	98	48	346	27,363	$26,570	$19,306	$3,711	$163,485	$10,844,378
1995	432	269	22	346	48,456	$54,450	$39,717	$3,856	$164,958	$18,412,999
1996	641	100	31	377	60,328	$93,522	$37,354	$8,900	$165,602	$28,859,452
1997	3,394	1,165	7	513	44,056	$331,428	$114,945	$533	$99,115	$14,146,940
1998	1,155	1,314		208	2,449	$104,112	$71,246		$84,019	$1,463,711
1999	2,545	215	<1	2,233	52,281	$256,975	$38,033	$9	$340,930	$21,129,611
2000	3,048	230	9	3,548	47,928	$306,041	$22,232	$902	$404,926	$10,193,168
2001	3,957	72	<1	3,909	31,876	$373,681	$6,719	$30	$456,050	$5,750,557
2002	5,065	<1	<1	732	11,409	$623,536	$14	$2	$181,686	$2,986,628
San Luis Obispo										
1981		1	<1	17	<1		$878	$15	$11,400	$135
1982		3	<1		<1		$1,985	$9		$401
1983		<1			<1		$515			$209
1984		5			<1		$2,955			$119
1985	<1	20	<1	48	<1	$94	$4,410	$53	$23,434	$402
1986		<1	<1	11	<1		$310	$17	$4,562	$124
1987		<1		2	<1		$654		$894	$370
1988	<1	<1			<1	$1	$287			$81
1989		1	<1	<1	19		$788	$2	$1,183	$5,678
1990	121	2	17		<1	$13,934	$1,096	$1,886		$71
1991		1	<1		<1		$581	$10		$21
1992		<1	<1		<1		$291	$65		$120
1993		<1	<1	1	2,036		$51	$15	$588	$950,694
1994	<1	<1	<1	<1	1,344	$30	$109	$5	$415	$672,170
1995		<1	<1		183		$18	$3		$45,111
1996		<1			217		$5			$68,307
1997	<1	<1		23	<1	$21	$2		$10,153	$17
1998	<1	<1	<1		4	$35	$158	$43		$2,318
1999		<1		2	17		$29		$942	$4,905
2000		<1	<1		<1		$2	$1		$7
2001		<1		4	79		$18		$1,546	$15,780
2002	102				356	$6,741				$76,015

	Landings (mt)					Exvessel Revenues (2002 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
Monterey/Santa Cruz										
1981		1,359	212	4,617	12,823		$396,448	$80,293	$480,194	$6,918,925
1982	<1	2,053	280	2,609	10,607	$72	$629,051	$93,337	$248,734	$4,750,842
1983	<1	3,449	2,457	321	500	$20	$823,686	$499,983	$72,654	$355,704
1984	<1	7,149	5,481	1,895	391	$413	$1,275,236	$1,000,255	$180,054	$307,379
1985	2	2,704	228	1,138	3,813	$806	$579,530	$82,184	$132,588	$2,719,531
1986	85	1,988	191	808	5,488	$26,919	$350,651	$85,044	$214,760	$1,956,198
1987	48	957	210	676	5,611	$7,512	$167,995	$46,862	$111,161	$1,733,557
1988	3	59	122	696	4,897	$1,055	$24,970	$40,819	$232,608	$1,589,009
1989	238	60	37	929	7,140	$149,546	$17,323	$9,112	$672,103	$2,091,912
1990	127	2,496	192	2,132	7,918	$26,323	$401,029	$47,860	$409,362	$1,794,261
1991	986	298	44	2,527	6,700	$136,635	$72,324	$20,134	$378,080	$1,993,607
1992	3,093	375	110	608	6,111	$454,747	$91,609	$21,513	$121,579	$1,566,717
1993	676	38	345	1,285	6,040	$93,124	$15,294	$105,264	$296,319	$2,263,086
1994	2,289	38	191	986	13,648	$920,633	$20,371	$96,892	$288,617	$5,266,384
1995	5,678	461	109	1,111	2,449	$714,921	$54,002	$82,997	$153,147	$934,874
1996	7,988	703	91	3,554	4,672	$886,343	$110,091	$14,584	$700,580	$1,516,424
1997	13,357	3,208	327	3,895	8,283	$1,374,513	$469,759	$107,738	$622,359	$3,189,522
1998	9,945	1,457	33	901		$737,376	$298,560	$11,840	$62,559	
1999	16,180	3	24	1,511	267	$1,241,330	$10,560	$1,846	$354,882	$83,120
2000	11,367	39	50	6,804	6,995	$1,001,842	$6,584	$27,624	$820,587	$1,945,375
2001	7,103	172		11,609	7,760	$1,451,401	$19,145		$573,660	$1,785,122
2002	13,607	<1	2	2,690	25,067	$1,297,728	$72	$388	$255,116	$6,792,794
San Francisco										
1981	<1	<1	2	211	<1	$1	$39	$1,511	$93,183	$13
1982		4	<1	395	2		$2,690	$267	$177,526	$869
1983		13	1	332	462		$4,802	$335	$121,148	$330,479
1984		16	<1	538	97		$8,844	$145	$212,876	$83,611
1985		15	<1	259	77		$8,553	$38	$98,187	$51,021
1986		12		393	832		$8,072		$134,993	$320,288
1987	<1	6	<1	424	343	$92	$5,026	$594	$150,384	$113,500
1988	<1	6	<1	492	299	$5	$5,077	$438	$169,003	$93,807
1989	<1	9	4	755	9	$16	$7,065	$4,030	$215,977	$3,468
1990	<1	14	2	714	129	$37	$9,071	$939	$195,990	$39,386
1991		3	<1	459	1,475		$1,853	$86	$133,406	$428,983
1992	35	12	1	164	2,448	$7,326	$11,648	$416	$41,456	$567,554
1993		1	<1	244	1,018		$1,363	$248	$128,208	$426,703
1994	<1	2	<1	280	2,236	$661	$1,775	$324	$95,780	$737,949
1995	2	<1	<1	93	747	$544	$589	$351	$9,871	$245,091
1996		5	<1	105	333		$2,698	$627	$27,492	$120,992
1997	3	4	<1	156	205	$1,404	$2,638	$387	$11,549	$77,006
1998	464	4	1	<1	16	$33,486	$3,812	$863	$21	$16,753
1999	949	<1	<1	47	5	$85,946	$608	$30	$15,479	$1,869
2000	<1	<1	<1	117	<1	$216	$21	$702	$65,580	$4
2001	<1	<1		4	9	$96	$1,678		$2,149	$2,406
2002	172	<1		17	865	$31,952	$2		$9,466	$214,735

Year	Landings (mt) Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Exvessel Revenues (2002 $) Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
Northern California										
1981		2	<1		2		$893	$15		$1,840
1982		4	1		2		$1,416	$483		$1,643
1983		3	<1		<1		$1,277	$27		$52
1984		<1	<1	<1	<1		$68	$2	$929	$130
1985					<1					$18
1986		<1			<1		$29			$311
1987		<1	<1		<1		$15	$3		$57
1988			<1		30			$3		$10,353
1989		<1			<1		$75			$486
1990		2			<1		$1,145			$184
1991		<1			2		$55			$1,200
1992		<1	1	<1	<1		$406	$546	$114	$1,334
1993		<1	55	<1	<1		$132	$9,082	$106	$6
1994	5	<1	<1	8	38	$1,728	$187	$77	$3,221	$12,095
1995	2	<1	<1		2	$958	$37	$36		$523
1996	<1	5				$129	$2,711			
1997		6	2		4		$3,410	$690		$2,392
1998	21	9	6		<1	$3,111	$3,158	$4,878		$45
1999		3	<1		<1		$816	$14		$6
2000		2	<1		<1		$347	$93		$600
2001	<1			2	<1	$40			$6,420	$84
2002		<1	<1		4		$478	$35		$1,286
Other California										
1981		<1					$13			
1982										
1983										
1984		<1					$27			
1985										
1986		<1					$95			
1987										
1988										
1989		<1					$8			
1990										
1991										
1992										
1993										
1994		4		4	33		$10,475		$281	$8,299
1995										
1996										
1997										
1998										
1999										
2000										
2001		<1					$76			
2002										

	Landings (mt)					Exvessel Revenues (2002 $)				
Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
	Oregon									
1981		<1					$2			
1982		<1		<1			$69		$167	
1983		8					$12,537			
1984		3					$1,251			
1985		<1	<1	<1			$3	$1	$58	
1986		<1					$1			
1987		2					$742			
1988		<1		<1			$474		$18	
1989		5		<1			$1,490		$20	
1990		10					$4,606			
1991		<1	19				$191	$2,993		
1992	4	462	317				$186	$961		
1993	<1	280	277				$1,009	$3,130		
1994		252	202	<1			$11,075	$8,926	$231	
1995		189	149	<1			$4,018	$8,110	$547	
1996		61	259				$4,232	$8,484		
1997		1,611	373				$2,483	$815		
1998	1	536	686			$831	$9,258	$46,901		
1999	776	259	518			$90,715	$1,065	$6,290		
2000	9,528	119	161	<1		$1,188,199	$6,509	$17,817	$310	
2001	12,780	322	183			$1,612,291	$71,927	$44,921		
2002	23,126	127	9	3		$2,839,110	$6,453	$2,128	$1,777	
	Washington									
1981				1					$524	
1982				5					$15,833	
1983				3					$8,634	
1984		<1		10			$133		$15,500	
1985				12					$17,766	
1986				22					$29,127	
1987				78					$83,775	
1988				40					$45,001	
1989		<1		62			$66		$71,885	
1990		<1		50			$199		$53,462	
1991		<1		55			$49		$46,016	
1992		6		42			$3,336		$39,725	
1993		30		20			$4,895		$12,774	
1994		33		39			$3,388		$31,332	
1995		8		118			$922		$73,749	
1996		65	3	86			$22,015	$758	$70,146	
1997		153	<1	59			$18,249	$86	$45,169	
1998		46	39	103			$4,405	$3,764	$64,877	
1999	1	47	108	98		$1,743	$3,868	$8,026	$70,023	
2000	4,842	19	20	79		$685,945	$2,018	$2,301	$49,362	
2001	11,127	371	32	68		$1,254,160	$133,526	$7,876	$70,361	
2002	15,833	248	12	229		$1,936,900	$29,429	$1,799	$70,602	

Source: PacFIN data extracted May, 2003.

[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 2002.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

Table 2. Average annual real[1] exvessel prices ($ 2002) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2002.

Year	Pacific Sardine $/lb	Pacific Mackerel $/lb	Jack Mackerel $/lb	Anchovy $/lb	Squid $/lb
1981	$0.16	$0.17	$0.17	$0.05	$0.17
1982	$0.20	$0.15	$0.15	$0.04	$0.17
1983	$0.13	$0.14	$0.13	$0.07	$0.30
1984	$0.61	$0.13	$0.10	$0.10	$0.37
1985	$0.16	$0.12	$0.13	$0.10	$0.25
1986	$0.14	$0.11	$0.12	$0.14	$0.14
1987	$0.09	$0.09	$0.10	$0.14	$0.13
1988	$0.08	$0.10	$0.10	$0.17	$0.13
1989	$0.13	$0.09	$0.09	$0.24	$0.10
1990	$0.07	$0.08	$0.08	$0.11	$0.10
1991	$0.07	$0.09	$0.08	$0.09	$0.09
1992	$0.06	$0.11	$0.09	$0.11	$0.10
1993	$0.05	$0.07	$0.08	$0.13	$0.13
1994	$0.08	$0.07	$0.07	$0.16	$0.16
1995	$0.05	$0.07	$0.08	$0.11	$0.16
1996	$0.05	$0.07	$0.06	$0.11	$0.20
1997	$0.05	$0.07	$0.09	$0.07	$0.15
1998	$0.04	$0.06	$0.10	$0.07	$0.27
1999	$0.04	$0.06	$0.06	$0.09	$0.17
2000	$0.05	$0.06	$0.09	$0.06	$0.11
2001	$0.06	$0.08	$0.07	$0.03	$0.09
2002	$0.05	$0.06	$0.09	$0.06	$0.11

Source: PacFIN data extracted May, 2003.

Table ⁝ st coast landings (mt) and real[1] exvessel revenues ($ 2002) for Pacific ne, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-2002.

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
	California									
1981	15	$5,355	35,388	$12,920,671	17,778	$6,482,366	52308	$5,807,544	23,510	$9,012,896
1982	2	$899	36,065	$12,142,116	19,617	$6,655,295	42150	$3,613,837	16,308	$5,966,853
1983	1	$281	41,471	$12,926,574	9,829	$2,883,549	4427	$665,537	1,824	$1,217,719
1984	1	$1,346	44,081	$12,883,761	9,149	$2,115,521	2889	$628,250	564	$463,595
1985	6	$2,123	37,772	$9,958,372	6,876	$1,937,404	1626	$329,751	10,276	$5,625,463
1986	388	$120,140	48,089	$11,706,259	4,777	$1,242,854	1535	$455,324	21,278	$6,647,506
1987	439	$89,183	46,724	$9,544,375	8,020	$1,688,696	1390	$358,228	19,984	$5,647,446
1988	1,188	$219,728	50,863	$11,689,894	5,068	$1,097,825	1478	$507,880	37,232	$10,854,819
1989	837	$243,796	47,708	$9,506,665	10,745	$2,082,516	2449	$1,249,292	40,893	$9,241,830
1990	1,664	$254,207	40,081	$6,837,608	3,223	$556,634	3208	$758,977	28,447	$6,073,399
1991	7,587	$1,105,183	32,018	$6,593,887	1,693	$304,131	4014	$773,721	37,389	$7,512,415
1992	17,950	$2,203,084	18,577	$4,778,743	1,209	$286,269	1124	$248,805	13,110	$3,006,019
1993	15,346	$1,811,677	11,819	$1,771,693	1,673	$333,778	1959	$546,103	42,830	$11,956,914
1994	11,644	$2,087,651	10,008	$1,642,832	2,704	$439,728	1789	$581,965	55,892	$20,294,448
1995	40,256	$4,157,745	8,626	$1,275,229	1,728	$306,643	1886	$402,807	70,252	$25,460,763
1996	32,553	$3,391,813	9,599	$1,425,968	2,176	$326,452	4419	$996,068	80,320	$35,361,701
1997	42,839	$4,420,752	18,395	$2,997,885	1,160	$305,029	5719	$852,683	70,247	$23,721,838
1998	42,580	$3,872,228	19,823	$2,708,875	838	$279,861	1450	$191,708	2,709	$1,629,804
1999	59,353	$5,355,718	8,788	$1,149,879	952	$198,172	5214	$943,281	91,519	$35,146,611
2000	53,664	$5,658,179	21,904	$3,017,158	1,269	$263,093	11752	$1,444,222	117,953	$27,986,222
2001	51,812	$6,355,202	6,925	$1,109,340	3,624	$568,525	19188	$1,366,593	85,829	$17,756,115
2002	57,866	$5,806,215	3,359	$488,061	1,005	$202,707	4650	$550,987	72,317	$18,067,636
	Oregon									
1981			<1	$2						
1982			<1	$69			<1	$167		
1983			8	$12,537						
1984			3	$1,251						
1985			<1	$3	<1	$1	<1	$58		
1986			<1	$1						
1987			1	$742						
1988			1	$474			<1	$18		
1989			5	$1,490			<1	$20		
1990			10	$4,619						
1991			<1	$191	19	$2,993				
1992			462	$186	317	$962				
1993			280	$1,009	277	$3,130				
1994			252	$11,075	202	$8,926	1	$231		
1995			189	$4,018	149	$8,110	<1	$547		
1996			61	$4,232	259	$8,484				
1997			1,611	$2,483	373	$815				
1998	1	$831	536	$9,258	686	$46,901				
1999	776	$90,715	259	$1,065	518	$6,290				
2000	9,528	$1,188,199	119	$6,509	161	$17,817	<1	$310		
2001	12,780	$1,612,291	322	$71,927	183	$44,921				
2002	23,126	$2,839,110	127	$6,453	9	$2,128	3	$1,777		

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	$524		
1982							5	$15,833		
1983							3	$8,634		
1984			<1	$133			10	$15,500		
1985							12	$17,766		
1986							22	$29,127		
1987							78	$83,775		
1988							40	$45,001		
1989			<1	$66			62	$71,885		
1990			<1	$199			50	$53,462		
1991			<1	$49			54	$46,016		
1992			6	$3,336			42	$39,725		
1993			30	$4,895			44	$31,852		
1994			33	$3,388			70	$55,462		
1995			7	$922			130	$86,406		
1996			65	$22,015	3	$758	86	$70,146		
1997			156	$18,823	1	$86	59	$45,169		
1998			46	$4,411	39	$3,764	103	$64,877		
1999	1	$1,743	47	$3,868	108	$8,026	98	$70,023		
2000	4,842	$685,945	19	$2,018	20	$2,301	79	$49,362		
2001	11,127	$1,254,160	371	$133,539	32	$7,876	68	$70,361		
2002	15,833	$1,936,900	248	$29,429	12	$1,799	229	$70,602		

Source: PacFIN data extracted May, 2003.

[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 2002.

[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.

Table 4. Pacific coast CPS landings (mt) and real[1] exvessel revenues ($ 2002) by gear group, 1981-2002.

Year	Roundhaul or Lampara	Dip Net	Pot or Trap	Trawl	Hook and Line	Gillnet	Other or Unknown
Landings (metric tons)							
1981	120,510	8,231	<1	11	92	75	81
1982	108,952	3,668	1	13	102	71	1,341
1983	41,397	490	<1	8	29	27	15,611
1984	48,057	64	<1	3	147	144	8,281
1985	50,312	494	<1	20	120	374	5,247
1986	65,595	88	4	2	71	107	10,224
1987	64,607	213	1	6	41	1,296	10,471
1988	86,612	138	1	39	153	1,377	7,550
1989	94,757	248	<1	132	272	96	7,194
1990	70,263	489	2	15	127	64	5,725
1991	58,327	724	37	127	53	56	23,452
1992	45,788	4,322	3	802	77	28	1,780
1993	68,233	5,171	2	592	102	43	114
1994	77,694	2,988	59	510	128	9	1,084
1995	119,406	1,341	4	386	400	8	1,600
1996	128,160	808	1	401	124	22	<1
1997	138,070	165	<1	2,157	127	12	10
1998	67,338	36	2	1,334	76	5	5
1999	165,912	528	72	983	12	10	93
2000	218,785	1,552	45	275	420	4	153
2001	189,565	1,827	82	587	156	3	<1
2002	177,804	757	152	35	10	2	
Revenues (2002 $)							
1981	$32,602,523	$1,486,183	$341	$6,860	$55,750	$48,532	$29,170
1982	$27,219,285	$751,610	$3,243	$6,942	$51,405	$36,210	$326,372
1983	$13,118,200	$308,339	$1,458	$4,387	$22,513	$13,862	$4,246,072
1984	$13,805,162	$53,779	$2,560	$2,870	$61,549	$49,637	$2,133,800
1985	$14,571,721	$466,324	$400	$13,703	$49,750	$175,287	$2,593,757
1986	$16,968,525	$38,901	$1,530	$1,908	$48,392	$48,330	$3,093,626
1987	$14,456,411	$57,936	$1,883	$3,357	$45,239	$341,551	$2,506,068
1988	$21,734,456	$44,369	$1,214	$40,111	$57,203	$341,166	$2,197,120
1989	$20,555,578	$56,951	$219	$39,805	$67,077	$30,975	$1,646,955
1990	$13,243,113	$58,485	$1,115	$8,395	$86,413	$33,982	$1,107,601
1991	$12,201,173	$66,361	$8,494	$28,420	$52,868	$19,146	$3,962,123
1992	$9,477,161	$629,774	$2,373	$8,537	$65,313	$12,187	$371,784
1993	$15,385,622	$923,010	$2,090	$10,738	$89,310	$22,109	$28,171
1994	$24,104,322	$602,435	$16,298	$32,180	$95,603	$5,310	$239,569
1995	$30,782,085	$390,482	$2,241	$19,714	$135,495	$4,794	$345,361
1996	$41,230,898	$199,507	$547	$44,618	$100,249	$11,368	$9
1997	$32,123,843	$63,443	$69	$32,403	$127,415	$6,217	$3,712
1998	$8,620,158	$26,035	$680	$83,018	$74,736	$3,156	$3,021
1999	$42,673,276	$198,633	$16,838	$36,942	$26,844	$6,257	$7,367
2000	$39,742,075	$401,005	$10,429	$27,990	$91,405	$2,059	$13,435
2001	$29,585,863	$459,601	$6,746	$224,043	$40,418	$1,647	$223
2002	$29,735,242	$184,597	$40,047	$10,543	$23,857	$1,308	

Source: PacFIN data extracted May, 2003.

[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 2002.

Table 5. Number of vessels with Pacific coast landings of CPS finfish and/or market squid by landing area, 1981-2002.

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	52	131	71	29	60	7	5	1		4	
1982	28	99	20	5	57	7	4		1	1	
1983	29	75	18		48	10	3			1	
1984	14	72	12		71	11	2			1	
1985	13	69	18	7	77	26			3	2	
1986	15	79	19	5	52	15				2	
1987	30	107	43	1	43	18	1			2	
1988	35	99	42	3	44	25	2		1	3	
1989	44	96	27	8	24	13	1		1	2	
1990	41	87	36	15	81	25				2	
1991	52	94	33	11	30	6			2	2	
1992	53	93	17	27	150	143	6		20	3	1
1993	46	105	21	16	73	43	6		14	3	3
1994	49	95	21	7	52	53	8	4	38	2	2
1995	40	96	44	3	35	39	3		43	1	1
1996	35	101	50	1	41	38	4		41	9	
1997	26	98	30	2	49	36	2		50	9	
1998	20	80	19	8	37	57	12		46	8	
1999	18	80	17	2	23	18	4		44	10	7
2000	16	83	18	2	40	35	7		43	18	10
2001	18	74	17	2	27	13	4	1	43	27	5
2002	8	79	9	2	19	6	3		42	23	7
					Market Squid						
1981	6	61	26	9	53	1	11				
1982	1	51	26	7	53	2	9				
1983	4	44	17	4	32	22	3				
1984	1	9	20	6	31	8	2				
1985	1	45	46	5	59	10	1				
1986	2	43	32	7	41	4	2				
1987	7	41	35	3	33	17	1				
1988	10	51	34	4	30	7	9				
1989	3	48	33	7	28	4	2				
1990	7	43	27	3	36	9	2				
1991		37	24	2	30	8	2				
1992	1	18	15	4	36	16	4				
1993	1	43	31	13	33	13	1				
1994	3	42	39	11	34	6	3	1			
1995	2	59	54	8	28	4	2				
1996	4	63	90	8	28	2					
1997	3	54	61	3	28	6	15				
1998	3	21	58	2		5	2				
1999	1	76	81	3	13	1	2				44
2000	2	86	65	1	23	1	2				42
2001	4	62	50	2	17	3	3				27
2002	2	72	59	5	34	3	1				31

Source: PacFIN data extracted May, 2003.

Table 6. Number of vessels with CPS finfish or market squid as principle species[1] by principle landing area[2], 1981-2002.

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	3	54	7	1	3	2				1	
1982	2	43	5	1	2	1				1	
1983	4	18	4		4					1	
1984		22	7		17	1				1	
1985	1	23	4	2	1	1				2	
1986		17	3	1	2	1				2	
1987	1	31	4		1	2				2	
1988	2	19	3		1	2			1	2	
1989	6	22	2	1	4	1				2	
1990	4	23	3		2					2	
1991	6	36	4		4					2	
1992	5	38	4		3	1	1			1	
1993	2	24	4	1	1	1					1
1994	2	27	6	1	2			1			
1995	2	18	5		2				1		
1996	2	20	7		8						
1997	1	26	3	1	5						
1998	3	39	4		9		1				
1999	1	19	2		6	1			2	1	
2000		26	3		4				6	1	
2001		23	3		3				11	7	
2002	2	22	4		1				10	8	
					Market Squid						
1981	2	14	3		33					1	
1982		16	2		35					2	
1983		6	1		4	1				7	
1984					3				4	7	
1985		8	8		27				3		
1986		10	5		17	1					
1987	3	7	8		14						
1988	4	19	19		15						
1989	2	19	12		15						
1990	1	8	13		12						
1991		5	15		12	1					
1992			4		16	2					
1993		15	15	3	16						
1994		8	24		17	2					
1995		24	37		3	2				2	
1996		30	58		8					1	
1997		26	42		8						
1998		4	26								
1999		31	48		1						20
2000	1	44	32		8						9
2001	1	33	22		8						5
2002		34	11		18	1					7

Source: PacFIN data extracted May, 2003.

[1]Principle species is the species that accounts for the greatest share of a vessel's total exvessel revenues across all species landed.

[2]Principle landing area is the area that accounts for the greatest share of a vessel's total exvessel revenues accross all areas in which it had landings.

Table 7. 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, 1981-2002.

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	7	5	1	1	1					
1982		7	6							1	
1983	1	5	3		1	1				1	
1984		3	4		2	2				1	
1985		3	2	1	1	1				1	
1986		4	1		1	1				1	
1987		3	2		1	2				2	
1988		4	3		1	1				2	
1989	3	3	1		1	1				2	
1990	5	3	2		1	2				2	
1991	2	9	3		2	1				2	
1992	1	8	4		1	1				1	
1993		5	5		2	1				1	
1994	1	6	5		2	1		1		1	
1995	1	7	5			1			1		1
1996	2	4	6		1	1				1	
1997	1	8	5		1	1				1	
1998	1	10	8		3	1	1	1		1	
1999	2	5	4		2	2	1			1	
2000		9	4		3				2	1	1
2001		6	6	1			1		4	1	
2002	2	5	5		1	1			3	1	
Market Squid											
1981		1	2		5	4					
1982		1			7	1				2	
1983			1			1				3	
1984					1					2	
1985			3		5						
1986		1	7		6						
1987		1	6		4						
1988		2	4	2	2	1					
1989		2	11		3	2					
1990		2	5		4						
1991			6			1					
1992			4			3					
1993	1		8	1	1	1					
1994		2	17	1	2			1			
1995		1	17								
1996		4	14		2					1	
1997		6	13		1						
1998	1		2								
1999		4	18								5
2000	1	9	19	1	1						5
2001	1	3	14	1	2						2
2002		4	11								3

Source: PacFIN data extracted May, 2003.

Figure 1. Percentage contribution of Pacific coast CPS finfish and market squid landings to the total exvessel value of all Pacific coast landings, 1981-2002.

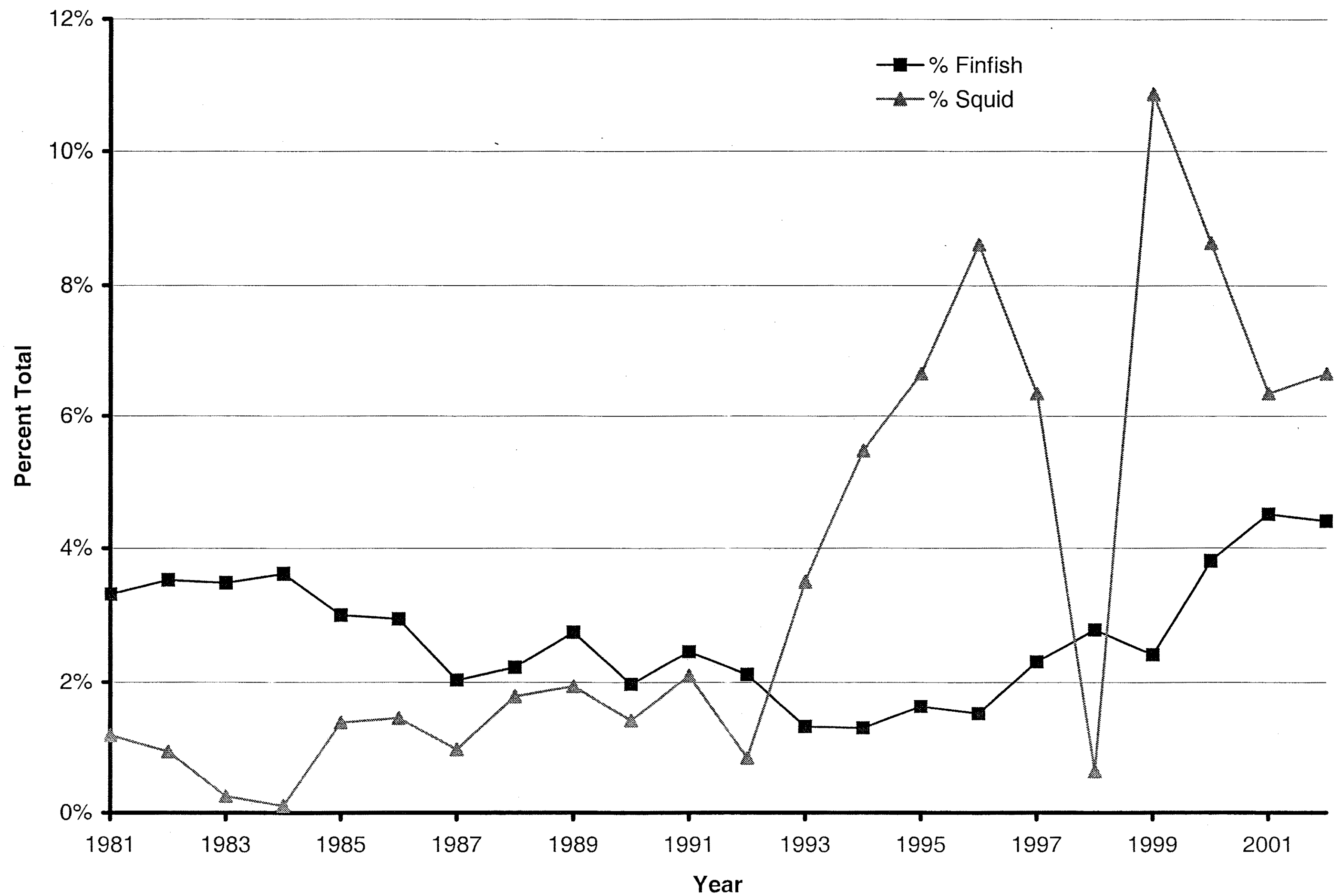


Figure 2. Pacific coast CPS finfish landings and real exvessel price $/lb (2002 $), 1981-2002.

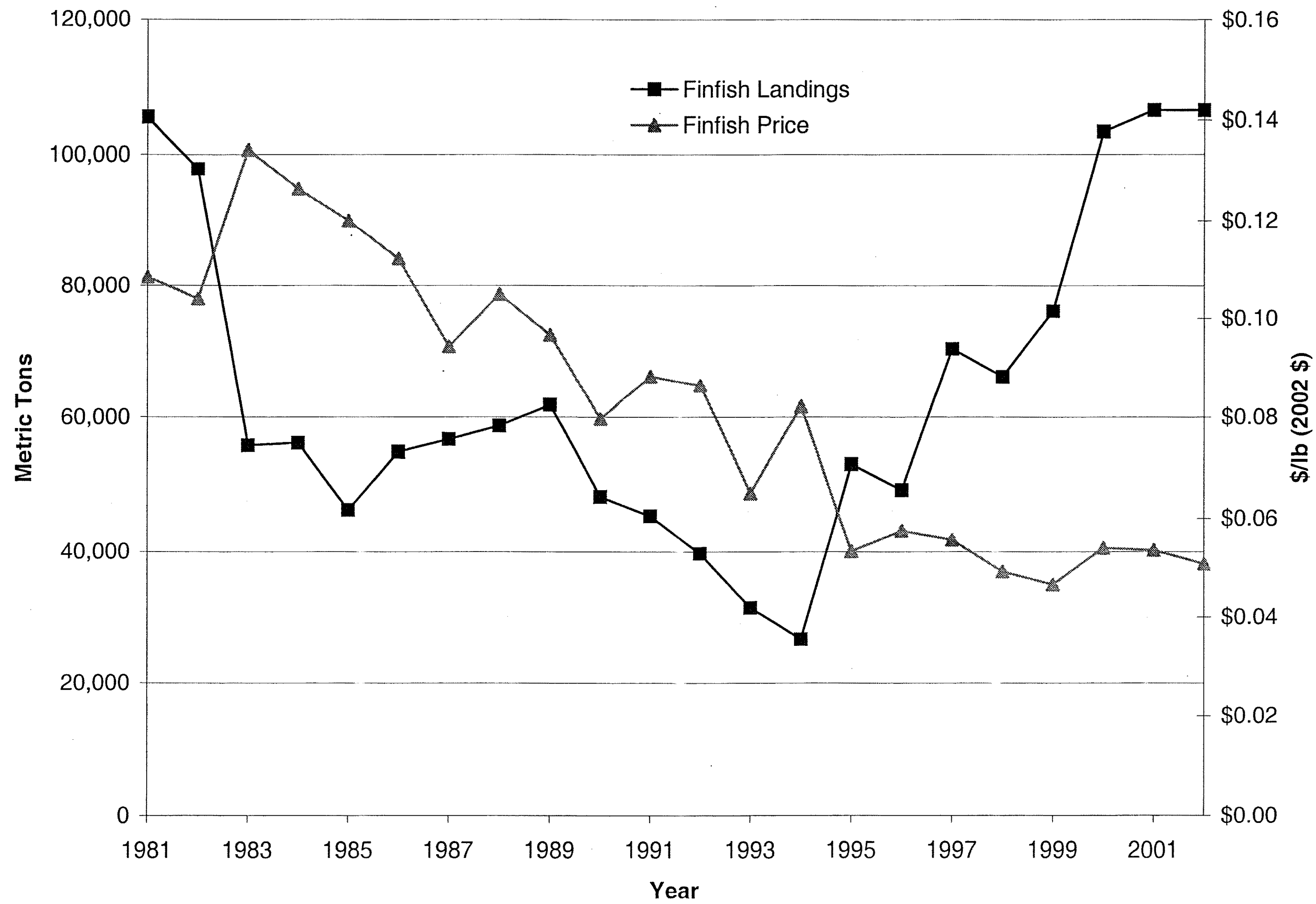


Figure 3. Pacific coast market squid landings and real exvessel price $/lb (2002 $), 1981-2002.

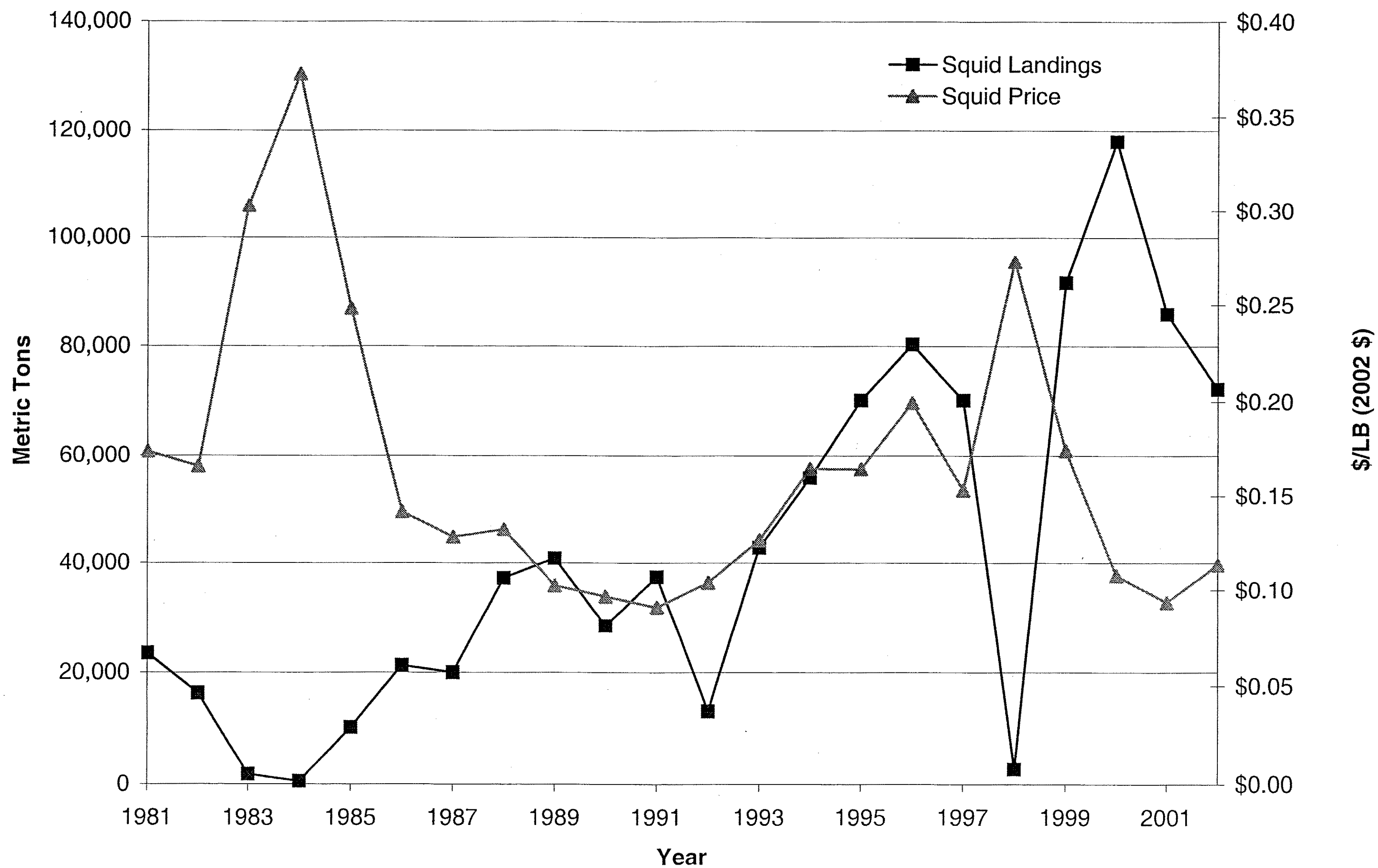


Figure 4. Number of vessels with Pacific coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2002.

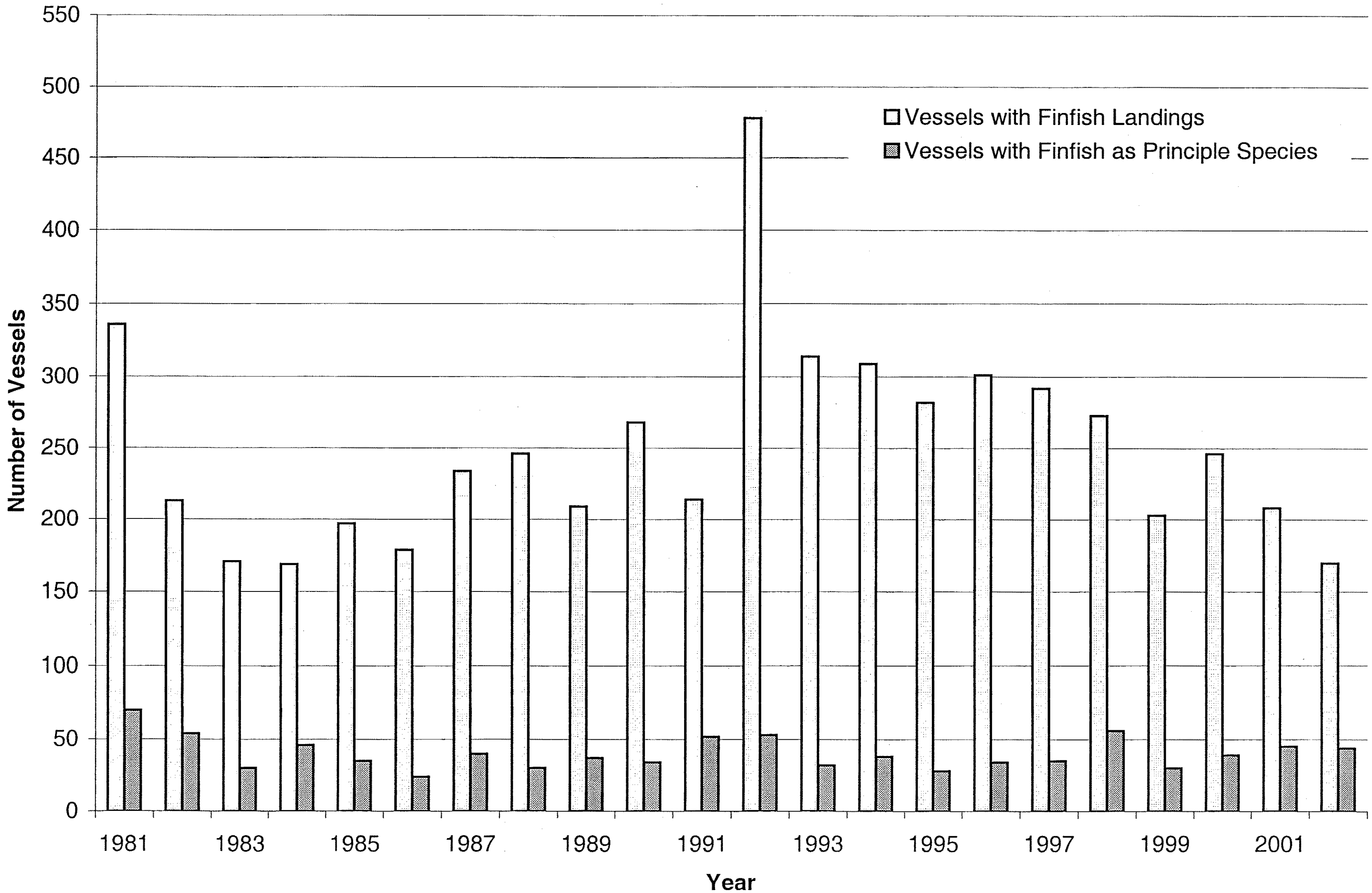
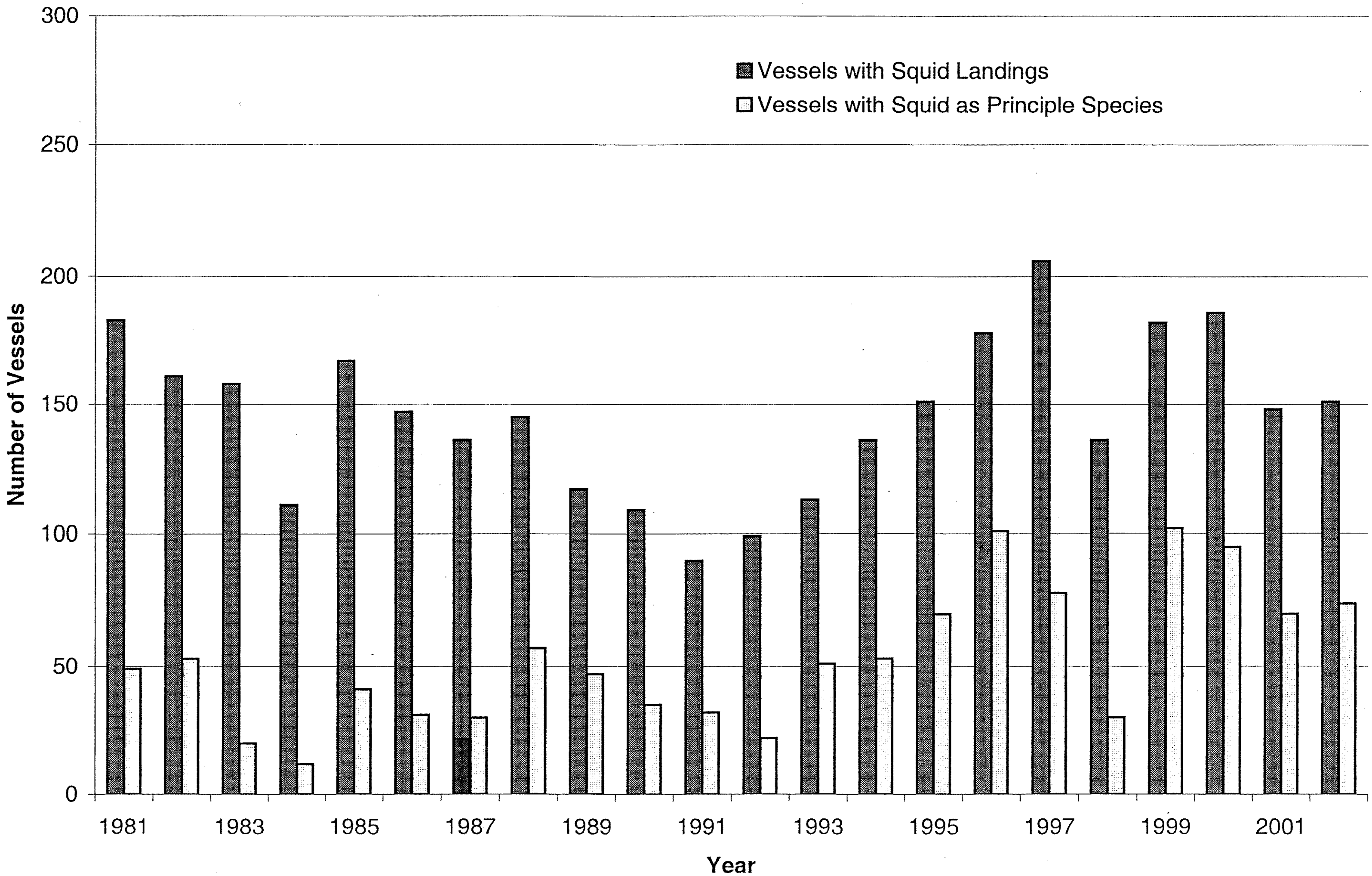


Figure 5. Number of vessels with Pacific coast landings of market squid, and number for which market squid was the principle species, 1981-2002.



APPENDIX 2

STOCK ASSESSMENTS FOR ACTIVELY MANAGED SPECIES

PACIFIC MACKEREL

AND

PACIFIC SARDINE

STOCK ASSESSMENT OF PACIFIC MACKEREL (*SCOMBER JAPONICUS*) WITH RECOMMENDATIONS FOR THE 2003-2004 MANAGEMENT SEASON

EXECUTIVE SUMMARY

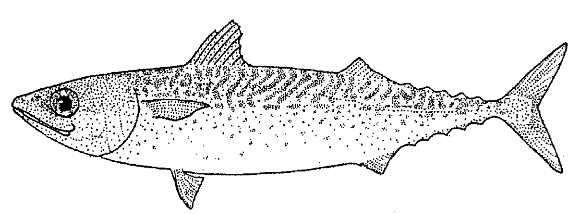
28 May 2003

by

Kevin T. Hill[1], Darrin R. Bergen[1], Paul R. Crone[2], and Ramon J. Conser[2]

Submitted to

Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, Oregon 97220-1384



[1] California Department of Fish and Game
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California 92037

[2] NOAA/NMFS
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California 92037

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INTRODUCTION

The following summarizes stock assessment results and harvest guideline (HG) recommendations for Pacific mackerel (*Scomber japonicus*) developed for the Pacific Fishery Management Council's (PFMC) management season of July 1, 2003 to June 30, 2004. This summary will also be included in the PFMC's Stock Assessment and Fishery Evaluation (SAFE) report for coastal pelagic species (CPS), and will be distributed prior to the June 2003 PFMC meeting. A comprehensive stock assessment report will be developed in spring 2004 when the PFMC's first formal stock assessment review (STAR) for this species will be conducted.

SUMMARY OF THE 2002-2003 FISHING SEASON

The coast-wide harvest of Pacific mackerel increased slightly (3%) in calendar year 2002 (Table 2). The directed fisheries off California and northern Baja California (Ensenada, Mexico) had a combined yield of 12,775 mt, compared to 12,424 mt in 2001. California's directed fishery for calendar year 2002 landed 4,536 mt – a drop of about 42% from the 2001 yield. The Ensenada fishery experienced a 95% increase in yield, from 4,078 mt in 2001 to 7,963 mt in 2002 (García and Sánchez 2003). The RecFIN estimate of recreational take was 276 mt in 2002, down from 561 mt in 2001.

The U.S. commercial fishery was provided a 12,535 mt HG for the 2002-2003 (July-June) season based on a July 1, 2002 biomass forecast of 77,892 mt (Hill et al. 2002). Through the PFMC management process, it was determined that in order to stay within the HG, there would be an initial directed fishery of 9,500 mt, with 3,035 mt set aside for incidental catch in other CPS fisheries. The 2002-2003 season has progressed slowly, with only 3,378 mt of the directed HG allocation being landed from July 2002 through April 2003. The directed fishery will likely remain open through June 30, 2003.

Some members of southern California's fishing industry attribute the slow season to poor availability rather than market demand. The same has been stated for the Ensenada fishery (Walterio Garcia-Franco, INP Ensenada, pers comm), which typically harvests larger yields when the fish are available. Little is known about mackerel abundance south of Ensenada, but spawning activity has historically been centered off the central and northern Baja California coast. Pacific mackerel have been present as incidental catch in whiting and salmon fisheries off Oregon and Washington since 1992. Mackerel catches in northern waters usually increase during El Niño events, and the presence of older and larger mackerel in the region may explain the relative paucity of older mackerel (ages ≥3) in the southern California catch. Sardine fishermen in the Pacific Northwest encountered 'catchable' quantities (i.e., pure schools) of mackerel through summer 2002.

ASSESSMENT METHODS

Model

A modified virtual population analysis (VPA) stock assessment model ('ADEPT,' Jacobson 1993), based on Gavaris' (1988) ADAPT procedure, was used to estimate biomass of Pacific mackerel. The ADEPT model has been used to assess Pacific mackerel for the past ten years and is described in detail in Jacobson (1993), Jacobson et al. (1994), and Hill et al. (1999a,b). Conventional VPAs back-calculate age-structured abundance utilizing catch-at-age and weight-at-age data, as well as assumptions regarding both age-specific natural mortality in each year of the time series and fishing mortality (F) estimates for the most recent year (referred to as 'terminal F'). The ADEPT model improves upon a conventional VPA by evaluating terminal F and other parameters to obtain the best statistical fit between VPA output and survey indices of relative abundance. The crux of the statistical procedure lies in the model's ability to estimate terminal F based upon the survey indices, using them to adjust the conventional VPA output.

The ADEPT model uses a standard suite of subroutines to estimate parameters in a VPA model using the simplex algorithm and subroutine from Press et al. (1990) with minor modifications. The standard program for parameter estimation is similar to that described by Mittertreiner and Schnute (1985). The ADEPT approach is based on maximum likelihood estimation algorithms. Parameters are estimated by minimizing an objective function which, in the case of ADEPT, is the negative log-likelihood of the data, given the model and parameter estimates (rather than the equivalent sums of squares used by Gavaris 1988). Two types of parameters are estimated in the ADEPT model: observation parameters (survey q's and exponents) and terminal F parameters. Observation parameters are used to interpret index data, which are used in turn to estimate terminal F parameters. Terminal F parameters are highly influential for estimating population biomass for recent years. Natural mortality was assumed to be 0.5 yr^{-1} for all ages in all analyses (Parrish and MacCall 1978).

Data

The assessment model uses an annual time step and now incorporates 74 years (1929-2002) of fishery data, including landings (Table 2, Figure 1), age composition (Figure 2), and mean weights-at-age (Figure 3). Fishery data for the early historical period (1929-1965) were obtained from previously published assessments (Parrish and MacCall 1978; Prager and MacCall 1988). Abundance estimates from the VPA are adjusted by the model to better match trends in the survey data, which includes aerial spotter sightings (Lo et al. 1992; Figure 4), CalCOFI larval data (Figure 5), recreational fishery catch-per-unit-effort information (Figures 6 and 7), triennial shelf survey data (Figure 8), and power plant impingement rates (Figure 9). As in past assessments, component likelihoods for most surveys were weighted equally to a value of 1.0. The power plant impingement index (age-0 mackerel caught in cooling water at San Onofre Nuclear Generating Station) represents a relatively small portion of the coastline and was therefore down-weighted to 0.1. The ADEPT model can also accommodate weighted annual survey observations based on coefficients of variation (CVs) associated with the individual estimates. As per Hill et al. (2002), we calculated CVs for each survey observation and re-scaled them to a median value. Re-scaling CVs to a value of 1.0 had the benefit of maintaining equal weighting among surveys, while down-weighting annual observations within surveys for poorly-sampled or highly-variable years.

Fishing Mortality in the Terminal Year

The ADEPT model estimate of terminal F largely determines biomass estimates for the most recent years. Terminal F estimates for each age group were calculated using age-specific vulnerability parameters and a parameter for the overall fishing mortality rate:

$$[1] \quad F_a = V_a \bullet F \, ,$$

where F_a is the fishing mortality rate at age a in the terminal year, V_a is the vulnerability for age a, and F is the fishing mortality rate experienced by fully recruited age groups (ages with V_a=1). The parameters F_a, V_a, and F were estimated after log transformation to improve statistical properties of the estimates. Vulnerability parameters in [1] could, in principle, be estimated individually by ADEPT or set manually to any fixed values based on 'prior' information. It is always desirable to estimate selectivities individually, however, data limitations often cause convergence problems making direct estimation impractical. When specified individually (fixed), the best that can be done is to estimate average vulnerability values by preliminary VPA analysis, then fix terminal selectivities to average values.

For this assessment, we enveloped uncertainty in recent biomass estimates by exploring a wide range of terminal year vulnerability scenarios. The default method, consistent with the previous two assessments (Hill et al. 2001 and 2002), was to use fixed age-specific parameters based on vulnerabilities averaged for prior years with catch-at-age similar to 2002 (i.e., large proportion of age 0 and 1 fish in the catch; see Figure 2). After an initial model run using fixed values, ADEPT was configured to estimate selectivities of age 0-3 fish individually (ages 4 and ≥5 were necessarily fully selected, i.e., V_a =1 for all model runs). The model converged, however, the parameter for age 2 fish was the only one estimated with any degree of certainty (CV=27%). Model estimates for age 0, 1, and 3 fish were similar to initial values from the default method, but CVs for the estimates were extremely high. We therefore used fixed values for 0, 1, and 3 year-old fish. Selectivities for age 0 fish are typically low (<0.2), and age 3 fish are moderately vulnerable to the fishery (roughly, 0.4-0.8).

A major area of uncertainty lies in the vulnerability of age-1 mackerel to the fishery. Age-1 vulnerability in the terminal year has the greatest potential impact on biomass calculations for recent most years. In other words, a high proportion of age 1 fish in the 2002 catch may be interpreted in two ways: assumed lower vulnerability equates to relatively higher abundance; or assumed higher vulnerability results in relatively lower abundance. Prior model estimates of age-1 vulnerability range from low (~0.2) to high (1.0), with no consistent pattern over the past fifteen years. For the final model run, we developed a broad range of 'states of nature' by calculating the frequency of occurrence of vulnerabilities for four general vulnerability categories (V_a=0.2, 0.4, 0.6, and 0.8) and subsequently, calculated an average vulnerability within each category. Ultimately, four model runs were conducted based on the age-1 vulnerabilities above and finally, these model outputs were used to derive a weighted estimate of important management stock parameters (e.g., biomass and recruits). A summary of final V_a parameters is provided in Table 1.

Table 1. Age-specific vulnerability parameters applied in the final model run.

Age	Vulnerability Parameter (V_a)	Source
0	0.066	fixed average based on catch-at-age
1	0.209, 0.408, 0.602, 0.990	four values used to calculate weighted average
2	0.035	model est. (CV=27%)
3	0.722	fixed average based on catch-at-age
4 and ≥5	1.000	fixed at 1

Biomass Projection

Biomass was estimated through the beginning of 2002 (calendar year), then a projected estimate of biomass for July 1, 2003 was calculated based on: 1) the number of mackerel estimated to comprise each year class at the beginning of 2002; 2) model estimates of fishing mortality during 2002; 3) assumptions for natural mortality (M=0.5) and F through the first half of 2003; and 4) mean weight-at-age for the terminal year. Weight-at-age data were used to convert numbers of fish to biomass for each age, which was summed across ages to obtain total (≥1 year-old fish) biomass.

RESULTS and DISCUSSION

The ADEPT model recalculates biomass and recruitment for all years in the 74-year time series. Differences in biomass estimates among assessment years can be caused by changes in landings, shifts in fishery age compositions, trends in fishery-independent surveys, and assumptions of terminal year fishing vulnerability. As is true for all age-structured population models, abundance-at-age estimates are the least certain for the most recent years when the youngest year classes have not yet become fully vulnerable to, or utilized by, the fishery. Compounding this uncertainty is the general lack of fishery or survey data for Pacific mackerel outside the Southern California Bight and the lack of fishery-independent information on recruitment. Catch-at-age and weight-at-age data have not yet been made available from the Ensenada fishery, which is comparable in volume to California's commercial fishery.

Biomass Trend

Pacific mackerel biomass peaked in 1982 at approximately 1.4 million mt, declining steadily to a low of 22,252 mt in 2000 (Table 3, Figure 13). The peak biomass observed twenty years ago was primarily built by exceptional year classes in 1978, 1980, and 1981 (Table 3, Figure 10). These recruitment pulses occurred after a decade of extremely low biomass from the mid-1960s to mid-1970s (Figure 13). The decline in biomass since 1982 has resulted from a steady decline in year class strength (Figure 10) and relatively low reproductive success (recruits per spawning stock biomass; Figure 11) since that time. Model estimates of

2000 and 2001 year class abundance are slightly higher than for the previous few years and recent reproductive success (recruits per spawning stock biomass) is more optimistic relative to the past 18 years.

The overall trend in ≥1year-old biomass for the current assessment was similar to that estimated in the 2002 stock assessment (Hill et al. 2002). Compared to Hill et al. (2002), the biomass time series for the current assessment is 10% lower over the most recent decade. The current estimate of July 1, 2002 biomass is estimated to be 30% lower than last years' projection for that same time. A more precipitous decline in biomass was observed from 1997 to 2000. This decrease is attributed to relatively weak year classes in 1998 and 1999 (Figure 10), combined with high fishing mortality during the 1998 fishery. The 1998 fishery was the second largest on record (71,355 mt), with the majority (50,726 mt) of the total harvest being landed in Ensenada, Mexico (Table 2, Figure 1). Despite the lower overall estimates of biomass compared with Hill et al (2002), the current time series indicates a stabilization in biomass in the past two years (Figure 13). This may be attributed to what appears to be a relatively strong 2000 year class that contributes substantially to the exploitable biomass in 2002.

Biomass Projection

The July 1, 2003 biomass projection, used to calculate the 2003-2004 HG, was based on ADEPT outputs and certain assumptions about recruitment and fishing mortality during the first half of 2002. Estimates of year class strength (age-0 abundance) for the terminal year (2002) are included in the forecast. Various approaches may be used to address uncertainty in model estimates of age-0 abundance: 1) use a model-derived estimate; 2) use an average of model-derived estimates; or 3) rely strictly on a stock-recruit relationship. Decisions concerning the best approach necessarily depend on assumptions regarding the accuracy of the hypothesized stock-recruit relationship and in particular, the existence of compensatory responses by the stock, i.e., relatively speaking, increased recruitment at low spawning biomass levels.

Reliance on the stock-recruit relationship seems reasonable when model estimates are considerably higher or lower than recently observed values and when no ancillary information exists to suggest that recruitment is atypically high (e.g., year class failure or a compensatory increase in juvenile production and/or survival). The model estimate of age-0 abundance for January 2002 was 337 million fish, well within the range of recruitments observed for the past seven years. Some evidence exists that suggests relatively strong year classes occurred in 2000 and 2001. The 2001 fishery contained the highest proportion of age-0 fish (2000 year class) in recent history (33%; Figure 2), in spite of market orders to not land smaller fish due to low oil content (Stephen Wertz, CDFG, pers comm). The 2000 year class comprised the largest proportion (63%) of the 2002 catch. Length data from recreational angler surveys indicated increased catches of young mackerel by 'shore mode' anglers in 2000 and 2001. Based on the above evidence for stronger 2000 and 2001 year classes, we applied the model estimate of 2002 age-0 abundance in the forecast. Finally, the projected estimate of July 1, 2003 population (≥1 year-old fish) biomass was approximately 68,934 mt.

HARVEST GUIDELINE RECOMMENDATION FOR 2003-2004

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

HARVEST = (BIOMASS-CUTOFF) x FRACTION x STOCK 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 can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS in U.S. waters. CUTOFF and FRACTION values applied in the Council's harvest policy for mackerel are based on analyses published by MacCall et al. (1985). BIOMASS (68,924 mt) is the estimated biomass of fish age 1 and older for the whole stock as of July 1, 2003. Based on this formula, the 2003-2004 season HG would be 10,652 mt (Table 4, Figure 14). The recommended HG is 1,883 mt lower (-15%) than the 2002-2003 HG, and lower than the average yield (~13,500 mt) realized by the fishery since the 1992-1993 season (Table 4).

ACKNOWLEDGMENTS

This annual stock assessment depends in large part on the diligent efforts of many colleagues and the timely receipt of their data products. Data were received in record time this year, and we hope to strive for this same goal in preparation for the STAR panel review in spring of 2004. Landings data from the Ensenada fishery were kindly provided by Walterio Garcia-Franco, INP-CRIP, Ensenada, Mexico. Port samples and a portion of the age data were provided by CDFG Marine Region personnel in Los Alamitos and Monterey with special thanks to Leeanne Laughlin, Valerie Taylor, Kelly O'Reilly, Travis Tanaka, Dianna Porzio, Tom Mason, Sonia Torres, Melissa Nugent 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. Mark Wilkins (NMFS, Alaska Fishery Science Center, Seattle, WA) provided swept area estimates from the triennial trawl survey. Kevin Herbinson (Southern California Edison, Rosemead, CA) provided data on mackerel impingement at San Onofre Nuclear Generating Station.

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Table 2. Commercial and recreational landings (metric tons) of Pacific mackerel in California and northern Baja California (Ensenada, Mexico), for calendar years 1929 to 2002. See also Figure 1.

Year	CA Com.	CA Rec.	MX Com.	TOTAL	Year	CA Com.	CA Rec.	MX Com.	TOTAL
1929	26,297	134	0	26,431	1966	2,100	493	5,290	7,883
1930	7,499	134	0	7,632	1967	530	260	949	1,738
1931	6,466	134	0	6,600	1968	1,422	190	107	1,717
1932	5,658	134	0	5,792	1969	1,070	288	201	1,559
1933	31,576	134	0	31,711	1970	282	311	0	593
1934	51,641	134	0	51,775	1971	71	538	0	609
1935	66,419	135	0	66,554	1972	49	590	0	639
1936	45,605	43	0	45,648	1973	25	478	0	503
1937	27,641	85	0	27,725	1974	61	246	0	307
1938	36,218	119	0	36,337	1975	131	312	0	443
1939	36,700	234	0	36,934	1976	298	123	0	421
1940	54,660	196	0	54,856	1977	9,220	1,163	0	10,383
1941	35,456	112	0	35,568	1978	21,520	2,256	0	23,776
1942	23,838	112	0	23,950	1979	35,823	3,053	0	38,876
1943	34,117	112	0	34,228	1980	38,188	2,668	0	40,856
1944	37,947	112	0	38,057	1981	42,450	1,401	0	43,851
1945	24,366	112	0	24,477	1982	35,019	1,684	0	36,703
1946	24,438	112	852	25,400	1983	35,454	1,481	135	37,069
1947	21,082	345	1,263	22,690	1984	45,572	1,445	128	47,145
1948	17,865	479	515	18,859	1985	40,514	1,105	2,581	44,200
1949	22,576	225	1,352	24,153	1986	46,557	1,020	4,882	52,458
1950	14,810	142	2,029	16,980	1987	41,212	1,334	2,081	44,628
1951	15,204	99	1,321	16,623	1988	43,991	871	4,882	49,745
1952	9,347	148	1,052	10,547	1989	38,637	639	13,383	52,659
1953	3,403	118	1,178	4,697	1990	39,850	1,126	35,757	76,732
1954	11,519	700	5,681	17,900	1991	32,162	1,190	17,445	50,798
1955	10,573	338	9,799	20,710	1992	19,699	779	24,338	44,815
1956	22,686	259	10,725	33,668	1993	12,680	623	7,739	21,041
1957	28,143	365	2,035	30,541	1994	10,043	1,009	13,318	24,370
1958	12,541	327	449	13,317	1995	8,667	1,042	4,821	14,530
1959	17,056	213	495	17,764	1996	10,287	708	5,604	16,598
1960	16,697	191	2,982	19,868	1997	20,615	1,003	12,477	34,095
1961	20,008	274	5,965	26,246	1998	20,073	465	50,726	71,264
1962	22,036	280	3,231	25,546	1999	9,527	201	10,168	19,896
1963	18,254	352	7,966	26,571	2000	23,206	259	7,182	30,647
1964	12,169	243	8,618	21,029	2001	7,785	561	4,078	12,424
1965	3,198	365	7,615	11,177	2002	4,536	276	7,963	12,775

Figure 1. Pacific mackerel landings for calendar years 1929 to 2002.

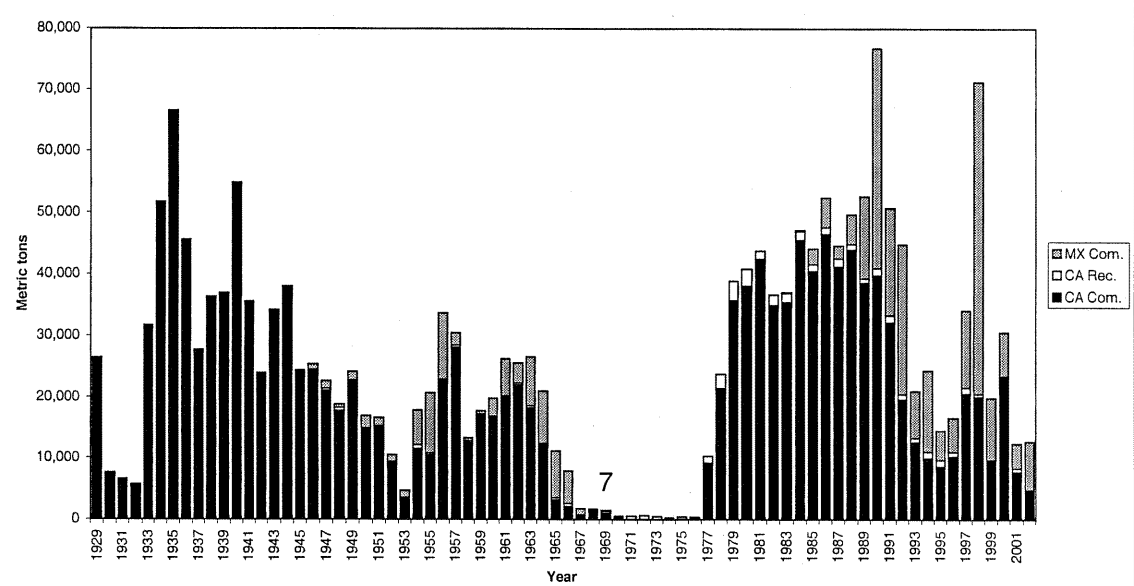


Figure 2. Proportional catch-at-age for California's commercial mackerel fishery, 1983-2002. The assessment model includes data from 1929-2002.

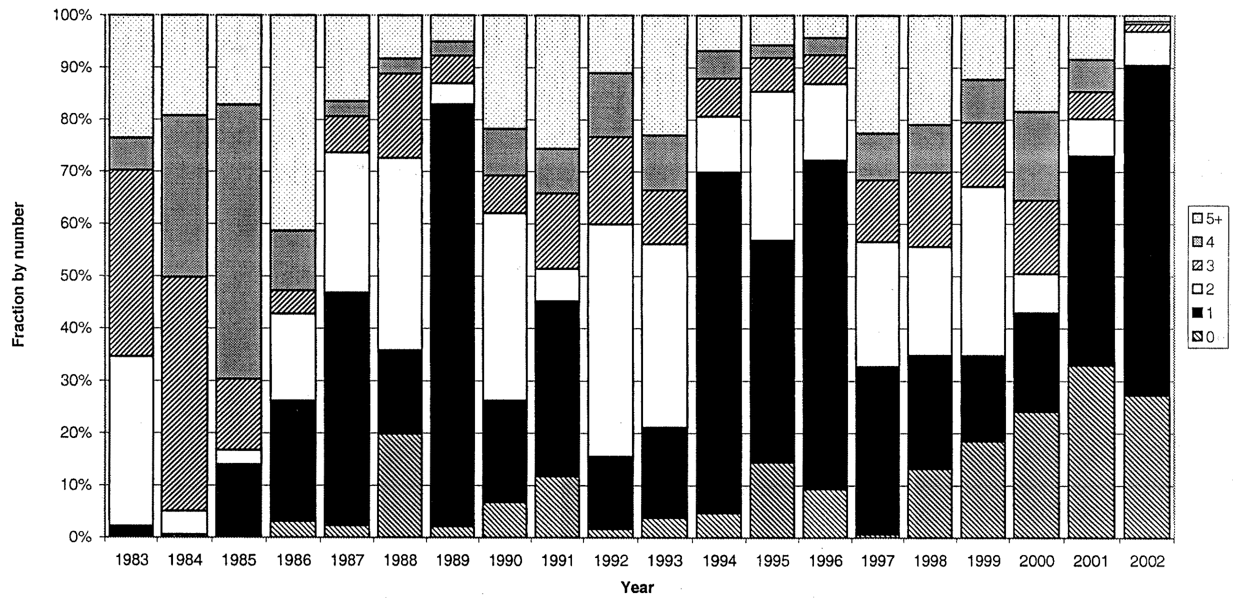


Figure 3. Mean weight-at-age of Pacific mackerel from California's commercial fishery, 1983-2002. The assessment model includes data from 1929 to 2002.

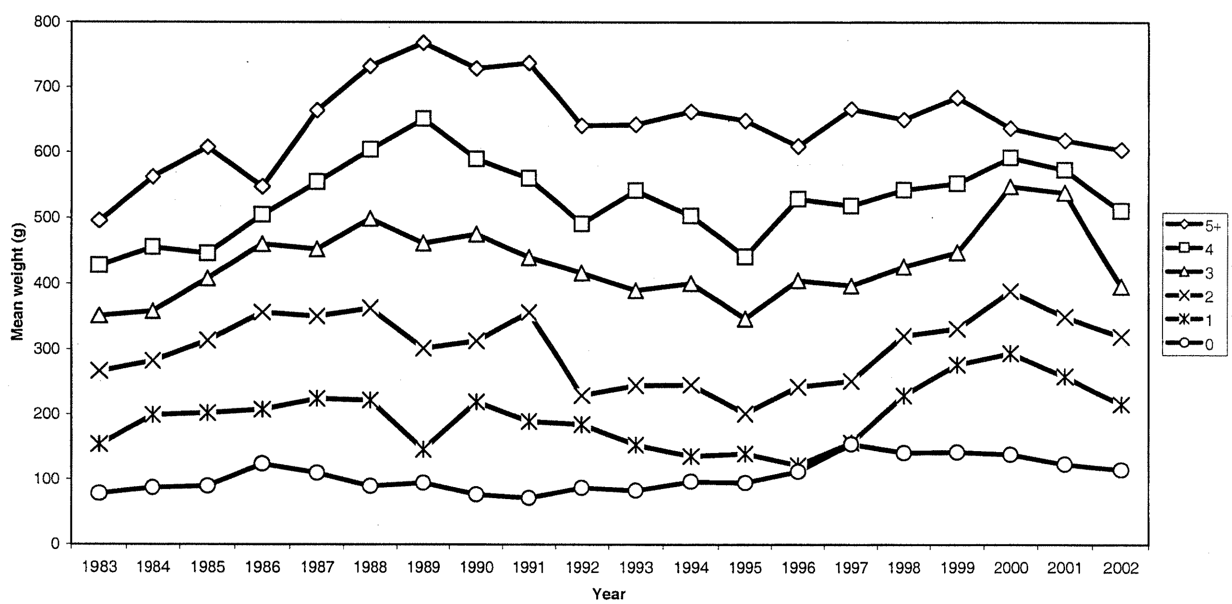


Figure 4. Aerial spotter index of relative abundance.

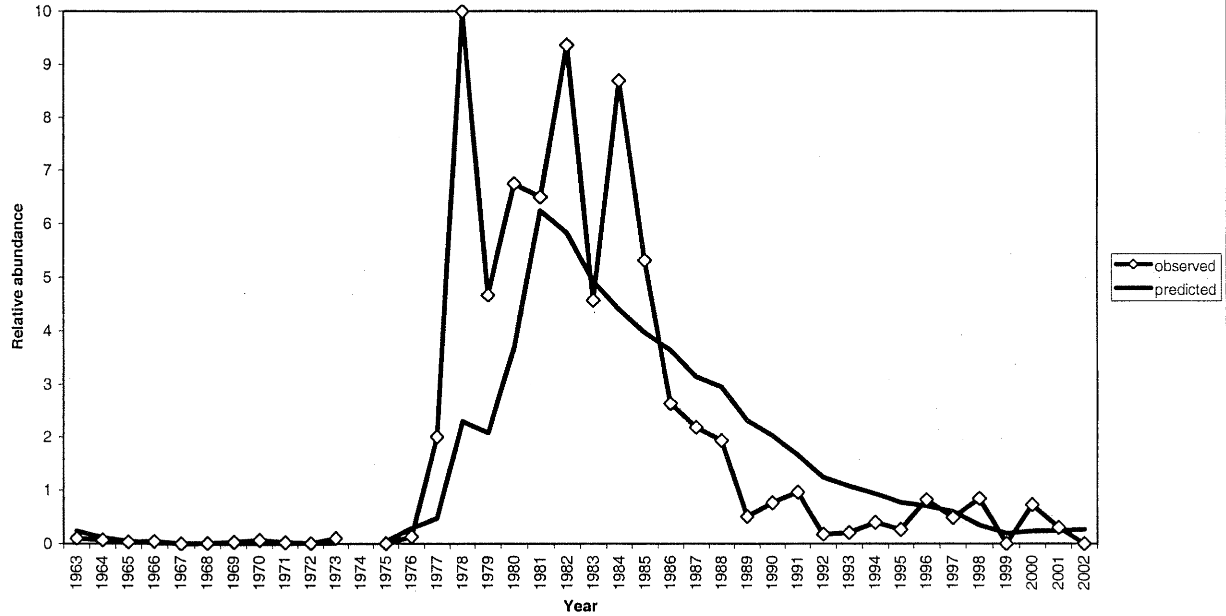


Figure 5. CalCOFI Index - proportion bongo tows positive for Pacific mackerel larvae.

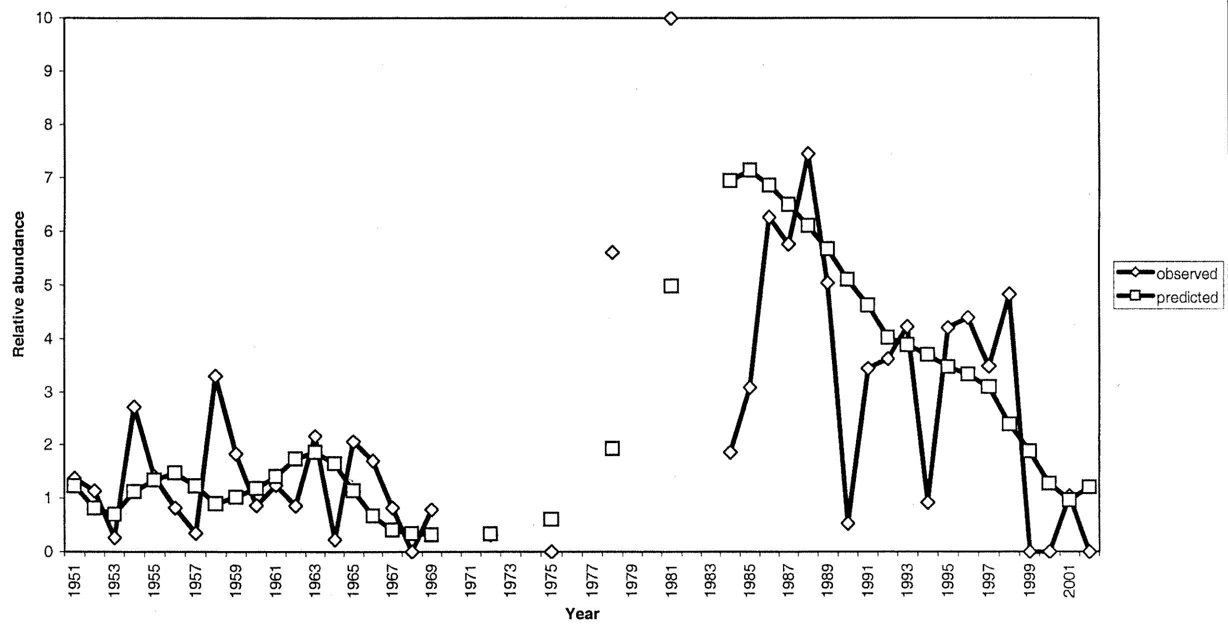


Figure 6. Southern California CPFV CPUE index.

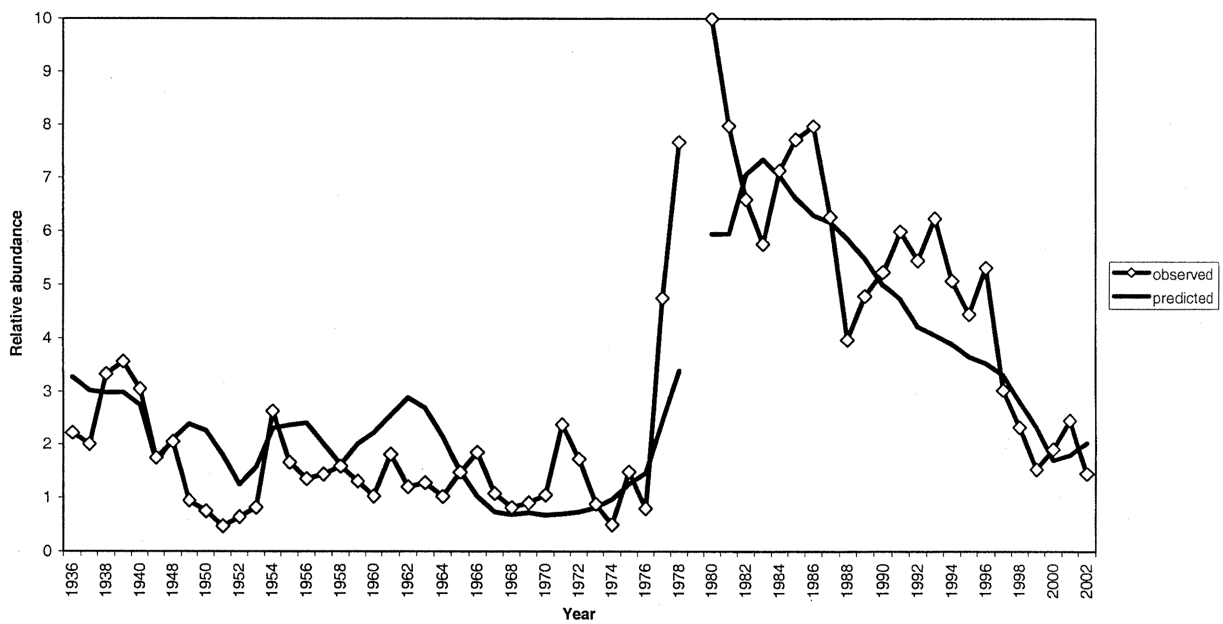


Figure 7. Northern California CPFV CPUE Index.

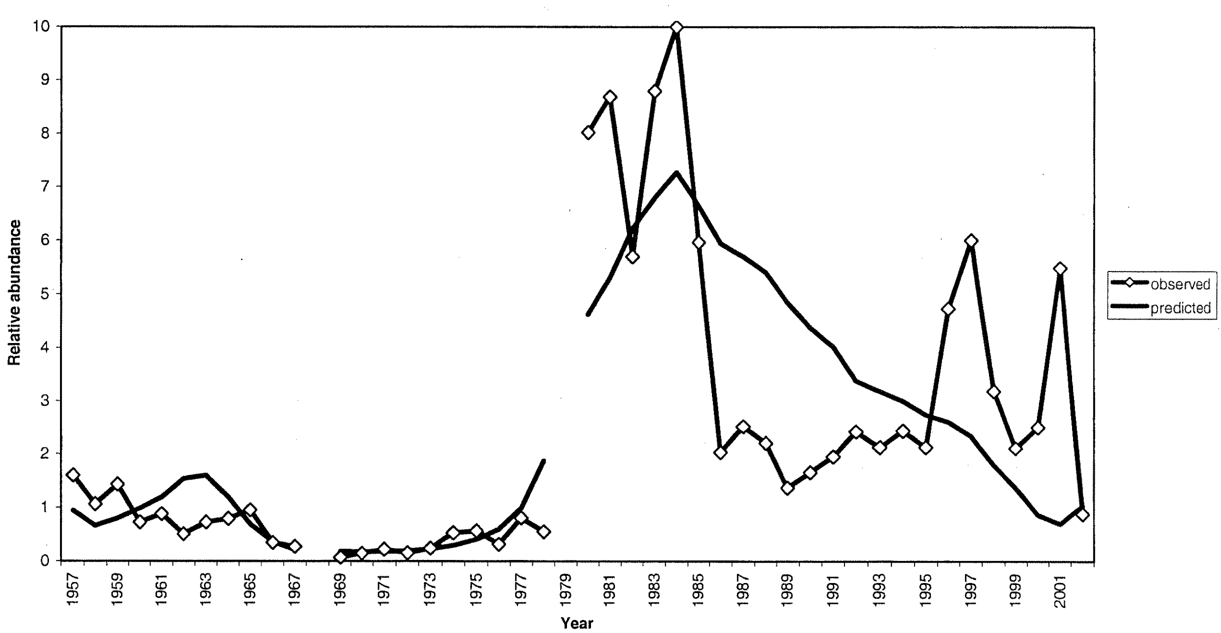


Figure 8. Relative abundance of Pacific mackerel in the trienniel shelf survey, Pt. Conception to US-Canada border.

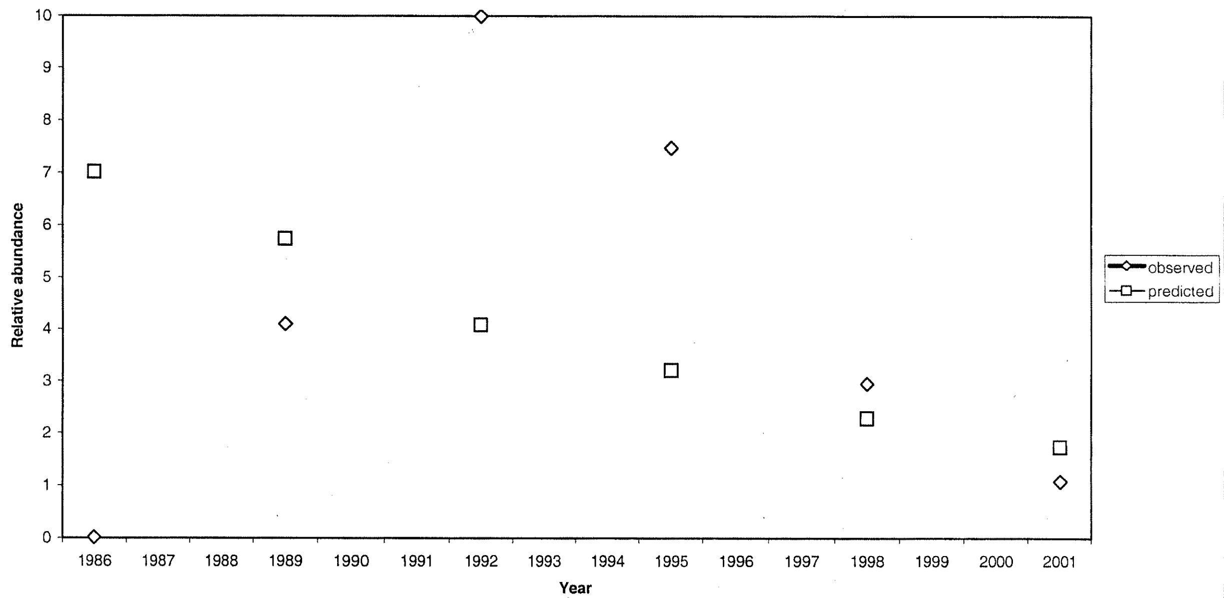


Figure 9. Pacific mackerel impingement at San Onofre Nuclear Generating Station. Index downweighted to lambda=0.1.

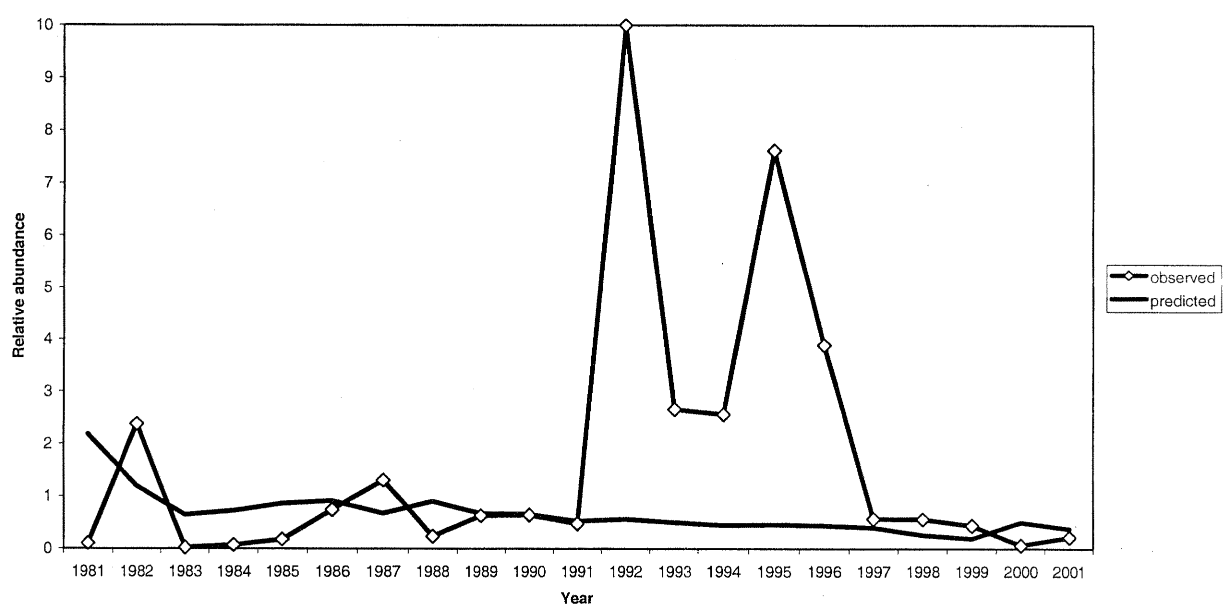


Figure 10. Year class abundance, January 1.

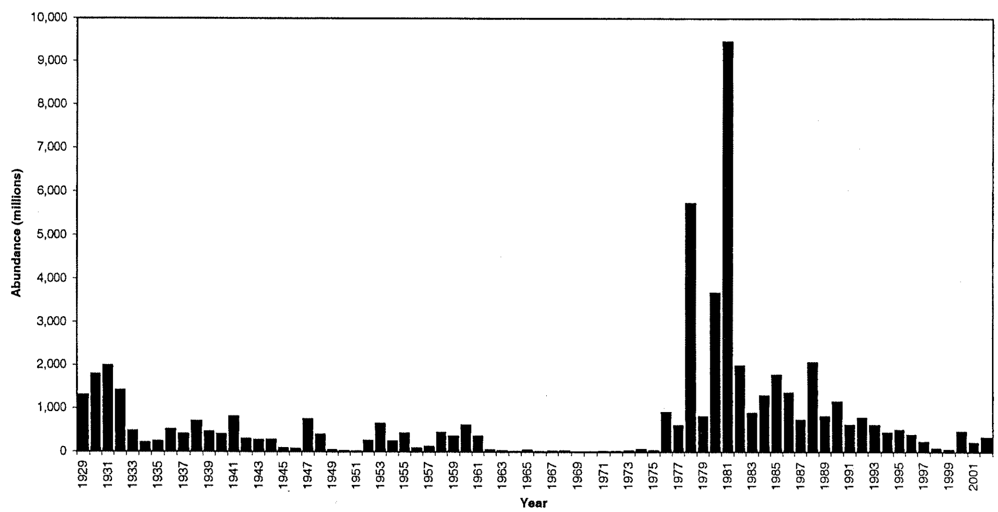


Figure 11. Relative reproductive success of Pacific mackerel, 1930-2002.

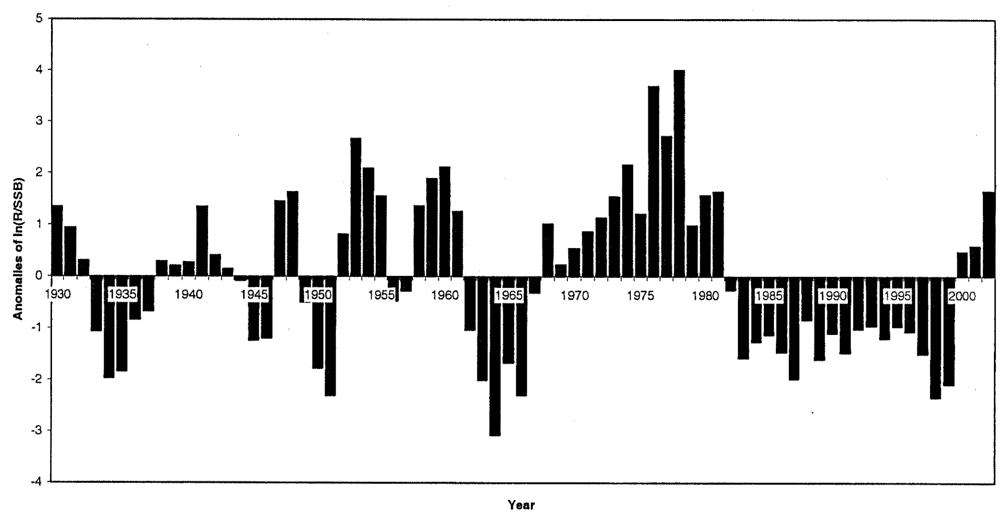


Figure 12. Spawning stock biomass and recruitment, 1982/83 through 2001/02.

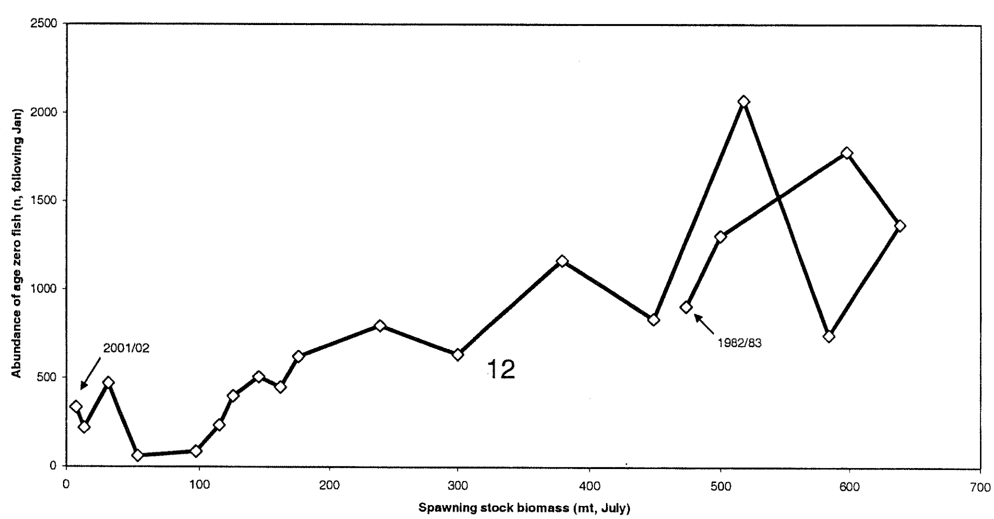


Table 3. Historical July 1 estimates of Pacific mackerel biomass (age 1+, metric tons) and recruitment (age 0, number $1x10^6$) estimated using the ADEPT model. See also Figures 10 and 13.

Year	Age 1+ Biomass (metric tons)	Recruits (millions)	Year	Age 1+ Biomass (metric tons)	Recruits (millions)
1929	155,896	1020	1966	4,765	6
1930	223,033	1392	1967	1,876	10
1931	296,408	1552	1968	1,696	15
1932	365,252	1106	1969	2,127	6
1933	350,660	373	1970	1,602	7
1934	289,642	167	1971	1,763	9
1935	192,454	187	1972	2,072	13
1936	127,778	399	1973	2,894	21
1937	114,806	319	1974	4,834	51
1938	105,650	549	1975	10,955	31
1939	116,944	363	1976	13,787	719
1940	91,214	312	1977	91,885	474
1941	86,466	635	1978	159,887	4466
1942	114,291	233	1979	518,344	640
1943	105,889	210	1980	684,946	2868
1944	84,429	217	1981	797,776	7372
1945	65,560	68	1982	1,394,964	1562
1946	41,260	57	1983	1,255,031	706
1947	20,911	582	1984	1,088,583	1015
1948	57,101	311	1985	940,048	1388
1949	60,937	35	1986	849,370	1064
1950	42,660	15	1987	787,238	576
1951	22,102	10	1988	657,432	1601
1952	8,371	199	1989	576,342	648
1953	26,419	497	1990	493,058	902
1954	61,973	193	1991	429,107	487
1955	55,240	328	1992	297,224	620
1956	62,799	66	1993	267,186	484
1957	33,036	98	1994	233,221	348
1958	21,457	332	1995	186,979	389
1959	44,194	282	1996	171,115	306
1960	51,912	473	1997	147,083	184
1961	81,419	266	1998	96,716	53
1962	97,143	41	1999	51,965	43
1963	70,707	25	2000	22,252	358
1964	36,733	10	2001	57,070	165
1965	13,080	26	2002	54,006	254
		Forecast for July 1 ==>	**2003**	**68,924**	---

Figure 13. Pacific mackerel biomass estimates and projection, Ages 1+, July 1.

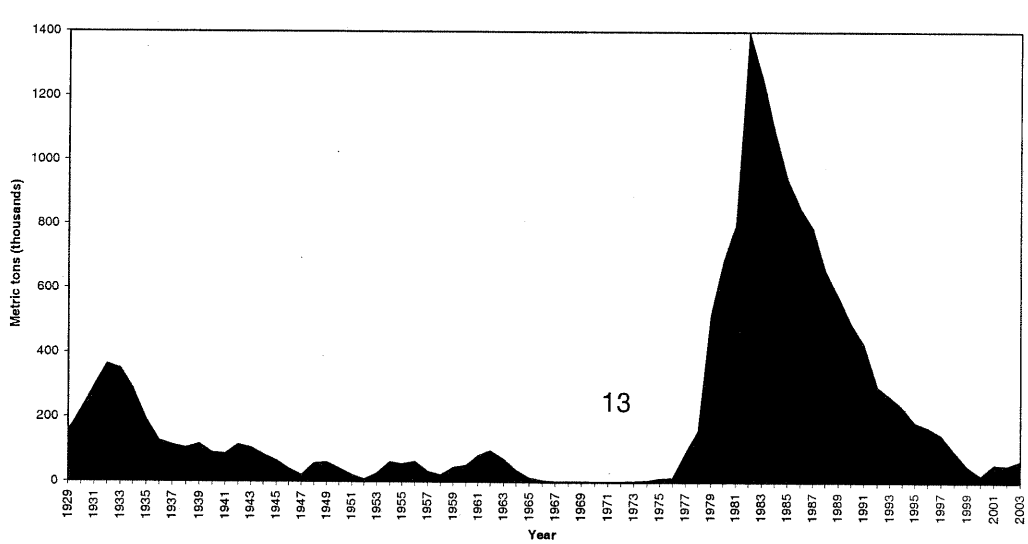


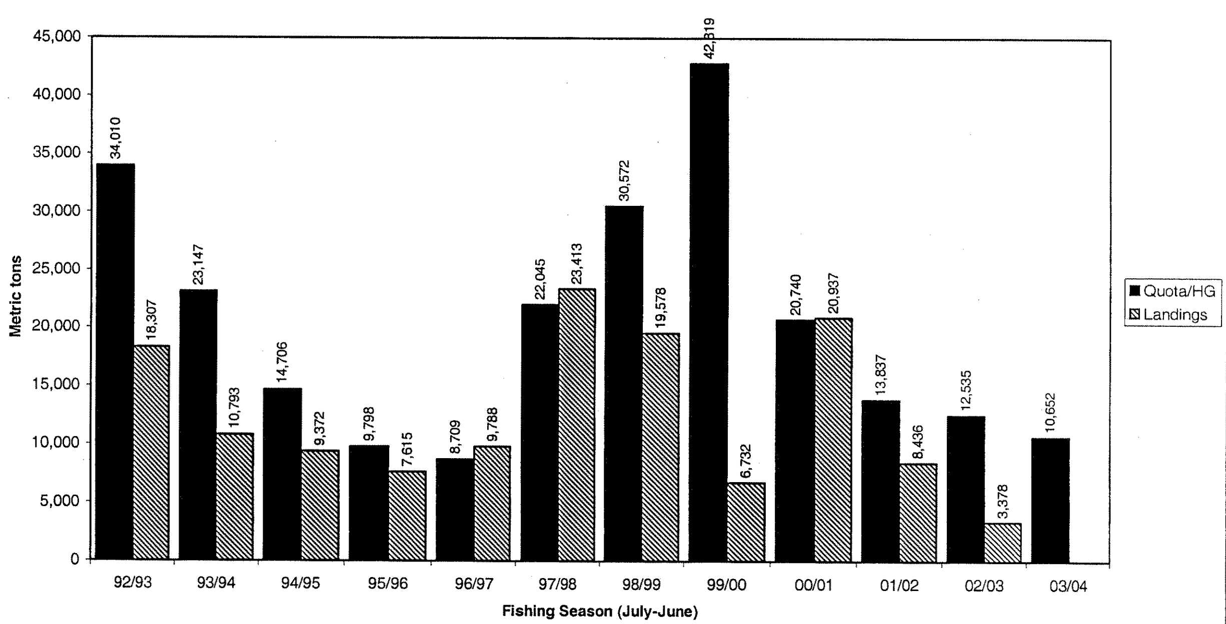
Table 4. Commercial landings (California directed fishery) and quotas (92/93 to 98/99) or harvest guidelines (99/00 to present) for Pacific mackerel. See also Figure 14.

Season	Quota/HG (MT)	Landings (MT)
92/93	34,010	18,307
93/94	23,147	10,793
94/95	14,706	9,372
95/96	9,798	7,615
96/97	8,709	9,788
97/98	22,045	23,413
98/99	30,572	19,578
99/00	42,819	6,732
00/01	20,740	20,937
01/02	13,837	8,436
02/03*	12,535	*3,378*
03/04**	***10,652***	---

* landed as of 30 Apr 2003

** proposed harvest guideline

Figure 14. Pacific mackerel quotas (CA, pre-99/00) and harvest guidelines (PFMC, 99/00 onward), and resultant landings for each management season. The proposed HG for 2003/04 is 10,652 mt.



Stock Assessment of Pacific Sardine with Management Recommendations for 2003

Executive Summary

by

Ramon J. Conser[1], Kevin T. Hill[2], Paul R. Crone[1], Nancy C.H. Lo[1], and Darrin Bergen[2]

Submitted to:
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 200
Portland, OR 97220

October 2002

Addresses for authors:

[1] NOAA/NMFS
Southwest Fisheries Science Center
8604 La Jolla Shores Dr.
La Jolla, CA 92038

[2] California Department of Fish and Game
Southwest Fisheries Science Center
8604 La Jolla Shores Dr.
La Jolla, CA 92038

This document is available electronically at:
http://swfsc.nmfs.noaa.gov/frd/Coastal%20Pelagics/Sardine/sardine1.htm

Introduction

The following summary presents pertinent results and harvest recommendations from a stock assessment conducted on Pacific sardine (*Sardinops sagax*). It is an update to the stock assessment carried out last year (Conser et al. 2001), and is intended for use by the Pacific Fishery Management Council (PFMC) when developing management goals for the upcoming fishing season for sardine beginning January 2003.

The assessment results presented here are applicable to the sardine population off the North America Pacific coast from Baja California, Mexico to British Columbia, Canada. Research surveys (fishery-independent) have been conducted on an annual basis in the spawning areas off central and southern California. For most of the contemporary time series (1983-98), significant fishing for sardine occurred only off northern Mexico and California (Area 1 or *Inside* Area). As the sardine population rebuilt and expanded its range through the mid-1990's, sardine became more available seasonally off Oregon, Washington, and British Columbia. Subsequently, fisheries in these more northerly areas expanded with significant landings beginning in 2000. As in past assessments, research survey data (fishery-independent) are used to index the size of the sardine spawning biomass; and when coupled in a modelling framework with fishery-dependent data and structural information on sardine biology and migration, provide the stock size estimates and demographics needed by the PFMC to establish harvest guidelines for the USA fisheries.

Methods

An age-structured stock assessment model (CANSAR-TAM, **C**atch-at-age **AN**alysis for **SAR**dine - **T**wo **A**rea **M**odel, see Hill et al.1999) was applied to fishery-dependent and fishery-independent data to derive estimates of population abundance and age-specific fishing mortality rates. In 1998, the original CANSAR model (Deriso et al. 1996) was modified to account for the expansion of the population northward to waters off the Pacific northwest. The models are based on a 'forward-simulation' approach, whereby parameters (e.g., population sizes, recruitments, fishing mortality rates, gear selectivities, and catchability coefficients) are estimated after log transformation using the method of nonlinear least squares. The terms in the objective function (to be minimized) included the sum of squared differences in ($\log_e$) observed and ($\log_e$) predicted estimates from the catch-at-age and various sources of auxiliary data used for 'tuning' the model, e.g., indices of abundance from research survey data. Bootstrap procedures were used to calculate variance and bias (95% confidence intervals) of sardine biomass and recruitment estimates generated from the assessment model. The CANSAR-TAM model was based on two fisheries (California, U.S. and Ensenada, Mexico) and semesters within a year were used as time steps, with ages being incremented between semesters on July 1 and spawning that was assumed to occur on April 1 (middle of the first semester).

Fishery-dependent data from the California and Ensenada fisheries (1983 to first semester 2002) were used to develop the following time series: (1) catch (in mt)-Table 1 and Figure-1; (2) catch-at-age in numbers of fish; and (3) estimates of weight-at-age. Fishery-independent data (time series) from research surveys included the following indices, which were developed from data collected from Area 1 (*Inside Area*, primarily waters off central and southern California) and used as relative abundance measures (Table 2): (1) index (proportion-positive stations) of sardine egg abundance from California Cooperative Oceanic and Fisheries Investigations (CalCOFI) survey data (*CalCOFI Index*)-Figure 2; (2) index of spawning biomass (mt) based on the Daily Egg Production Method (DEPM) survey data (*DEPM Index*)-Figure 3, see Lo et al. (1996); (3) index of spawning area (Nmi^2) from CalCOFI and DEPM survey data (*Spawning Area Index*)-Figure 4, see Barnes et al. (1997); and (4) index of pre-adult biomass (mt) from aerial spotter plane survey data (*Aerial Spotter Index*)-Figure 5, see Lo et al. (1992). Time series of sea-surface temperatures (Figure 6) recorded at Scripps Pier, La Jolla, California were used to determine appropriate harvest guidelines (*Sea-*

surface Temperature Index), see Amendment 8 of the Coastal Pelagic Species Fishery Management Plan, Option J, Table 4.2.5-1, PFMC (1998).

Survey indices of relative abundance were re-estimated using generally similar techniques as was done in previous assessments (Hill et al. 1999; Conser et al. 2000; and Conser et al. 2001). The final model configuration was based on equally 'weighted' indices except for the CalCOFI index, which was downweighted to 0.7 (relative to 1.0 for the other indices). The relative weight used for the CalCOFI index (0.7) was consistent with previous assessments in which the proportion of the total spawning area covered by the CalCOFI surveys (~70%) was used to determine its relative weighting in the model. Further the CalCOFI Index has undergone considerable saturation in recent years due to the higher frequency of positive stations as the sardine stock expanded throughout and beyond the southern California Bight. As in the previous assessment, the CalCOFI index was fit with a non-unity exponent (0.3547) to allow for a nonlinear relationship between the index and sardine spawning biomass. This procedure produced a better fit to these data and a more acceptable residual pattern than assuming the classical linear relationship between the index of abundance and population size. As in the two previous assessments, the Aerial Spotter Index was assumed to primarily track pre-adult fish (ages 0 and 1 plus a portion of age 2 fish). All of the other fishery-independent indices were used as indices of the spawning stock biomass, which can be approximated by the biomass of ages 1+ sardine.

Recognizing that the geographical extent of the sardine population tends to increase as population size increases (inferred largely from tagging data and the expansion of the fishery in the 1930's), the CANSAR-TAM model uses explicit time-varying migration rates to `move' sardine from the well-sampled Area 1 (roughly Baja California through central California) to the larger, coastwide stock area. Internal consistency checks are done to ensure that reasonable numbers of sardine are present outside Area 1 to account for the catches of the developing fisheries in the Pacific Northwest. In conjunction with this assessment, a sensitivity run was carried out in which (i) the available catch-at-age from Oregon and Washington fisheries (mostly 2000 and 2001) were formally incorporated into the model and (ii) no structural assumptions regarding migration rates were imposed. As the time series of catch-at-age data from the Pacific Northwest fisheries accumulates and fishery-independent data become available from northern areas, the structure of this sensitivity run is likely to become the template for future sardine stock assessments.

Results

Pacific sardine landings for the directed fisheries off California, USA and Ensenada, Mexico decreased from the high levels that were reached during 2000 (109,000 mt), with a total 2002 harvest of roughly 81,000 mt (Table 1, Figure 1); however, note that semester 2 landings in 2002 reflect projected estimates based on landing patterns observed in the fisheries during the mid to late 1990s (Table 1). Both California and Ensenada landings in 2002 are expected to decrease from the 2000 level, with a more notable decrease in the projected Ensenada landings (51,000 mt in 2000, decreasing to 27,000 mt in 2002). Currently, the USA fishery is regulated using a quota (harvest guideline) management scheme and the Mexico fishery (Ensenada landings) is essentially unregulated.

As has been the case in recent years, landings from the USA Pacific sardine fishery (California, Oregon, and Washington) are below the harvest guideline recommended for 2002 (118,000 mt), with roughly 79,000 mt landed through September 2002 and 87,000 mt projected landings for the entire year (the fishing year ends December 31, 2002).

Estimated stock biomass ($\geq$1-year old fish on July 1, 2002) from the assessment conducted this year indicated the sardine population has remained at a relatively high abundance level, with a bias-corrected estimate of nearly 1.0 million mt (Table 3 and Figure 7). Estimated recruitment (age-0 fish on July 1) during the past four years has declined considerably from that estimated for the strong 1998 year-class (Table 3 and Figure 8). However, it should be noted that recent recruitment (4-22 billion recruits) is not estimated precisely (Figure 8), and another 2-3 years of data may be needed to ascertain whether the sardine population biomass has reached a plateau at the 1.0 million mt level (Figure 7).

Estimates of Pacific sardine biomass from the 1930's (Murphy 1966 and MacCall 1979) indicate that the sardine population may have been more than three times its current size prior to the population decline and eventual collapse in the 1960's (Figure 9). Considering the historical perspective, it would appear that the sardine population, under the right conditions, may still have growth potential beyond its present size. However, per capita recruitment estimates show a downward trend in recruits per spawner in recent years that may be indicative of a stock that has reached a plateau under current environmental conditions (Conser et al. 2001).

The estimate of 2002 stock biomass from the sensitivity run (in which available catch-at-age from Oregon and Washington fisheries were formally incorporated into the model and no structural assumptions regarding migration rates were imposed) was virtually identical to the corresponding estimate from the baseline assessment model, described above (Figure 10). Most annual biomass estimates from the sensitivity run fell within the 95% confidence interval from the baseline assessment (with notable exceptions in 1998 and 1999). However, biomass estimates from the sensitivity run were systematically smaller than those from the baseline during the (recent) years of rapid stock size increase. This may be indicative of a rapidly growing and expanding stock coupled with a lag in the development of fisheries in the northern area to `sample' the sardine in that area. Overall, confidence intervals on stock biomass from the sensitivity run were much broader than those from the baseline and some parameters were poorly estimated (e.g. selectivity for the northern fishery). It is reasonable to expect the performance of this model configuration to improve as the time series of catch-at-age data from the Pacific Northwest fisheries accumulates and fishery-independent data become available for northern areas.

Harvest Guideline for 2003

The harvest guideline recommended for the U.S. (California, Oregon, and Washington) Pacific sardine fishery for 2003 is 110,908 mt. Statistics used to determine this harvest guideline are discussed below and presented in Table 4. To calculate the proposed harvest guideline for 2003, we used 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). This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over a long-term horizon. The Amendment 8 harvest formula for sardine is:

$$HG_{2003} = (\text{TOTAL STOCK BIOMASS}_{2002} - \text{CUTOFF}) \bullet \text{FRACTION} \bullet \text{U.S. DISTRIBUTION},$$

where HG_{2003} is the total U.S. (California, Oregon, and Washington) harvest guideline recommended for 2003, TOTAL STOCK $BIOMASS_{2002}$ is the estimated stock biomass (ages 1+) from the current assessment conducted in 2002 (see above), 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 (see below), and U.S. DISTRIBUTION is the percentage of TOTAL STOCK $BIOMASS_{2002}$ 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-water 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 years. Ultimately, under Option J (PFMC 1998), F_{msy} is constrained and ranges between 5% and 15% (Figure 11).

Based on the T values observed throughout the period covered by this stock assessment (1983-2002), the appropriate F_{msy} exploitation fraction has consistently been 15% (see Figures 6 and 11); and this remains the case under current oceanic conditions (T_{2002} = 17.3 °C). However, it should be noted that the decline in sea-surface temperature observed in recent years (1998-2002) may invoke environmentally-based reductions in the exploitation fraction as early as next year (i.e. in setting the harvest guideline for the 2004 fishing season) – see Figure 11.

Although the 2003 USA harvest guideline (110,908 mt) is less than the 2002 level (118,442 mt), recent fishery practices indicate that it may not be constraining with regard to USA fishery landings in 2003 (Figure 12). However, should the recent declining recruitment trend estimated in this assessment be confirmed with future work, and should the sea-surface temperature decline, it is likely that harvest guidelines in the out years will constrain USA fishery practices and removals.

Further when viewed on a stock-wide basis and considering the landings of Mexico and Canada as well as the USA, adherence to an implied 'stock-wide harvest guideline' may constrain fisheries even without sea-surface temperature declines. Figure 13 compares recent international landings with the annual harvest guidelines that would have resulted from applying the PFMC CPS FMP harvest formula (above) absent the "U.S. Distribution" term. Should Oregon and Washington landings continue to increase (at rates comparable to the past few years) and/or Mexican landings return to their 1999-2000 levels, the implied stock-wide harvest guideline may be exceeded as early as next year (2003).

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Table 1. Pacific sardine time series of landings (mt) by semester (1 is January-June and 2 is July-December) in California and Baja California (Ensenada), 1983-2002. Semester 2 (2002) estimates are projections.

	CALIFORNIA			ENSENADA			
Year	**Semester 1**	**Semester 2**	**Total**	**Semester 1**	**Semester 2**	**Total**	**Grand Total**
83	245	244	489	150	124	274	762
84	188	187	375	<1	<1	0	375
85	330	335	665	3,174	548	3,722	4,388
86	804	483	1,287	99	143	243	1,529
87	1,625	1,296	2,921	975	1,457	2,432	5,352
88	2,516	1,611	4,128	620	1,415	2,035	6,163
89	2,161	1,561	3,722	461	5,763	6,224	9,947
90	2,272	1,033	3,305	5,900	5,475	11,375	14,681
91	5,680	3,354	9,034	9,271	22,121	31,392	40,426
92	8,021	13,216	21,238	3,327	31,242	34,568	55,806
93	12,953	4,889	17,842	18,649	13,396	32,045	49,887
94	9,040	5,010	14,050	5,712	15,165	20,877	34,927
95	29,565	13,925	43,490	18,227	17,169	35,396	78,886
96	17,896	18,161	36,057	15,666	23,399	39,065	75,121
97	11,865	34,331	46,196	13,499	54,941	68,439	114,636
98	21,841	19,215	41,055	20,239	27,573	47,812	88,868
99	31,791	24,956	56,747	34,760	23,810	58,569	115,316
00	35,174	22,761	57,935	25,800	25,373	51,173	109,108
01	30,118	24,785	54,903	9,307	12,939	22,246	77,149
02	28,079	25,624	53,703	14,453	12,969	27,422	81,125

Table 2. Pacific sardine time series of survey indices of relative abundance and sea-surface temperature, 1983-02.

Year	CalCOFI (% positive)	DEPM (mt)	Spawning area (Nmi^2)	Spotter plane (mt)	Sea-surface temperature (C)
83	na	na	40	na	17.25
84	4.9	na	480	na	17.58
85	3.8	na	760	na	17.80
86	1.9	7,659	1,260	22,049	17.87
87	4.0	15,704	2,120	11,498	17.71
88	7.9	13,526	3,120	55,882	17.55
89	7.2	na	3,720	32,929	17.24
90	3.7	na	1,760	21,144	17.19
91	16.7	na	5,550	40,571	17.35
92	8.8	na	9,697	49,065	17.61
93	6.1	na	7,685	84,070	17.84
94	17.8	127,096	24,539	211,293	17.97
95	13.4	na	23,816	188,924	18.04
96	28.0	83,175	25,890	119,731	18.06
97	27.3	409,585	40,591	66,943	18.06
98	24.3	313,985	33,446	118,492	18.44
99	16.7	282,236	55,171	40,506	18.04
00	7.8	1,063,845	32,784	48,373	17.73
01	12.5	790,958	31,663	na	17.24
02	7.1	206,323	61,753	na	17.31

Table 3. Pacific sardine time series of stock biomass (age 1+ fish in mt) and recruitment (age 0 fish in 1,000s) estimated at the beginning of semester 2 of each year. Stock biomass estimates are presented for Area 1 (Inside) and the Total Area of the stock. The 95% CIs for Total Area biomass and recruitment estimates are also presented.

	Stock biomass				Recruitment		
Year	Area 1	Total Area	Lower CI	Upper CI	Total Area	Lower CI	Upper CI
83	5,145	5,145	2,988	10,237	149,689	89,658	270,675
84	13,409	13,473	9,132	23,233	224,302	147,543	392,307
85	21,173	21,675	15,754	36,295	217,919	147,483	370,813
86	29,917	31,546	24,369	49,475	866,710	623,621	1,366,185
87	73,715	77,313	60,204	115,178	839,143	605,890	1,256,424
88	107,013	116,721	95,152	162,348	1,465,991	1,032,887	2,389,804
89	162,381	181,604	148,898	254,547	1,157,082	791,458	1,975,840
90	176,794	210,440	173,500	301,142	4,792,851	3,130,855	8,333,861
91	226,334	263,632	203,648	413,259	5,889,816	3,719,993	10,548,967
92	353,005	421,519	323,045	659,025	4,170,058	2,597,005	7,521,409
93	335,486	447,224	344,253	681,348	9,244,272	6,537,849	15,455,594
94	494,524	654,337	535,996	955,097	10,755,601	7,664,169	17,160,261
95	508,294	726,690	598,227	1,029,945	6,607,815	4,604,385	10,396,623
96	531,651	791,496	667,663	1,094,850	5,550,420	4,069,965	8,823,371
97	482,595	770,613	659,886	1,030,390	9,424,984	6,870,295	14,799,898
98	457,126	775,882	668,011	1,056,753	15,082,296	10,943,898	23,682,041
99	610,828	992,323	833,745	1,384,818	8,217,217	5,254,279	14,563,581
00	586,710	1,000,871	827,203	1,404,431	9,386,310	5,567,436	17,800,084
01	510,877	928,578	728,391	1,405,681	10,773,256	5,945,732	22,997,633
02	570,306	999,871	704,161	1,668,985	8,362,928	3,677,163	21,765,966

Table 4. Proposed harvest guideline for Pacific sardine for the 2003 fishing season. See Harvest Guideline for 2003 section for methods used to derive harvest guideline.

Total stock biomass (mt)	Cutoff (mt)	Fraction (%)	U.S. Distribution (%)	Harvest guideline (mt)
999,871	150,000	15%	87%	**110,908**

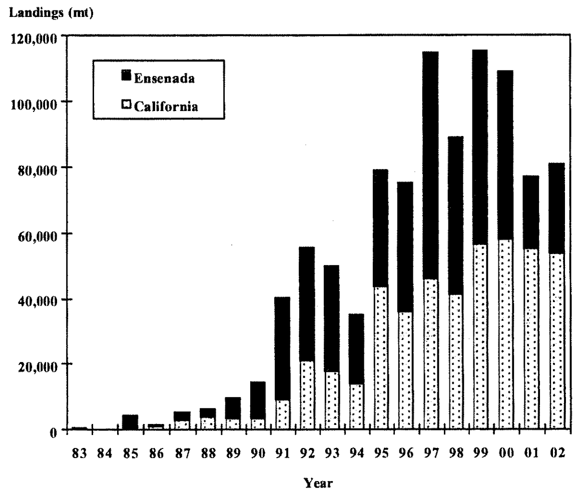

Figure 1. Pacific sardine landings (mt) in California and Baja California (Ensenada), 1983-02.

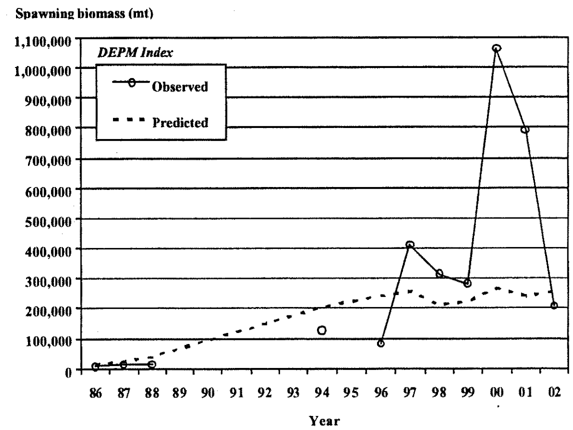

Figure 3. Index of relative abundance of Pacific sardine spawning biomass (mt) off California based on daily egg production method (DEPM) estimates from ichthyoplankton survey data (1986-02). Note that no sample data (Observed estimates) were available for years 1989-93 and 1995.

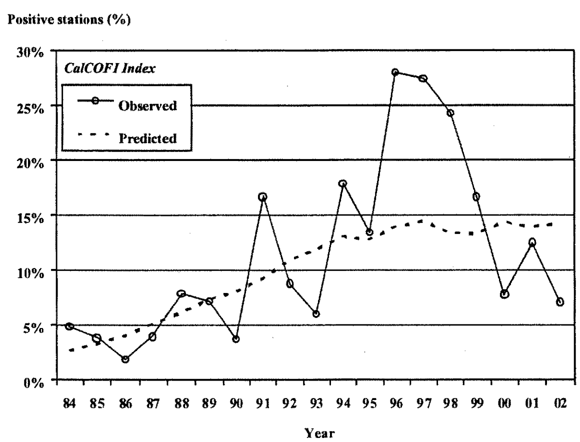

Figure 2. Index of relative abundance of Pacific sardine eggs (proportion-positive stations) off California based on CalCOFI bongo-net survey (1984-02).

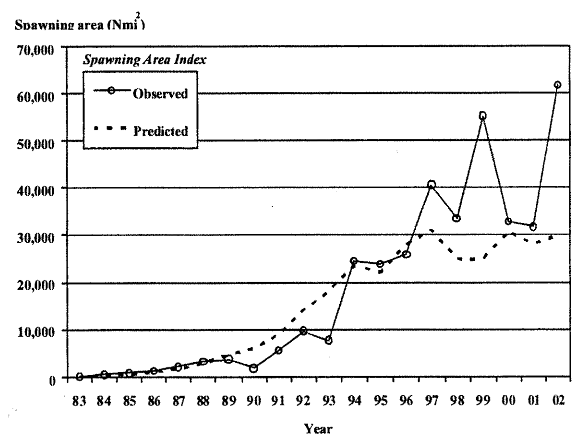

Figure 4. Index of relative abundance of Pacific sardine spawning stock size based on estimates of spawning area (Nmi^2) calculated from CalCOFI and DEPM survey data (1983-02).

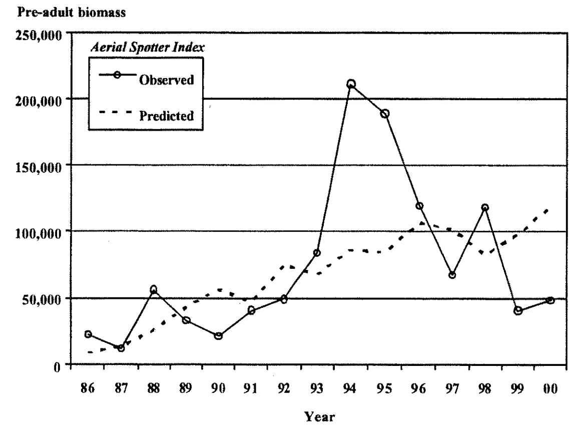

Figure 5. Index of relative abundance of Pacific sardine pre-adult biomass (primarily age 0-2 fish in mt) off California based on aerial spotter plane survey data (1986-00). Note that no sample data were available for 2001-02.

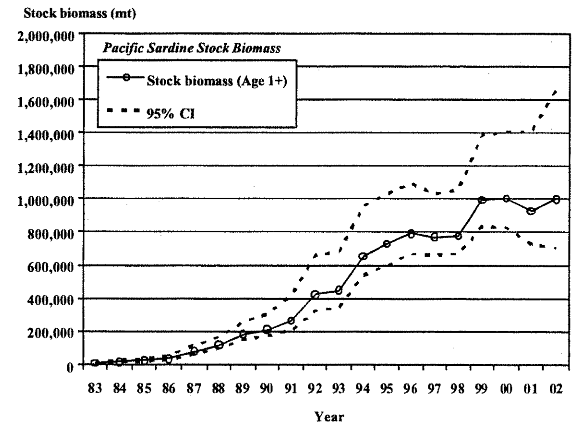

Figure 7. Time series (1983-02) of Pacific sardine stock biomass (age 1+ fish on July 1 of each year in mt) estimated from an age-structured stock assessment model (CANSAR-TAM, see Hill et al. 1999).

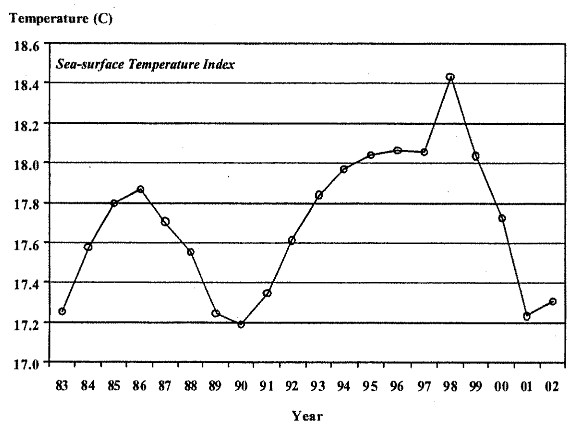

Figure 6. Time series of sea-surface temperature (C) recorded at Scripps Pier, La Jolla, CA (1983-02). Annual estimates reflect 3-year 'running' averages, see Jacobson and MacCall (1995).

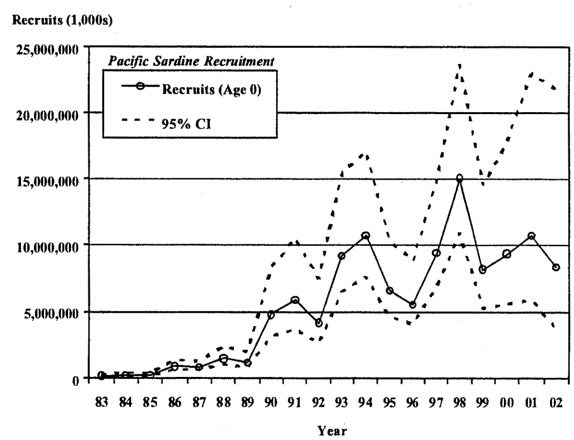

Figure 8. Time series (1983-02) of Pacific sardine recruitment (0-yr old fish on July 1 of each year in 1,000s) estimated from an age-structured stock assessment model (CANSAR-TAM, see Hill et al. 1999).

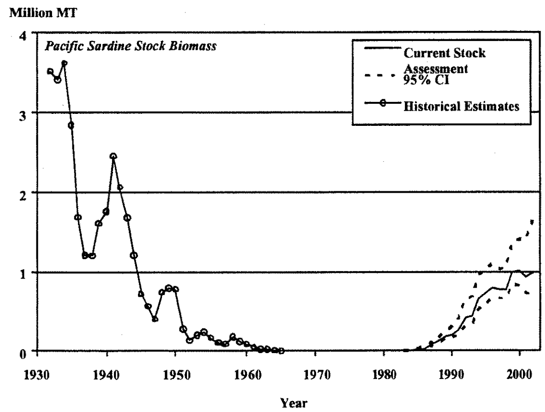

Figure 9. Time series (1983-2002) of Pacific sardine stock biomass (age 1+ fish on July 1 of each year in million mt) and associated 95% confidence intervals estimated in the current stock assessment (cf. Figure 7); and historical stock biomass estimates (1932-65) from Murphy (1966). Confidence intervals or other measures of precision are not available for the historical estimates. No stock assessment-based estimates are available for the period 1966-82. The sardine fishery was closed during much of this period and biomass was at very low levels.

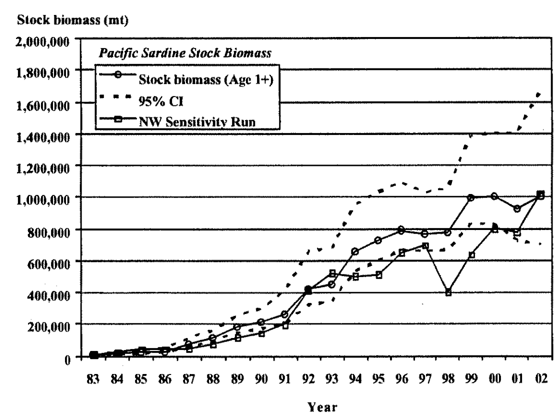

Figure 10. Time series (1983-02) of Pacific sardine stock biomass (age 1+ fish on July 1 of each year in mt) and 95% confidence intervals from this stock assessment (cf. Figure 7); and the stock biomass estimates from a sensitivity run using the NW fisheries data (Oregon and Washington) during 1999-2002. See text for details regarding the sensitivity run.

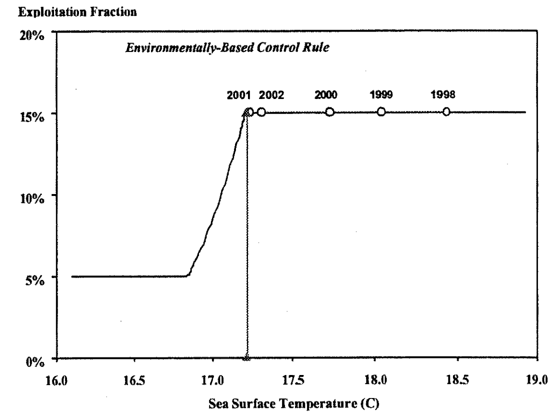

Figure 11. Environmentally-based harvest rate control rule for Pacific sardine as specified in the Coastal Pelagic Species Fishery Management Plan (PFMC 1998). For any given year, sea surface temperature (X-axis) is the running average sea surface temperature at Scripps Pier (La Jolla, CA) during the three preceding years. The exploitation fraction (Y-axis), which can range between 5-15%, is an explicit part of the algorithm used to determine the annual harvest guideline (quota) for the coastwide U.S. fishery – see Table 4. Open circles illustrate the sea surface temperature and exploitation fraction for recent years (1998-2002).

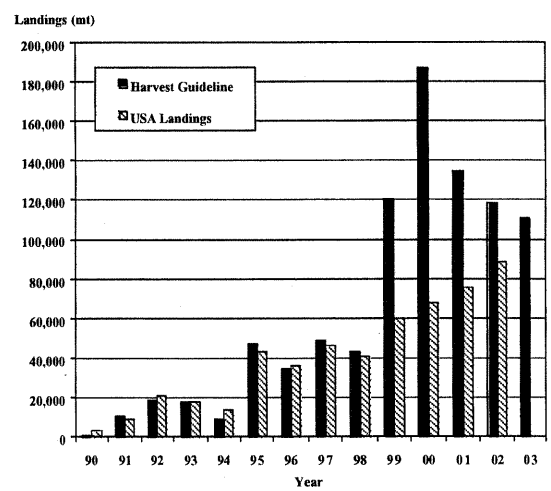

Figure 12. Time series (1990-03) of Pacific sardine harvest guidelines ('quotas') and actual USA landings (mt). State-based (California) regulations were in place for 1990-99, with federal-based (California, Oregon, and Washington) regulations beginning in 2000. Note that landings in 2002 represent an estimate projected through the end of the year. The 2003 harvest guideline is based on the 2002 stock biomass estimated in this assessment (Figure 7).

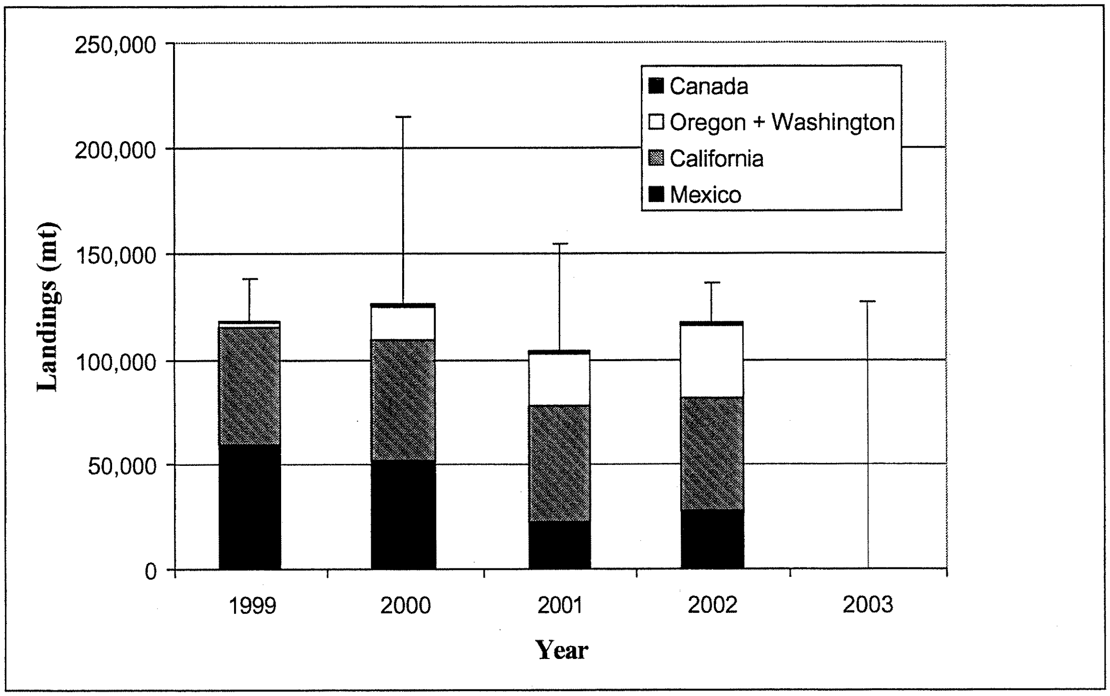

Figure 13. Pacific sardine landings (mt) from Mexico (Ensenada); California; Oregon and Washington; and Canada during 1999-2002. Landings shown for 2002 are estimates projected through the end of the calendar year. The thin bars illustrate the annual harvest guidelines that would have resulted from applying the PFMC CPS FMP harvest formula (see Table 4 and related text) on a stock-wide basis, i.e. applying the harvest guideline formula absent the "U.S. Distribution" term.

APPENDIX 3

TERMS OF REFERENCE FOR
A CPS STOCK ASSESSMENT REVIEW PROCESS

TERMS OF REFERENCE FOR A COASTAL PELAGIC SPECIES
STOCK ASSESSMENT REVIEW PROCESS
APRIL 2003

Introduction

The purpose of this document is to help the Council family and others understand the coastal pelagic stock assessment review process (STAR). Parties involved are the National Marine Fisheries Service (NMFS); state agencies; the Council and its advisors, including the Scientific and Statistical Committee (SSC), Coastal Pelagic Species Management Team (CPSMT), Coastal Pelagic Species Advisory Subpanel (CPSAS), Council staff; and interested persons. The STAR process is a key element in an overall process designed to make timely use of new fishery and survey data, to analyze and understand these data as completely as possible, to provide opportunity for public comment, and to assure the results are as accurate and error-free as possible. The STAR process is designed to assist in balancing these somewhat conflicting goals of timeliness, completeness and openness.

Stock assessments for Pacific sardine and Pacific mackerel are conducted annually to assess the abundance, trends and appropriate harvest levels for these species.[1/] Assessments use statistical population models to analyze and integrate a combination of survey, fishery, and biological data. At its November 2001 meeting, the SSC reported that

> *The Coastal Pelagic Species Management Team (CPSMT) has recommended a peer review process for the coastal pelagic species similar to the groundfish STAR process. The CPSMT suggests that full sardine and Pacific mackerel stock assessments and reviews be conducted on a triennial cycle, with a less formal review by the CPSMT and SSC during interim years. Full stock assessment reports would be developed and distributed following each STAR Panel review. Details from interim-year assessments could be documented in executive summaries similar to the one produced for this year's (2001) sardine assessment. As entirely new assessments are developed, a STAR Panel would be convened to review the assessment prior to implementation of results for setting harvest guidelines. The SSC supports the CPSMT's proposal.*

At its June 2002 meeting, the SSC further noted that the methodology on which the 2002 Pacific mackerel stock assessment was based...

> *is not fully documented in the Stock Assessment and Fishery Evaluation (SAFE) report precluding a detailed review by the SSC at this time. The SSC recommends the methodology be reviewed in detail by a stock assessment review panel in 2003. The CPS subcommittee of the SSC will develop Terms of Reference for such a review if it is supported and funded. The timing of any review needs to be coordinated with the timing of the groundfish Stock Assessment Review (STAR) Panels for 2003.*

Clearly there is a need to develop and implement a stock assessment and review (STAR) process for coastal pelagic species similar to that for groundfish. The first and most pressing candidates are Pacific sardine and Pacific mackerel.

Pacific sardine is now, along with Pacific whiting, the most abundant fish resource off the West Coast; at

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1/ Stock assessments are conducted for species "actively" managed under the Coastal Pelagic Species Fishery Management Plan (FMP). That is, fisheries for Pacific sardine and Pacific mackerel are actively managed via annual harvest guidelines and management specifications, which are based on current stock assessment information. Jack mackerel, Northern anchovy, and market squid are "monitored" species under the FMP. Annual landings of these species are monitored and reported in the annual Stock Assessment and Fishery Evaluation (SAFE) report, but harvest guidelines are not set for them.

one time sardine was the largest single-species fishery in the world, yet the research program for supporting sardine assessment is seriously under funded and under reviewed. The current fishery independent surveys only provide indices of sardine egg abundance and daily egg production. The aerial fish spotter index (used as a measure of sardine recruitment) only covers the nearshore areas of the southern California Bight and, more recently, spotter effort has been at negligible levels as spotter pilots have focused on other non-CPS fisheries. The adult parameters used in recent biomass estimates are computed on the basis of biological data collected in 1994, at a time when the population was one-tenth of the 2002 biomass. The data sources for sardine are limited to geographic areas off Baja California, Mexico, and the State of California (particularly the area from San Diego to Monterey Bay). A migration model parameterized with historical estimates of sardine migration rates is used to extrapolate the stock assessment to the northern areas of the sardine distribution. With the recent expansion of the sardine population off Oregon, Washington, and British Columbia, there is an urgent need to incorporate fishery-dependent data for northern areas into the stock assessment and to initiate resource surveys to establish a fishery-independent time series for those areas.

The same can be said for Pacific mackerel. The 2002 harvest guideline (HG) was based on the same stock assessment methodology and harvest control rule used in 2001, with the addition of one additional year's data. Compared with the 2001 assessment, the biomass time series for the 2002 assessment was 14% lower over the last decade, and the July 1, 2001 biomass, a projection in the 2001 assessment, 30% lower. The methodology on which this (current) assessment is based is not fully documented in the SAFE report precluding a detailed review by the SSC. Therefore, in 2002 the SSC recommended (June 2002 minutes) that the methodology be reviewed in detail by a stock assessment review panel as soon as possible.

STAR Goals and Objectives

The goals and objectives for the CPS assessment and review process[2/] are:

a. Ensure that CPS stock assessments provide the kinds and quality of information required by all members of the Council family.

b. Satisfy the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and other legal requirements.

c. Provide a well-defined, Council oriented process that helps make CPS stock assessments the "best available" scientific information and facilitates use of the information by the Council. In this context, "well-defined" means with a detailed calendar, explicit responsibilities for all participants, and specified outcomes and reports.

d. Emphasize external, independent review of CPS stock assessment work.

e. Increase understanding and acceptance of CPS stock assessment and review work by all members of the Council family.

f. Identify research needed to improve assessments, reviews and fishery management in the future.

g. Use assessment and review resources effectively and efficiently.

Shared Responsibilities

All parties have a stake in assuring adequate technical review of stock assessments. NMFS must determine that the best scientific advice has been used when it approves fishery management

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2/ In this document, the term "stock assessment" includes activities, analyses, and management recommendations, beginning with data collection and continuing through to the development of management recommendations by the Coastal Pelagic Species Management Team and information presented to the Council as a basis for management decisions.

recommendations made by the Council. The Council uses advice from the SSC to determine whether the information on which it will base its recommendation is the "best available" scientific advice. Fishery managers and scientists providing technical documents to the Council for use in management need to ensure the work is technically correct. Program reviews, in-depth external reviews, and peer-reviewed scientific publications are used by federal and state agencies to provide quality assurance for the basic scientific methods used to produce stock assessments. However, the time-frame for this sort of review is not suited to the routine examination of assessments that are, generally, the primary basis for a harvest recommendation.

The review of current stock assessments requires a routine, dedicated effort that simultaneously meets the needs of NMFS, the Council, and others. Leadership, in the context of the stock assessment review process for CPS species, means consulting with all interested parties to plan, prepare terms of reference, and develop a calendar of events and a list of deliverables. Coordination means organizing and carrying out review meetings, distributing documents in a timely fashion, and making sure that assessments and reviews are completed according to plan. Leadership and coordination both involve costs, both monetary and time, which have not been calculated, but are likely substantial.

The Council and NMFS share primary responsibility to a successful STAR process. The Council will sponsor the process and involve its standing advisory committees, especially the SSC. The chair of the SSC CPS subcommittee will coordinate, oversee and facilitate the process. Together they will consult with all interested parties to plan, prepare terms of reference, and develop a calendar of events and a list of deliverables. NMFS and the Council will share fiscal and logistical responsibilities.

The CPS STAR process is sponsored by the Council, because the Federal Advisory Committee Act (FACA) limits the ability of NMFS to establish advisory committees. FACA specifies a procedure for convening advisory committees that provide consensus recommendations to the federal government. The intent of FACA was to limit the number of advisory committees; ensure that advisory committees fairly represent affected parties; and insure that advisory committee meetings, discussions, and reports are carried out and prepared in full public view. Under FACA, advisory committees must be chartered by the Department of Commerce through a rather cumbersome process. However, the Magnuson-Stevens Act exempts the Council from FACA per se, but requires public notice and open meetings similar to those under FACA.

CPS STAR Coordination

The SSC CPS subcommittee chair will work with the Council, Council staff, other agencies, groups or interested persons that carry out assessment work to coordinate and organize Stock Assessment Team (STAT) Teams and STAR Panels, and make sure that work is carried out in a timely fashion according to the calendar and terms of reference.

The SSC CPS Subcommittee chair, in consultation with the SSC, will select STAR Panel chairs, and will coordinate the selection of external reviewers following criteria for reviewer qualifications, nomination, and selection. The public is welcome to nominate qualified reviewers. Following any modifications to the stock assessments resulting from STAR Panel reviews and prior to distribution of stock assessment documents and STAR Panel reports, the coordinator will review the stock assessments and panel reports for consistency with the terms of reference, especially completeness. Inconsistencies will be identified. Authors will be requested to make appropriate revisions in time to meet the deadline for distributing documents for the CPSMT meeting at which HG recommendations are developed.

Individuals (employed by NMFS, state agencies, or other entities) that conduct assessments or technical work in connection with CPS stock assessments are responsible for ensuring their work is technically sound and complete. The Council's review process is the principal means for review of complete stock assessments, although additional in-depth technical review of methods and data is desirable. Stock assessments conducted by NMFS, state agencies, or other entities must be completed and reviewed in full accordance with the terms of reference, at times specified in the calendar.

CPSMT Responsibilities

The CPSMT is responsible for identifying and evaluating potential management actions based on the best available scientific information. In particular, the CPSMT makes HG recommendations to the Council based on agreed control rules. The CPSMT will use stock assessments, STAR Panel reports, and other information in making their HG recommendations. Preliminary HG recommendations will be developed by the CPSMT according to the management process defined in Council Operating Procedures (COP-9). A representative of the CPSMT will serve as a liaison to each STAR Panel, but will not serve as a member of the Panel. The CPSMT will not seek revision or additional review of the stock assessments after they have been reviewed by the STAR Panel. The CPSMT chair will communicate any unresolved issues to the SSC for consideration. Successful separation of scientific (i.e., STAT Team and STAR Panels) from management (i.e., CPSMT) work depends on stock assessment documents and STAR reviews being completed by the time the CPSMT meets to discuss preliminary HG levels. However, the CPSMT can request additional model projections, based on reviewed model scenarios, in order to develop a full evaluation of potential management actions.

CPSAS Responsibilities

The chair of the CPSAS will appoint a representative to participate at the STAR Panel meeting. The CPSAS representative will participate in review discussions as an advisor to the STAR Panel, in the same capacity as the CPSMT advisor.

The CPSAS representative will attend the CPSMT meeting at which preliminary HG recommendations are developed. The CPSAS representative will also attend subsequent CPSMT, Council, and other necessary meetings.

The CPSAS representative will provide appropriate data and advice to the STAR Panel and CPSMT and will report to the CPSAS on STAR Panel and CPSMT meeting proceedings.

SSC Responsibilities

The SSC will participate in the stock assessment review process and provide the CPSMT and Council with technical advice related to the stock assessments and the review process. The SSC will assign one member from its CPS Subcommittee to each STAR Panel. This member is expected to attend the assigned STAR Panel meeting, the CPSMT meeting at which HG recommendations are made, and the Council meetings when CPS stock assessment agenda items are discussed. The SSC representative on the STAR Panel will present the STAR Panel report at CPSMT, SSC and Council meetings. The SSC representative will communicate SSC comments or questions to the CPSMT and STAR Panel chair. The SSC will review any additional analytical work on any of the stock assessments required or carried out by the CPSMT after the stock assessments have been reviewed by the STAR Panels. In addition, the SSC will review and advise the CPSMT and Council on harvest guideline recommendations.

The SSC, during their normally scheduled meetings, will serve as arbitrator to resolve disagreements between the STAT Team, STAR Panel, or CPSMT. The STAT Team and the STAR Panel may disagree on technical issues regarding an assessment. In this case, a complete stock assessment must include a point-by-point response by the STAT Team to each of the STAR Panel recommendations. Estimates and projections representing all sides of the disagreement need to be presented, reviewed, and commented on by the SSC.

Council Staff Responsibilities

Council staff will prepare meeting notices and distribute stock assessment documents, stock summaries, meeting minutes, and other appropriate documents. Council staff will assist in coordination of the STAR process. Staff will also publish or maintain file copies of reports from each STAR Panel (containing items specified in the STAR Panel's term of reference), the outline for CPS stock assessment documents, comments from external reviewers, SSC, CPSMT, and CPSAS, letters from the public, and any other relevant information. At a minimum, the stock assessments (STAT Team reports, STAR Panel reports, and stock summaries) should be published and distributed in the Council's annual CPS SAFE document.

Terms of Reference for STAR Panels and Their Meetings

The principal responsibility of the STAR Panel is to carry out the following terms of reference. The STAR Panel's work includes:

1. reviewing draft stock assessment documents and any other pertinent information (e.g.; previous assessments and STAR Panel reports, if available);
2. working with STAT Teams to ensure assessments are reviewed as needed;
3. documenting meeting discussions; and
4. reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the SAFE document.

STAR Panels normally include a chair, at least one "external" member (i.e., outside the Council family and not involved in management or assessment of West Coast CPS), and one SSC member. The total number of STAR members should be at least "n+2" where n is the number of stock assessments and "2" counts the chair and external reviewer. In addition to Panel members, STAR meetings will include CPSMT and CPSAS advisory representatives with responsibilities laid out in their terms of reference.

STAR Panels normally meet for one week.

The number of assessments reviewed per Panel should not exceed two.

The STAR Panel is responsible for determining if a stock assessment document is sufficiently complete. It is the Panel's responsibility to identify assessments that cannot be reviewed or completed for any reason. The Panel's decision that an assessment is complete should be made by consensus. If a Panel cannot reach agreement, then the nature of the disagreement must be described in the Panel's report.

The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations. Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels. The STAR Panel should identify scenarios that are unlikely or have a flawed technical basis.

Recommendations and requests to the STAT Team for additional or revised analyses must be clear, explicit and in writing. A written summary of discussion on significant technical points and lists of all STAR Panel recommendations and requests to the STAT Team are required in the STAR Panel's report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel's responsibility to carry out any follow-up review work that is required.

Additional analyses required in the stock assessment should be completed during the STAR Panel meeting. If follow-up work by the STAT Team is required after the review meeting, then it is the Panel's responsibility to track STAT Team progress. In particular, the chair is responsible for communicating with all Panel members (by phone, email, or any convenient means) to determine if the revised stock assessment and documents are complete and ready to be used by managers in the Council family. If stock assessments and reviews are not complete at the end of the STAR Panel meeting, then the work must be completed prior to the CPSMT meeting where the assessments and preliminary HG levels are discussed.

The STAR Panel, STAT Team, and all interested parties are legitimate meeting participants that must be accommodated in discussions. It is the STAR Panel chair's responsibility to manage discussions and public comment so that work can be completed.

STAT Teams and STAR Panels may disagree on technical issues. If the STAR Panel and STAT Team disagree, the STAR Panel must document the areas of disagreement in its report. The STAR Panel may request additional analysis based on alternative approaches. Estimates and projections representing all sides of the disagreement need to be presented in the assessment document, reviewed, and commented on by the SSC. It is expected that the STAT Team will make a good faith effort to complete these analyses.

The SSC representative on the STAR Panel is expected to attend CPSMT and Council meetings where stock assessments and harvest projections are discussed to explain the reviews and provide other technical information and advice.

The chair is responsible for providing Council staff with a camera ready and suitable electronic version of the Panel's report for inclusion in the annual SAFE report.

Suggested Template for STAR Panel Report

- Minutes of the STAR Panel meeting, including name and affiliation of STAR Panel members.
- List of analyses requested by the STAR Panel.
- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.
- Explanation of areas of disagreement regarding STAR Panel recommendations:
    - among STAR Panel members (majority and minority reports), and
    - between the STAR Panel and STAT Team.
- Unresolved problems and major uncertainties, (e.g., any special issues that complicate scientific assessment, questions about the best model scenario).
- Prioritized recommendations for future research and data collection.

Terms of Reference for CPS STAT Teams

The STAT Team will carry out its work according to these terms of reference.

Each STAT Team will appoint a representative to coordinate work with the STAR Panel and attend the STAR Panel meeting.

Each STAT Team will appoint a representative who will attend the CPSMT, CPSAS, and Council meetings where preliminary harvest levels are discussed. In addition, a representative of the STAT Team should attend the CPSMT and Council meeting where final HG recommendations are developed, if requested or necessary. At these meetings, the STAT Team member shall be available to answer questions about the STAT Team report.

The STAT Team is responsible for preparing three versions of the stock assessment document, (1) a "draft" for discussion at the stock assessment review meeting; (2) a revised "complete draft" for distribution to the CPSMT, CPSAS, SSC, and Council for discussions about preliminary harvest levels; (3) a "final" version published in the SAFE report. Other than authorized changes, only editorial and other minor changes should be made between the "complete draft" and "final" versions. The STAT Team will distribute "draft" assessment documents to the STAR Panel, Council, and CPSMT and CPSAS representatives at least two weeks prior to the STAR Panel meeting.

The STAT Team is responsible for bringing computerized data and working assessment models to the review meeting in a form that can be analyzed on site. STAT Teams should take the initiative in building and selecting candidate models. If possible, the STAT Team should have several complete models and be prepared to justify model recommendations.

The STAT Team is responsible for producing the complete draft by the end of the STAR Panel meeting. In the event that the complete draft is not completed, the Team is responsible for completing the work as soon as possible and to the satisfaction of the STAR Panel at least one week before the CPSMT meeting.

The STAT Team and the STAR Panel may disagree on technical issues regarding an assessment, but a complete stock assessment must include a point-by-point response by the STAT Team to each of the

STAR Panel recommendations. Estimates and projections representing all sides of the disagreement need to be presented, reviewed, and commented on by the SSC.

Electronic versions of final assessment documents, parameter files, data files, and key output files will be provided to Council staff.

Appendix A: Outline for CPS Stock Assessment Documents

This is an outline of items that should be included in stock assessment reports for CPS managed by the Pacific Fishery Management Council. The outline is a working document meant to provide assessment authors with flexible guidelines about how to organize and communicate their work. All items listed in the outline may not be appropriate or available for each assessment. In the interest of clarity and uniformity of presentation, stock assessment authors and reviewers are encouraged (but not required) to use the same organization and section names as in the outline. It is important that time trends of catch, abundance, harvest rates, recruitment and other key quantities be presented in tabular form to facilitate full understanding and followup work.

1. <u>Title page and list of preparers</u> (the names and affiliations of the stock assessment team (STAT) either alphabetically or as first and secondary authors)

2. <u>Executive Summary</u> (this also serves as the STAT summary included in the SAFE)

3. <u>Introduction</u>
   a. Scientific name, distribution, stock structure, management units
   b. Important features of life history that affect management (e.g., migration, sexual dimorphism, bathymetric demography)
   c. Important features of current fishery and relevant history of fishery
   d. Management history (e.g., changes in management measures, harvest guidelines)
   e. Management performance – a table or tables comparing annual biomass, harvest guidelines, and landings for each management subarea and year

4. <u>Assessment</u>
   a. Data
      i. Landings by year and fishery, catch-at-age, weight-at-age, survey and CPUE data, data used to estimate biological parameters (e.g., growth rates, maturity schedules, and natural mortality) with coefficients of variances (CVs) or variances if available. Include complete tables and figures if practical
      ii. Sample size information for length and age composition data by area, year, etc.

   b. History of modeling approaches used for this stock – changes between current and previous assessment models

   c. Model description
      i. Complete description of any new modeling approaches
      ii. Assessment program with last revision date (i.e., date executable program file was compiled)
      iii. List and description of all likelihood components in the model
      iv. Constraints on parameters, selectivity assumptions, natural mortality, assumed level of age reader agreement or assumed ageing error (if applicable), and other assumed parameters
      v. Description of stock-recruitment constraint or components
      vi. Critical assumptions and consequences of assumption failures
      vii. Convergence criteria

   d. Model selection and evaluation
      i. Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models
      ii. Use hierarchical approach where possible (e.g., asymptotic vs. domed selectivities,

constant vs. time varying selectivities)

iii. Do parameter estimates make sense, are they credible?
iv. Residual analysis (e.g., residual plots, time series plots of observed and predicted values, or other approach)
v. Convergence status and convergence criteria for "base-run(s)"
vi. Randomization run results or other evidence of search for global best estimates

e. Base-run(s) results
   i. Table listing all parameters in the stock assessment model used for base runs, their purpose (e.g., recruitment parameter, selectivity parameter) and whether or not the parameter was actually estimated in the stock assessment model
   ii. Time-series of total and spawning biomass, recruitment and fishing mortality or exploitation rate estimates (table and figures)
   iii. Selectivity estimates (if not included elsewhere)
   iv. Stock-recruitment relationship

f. Uncertainty and sensitivity analyses
   i. The best approach for describing uncertainty and range of probable biomass estimates in CPS assessments may depend on the situation. Possible approaches include:
      A. Sensitivity analyses (tables or figures) that show ending biomass levels or likelihood component values obtained while systematically varying emphasis factors for each type of data in the model
      B. Likelihood profiles for parameters or biomass levels may also be used
      C. CVs for biomass estimated by bootstrap, implicit autodifferentiation, or the delta method
      D. Subjective appraisal of magnitude and sources of uncertainty
      E. Comparison of alternate models
      F. Comparison of alternate assumptions about recent recruitment
   ii. If a range of model runs (e.g., based on CV's or alternate assumptions about model structure or recruitment) is used to depict uncertainty, then it is important that some qualitative or quantitative information about relative probability be included. If no statements about relative probability can be made, then it is important to state that all scenarios (or all scenarios between the bounds depicted by the runs) are equally likely
   iii. If possible, ranges depicting uncertainty should include at least three runs: (a) one judged most probable; (b) at least one that depicts the range of uncertainty in the direction of lower current biomass levels; and (c) one that depicts the range of uncertainty in the direction of higher current biomass levels. The entire range of uncertainty should be carried through stock projections and decision table analyses
   iv. Retrospective analysis (retrospective bias in base model or models for each area)
   v. Historic analysis (plot of actual estimates from current and previous assessments for each area)
   vi Simulation results (if available)

5. <u>Harvest Control Rules</u>

Pacific Sardine

The CPS FMP defines the maximum sustainable yield (MSY) control rule for Pacific sardine. This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over a long-term. The harvest formula for sardine is:

HG = (TOTAL STOCK BIOMASS - CUTOFF) • FRACTION • U.S. DISTRIBUTION,

where harvest guideline (HG) is the total U.S. (California, Oregon, and Washington) harvest recommended for the next fishing year, TOTAL STOCK BIOMASS is the estimated stock biomass (ages 1+) from the current assessment, 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 U.S. DISTRIBUTION is the percentage of TOTAL STOCK BIOMASS 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 during relatively warm-water ocean conditions, 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 years. Under the harvest control rule, F_{MSY} is constrained and ranges between 5% and 15% depending on the value of T. Based on the T values observed throughout the period covered by this stock assessment (1983-2002), the appropriate F_{MSY} exploitation fraction has consistently been 15%; and this remains the case under current oceanic conditions (T_{2002} = 17.3 °C). However, it should be noted that the decline in sea-surface temperature observed in recent years (1998-2002) may invoke environmentally-based reductions in the exploitation fraction in the near future and could substantially reduce the harvest guideline.

The harvest guideline recommended for the U.S. (California, Oregon, and Washington) Pacific sardine fishery for 2003 was 110,908 mt.

Pacific Mackerel

The CPS FMP defines the MSY control rule for Pacific mackerel as:

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

where HG is the U.S. harvest guideline, CUTOFF (18,200 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that can be taken by fisheries, and STOCK DISTRIBUTION (70%) is the average fraction of total BIOMASS in U.S. waters.

CUTOFF and FRACTION values applied in the Council's harvest policy for mackerel are based on simulations published by MacCall et al. in 1985. BIOMASS is the estimated biomass of fish age 1 and older for the whole stock as of July 1. As for Pacific sardine, FRACTION is a proxy for F_{MSY}.

Based on this formula and current BIOMASS of 77, 516 mt, the HG for the July 1, 2002 - June 30, 2003 season was 12,456 mt. The recommended harvest guideline was 1,381 mt lower (-10%) than the 2001-2002 HG, but similar to the average yield (14,053 mt) realized by the fishery since the 1992-1993 season.

6. Target Fishing Mortality Rates (if changes are proposed)

7. Harvest Projections and Decision Tables

   a. Harvest projections and decision tables should cover the plausible range of uncertainty about current biomass and the full range of candidate fishing mortality targets used for the stock or requested by the CPSMT. Ideally, the alternatives described in the decision table will be drawn from a probability distribution which describes the pattern of uncertainty regarding the status of the stock and the consequences of alternative future management actions. Where alternatives are not formally associated with a probability distribution, the document needs to present sufficient information to guide assignment of approximate probabilities to each alternative

   b. Information presented should include biomass and yield projections for at least three years into the future, beginning with the first year for which management action could be based upon the assessment

8. Management Recommendations

9. Research Needs (prioritized)

10. Acknowledgments (include STAR Panel members and affiliations as well as names and affiliations of persons who contributed data, advice or information but were not part of the assessment team)

11. Literature Cited

12. Complete Parameter Files and Results for Base Runs

APPENDIX 4

PACIFIC SARDINE ALLOCATION

Excerpt (sections 1 and 2) from: *Allocation of the Pacific Sardine Harvest Guideline – Regulatory Amendment for the Coastal Pelagic Species Fishery Management Plan, Including Environmental Assessment, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis*. April 2003.

This regulatory amendment was submitted to National Marine Fisheries Service on April 28, 2003. These excerpts are provided for informational purposes. The full document is available on the Council website www.pcouncil.org. Hard copies are available from the Council office, see contact information on the cover page of this document.

Section 1 – Purpose and need for the regulatory amendment.

Purpose: Implement an interim[1/] allocation framework that seeks optimal use of the annual Pacific sardine harvest guideline to benefit all sectors of the West Coast sardine fishing industry and fishing communities.

Proposed Action: The Pacific Fishery Management Council is recommending National Marine Fisheries Service (NMFS) implement a regulatory amendment to: (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% to both subareas to 20% to Subarea A and 80% to Subarea B, and (4) reallocate all unharvested sardine that remains on December 1 coast wide.

Need: Problems for Resolution

Critical to any environmental assessment (EA) is the degree to which the alternative management actions have biological and/or socioeconomic impacts on the affected environment. The affected environment germane to this EA is the West Coast population of Pacific sardine, the ecosystem in which they reside, the various regional harvesting and processing sectors, and the communities dependent on the sardine resource. The critical consideration for this proposed action is the distinction between biological and economic effects of the various management alternatives.

Information in this EA was developed and analyzed by the Council's Coastal Pelagic Species Management Team (CPSMT). Council recommendations to NMFS are based on CPSMT analysis, advice of the Coastal Pelagic Species Advisory Subpanel (CPSAS), and public comment.

In developing this analysis, the CPSMT generally agreed that (measurable) implications of alternative allocation schemes used to partition the Pacific sardine harvest guideline largely involve socioeconomic considerations, given that the current recommended yield is generated from analysis based on the dynamics of a single, coast-wide population. Moreover, the CPSMT is confident the sardine harvest guideline control rule provides an appropriate means to manage the sardine fishery (see Section 1.2.3). However, in the future, the CPSMT suggests that biological-based implications of different allocation schemes be further evaluated, at least in qualitative terms, to provide management some guidance regarding how the operations of the sectoral fisheries might impact the dynamics of the sardine population at-large. For example, research on coastwide abundance of sardine and a CPS stock assessment review (STAR) process will occur in 2004. These initiatives should provide useful information that could be incorporated into considerations of longer-term allocation measures.

In summary, recent assessments generally indicate the sardine population off the U.S. Pacific Coast has responded relatively well to levels of exploitation over the last several years. That is, in the short-term, overall fishing practices are in accordance with concerns related to resource sustainability.

Currently, there is an immediate need to prevent socioeconomic problems that are likely to occur under the current allocation framework. Therefore, development of an interim management measure for allocation of the coastwide harvest guideline is being pursued, and analysis of alternatives will focus on economic information. It is the intent of the Council to follow this action with a more comprehensive development of a longer-term allocation mechanism that would entail a more detailed analysis of alternative allocation frameworks in terms of socioeconomic and biological impacts. It is important to note that a more detailed

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1/ Interim measures are being considered for 2003 and 2004 (and potentially 2005). The intent is to develop a longer-term allocation scheme after this action is completed.

analysis, to meet longer-term allocation needs, may require substantial work and subsequent time demands on researchers and managers. In this regard, the CPSMT strongly advised that the revisions to the current allocation scheme discussed in this EA be considered strictly temporary measures that address emergency-related issues associated with early closures to fisheries based on quota stipulations. The Council concurred and recommends the interim measures be considered for 2003 and 2004, with possible extension to the 2005 fishing season.

The proposed action is consistent with FMP objectives (see Section 5)–it seeks to promote efficiency and profitability in the fishery, including stability of catch and aims to ensure the optimum yield (OY) is achieved. The proposed action is also consistent with recently implemented Amendment 10 to the CPS FMP (68*FR*3819). Amendment 10 established a maximum fleet capacity for the CPS limited entry fishery, allows the transfer of limited entry permits, and establishes criteria for issuing new permits if economic or resource conditions indicate that such permits would be beneficial. One element of the proposed action would move the management subarea line from 35°40' N latitude (Point Piedras Blancas) to 39° N latitude (Point Arena). This action would make the management subarea line and the limited entry fishery line complementary. This should provide additional stability to all sectors of the sardine fishery by explicitly dividing the harvest guideline among the limited entry fishery and open access fishery[2/]. See Section 5 for more information on the consistency of the proposed action with the CPS FMP and the Magnuson-Stevens Act.

Background

The current allocation framework partitions the annual harvest guideline 66% to the southern subarea and 33% to the northern subarea. Nine months after the January 1 start of the fishery (i.e., October 1), the remaining harvest guideline is pooled and re-allocated 50%-50% to each subarea. The current subarea line is 35° 40' N latitude (approximately Point Piedras Blancas). This formula was incorporated into federal management from existing California state law. The state law was designed to balance fishing opportunity between the Southern California-based fishery ("South") and Monterey-based fishery ("North"). At the time of the FMP's implementation, this was considered a status quo action (as the sardine fishery occurred, principally, in California) with no environmental impacts. No alternative allocation formulae were considered. The FMP does not preclude additional allocations based on other geographic areas or other factors developed under the authority of the FMP and provides for allocation matters to be addressed under the socioeconomic point-of-concern framework. Currently, the southern subarea primarily includes the fleet based in San Pedro and Los Angeles, California; the northern subarea includes fisheries off Monterey, California; Oregon; and Washington.

With expansion of the Pacific sardine fishery into the Pacific Northwest, the northern area allocation is now shared by Monterey, Oregon, and Washington-based fisheries. Concern has been expressed that the current allocation framework does not provide optimal harvest opportunity to these respective fisheries. For example, under the current allocation framework (and given status quo harvest levels), there is a high likelihood the northern area fisheries will attain their portion of the annual harvest guideline prior to the scheduled October 1 reallocation, which (as described below) effectively causes premature closure of the Pacific Northwest fishery. Specific socioeconomic concerns include:

- Pacific Northwest fisheries generally finish operations in October, because weather and ocean conditions make fishing difficult or impossible for purse seine gear and less productive because sardine schools are harder to locate. In 2002, the northern area allocation was reached, and the fishery closed on September 14, 2002 (67*FR*58733). Due to concern over community impacts resulting from this closure, NMFS promulgated an emergency rule to re-allocate the unused amount of the coastwide harvest guideline on September 26, 2002 (67*FR*60601). That is, emergency action was taken to reallocate before October 1, 2002. The express purpose of this emergency rule was to avoid unnecessary economic hardship. At the time of the emergency action, sufficient amounts of the sardine harvest guideline remained to satisfy all users. At the end of the year, the harvest guideline had not been attained (approximately 17,400 metric tons (mt) remained unharvested). Had the reallocation occurred earlier,

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2/ North of 39° N latitude the federal fishery is an open access fishery. However, Oregon and Washington actively limit participation in fisheries off their coasts.

avoiding the September 14 closure, there likely would have been a net gain in harvest and producer surplus.

- Monterey area fisheries target squid (when available) during the first half of the year and begin to target sardine around August, with their season running through January or February of the following year. Concern has been expressed that harvest opportunity for the Monterey fishery could be preempted by the Pacific Northwest fishery. The existing allocation system (as incorporated from the former California state management system) was designed to prevent the Southern California fishery from preempting the fishery in Monterey. However, the development of significant fisheries off Oregon and Washington has changed the harvesting dynamics. Additional fishing opportunity could be provided to the northern fisheries without adverse impacts on southern fisheries at current harvest guideline levels.

- The harvest control rule for Pacific sardine is environmentally-based and tuned to the importance of sardine within the ecosystem. It is based on the best available science, and the annual harvest guideline is set at a sustainable level. A principle goal of the CPS FMP is to ensure full utilization of the annual coastwide harvest guideline. However, in recent years as much as 59,000 mt of the harvest guideline was left unharvested at the end of the season. Concern has been expressed that this foregone harvest opportunity could be exacerbated by the current allocation formula, and could result in an unnecessary impact to the coastwide fishery and loss in net national benefit.

Each of the three sectors operates over a unique schedule. Generally, Southern California starts harvesting sardine January 1 and increases steadily throughout the year; Northern California starts in August (tied to market squid availability) and increases through January or February of the following year; and Oregon and Washington have a much more abbreviated season, which starts in June and ends in October. Because these sectors operate on very different schedules, annual allocations help to ensure that each sector receives a reasonable fishing opportunity. Exvessel landings in all sectors are driven by domestic and international market forces for sardines, as well as the availability and markets for other species of economic benefit to sardine vessels and processors. The Northern California fishery is also influenced by availability of market squid and adverse weather. The Pacific Northwest fishery is affected by sardine availability and adverse weather. Figure 1 displays the seasonal structure of the three regional sectors.

Pacific Sardine Harvest Guideline Formula

The following excerpt from the CPS FMP Environmental Impact Statement (EIS) reviews the environmentally-based formula for determining the annual allowable harvest (harvest guideline; also known as OY) for the Pacific sardine fishery. Information is excerpted from page EIS-9 and Appendix B, Section 4 of the CPS FMP. This information is provided to bolster the Council's finding that the proposed action does not pose an environmental risk. That is, the proposed action is not expected to change the nature of the fishery, a fishery which is managed sustainably under a conservative, environment-based harvest control rule.

For CPS, an maximum sustainable yield (MSY) control rule is defined to be a harvest strategy that provides biomass levels at least as high as the F_{MSY} approach while also providing relatively high and relatively consistent levels of catch. By definition, candidate MSY control rules for CPS take the F_{MSY} policy as a lower bound in terms of biomass and catch. This means that any candidate MSY control rule must provide biomass levels that are at least as high as those from the F_{MSY} policy while also providing relatively high and consistent levels of catch.

The definition of an MSY control rule for CPS is compatible with National Standard 1, but more conservative and more general. According to National Standard 1 (50 CFR §600.210) 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 in National Standard 1 "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. The definition for CPS is more conservative, because the focus for CPS is oriented primarily towards stock biomass levels at least as high as the MSY stock size. In the definition for CPS, "relatively high and consistent catch levels" are important, and MSY *is used as a lower bound. The primary focus on biomass, rather than catch, is appropriate for CPS, because most species (Pacific sardine, northern anchovy, and market squid) are very important in the ecosystem for forage. MSY control rules for CPS (e.g., for sardine) are superior to the F_{MSY} approach in economic, social, and ecological terms. However, the F_{MSY} approach serves as a lower bound (with respect to biomass and catch) in their definition, and adjustments can be made to account for stock biomass, precision of biomass estimates and data, statistical characteristics in recruitment patterns (e.g., runs of years with good or bad recruitment), and other characteristics of the stock and fishery.*

Sardine are important as forage to a large number of birds, marine mammals, and fish predators (including endangered species) although few data are available, because of the scarcity of sardine, until recently. Decisions about harvest formula options and the definition of overfishing for sardine must, therefore, consider sardine as forage. Forage and ecosystem-related goals and objectives are included in this FMP.

Of all CPS, sardine productivity is most strongly affected by environmental variation. Favorable and unfavorable periods or "regimes" for sardine tend to occur in cycles of about 60 years. This means that periods of low abundance for sardine are probably inevitable, even in the absence of a fishery.

It is important to remember that sardine productivity changes substantially in response to long term environmental variation. Favorable conditions for sardine are characterized by warm sea surface temperatures in the Southern California Bight while unfavorable conditions are characterized by cold sea surface temperatures. This means that the best MSY control rule in a particular year might depend on ocean conditions.

For Pacific sardine, MSY control rule options are analyzed using a species and fishery- specific simulation model. The general approach is to simulate the stock and fishery over a long period of time and using a large number of MSY control rule parameter values. Results are used to find MSY control rules and control rule parameters that give good results for most measures of performance.

Options for Pacific sardine and Pacific (chub) mackerel are based on the general formula

H=(BIOMASS-CUTOFF) x FRACTION

where H is the harvest level, BIOMASS is the estimated stock biomass, CUTOFF is the lowest level of estimated biomass at which directed harvest is allowed, and FRACTION is an exploitation rate parameter. In some cases, it is useful to define a maximum harvest level (MAXCAT) so that total harvest never exceeds MAXCAT. MSY control rule parameters might be constant from year to year or might change, depending on environmental conditions or conditions in the fishery. Most CPS are transboundary resources distributed off Mexico, the U.S., and Canada. It is, therefore, necessary to adjust harvest levels for U.S. fisheries in proportion to the biomass in U.S. waters. This is typically done by multiplying the overall acceptable biological catch (ABC) from the MSY control rule by an estimate of the percentage of the stock in U.S. waters.

For sardine, the Council chose a harvest control rule that provides biomass and catch levels comparable to or better than the deterministic equilibrium F_{MSY} projected for other options and because it has a CUTOFF of 150,000 mt. This option was chosen, because it best achieves the FMP goals and objectives of preventing overfishing, providing adequate forage for dependent species, and promoting stability of catch. FRACTION, the variable tied to sea surface temperature, provides an element of environmental sensitivity in recognition of the sensitivity of the sardine biomass to changes in ocean temperature.

In general, the sea surface temperature (SST) used for determining FRACTION has been declining since the inception of federal management. If this trend continues, a swift reduction of catch from 15% of the available biomass to 5% (based on how FRACTION is applied in the harvest guideline formula) could occur. To gauge the importance of this issue, the CPSMT reviewed the development and application of the harvest guideline formula. Three issues of concern were discussed: (A) the quality of the contemporary versus historical entries in the SST time series; (B) the availability of alternative temperature time series for use in the harvest control rule; and (C) reevaluation of the functional relation between sardine productivity (e.g., recruitment and abundance) and oceanographic conditions.

A. Contemporary versus Historical Scripps Pier Sea Surface Temperatures

The basis for the time series of sardine-environment is the relationship between the Scripp's Institution of Oceanography ([SIO]; La Jolla, California) pier SST and age 1-5 biomass of sardines in the period 1930-1990. The CPSMT is exploring ways to ensure application of the FRACTION range (5% to 15%) is flexible enough to prevent over harvest without unnecessarily burdening the fishery. In the future, the CPSMT may revise the relationships based on new ideas and data. In particular, some have expressed concern that the SIO pier is central to the California-Baja California fisheries' reduced population of Pacific sardines in this time period, the current population range is now several times as great, reaching into Alaska and prominent in British Columbia, Canada.

B. Better Temperature Time Series

There are now several data sets of temperatures representing large portions of the ocean. The California Cooperative Oceanic Fisheries Investigations (CalCOFI) time series have been compared to the SIO Pier SST data set and found to be comparable. There are also shore station and air temperature time series throughout the range of Pacific sardine and some method of assembly could be adapted for use in a regulatory control rule.

C. Environmental Influence

There are also compendia describing environmental influences on sardine recruitment. For example, 20 environmental mechanisms have been proposed as controlling factors for regulating sardine growth. The Pacific sardine stock covered by the FMP ranges along the entire West Coast of North America. Functional solutions to sardine production have not been fully developed. While the mechanisms appear plausible, the current level of biological oceanography effort, fisheries oceanography commitment, and physical oceanography approaches have not led to definitive conclusions about sardine production.

Based on this consideration and review, the CPSMT concluded:

1. The current harvest control rule for sardine is sound and based on good analyses.
2. The SIO pier SST data set constitutes a reliable data source.
3. A stepped (gradual) transition from 15% to 5% might be a useful management tool for managing a dynamic fishery.

Future Considerations

In the future, when information becomes available, some biological questions relating to allocation and differential impacts on the coastwide resource from the three fishing sectors that could be evaluated generally include:

- Impacts to the coastwide population from a fishery that targets older, mature fish.
- Impacts to the coastwide population from a fishery that targets younger, immature fish.
- Recent indications of changes in maturity rates (i.e., delayed maturity) in the southern fishery resulting from density-dependent factors.
- Potential refinements to the Pacific sardine assessment and/or harvest control rule in response to new biological information.

Future biological information will include NMFS research surveys off the Pacific Northwest scheduled for summer 2003 and a STAR scheduled for spring 2004.

NMFS-Southwest Fisheries Science Center (SWFSC) will conduct sardine acoustic trawl and Continuous Underway Fish Egg Sampler (CUFES) surveys off the coast of Oregon and Washington in July 2003 and January-February 2004 (acoustic-trawl only). These surveys are designed to fill major gaps in knowledge of sardine populations, by measuring the age structure and reproductive rates, and assessing the extent the fishery is dependent on migration and on local production of sardine. The objective of the surveys is to estimate the biomass present at these two times of the year, with the ratio of the two values providing an estimation of the relative proportion, as well as size/age structure of the sardine stock, which is hypothesized to over-winter off the coast of Oregon and Washington.

A CPS STAR workshop is scheduled for May 2004. The goals and objectives for the CPS assessment and review process are: ensure that CPS stock assessments provide the kinds and quality of information required by all members of the Council family; satisfy the Magnuson-Stevens Act and other legal requirements; and provide a well-defined, Council oriented process that helps make CPS stock assessments the "best available" scientific information and facilitates use of the information by the Council. In this context, "well-defined" means: based on a detailed calendar, with explicit responsibilities for all participants, and provides specified outcomes and reports; emphasizes external, independent review of CPS stock assessment work; increases understanding and acceptance of CPS stock assessment and review work by all members of the Council family; identifies research needed to improve assessments, reviews, and fishery management in the future; and uses assessment and review resources effectively and efficiently. The CPS STAR process will be used in crafting alternatives for a longer-term allocation framework and information for Pacific sardine management in 2005.

As data become available, this information, along with more robust economic information on producer profit and surplus, will be considered in crafting longer-term management alternatives for annual allocation of the Pacific sardine harvest guideline. As noted, it is expected that once an interim measure is in place, the Council will embark on an amendment to the CPS FMP.

Scoping Summary

The Council process offers many opportunities to determine the scope of the action and the likely environmental consequences that merit analysis and disclosure. This work is carried out by advisory bodies and at Council meetings, which are open to the public. The preceding background discussion and Section 4 describe how the proposed action analyzed in this document evolved with direction from the Council and development by various advisory bodies, in particular the CPSMT and CPSAS. Section 7.2 of this document lists public meetings where issues and analyses contained in this regulatory amendment were developed, analyzed, and adopted. This regulatory amendment and the proposed action were developed over the course of 10 meetings of the Council and its advisory bodies. Opportunity for public comment was provided at each of these meetings. The Council received approximately 50 letters from the public about this issue. Approximately 8 and 18 members of the public provided testimony to the Council at the March and April 2003 meetings, respectively.

A notice of availability for the public review draft of the regulatory amendment was distributed via email and U.S. post on March 19, 2003. The public review document was posted on the Council website and distributed via email, fax, and U.S. post on March 25, 2003. Final Council action occurred on April 10, 2003. The intent of the Council is for this action to be implemented in time to prevent premature closure of northern subarea sardine fisheries prior to reallocation of the harvest guideline (i.e., some time in August 2003). Thus, given the time necessary for the federal rulemaking process, this schedule required final Council action in April 2003.

Section 2 – Management alternatives for allocating Pacific sardine.

As noted above, the current FMP allocation framework partitions the annual harvest guideline 66% to the southern subarea and 33% to the northern subarea. Nine months after the January 1 start of the fishery (i.e., October 1) the remaining harvest guideline is pooled and re-allocated 50-50 to each subarea. The current subarea line is 35°40' N latitude (approximately Point Piedras Blancas).

In developing alternative management measures for an interim change to the allocation framework, the CPSMT started from an initial suite of management measures provided by the Council in November 2002. The Council gave discretion to the CPSMT to develop the most appropriate set of alternatives, including development of new alternatives. Through the analysis described in Section 4, the CPSMT settled on a suite of alternatives that could most practicably provide for consideration of an interim change that could be implemented in 2003.

The management measures initially reviewed by the CPSMT were:

- Status quo.
- No allocation – institute a coastwide harvest guideline.
- Move northern boundary of southern subarea from 35°40' N latitude to 39° N latitude, change reallocation date from October 1 to September 1 (or August 1), and provide for December 1 reallocation to a coastwide harvest guideline.
- Change reallocation date from October 1 to September 1 or (August 1), and provide for December 1 reallocation to a coastwide harvest guideline.

Sub-alternatives for the initial allocation were also considered.
- 33% to the north, 66% to the south.
- 50% to the north, 50% to the south.

In analyzing these initial management alternatives, some alternatives were eliminated and other alternatives were developed. The full range of alternatives considered is described in Section 4 along with the rationale for eliminating particular alternatives. A key consideration was – what are the most practicable alternatives for implementation in 2003 to prevent adverse fishery impacts? These alternatives and analyses were developed during public meetings of the CPSMT, CPSAS, and Council. Opportunity for public comment was provided, and public input was considered at each of these meetings.

In March 2003, from the initial management measures listed above, five alternatives were adopted by the Council for public review:

Alternative 1	Status quo.
Alternative 2	Move subarea line to 39° N latitude, change reallocation date to September 1 (50% to the south and 50% to the north), add December 1 coastwide reallocation.
Alternative 3	Move subarea line to 39° N latitude, change reallocation date to September 1 (80% to the south and 20% to the north), add December 1 coastwide reallocation.
Alternative 4	Do not change subarea line, change reallocation date to September 1 (50% to the south and 50% to the north), add December 1 coastwide reallocation.
Alternative 5	Move subarea line to 39° N latitude, reallocate the remaining harvest guideline coastwide on September 1.

At the April 2003 Council meeting, the Council selected Alternative 3 as their preferred alternative, i.e., the proposed action that would be recommended to NMFS. The Council recommends this revised allocation regime be in effect for the 2003 and 2004 fishing seasons, and could be extended to 2005 if the 2005 harvest guideline were at least 90% of the 2003 harvest guideline.

The Council discussed several reasons and considerations for recommending the proposed action (not in priority order) –

The proposed action should eliminate or, at least, greatly reduce risk of early closure of the northern subarea fishery, with minimal risk of early closure for the traditional California fisheries. Recently, the southern fishery has been constrained by markets and the coastwide harvest guideline has not been achieved since implementation of federal management. Moreover, current (as of April 2003) landings information from Southern California indicate lower landings than the same period during 2001 and 2002.

This action should provide considerable gains in producer surplus in Pacific Northwest fisheries, which report strong markets, increasing demand, and higher product prices than in California. It is also expected to provide considerable increases in Pacific Northwest employment and income, while resulting in no to minimal risk of disruption to other fishery sectors.

This action is consistent with FMP objectives. It recognizes the historic dependence of California fisheries and is not anticipated to have significantly impact nor disrupt the limited entry fishery. Thus, the proposed action should help to ensure stability in the southern sector while fostering a strong northern fishery at the peak of the season.

The Council acknowledges that the harvest guideline could dramatically decrease if sea surface temperature continues to decline. The Council accepts this as a low probability risk during the duration of this interim measure.

The Council notes that biological concerns about the proposed action are limited because the U.S. coastwide harvest will continue to be constrained by a risk-averse and environmentally-sensitive harvest control rule.

The interim nature of this recommendation acknowledges the potential for a decrease in available harvest by limiting its application to 2003 and 2004, and possibly 2005.

This action provides management stability for the short term (2003 and 2004), while a longer-term allocation framework is developed.

The Council anticipates new biological and economic information collections will provide the basis for developing a longer-term allocation. To that end, the Council fully supports increased research and is endeavoring to ensure science and management are based on the best available scientific information.

Alternative 1 (No Action)

Alternative 1 is the status quo (no action alternative). This alternative would maintain the current allocation framework. In Section 4, the status quo alternative is used to compare the relative impacts of the proposed action and alternative management actions.

Alternative 3 (Proposed Action)

Alternative 3 was selected by the Council as the proposed action. Under this proposed action, the management subarea line would be changed from 35°40' N latitude (Point Piedras Blancas, California) to 39° N latitude (Point Arena, California); on January 1 the harvest guideline would be initially allocated 66% to the southern subarea and 33% to the northern subarea; on September 1, the unused amount of the harvest guideline would be pooled and reallocated 80% to the southern subarea and 20% to the northern subarea; on December 1 the remaining unused harvest guideline would be reallocated coastwide.

Other Possible Alternatives

Under Alternative 2, the management subarea line would be changed from 35°40' N latitude (Point Piedras Blancas) to 39° N latitude (Point Arena); on January 1 the harvest guideline would be initially allocated 66% to the southern subarea and 33% to the northern subarea; on September 1, the unused amount of the harvest guideline would be pooled and reallocated 50% to the southern subarea and 50% to the northern subarea; on December 1 the remaining unused harvest guideline would be reallocated coastwide.

Under Alternative 4, the subarea line would remain 35°40' N latitude (Point Piedras Blancas); on January 1 the harvest guideline would be initially allocated 66% to the southern subarea and 33% to the northern subarea; on September 1, the unused amount of the harvest guideline would be pooled and reallocated 50% to the southern subarea and 50% to the northern subarea; on December 1 the remaining unused harvest guideline would be reallocated coastwide.

Under Alternative 5, the management subarea line would be changed from 35°40' N latitude (Point Piedras Blancas) to 39° N latitude (Point Arena); on January 1 the harvest guideline would be initially allocated 66% to the southern subarea and 33% to the northern subarea; on September 1, the unused amount of the harvest guideline would be pooled and reallocated coastwide and be equally available to all sectors for the remainder of the year.

Other Options Considered in Developing Alternatives

The complete range of alternatives considered is evaluated and compared in Section 4. This includes reasons why the rejected alternatives were not considered reasonable alternatives for addressing the problems described in Section 1.2.1.

The following table displays relative impacts of the five alternatives; impacts include early closure of a sector, gained or foregone harvest by sector, and un-attained coastwide harvest guideline.

TABLE 2-1. Options for restructuring the 2003 sardine allocation framework.

	Southern CA		Northern CA		OR/WA		Coastwide OY	
	Early Close	Landings (mt) Gained or Foregone Relative to Status Quo*	Early Close	Landings (mt) Gained or Foregone Relative to Status Quo*	Early Close	Landings (mt) Gained or Foregone Relative to Status Quo*	Achieved?	Amount left (mt)
1. Status Quo	N	0	Y	0	Y	0	N	9,847
2. (Pt. Arena, Sept. 50-50, Dec. coastwide)	Y	-3,618	Y	35	N	10,108	N	3,321
3. (Pt. Arena, Sept. 80-20, Dec. coastwide)	Y	-225	Y	2,449	Y	7,622	Y	0
4. (Sept. 50-50, Dec. coastwide)	Y	0	Y	274	Y	8,091	N	1,482
5. (Pt. Arena, Sept. reallocate coastwide)	Y	-2,500	Y	2,239	N	10,108	Y	0

* Status quo represents landings made in 2002 expanded by a 10% assumed growth.