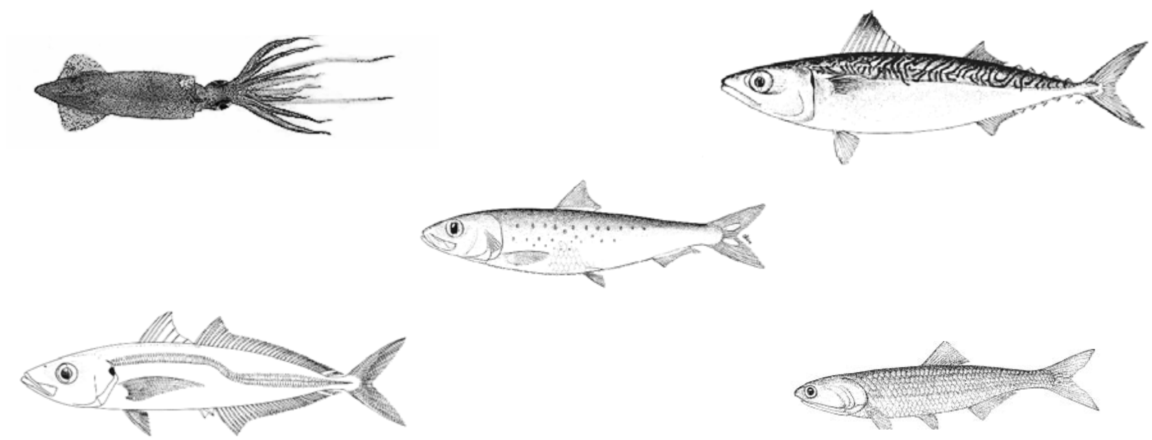
STATUS OF THE PACIFIC COAST COASTAL PELAGIC SPECIES FISHERY AND RECOMMENDED ACCEPTABLE BIOLOGICAL CATCHES

STOCK ASSESSMENT AND FISHERY EVALUATION 2011



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LIST OF ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
ACL	annual catch limit
ACT	annual catch target
ADEPT	a population analysis model
ASAP	Age-structured Assessment Program
BO	Biological Opinion
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CANSAR-TAM	Catch-at-age Analysis for Sardine - Two Area Model
CC	California Current
CCLME	California Current Large Marine Ecosystem
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
CFGC	California Fish and Game Commission
CONAPESCA	National Commission of Aquaculture and Fisheries (Mexico)
Council	Pacific Fishery Management Council
CPFV	commercial passenger fishing vessel
CPS	coastal pelagic species
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CPSPDT	Coastal Pelagic Species Plan Development Team
CPUE	catch per unit effort
CS	catch shares
EBFM	ecosystem based fishery conservation and management
EEZ	exclusive economic zone
EFH	essential fish habitat
EFMP	ecosystem fishery management plan
EIS	environmental impact statement
ENSO	El Niño southern oscillation
ESA	Endangered Species Act
FMP	fishery management plan
GT	gross tonnage
HCR	harvest control rule
HG	harvest guideline
INP	Instituto Nacional de la Pesca (Mexico)
LE	limited entry
LME	large marine ecosystem
Magnuson Act	Magnuson-Stevens Fishery Conservation and Management Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MAXCAT	maximum harvest level parameter
MEI	Multivariate El Niño Index
MSFMP	Market Squid Fishery Management Plan
MSY	maximum sustainable yield
mt	metric ton
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NOI	notice of intent
NWFSC	Northwest Fisheries Science Center (NMFS)
ODFW	Oregon Department of Fish and Wildlife
OFL	overfishing limit
OFWC	Oregon Fish and Wildlife Commission
OMB	Office of Management and Budget
OY	optimum yield
PacFIN	Pacific Coast Fisheries Information Network
PDO	Pacific Decadal Oscillation
PFAU	Pelagic Fisheries Assessment Unit
PRD	Protected Resource Division
RecFIN	Recreational Fishery Information Network
RIR	regulatory impact review
ROV	remotely operated vehicle
SAFE	stock assessment and fishery evaluation
Secretary	U.S. Secretary of Commerce
SFD	Sustainable Fisheries Division
SS2	Stock Synthesis 2
SSC	Scientific and Statistical Committee
SST	sea surface temperature
st	short ton
STAR	Stock Assessment Review (Panel)
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center (NMFS)
SWR	Southwest Region (NMFS)
TF	transformation frontier
USFWS	U.S. Fish and Wildlife Service
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.

Following NMFS guidelines, the purpose of this report is to briefly summarize aspects of the coastal pelagic species (CPS) FMP and to describe the history of the fishery and its management. Species managed under this FMP include: Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), market squid (*Loligo opalescens*), and krill (*euphausiid spp.)*. 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, the Southwest and Northwest Fisheries Science Centers (SWFSC, NWFSC), California Department of Fish and Game (CDFG), Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). Included in this report are descriptions of landings, fishing patterns, estimates of the status of stocks, and acceptable biological catches (ABCs). Stock assessments for Pacific sardine and Pacific mackerel are typically published in briefing book materials in November and June, respectively. In addition, they may be included as appendices to the SAFE report. The ABC recommendations, together with social and economic factors, are considered by the Council in determining annual harvest guidelines and other measures for actively managed fisheries (i.e., Pacific mackerel and Pacific sardine).

2.0 THE CPS FISHERY

2.1 Management History

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

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

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

2.2 Recent Management

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

2.2.1 Amendment 8

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

In June 1999, NMFS partially approved the CPS FMP. Approved FMP elements included: (1) the management unit species; (2) CPS fishery management areas, consisting of a limited entry (LE) zone and two subareas; (3) a procedure for setting annual specifications including harvest guidelines (HG), quotas, and allocations; (4) provisions for closing directed fisheries when the directed portion of a HG or quota is taken; (5) fishing seasons for Pacific sardine and Pacific mackerel; (6) catch restrictions in the LE zone and, when the directed fishery for a CPS is closed, limited harvest of that species to an incidental limit; (7) a LE program; (8) authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited; and (9) a framework process to make management decisions without amending the FMP.

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

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

2.2.2 Amendment 9

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

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

2.2.3 Amendment 10

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

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

2.2.4 Sardine Allocation Regulatory Amendment

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

2.2.5 Amendment 11

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

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

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

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

- Analyze each alternative in a consistent manner.

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

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

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

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

(1) January 1, 35% of the harvest guideline to be allocated coastwide;

(2) July 1, 40% of the HG, plus any portion not harvested from the initial allocation, to be reallocated coastwide; and

(3) September 15, the remaining 25% of the harvest guideline, plus any portion not harvested from earlier allocations, to be reallocated coastwide.

The Council also heeded the advice of the CPSAS, CPSMT, and SSC regarding the dynamic nature of the Pacific sardine resource and uncertainties inherent in long-term projections, and scheduled a formal review of the allocation formula in 2008. This review has been postponed and will be considered for rescheduling at the November 2009 Council meeting. The review is intended to provide a comparison of the performance of the fishery to the projections used to evaluate the adopted allocation scheme and will include any new information from Pacific sardine research.

2.2.6 Amendment 12

At its November 2004 meeting the Council initiated development of a formal prohibition on directed fisheries for krill, and directed staff to begin developing management measures to regulate directed fisheries for krill in Council-managed waters. The proposal for a krill ban was first proposed for West Coast National Marine Sanctuary waters by the National Marine Sanctuary Program.

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

At the November 2005 Council meeting, the Council recommended that all species of krill be included in the CPS FMP as prohibited harvest species, and approved a range of krill fishing alternatives for public review and additional analysis over the winter. The Council narrowed the range of alternatives to: 1) status quo, 2) a prohibition on krill fishing in all Council-managed waters, and 3) an initial prohibition combined with the establishment of a process for considering future krill fishing opportunities. Of these alternatives, the Council adopted the second, a complete ban on krill fishing as a preliminary preferred alternative.

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

Amendment 12 has been approved by the Secretary and, in 2009, NMFS published the implementing regulations in a final rule.

2.2.7 Amendment 13

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA) established several new fishery management provisions pertaining to National Standard 1 (NS1) of the MSA. The MSA sought to end overfishing and required rebuilding plans for those stocks considered to be overfished, It also introduced new fishery management concepts including overfishing levels (OFLs), annual catch limits (ACLs), annual catch targets (ACTs), and accountability measures (AMs) that are designed to better account for scientific and management uncertainty.

At its June, 2010 meeting, the Council selected preferred alternatives and approved a draft alternatives document that forms the backbone of Amendment 13 to the Coastal Pelagic Species Fishery Management Plan. Draft implementing regulations and Amendment 13 text were released for a 60-day public review on June 3, 2011.

2.3 The CPS Fleet

During the 1940s and 1950s, approximately 200 vessels participated in the Pacific sardine fishery. In California, 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 as bait or tuna feed). In addition to fishing for CPS finfish, many of these vessels fish for market squid, Pacific bonito, bluefin tuna, and Pacific herring.

Since 1999, a fishery for Pacific sardine has operated off Oregon and Washington. This fishery targets larger sardine, which have typically sold as bait for Asian longline tuna fisheries. Beginning in 2006, this fishery has been expanding into human consumption markets.

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

- Approximately 18 live bait vessels in southern California and two vessels in Oregon and Washington that landed about 4,000 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.
- In Washington, albacore tuna vessels using lampara gear target northern anchovy for use as live bait in the tuna fishery.

2.3.1 Limited Entry Fishery

The CPS LE fleet currently consists of 65 permits and 58 vessels (Table 2-3). The LE vessels range in age from 4 to 68 years, with an average age of 33 years (Table 2-4). Average vessel age has decreased by approximately two years since the initial fleet was established.

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

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

Vessel dimension data were obtained from the U.S. Coast Guard database, and each vessel's calculated GT was attached to the permit under Amendment 10. Original GT endorsements (specified in Table 2-3) remain with the permit, regardless of whether the permit is transferred to a smaller or larger vessel.

GT values for the current fleet range from 23.8 GT to 340.2 GT, with an average of 88.7 GT (Tables 2-3 and 2-4). Total fleet GT decreased from 5,462.9 GT to 5,408.4 GT during 2004. This decrease was due to the loss of the "Connie Marie" (permit 64; sank in 2002), which has yet to be replaced by the owner. The fleet capacity goal established through Amendment 10 is 5,650.9 GT, and the trigger for restricting transferability is 5,933.5 GT (Goal + 5%). The current LE fleet is 5,408.4 GT, well within the bounds of the capacity goal.

2.3.2 Northern Fisheries

2.3.2.1 Oregon State Limited Entry Sardine Fishery

The Pacific sardine fishery off Oregon started in 1935, but there are recorded landings of sardine in Oregon dating back to 1928. The catch dropped off in the 1940s with 1948 being the last year of directed fishery landings until 1999 when the fishery was revived. Pacific sardine was managed as a developmental fishery from 1999 to 2005. In 2004, the sardine industry asked ODFW to remove Pacific sardines from the developmental species list and create a LE system for the fishery.

ODFW began work with the Developmental Fisheries Board and the industry to develop alternatives for the fishery. In December 2005, the Oregon Fish and Wildlife Commission (OFWC) moved the Pacific sardine fishery from a developing fishery into a state-run LE fishery system. Twenty Oregon permits were initially established and made available to qualifying participants for the 2006 fishery. The OFWC amended an LE permit eligibility rule in August 2006, which resulted in an immediate addition of six permits for a total of 26 LE sardine fishery permits.

In April 2009 the OFWC enacted a number of rule changes for the Pacific sardine fishery. First, the OFWC modified the requirement for minimum landings of sardines into Oregon to qualify for permit renewal that was enacted in 2006. The minimum landing requirements for permit renewal are now effective only when the federal coastwide maximum HG for the fishing year exceeds 100,000 mt. The minimum landing requirements themselves, either a minimum of ten landings of at least five mt each or landings totaling at least $40,000 exvessel price, were not changed. Next, the OFWC eliminated a rule that became effective in 2008, which specified that permit holders must either own or operate a vessel that is permitted. The OFWC also established a lottery system for sardine permits. If the number of permits issued falls below 24 a lottery may be held the following year, but the total number issued shall not exceed 26 LE permits. Finally, a new rule defined catching vessels and limited catch sharing to catching vessels with state LE sardine permits.

The Pacific sardine fishery in Oregon operates as a day fishery with vessels based primarily in Astoria where processing plants for sardine operate. Many vessels utilize aircraft to assist in locating schools of sardine and setting their nets when weather permits. Weather and tides are major factors in fishing operations and timing of vessels transiting in and out of the Columbia River.

Twenty-five state limited entry vessels were permitted in Oregon in the 2010. Twenty of those vessels (80%) participated in the sardine fishery. Table 2-5 contains information for vessels that participated in the 2010 fishery. Note that seven vessels landing sardine in Oregon (35%) also held federal and/or Washington state LE permits. Oregon landings totaled 18,826 mt or 31.4% of the initial 60,039 mt federal directed sardine fishery harvest allocation. Only the first three years of the renewed Oregon sardine fishery, while it was ramping up beginning in 1999 after its more than 50 year hiatus, had lower total landings. Sardines were landed in all three allocation periods with 2.3% of the Oregon total landed in the 1st period, 73.9% landed in the 2nd period and 23.8% landed in the 3rd period. Landings ranged from less than 10 to over 100 mt with the most being between 40 and 50 mt. Like in the previous three years, all three allocation periods were closed to directed fishing before the end of the period because the allocation was reached. These early closures have resulted in a change in the timing of greatest harvest from August and September when sardine typically have their greatest oil content in the Pacific Northwest to July. The ex-vessel value of sardine landed in the directed fishery in Oregon totaled $4.8 million with the mode price being $264.54/mt in 2010.

2.3.2.2 Oregon Anchovy Fishery

State developmental fishery permits for harvesting anchovy were issued from 1995 to 2009. All developmental fisheries in Oregon have a limited number of permits available and landing requirements for permit renewal, but the number of permits and landing requirements differ by target species. In 2009 Oregon issued four of the 15 developmental fishery permits available for the anchovy fishery. Staffing for the developmental fisheries program was eliminated due to budget cuts for the 2009-2011 biennium and all developmental fisheries programmatic activities including permitting were suspended in December 2009. The OFWC moved the anchovy fishery to a Category C developmental fishery, those that are managed under a state or federal FMP that has established permit and/or gear limitations. Because the federal CPS FMP does not have permit restrictions for vessels operating north of 39^{o} N latitude, the ocean fishery for northern anchovy is now an open access fishery off Oregon limited to legal gear under the CPS FMP and state regulations. In 2010 directed anchovy landings in Oregon totaled 136.6 mt.

2.3.2.3 Washington State Limited Entry Sardine Fishery

Pacific sardines are the primary coastal pelagic species harvested in Washington waters. From 2000 through 2009, participation in the sardine fishery was managed under Washington's Emerging Commercial Fishery Act (ECFA), which provides for the harvest of a newly classified species or harvest of a classified species in a new area or by new means. The ECFA offers two choices for fishery-permit designations: trial, which does not limit the number of participants or experimental, which does limit participation and prohibits the transfer or sale of the permit. From 2000 through 2002, WDFW managed the purse seine fishery for sardine under the trial designation. Absent limited participation, the Washington fishery was managed to a state HG of 15,000 mt.

The Pacific Northwest sardine fishery saw a rapid expansion of catch between the years 1999 to 2002 when landings increased from 771mt to 37,923 mt. Landings into Washington were 4,842 mt in 2000 and increased to 15,820 mt in 2002. In response to this situation, WDFW engaged in an extensive public process to address management needs in the fishery. In 2003, following this public process, a formal Sardine Advisory Board (Board) was created, and the WDFW Director, in collaboration with the Board, advanced the sardine fishery designation from trial to experimental as provided for under the ECFA. The number of experimental fishery permits was capped at 25. The experimental fishery program continued through June 2009. Besides limiting participation, WDFW also restricted the amount of sardines sold for reduction to a 15 percent season cumulative total by weight by individual vessel.

During the 2009 Washington State legislative session, WDFW proposed legislation to establish a commercial license limitation program specifically for the harvest and delivery of Pacific sardines into the state. The legislation was passed into rule in July 2009. The new rules established 16 licenses to be issued to holders of a 2008 sardine experimental fishery permit only, with an exception for past participants of the experimental fishery that became ineligible because of loss of their vessel at sea. These newly created sardine licenses can be sold. In addition, the new rule provides criteria for the issuance of temporary annual permits at the discretion of the WDFW Director. In combination, the number of permanent and temporary annual licenses cannot exceed 25.

In 2009, 16 experimental fishery permits were issued to those who met the renewal criteria, which required that they previously held such a permit and also held a minimum of 50 percent ownership in the vessel designated on the sardine permit. After the the creation of the sardine license in July 2009, licenses could be transferred (sold). During the latter part of 2009 and in 2010, several licenses were transferred. WDFW issued a total of 16 licenses and one temporary annual permit in 2010. Of the 16 licenses issued eight (8) were actively fished in the 2010 fishery. The holder of the temporary annual permit did not actively participate in the fishery. Table 2-6 lists the vessels designated on Washington sardine fishery licenses/permits in 2010.

The Washington sardine opens annually by rule on April 1. However, Washington harvesters don't typically begin fishing until July. In recent years, the harvest guideline for the first period, which opens January 1, has been attained before April 1. Washington fishermen are then required to wait until the second period opens on July 1 to begin their summer sardine fishery. However, in 2010 the first period harvest guideline was not attained until mid June; Washington fishermen began fishing on June 5. By June 12, the harvest guideline was met and the first period fishery closed. Only a few Washington fishermen participated in June, but by the July 1 opening all eight of this year's participants were fully engaged in the sardine fishery.

A total of 12,379.3 mt of sardines were landed into Washington in 2010. Of the 232 landings, four, 75 and 21 percent were made in June, July and September, respectively. The average landing was about 53 mt. All landings were made into Westport or Ilwaco with the majority of the catch (93%) occurring in waters adjacent to Washington. A total of 311 sets were made with 287 (92%) of them successful. The average catch per successful set was about 46 mt. Total exvessel value for 2010 was $2.6 million.

Pacific sardines are the targeted catch in the Washington fishery, but anchovy, mackerel, and squid can also be retained and landed. In 2010 landings for these other coastal pelagic species were as follows 0 mt of anchovies, 0.07 mt of jack mackerel, and 2.0 mt of mackerel.

To document bycatch levels in the Pacific sardine fishery (see Section 6.3.2), WDFW conducted a five-year observer program from 2000 through 2004. Overall observer coverage in this program was in excess of 25 percent and results showed by-catch of non-targeted species in the Washington sardine fishery to be relatively low. A mandatory state logbook program has been in place since the fishery began in 2000. The logbook requires skippers to report incidental catch and bycatch. The logbook data are maintained in electronic format at the WDFW regional office at Montesano, WA.

2.3.2.4 Washington State Anchovy Fisheries

Although of a smaller magnitude than the sardine fishery, other coastal pelagic species – primarily northern anchovy – have supported important baitfish fisheries on the Washington Coast (ocean, Columbia River, Grays Harbor and Willapa Bay). These fisheries, distinguished by gear type, include a live-bait lampara gear fishery, and a seine gear fishery that provides both live and packaged bait to recreational and commercial fishers. About two dozen baitfish-lampara gear licenses and a couple of baitfish-purse seine licenses are issued annually. Excluding 2009, documented catch of anchovy has averaged about 108 mt a year since 1990. Actual catch has likely been higher; until recent years commercial fishermen were not required to report anchovy caught for their own use. To better account for this catch, the WDFW began in 2007 to require fishers to document all forage fish used for bait in another fishery on the fish receiving ticket for the target species.

Except for herring which is under a license limitation program, participation in baitfish fisheries is not limited. Other regulations include seasonal closures of Grays Harbor and Willapa Bay to protect out-migrating salmon. Harvest guidelines are not set, but in 2010 the WDFW adopted permanent rules restricting northern anchovy catch and disposition. The new rules limit the catch, possession or landing of anchovy to 5 mt daily and to 10 mt weekly. In addition, the rules limit the amount of anchovy taken for reduction (or the conversion of fish to products such as fish meal or fertilizer) to 15% of a landing by weight. These rules were intended to discourage the development of high-volume fisheries for anchovy and yet still accommodate traditional bait fishing activity. In 2010, Washington anchovy landings totaled 120 mt. This total includes 16.9 mt of anchovy landed by lampara gear and 103 mt landed by purse seine gear.

2.3.3 California's Market Squid Fishery

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

The goals of the MSFMP are to provide a framework that will be responsive to environmental and socioeconomic changes and to ensure long-term resource conservation and sustainability. The tools implemented to accomplish these goals include: (1) setting a seasonal catch limit of 107,048 mt (118,000 short tons (st)) to prevent the fishery from over-expanding; (2) maintaining monitoring programs designed to evaluate the impact of the fishery on the resource; (3) continuing weekend closures that provide for periods of uninterrupted spawning; (4) continuing gear regulations regarding light shields and wattage used to attract squid; (5) establishing a restricted access program that includes provisions for initial entry into the fleet, permit types, permit fees, and permit transferability that produces a moderately productive and specialized fleet; and (6) creating a seabird closure restricting the use of attracting lights for commercial purposes in any waters of the Gulf of the Farallones National Marine Sanctuary. Under this framework, the MSFMP provides the CFGC with specific guidelines for making management decisions. The CFGC has the ability to react quickly to changes in the market squid population off California and implement management strategies without the need for a full plan amendment. The MSFMP framework structure was also designed to achieve the goals and objectives of the MLMA and to be consistent with the management outlined in CPS FMP Amendment 10.

Under the restricted access program in the MSFMP, a permit is needed to participate in the fishery. Qualification for different types of permits and transferability options was based on historical participation in the fishery. In 2010, 83 vessel permits, 59 light boat permits, 23 brail (netted scoop) permits, and zero experimental permits were issued. Of the 83 vessel permits issued, 74 vessels made commercial landings in 2010, as compared to 70 active permitted vessels in 2009. Fifty-two vessels made 90 percent of the landings (by tonnage) in 2010. Market squid vessel permits allow a vessel to attract squid with lights and use large purse seine nets to capture squid. Brail permits allow a vessel to attract squid with lights and use brail gear to capture squid. Light boat permits only allow a vessel to attract squid with lights (30,000 watts, maximum). Experimental nontransferable market squid permits allow vessels to fish in areas not historically targeted by the market squid fishery (north of San Francisco). Landings of 2 st or less are considered incidental and no permit is required.

2.3.4 Treaty Tribe Fisheries

The CPS FMP recognizes the rights of treaty Indian tribes to harvest Pacific sardine and provides a framework for the development of a tribal allocation. An allocation or a regulation specific to the tribes shall be initiated by a written request from a Pacific Coast treaty Indian tribe to the NMFS Southwest Regional Administrator at least 120 days prior to the start of the fishing season.

The Makah Tribe sent a letter to NMFS expressing their intent to attain an allocation and to enter the Pacific sardine fishery in 2006. In response, the Council created the Ad Hoc Sardine Tribal Allocation Committee made up of state, Federal, and tribal representatives, to begin work on this issue. If a tribal allocation is established, the non-tribal allocation formula will likely be applied to the remainder of the harvest guideline after accommodation of the tribal fishery.

No tribal letters of intent have been received since 2006, and the Ad Hoc Sardine Tribal Allocation Committee has never met. Therefore, there is no Tribal allocation for 2011.

3.0 Stock Assessment Models

3.1 Pacific Sardine

The Pacific sardine resource is assessed each fall in support of the Council process that sets an annual harvest guideline (HG) for the U.S. commercial fishery. The primary purpose of the assessment is to provide an estimate of current biomass which is used to calculate HGs for the Jan 1 to Dec 31 management cycle. A general overview of the harvest control rule is provided in Sections 4.3.2 and 11.1.1.1 of this SAFE report. For background analyses regarding the harvest control rule, see Amendment 8 of the CPS FMP (PFMC 1998).

The Pacific sardine stock assessment update used for 2011 management (Hill *et al*. 2010) was conducted using 'Stock Synthesis' (SS) version 3.03a (Methot 2009). SS is a likelihood-based, length- and age-structured model. The general estimation approach used in SS is a flexible, 'forward-simulation' that allows for the efficient and reliable estimation of a large number of parameters. The general population dynamics and estimator theory that serves as the basis of forward estimation models such as SS is described in Fournier and Archibald (1982), Deriso et al. (1985), Megrey (1989), and Methot (1990, 1998, 2005).

The final SS model for 2011 management included catch and biological samples for the fisheries off Ensenada, Southern California, Central California, and the Pacific Northwest, 1981-2010.

Two time series of relative abundance were included in the base model: Daily Egg Production Method and Total Egg Production estimates of spawning stock biomass (1986-2010), both based on annual surveys conducted off California (see Lo et al. 1996, 2005, 2006, 2007, 2008, 2009, 2010). Finally, the tuned base model was run with addition of the 2009 and 2010 aerial survey estimates of absolute biomass (*q*=1) (Jagielo et al. 2009, 2010) to derive population quantities for 2011 management. For details regarding the current assessment model, readers should consult Hill et al. (2010; see Appendix 1 of this SAFE document). For descriptions of models used for previous Pacific sardine assessments (CANSAR, CANSAR-TAM, ASAP, SS), see Deriso et al. (1996), Legault and Restrepo (1999), and Hill et al. (1999, 2006, 2009).

3.1.1 Section References:

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

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

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

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

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

Hill, K. T., N. C. H. Lo, P. R. Crone, B. J. Macewicz, and R. Felix-Uraga. 2009. Assessment of the Pacific sardine resource in 2009 for USA management in 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-452. 182 p.

Hill, K. T., N. C. H. Lo, P. R. Crone, B. J. Macewicz, and R. Felix-Uraga. 2010. Assessment of the Pacific sardine resource in 2010 for USA management in 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-469. 142 p.

Jagielo, T., D. Hanan, and R. Howe. 2009. West coast aerial sardine survey: sampling results in 2009. PFMC, November 2009 Briefing Book, Agenda Item I.1.b., Attachment 1. 319 p.

Jagielo, T., D. Hanan, R. Howe, and M. Mikesell. 2010. West coast aerial sardine survey: sampling results in 2010. PFMC, November 2010 Briefing Book, Agenda Item I.2.b.

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

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

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

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

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

Lo, N.C.H., B. Macewicz, D.A. Griffith, and R.L. Charter 2008. Spawning biomass of Pacific sardine (*Sardinops sagax*) off U.S. in 2008. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-430. 33 p.

Lo, N. C. H., B. J. Macewicz, and D. A. Griffith. 2009. Spawning biomass of Pacific sardine (Sardinops sagax) off California in 2009. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-449. 31 pp.

Lo, N. C. H., B. J. Macewicz, and D. A. Griffith. 2010. Spawning biomass of Pacific sardine (Sardinops sagax) off California in 2010. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-463. 44 pp.

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

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

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

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

Methot, R. 2009. User manual for Stock Synthesis. Model version 3.03a. May 11, 2009. NOAA Fisheries, Seattle, WA. 143 p.

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

3.2 Pacific Mackerel

A Pacific mackerel stock assessment is conducted annually or biennially in support of the Council process, which ultimately establishes a harvest guideline (HG) for the West Coast Pacific mackerel fishery. Because Amendment 13 and associated management requirements consistent with National Standard 1 guidelines have not been fully implemented, the Council adopted management measures for 2011 that were designed to comport with both a pre- and a post-Amendment 13 regulatory structure. The HG for mackerel applies to a fishing/management season that spans from July 1st and ends on June 30th of the subsequent year (henceforth, presented as a 'fishing year'). Therefore, in this document, both a two-year (e.g., 2011-12) and single-year (e.g., 2011) reference refer to the same fishing year spanning from July 1, 2011 to June 30, 2012.

The primary purpose of the assessment is to provide an estimate of current abundance (in biomass), which is used in a harvest control rule for calculation of annual-based HGs. For details regarding this species' harvest control rule, see Amendment 8 of the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), Section 4.0 (PFMC 1998). Finally, recent Federal legislation concerning fisheries management now requires alternative methods for quota determination to be used in concert with the HG method above. See Amendment 13 of the CPS FMP (PFMC 2010a) for details regarding these changes, i.e., methods used to derive statistics, such as OFL, ABC, ACL, and associated buffer values.

Parrish and MacCall (1978) were the first to provide stock status determinations for Pacific mackerel using an age-structured population model (i.e., traditional virtual population analysis, VPA). The ADEPT model (the 'ADAPT' VPA modified for Pacific mackerel; Jacobson 1993 and Jacobson *et al*. 1994) was used to evaluate stock status and establish management quotas for approximately 10 years. The assessment conducted in 2004 (for 2004-05 management) represented the final ADEPT-based analysis for this stock (see Hill and Crone 2004). A forward-simulation model, Age-structured Assessment Program (ASAP; Legault and Restrepo 1998), was reviewed and adopted for Pacific mackerel at the 2004 STAR (Hill and Crone 2005). The ASAP model was used for assessments and management advice from 2005-08 (e.g., see Dorval *et al.* 2008). The STAR conducted in 2009 determined that the Stock Synthesis model (Methot 2005, 2010) provided the best (most flexible) platform for assessing the status of Pacific mackerel currently and in the future; see STAR (2009).

Prior to 2011, the last stock assessment and related reviews for this species were completed in 2009 (Crone et al. 2009), with a HG serving for two years (STAR 2009 and PFMC 2010b). That is, in the past, this species was assessed annually, but given both the population's biology and limited fishing pressure the two-year span was deemed reasonable and adopted by the Council in 2009. The stock assessment conducted in 2011 reflects a formal (full) assessment that has been prepared accordingly, i.e., for a stock assessment review (STAR panel through coordination of the Science and Statistical Committee (SSC), see PFMC 2010c) held at NOAA's Southwest Fisheries Science Center in La Jolla, CA, May 2-5, 2011. The STAR in 2011 resulted in a final SS Model (*XA*) for management purposes applicable to Pacific mackerel for the upcoming fishing year 2011-12 (STAR 2011).

The SS model is founded on the AD Model Builder software environment, which essentially is a C++ library of automatic differentiation code for nonlinear statistical optimization (Otter Research 2001). The model framework allows full integration of both population size and age structure, with explicit parameterization both spatially and temporally. The model incorporates all relevant sources of variability and estimates goodness of fit in terms of the original data, allowing for final estimates of precision that accurately reflect uncertainty associated with the sources of data used as input in the overall modeling effort. This modeling platform is also very flexible in terms of estimation of management quantities typically involved in forecast analysis. Finally, from an international context, the SS model is rapidly gaining popularity, with SS-based stock assessments being conducted on numerous marine species throughout the world.

The Pacific mackerel stock assessment conducted in 2011 was based on Model *XA* and included catch, biological distributions (age, length, and mean length-at-age), and two indices of relative abundance (catch-per-unit-effort, or CPUE) associated with the marine recreational fishery; see Crone *et al.* (2011) for the complete stock assessment documentation. Following the STAR in

May 2011, the completed assessment was presented, reviewed, and approved in June, 2011by the SSC, CPSMT, CPSAS, and the Council.

Finally, the Council, as recommended by the CPSMT, decided that no formal stock assessment should be conducted in 2012, meaning that management measures for the July 1, 2012 – June 30, 2013 fishing year will be based on this current stock assessment.

3.2.1 Section References:

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

Crone, P. R., K. T. Hill, J. D. McDaniel, and N. C. H. Lo. 2009. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2009-10 fishing year. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 197 p.

Crone, P. R., K. T. Hill, J. D. McDaniel, and K. Lynn. 2011. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2011-12 fishing year. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 99 p.

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

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

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

Dorval, E., K. T. Hill, N. C. H. Lo, and J. D. McDaniel. 2008. Assessment of Pacific mackerel (*Scomber japonicus*) stock for the U.S. management in the 2008-09 Season. PFMC June 2007 Briefing Book, Exhibit G.1b. Appendix 2. Pacific Fishery Management Council, Foster City California. 78 p.

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

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

Hill, K. T., and P. R. Crone. 2004. Stock assessment of Pacific mackerel (*Scomber japonicus*) in 2004. Paper can be obtained from Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 2000, Portland, OR 97220. 44 p. and Appendices.

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

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

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

Hill, K. T., E. Dorval, N. C. H. Lo, B. J. Macewicz, C. Show, and R. Felix-Uraga. 2008. Assessment of the Pacific sardine resource in 2008 for U.S. management in 2009. PFMC, Nov 2008, Agenda Item G.2.b, 236 p.

Hill, K. T., N. C. H. Lo, P. R. Crone, B. J. Macewicz, and R. Felix-Uraga. 2009. Assessment of the Pacific sardine resource in 2009 for USA management in 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-452. 182 p.

Jacobson, L. D. 1993. ADEPT: Software for VPA analysis using Gavaris's procedure. National Marine Fisheries Service, Southwest Fisheries Science Center. Admin. Rep. LJ-93-02: 71p.

Jacobson, L. D., E. S. Konno, and J. P. Pertierra. 1994. Status of Pacific mackerel and trends in biomass, 1978-1993. Calif. Coop. Oceanic Fish. Invest. Rep. 35: 36-39.

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

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

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

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

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

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

Lo, N.C.H., B. Macewicz, D.A. Griffith, and R.L. Charter 2008. Spawning biomass of Pacific sardine (*Sardinops sagax*) off U.S. in 2008. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-430. 33 p.

Lo, N. C. H., B. J. Macewicz, and D. A. Griffith. 2009. Spawning biomass of Pacific sardine (Sardinops sagax) off California in 2009. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-449. 31 pp.

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

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

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

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

Methot, R. 2011. User manual for Stock Synthesis: Model Version 3.20. January 21, 2011. 165 p.

Otter Research Ltd. 2001. An introduction to AD Model Builder (Version 6.0.2) for use in nonlinear modeling and statistics. Otter Research Ltd., Sidney, B.C., Canada. 202 p.

PFMC (Pacific Fishery Management Council). 1998. Amendment 8: (To the northern anchovy fishery management plan) incorporating a name change to: The coastal pelagic species fishery management plan. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR, 97220. OR. (http://www.pcouncil.org/wp-content/uploads/a8fmp.pdf)

PFMC. 2009a. Final Council recommendations for Pacific mackerel management in 2009-10. Spokane, WA, June 12-18, 2009.

PFMC. 2010a. Measures for integrating new provisions of the Magnuson-Stevens Fishery Conservation and Management Act and National Standard 1 Guidelines into coastal pelagic species management. Amendment 13 to the Coastal Pelagic Species Fishery Management Plan. Partial Draft Environmental Assessment. Pacific Fishery Management Council, Portland, OR. (http://www.pcouncil.org/wp-content/uploads/F2a_ATT1_DRAFT_EA_JUNE2010BB.pdf)

PFMC. 2010b. Agenda Item F.1: Pacific Mackerel Management for 2010-2011 June 2010 Briefing Book. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR, 97220. OR. (http://www.pcouncil.org/wp-content/uploads/F1_SITSUM_JUNE2010BB.pdf)

PFMC. 2010c. Terms of reference for a coastal pelagic species stock assessment review process. November 2010. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220. 20 p.

Parrish, R. H., and A. D. MacCall. 1978. Climatic variation and exploitation in the Pacific mackerel fishery. Calif. Dep. Fish Game Fish Bull. 167, 110 p.

Stock Assessment Review (STAR) Panel. 2009. Pacific mackerel STAR panel meeting report. A. Punt (chair) and members O. Hamel, A. MacCall, G. Melvin, and K. Burnham. NOAA Fisheries, Southwest Fisheries Science Center, La Jolla CA, May 4-8, 2009. 18 p.

Stock Assessment Review (STAR) Panel. 2011. Pacific mackerel STAR panel meeting report. A. Punt (chair) and members J. Deroba and J. Casey. NOAA Fisheries, Southwest Fisheries Science Center, La Jolla CA, February 3-5, 2011. 19 p.

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

Some 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. PFMC. Portland, Oregon. 1998.

In 2010 and 2011, all eight regional fishery management councils implemented changes to reflect Federally-mandated revisions to current regulations and FMPs, to meet the requirements of National Standard 1 of the MSA. This will result in changes to some of the management-related statistics defined below.

4.1 Optimum Yield

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

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

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

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

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

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

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

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

4.3 MSY Control Rules for CPS

The Council may use the default MSY control rule for monitored species, unless a better species-specific rule is available. The default MSY control rule can be modified under framework management procedures. The default MSY control rule sets the ABC for the entire stock (U.S., Mexico, Canada, and international fisheries) equal to 25 percent of the best estimate of the MSY catch level. Overfishing occurs whenever total catch (U.S., Mexico, Canada, and international fisheries) exceeds the 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 the ABC and catches in U.S. waters only. The ABC in U.S. waters is the quota for the entire stock prorated by an estimate of the fraction of the population in U.S. waters. It is important to note that 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.

As noted above, recent legislation concerning management of exploited fisheries in the U.S. now requires alternative methods for quota determination to be used in concert with the HG method. See Amendment 13 of the CPS FMP (PFMC 2010) for details regarding these changes, i.e., methods used to derive statistics, such as OFL, ABC, ACL, and associated buffer values.

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:

HG = (BIOMASS-CUTOFF) x FRACTION

where 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. The BIOMASS is generally the estimated biomass of fish age 1+ at the beginning of the fishing 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 entire stock in the following year (H), although projections or estimates of BIOMASS, index of abundance values, or other data may be relied upon as well. The BIOMASS represents an estimate and thus is subject to some amount of uncertainty. For example, recent CPS stock assessments resulted in coefficients of variation associated with terminal biomass estimates of roughly 30%.

The general MSY control rule for CPS (depending on parameter values) is compatible with the MSA and useful for related species that are important as forage for predators. 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 the FRACTION. If the 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 general formula never exceeds the MAXCAT. The MAXCAT is used to protect 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. Also, the MAXCAT prevents the catch from exceeding MSY at high stock levels and distributes the catch from strong year classes across 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 MSFCMA. The new National Standard 1 requires regional fishery councils to use a revised process for quota determination, which relies on additional statistics not previously included in stock assessment documents, see Amendment 13 of the CPS FMP (PFMC 2010).

4.3.2 MSY Control Rule for Pacific Sardine

The control rule for Pacific sardine sets an HG for the U.S. fishery based on an estimate of biomass for the whole sardine stock, a minimum biomass threshold (CUTOFF) equal to 150,000 mt, a harvest FRACTION between 5% and 15% (depending on oceanographic conditions as described below), and maximum allowable catch (MAXCAT) of 200,000 mt (PFMC 1998). The U.S. HG is calculated from the target harvest for the whole stock by prorating the total HG based on 87% DISTRIBUTION of total biomass in U.S. waters, e.g.:

$HG_{2011} = (BIOMASS_{2010} – CUTOFF) \bullet FRACTION \bullet DISTRIBUTION$

Harvest FRACTION depends on recent ocean temperatures, because sardine stock productivity is typically 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) (C°) at Scripps Pier (La Jolla, California) during the three preceding seasons. Thus, the control rule for Pacific sardine sets the control rule parameter FRACTION equal to F_{MSY} over a narrow range of temperatures, such that FRACTION is never allowed to be higher than 15% or lower than 5%.

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

4.3.3 MSY Control Rule for Pacific Mackerel

The MSY control rule for Pacific mackerel sets the CUTOFF and the definition of an overfished stock at 18,200 mt and the FRACTION at 30%. Overfishing is defined as any fishing in excess of the ABC calculated using the current MSY control rule. No MAXCAT is defined, given the U.S. fishery appears to be limited by markets and resource availability to about 40,000 mt per year; however, in the event landings increase substantially, then the need for such a cap should be revisited. The target harvest level is defined for the entire stock in Mexico, Canada, and U.S. waters (i.e., not just the U.S. portion), and the U.S. target harvest level is prorated based on 70% relative abundance in U.S. waters. As noted above, see also Amendment 13 of the CPS FMP (PFMC 2010) for further information concerning recent changes to quota determination for this species, i.e., via revised MSY control rules used in conjunction with the HG now in place.

4.3.4 MSY Control Rule for Market Squid

A potential MSY Control Rule for market squid, generally referred to as the Egg Escapement Method, was investigated over the course of several years during the early 2000s in efforts to provide a meaningful management tool for this species (e.g., see Dorval et al. 2008). This research addressed harvest and abundance relationships via per-recruit analysis, generally concluding that although such a monitoring/modeling effort provided informative (descriptive) statistics regarding population dynamics surrounding this species, further work in the laboratory (e.g., ‘potential’ fecundity estimation) and modeling (e.g., broader simulation analysis) were necessary before implementing the method for long-term management purposes. That is, the research highlighted substantial spatial and temporal variability in productivity of the population(s) off the central-southern California Coast, which in effect, hindered the applicability of the method in practical terms and ultimately, emphasized the need for timely data collection, laboratory processing, and modeling, if the method is employed formally in the future.

At this time in the development of the Egg Escapement Method, the approach should be considered strictly an “informal” management tool for this species (e.g., see Appendix 3 in PFMC (2002) for further discussion concerning specific details involved in this assessment approach, as well as review-related discussion). Ultimately, “formal” management is implemented via a state-based management plan that includes an annual landings cap and various spatial/temporal fishery-related constraints (CDFG 2005). The research in combination with the practical management approach appears the most reasonable at this time and supports this species' current status as a "monitored' stock. It is important to note that the main objective of a MSY Control Rule for a "monitored" stock (e.g., market squid) is to help assess the need for "active" management. That is, the MSY Control Rules and harvest policies for monitored CPS stocks may be based on broader concepts and constraints than those used for stocks with significant fisheries that fall under active management. Any fishery whereby catches approach an ABC or MSY level warrant consideration within active management processes, given catch statistics are scientifically based and management operations can be practically implemented. Overfishing of a monitored CPS stock is considered whenever current estimates or projections indicate that a minimum stock threshold will be realized within two years. In this context, it would be beneficial to conduct the Egg Escapement Method on a systematic basis to assess the reproductive dynamics of the stock and subsequently, the need for an "active" management policy for this species.

4.4 Section References:

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

Dorval, E., J. McDaniel, and P. Crone. 2008. Squid population modeling and assessment (January 2008). Final report submitted to the California Department of Fish and Game (Marine Region) and the Southwest Fisheries Science Center. 30 p.

Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). 1990. Public Law 94-265.

Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA). 2006. Public Law 109-479.

Restrepo, V. R., and ten co-authors. 1998. Technical guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO-31.

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

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

5.0 Overfishing Considerations

Some 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. PFMC. 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.

The proposed Amendment 13 defines overfishing as occurring when annual catch exceeds the OFL, which is annual amount of catch that corresponds to the estimate of MSY fishing mortality on an annual basis. This section of the SAFE document will be updated to reflect the newer definition of overfishing once Amendment 13 has been approved by the Secretary of Commerce.

5.2 Definition of an Overfished Stock

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

5.3 Rebuilding Programs

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

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

6.0 Bycatch and Discard Mortality

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

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

The MSA 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 fishermen target specific schools, which usually consists of one species. CPS typically school with similarly sized fish. The most common incidental catch in the CPS fishery is another CPS species (e.g., Pacific mackerel incidental to the Pacific sardine fishery). If larger fish are in the net, they can be released alive before pumping or brailing by lowering a section of the cork-line or by using a dip-net. The load is pumped out of the hold at the dock, where the catch is weighed and incidentally-caught fish can be observed and sorted. Because pumping at sea is so common, any incidental catch of small fish would not be sorted at sea. Grates can be used to sort larger non-CPS from the catch. Grates are mandatory in Oregon to sort larger non-CPS from the catch. At-sea observers have recorded discard at one time or another since the year 2000 off the states of Oregon, Washington, and California. Incidental harvest of non-prohibited larger fish are often taken home for personal use or processed.

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

- Establishing fishery control rules, including a seasonal catch limitation to prevent the fishery from over-expanding; continuing weekend closures, which provide for periods of uninterrupted spawning; continuing gear regulations regarding light shields and wattage used to attract squid; and maintaining monitoring programs designed to evaluate the impact of the fishery on the resource.
- Instituting a restricted access program, including provisions for initial entry into the fleet, types of permits, permit fees, and permit transferability.
- Establishing a general habitat closure area in northern California rarely used by the squid fishery to eliminate the potential of future negative interactions with seabirds, marine mammals, and important commercial and sport fishes, and adding limitations on using lights to attract squid around several of the Channel Islands, an effort intended to protect nesting seabirds.

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

1. Most of what would be called bycatch under the MSA is caught when roundhaul nets fish in shallow water over rocky bottom. Fishermen try to avoid these areas to protect their 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 harvesters can be sold for reduction, which reduces discard.
4. A provision in the CPS FMP allowing landings of less than five tons without a LE permit should reduce an regulatory discard, because those fish can be landed without penalty.
5. From 1996 to 2003, bycatch from the live bait logs was reported with an incidence of 10%. The primary species taken as incidental catch was barracuda. Virtually all fish caught incidentally in this fishery are either used for bait, for personal use, or released alive. See Table 16-11.
6. CDFG’s logbook program for the squid fishery collects data including bycatch.

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

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

6.1 Federal Protection Measures

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

Most recently, the NMFS SWR Sustainable Fisheries Division initiated a formal Section 7 consultation with NMFS SWR Protected Resources Division (PRD) on the continued management and prosecution of the Pacific sardine fishery. PRD completed a formal Section 7 consultation on this action and in a biological opinion (BO) dated December 21, 2010, determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species. Specifically, the current status of the Lower Columbia River Chinook, Snake River Fall Chinook, Upper Willamette Chinook, Puget Sound Chinook, Lower Columbia River coho and Oregon coast coho, were deemed not likely to be jeopardized by the Pacific sardine fishery.

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

These reporting requirements and conservation measures require all CPS fishermen and vessel operators to employ avoidance measures when sea otters are present in the fishing area and to report any interactions that may occur between their vessel and/or fishing gear and otters. Specifically, these new measures and regulations are:

1. CPS fishing boat operators and crew are prohibited from deploying their nets if a southern sea otter is observed within the area that would be encircled by the purse seine.
2. If a southern sea otter is entangled in a net, regardless of whether the animal is injured or killed, such an occurrence must be reported within 24 hours to the Regional Administrator, NMFS Southwest Region.
3. While fishing for CPS, vessel operators must record all observations of otter interactions (defined as otters within encircled nets or coming into contact with nets or vessels, including but not limited to entanglement) with their purse seine net(s) or vessel(s). With the exception of an entanglement, which will be initially reported as described in #2

above, all other observations must be reported within 20 days to the Regional Administrator.

6.1.1 California Coastal Pelagic Species Pilot Observer Program

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

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

Data from this program was been compiled though 2008 (Tables 6-1 through 6-4). A total of 107 trips by vessels targeting CPS (228 sets) were observed from July 2004 to January 2006. Tables 6-1 through 6-4 show how incidental catch and bycatch data collected during this time and are categorized by target species of the trip (i.e., Pacific sardine, Pacific mackerel, market squid or anchovy). Additionally, from January 2006 to January 2008 a total of 199 trips (426 sets) were observed.

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

6.2 Fishery South of Pigeon Point

Information from at-sea observations by the CDFG and conversations with CPS fishermen suggest that bycatch south of Pigeon Point 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 can be forage for these predators, but there are no data to confirm significant bycatch of these species. CDFG port samples indicate minimal incidental catch in the California fishery (Tables 6-5). The behavior of predators, which tend to dart through a school of prey rather than linger in it, and can more easily avoid encirclement with a purse seine, may help to minimize bycatch.

CDFG port samplers collect information from CPS landings in Moss Landing and ports to the south. Biological samples are taken to monitor the fish stocks, and port samplers report incidentally caught fish. Reports of incidental catch by CDFG port samplers confirm small and insignificant landings of bycatch at California off-loading sites (Tables 6-5). These data are likely representatives of actual bycatch, because (as noted) fish are pumped from the sea directly into fish holds aboard the vessel. Fishermen do not sort catch at sea or what passes through the pump. Unloading of fish also occurs with pumps. The fish are either pumped into ice bins and trucked to processing facilities in another location or to a conveyor belt in a processing facility, where fish are sorted, boxed, and frozen.

From 1985 through 1999, there were 5,306 CDFG port samples taken from the sardine and mackerel landings. From 1992 to 1999, incidental catch was reported on only 179 occasions, representing a 3.4 percent occurrence. Up to 1999 reports of incidental catch were sparse, and prior to 1992 none were reported. Earlier incidents of bycatch may not have been noted, because the harvest of anchovy and sardine was small, and only since 1995 has the harvest of sardine increased substantially (see Table 9-1). The incidental catch reported are primarily marketable species that do not meet the definition of bycatch in the MSA. 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 percent, and northern anchovy at 12 percent incidence within samples (not by load composition). CDFG port samples provide useful information for determining the significance of bycatch in the CPS fishery off California (south of Pigeon Point).

In 2001, California wetfish port samplers began tallying undocumented incidental catch observed during landings in greater detail, and listed the occurrence of species in each sampled landing. The port sampling program records bycatch observed (i.e., presence or absence evaluations), but actual amounts of incidental catch have not been quantified to date. These observations are summarized in Table 6-5 for the 5 years between 2006 and 2010. The dynamic of the 2008 sardine fishery changed due to a decrease in the annual harvest guideline. Since then, fishing activity no longer takes place year around, but has been truncated within each allocation period. This may have affected the types and frequencies of organisms observed during the offloading process of sardine. The most commonly occurring flora and fauna in wetfish landings during 2010 were market squid, kelp, bat ray, white croaker, crab, Pacific sanddab, jack mackerel, butterfish, and northern anchovy. Seventy-eight incidental species were observed in total.

Larger fish and animals are typically sorted for market, personal consumption, or nutrient recycling in the harbor. To document bycatch more fully at sea, including marine mammal and bird interactions, NOAA Fisheries placed observers on a number of California purse seine vessels beginning in the summer of 2004, under a pilot program that continued until 2008 (see Sec. 11.6).

6.2.1 Incidental Catch Associated with the Market Squid Fishery

Because market squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur intermittently. In 2010, less than one percent of round haul market squid landings (by tonnage) included reported incidental catch of CPS (Table 6-6).

Although non-target catch in market squid landings is considered minimal, the presence of incidental catch (species that are landed along with market squid that are not recorded through landing receipt processes [i.e., not sold] as is typically done for incidentally-caught species) has been documented through CDFG's port sampling program. The port sampling program records incidental catch observed (presence or absence), but actual amounts of incidental catch have not been quantified to date. During 2010, incidental catch consisted of 33 species (Table 6-7). Similar to previous years, most of this catch was other pelagic species, including Pacific sardine and mackerel. However, kelp was also observed frequently.

The extent that market squid egg beds and bottom substrate are damaged by purse seine operations, which may contribute to mortality of early life stages, is not known at this time. One way to determine if nets are disturbing egg beds is to look for egg cases in market squid landings. When market squid egg cases are observed at offloading sites, there are two potential reasons that egg cases may be in the net: 1) market squid released eggs in the net after being captured, or 2) egg cases were taken from the ocean floor during fishing activity. In 2010, market squid egg cases were identified in 8.4 percent of observed landings. Since market squid exude egg cases while in a purse seine net, the observed egg cases need to be collected and aged. If egg cases are more than one day old, then egg cases were likely to have been taken from the bottom.

According to CDFG market squid logbooks, fishing nets in the northern fishery have the potential to contact the bottom more frequently than in the southern fishery. Further investigations into potential damage to market squid spawning beds from fishing operations would benefit status-based analyses of the overall market squid population off California, given eggs-per-recruit theory underlies the recently adopted market squid assessment method. In 2007, CDFG developed a protocol to retain egg capsules in order to determine if capsule age can be quickly determined in the laboratory. Based on market squid embryo development and the condition of the outside of the egg capsule, determining if the egg case was laid in the net or collected from the bottom is possible.

6.3 Fishery North of Point Arena

The Pacific sardine fishery north of Point Arena began again in 1999 after more than a 50 year hiatus. Oregon and Washington closely monitor these fisheries and collect information about landings. Information on bycatch and incidental catch from Oregon and Washington is summarized in Tables 6-8 through 6-10.

6.3.1 Oregon

CPS vessels landing in Oregon primarily target Pacific sardine. Oregon's LE sardine permit rules stipulate that an at sea observer be accommodated aboard vessels when requested by ODFW. ODFW currently does not have personnel dedicated to observe and document bycatch of non-target species on sardine vessels; and no federal observers were placed on the vessels. Available state personnel were unable to conduct onboard observations of any CPS fishery vessels in 2010. The state requires the use of a grate over the intake of the hold to sort out larger species of fish, such as salmon or mackerel. The grate size spacing can be no larger than 2-3/8 inches between bars.

Oregon rules require seine gear logbooks that record incidental catch including salmonids and other species (Table 6-9). Based on logbook records, bycatch of salmonids remained low in 2010 and 59% of the 186 salmon caught were released live. Thus, the incidental catch rate was 0.0098 salmon per mt of sardines landed. Both logbook data (Table 6.9) and fish ticket data (Table 6.10) indicate that other non-target species catch in the sardine fishery remained low and in 2010 was composed entirely of other coastal pelagic species (CPS). Non-target species catch in the sardine fishery included 39.7 mt of Pacific mackerel, 1.2 mt of northern anchovy, and less the 0.01 mt of jack mackerel (Table 6.10) with the 18,826 mt of sardines landed. Thus, non-target species accounted for 0.2% of total landings in the 2010 sardine fishery. Similarly, vessels targeting northern anchovy landed only Pacific sardine as incidental catch, and the quantity of sardine landed was 1.2 mt or 0.9% of targeted catch.

In June 2010, the COUNCIL designated Pacific herring, which occur in waters off all three states, and jacksmelt, which typically occur only in waters off California, as “ecosystem component species” defined in the National Standard 1 guidelines when Amendment 13 to the CPS FMP was adopted (see section 2.2 for more on the status of Amendment 13). The Council also required that incidental catch of these two species continue to be reported in the SAFE document. Neither of these two species was landed as incidental catch or recorded in logbooks in 2010 Oregon CPS fisheries. In the sardine fishery, Pacific herring have been landed in Oregon in 5 of the last 10 years (Table 6-10).

6.3.2 Washington

From 2000 through 2004, WDFW required fishers to carry at-sea observers, and to provide financial support for this observer effort. Bycatch information was collected in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether alive, dead, or in poor condition. During the five-year period of the program, overall observer coverage averaged over 25 percent of both total landed catch and number of landings made. Based on observer data, the bycatch of non-targeted species in the Washington sardine fishery was relatively low. Due to low bycatch levels, as well as a WDFW commitment to industry that the observer fee would only be assessed until bycatch in the sardine fishery could be characterized, the mandatory observer program was suspended at the conclusion of the 2004 season. A comparison of logbook and observer data from 2000 to 2004 indicated that logbook data, in general, tended to under report bycatch by 20 to 80 percent (Culver and Henry, 2006). For this reason, salmon bycatch in the Washington sardine fishery for years subsequent to the observer program is calculated by multiplying total sardine catch and the observed five-year average bycatch rates. Bycatch and mortality estimates of incidentally captured salmon by year and species are shown in Table 6-8. Estimated bycatch of salmon for 2010 totaled 756 fish: 375 Chinook and 381 Coho.

Incidental species caught and reported on Washington fish tickets are shown in Table 6. 14. Mackerel, both Pacific and jack, comprise the majority of non-target catch in the sardine fishery. In 2010, 2.0 tons of mackerel, unspecified, and 0.07 mt of jack mackerel were landed; no other species were recorded on fish tickets.

6.4 Section References

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

7.0 LIVE BAIT FISHERY

7.1 California Live Bait Fishery

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

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

7.1.1 Legislative History

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

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

7.1.2 Species Composition

The ratio of anchovy to sardine in the southern California live bait harvests shifts significantly as the populations of these two fish expand and contract over periods of years or decades. Much of the early reported harvest consisted of anchovy, following the collapse of the sardine fishery in the 1940s. Through the years 1994 to 2006 the proportion of anchovy in the total reported harvest ranged from a high of 58 percent in 1994 to a new low in 2004 of five percent. The proportion of sardine ranged from a low of 42 percent in 1994, to a new high of 95 percent in 2004 (Table 6-13).

A new market squid live bait fishery has expanded in southern California in recent years. However, the amount of market squid harvested and the value of the fishery is largely unknown, as there are no permitting and reporting requirements. The live bait fishery is likely a low-volume, high-value endeavor, as recreational anglers targeting mainly white seabass are willing to pay up to $85 for a "scoop" of live squid.

7.1.3 Logbook Information

The CDFG Live Bait Log (Title 14, Section 158, California Code of Regulations: DFG 158, October 1989) requires only the estimated scoops taken daily of either anchovy or sardine be reported, and a check mark be made if certain other species are 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, and various small fishes collectively known as "brown bait" that can include juvenile barracuda (*Sphyraena argentea*), Osmerids, Atherinids, and market squid (Table 6-11). Estimates of ancillary catch data has been documented in earlier reports, and in CPS FMP Amendment 9.

The CDFG Pelagic Fisheries Assessment Unit at the SWFSC in La Jolla presently archives the CDFG live bait logs. Preliminary estimates of the reported total live bait harvest in California through 2008 have been appended to previously reported estimates from Thomson *et al.* (1991, 1992, 1994) (Table 6-12). The CDFG is in the process of an evaluation of the current logbook structure, reporting requirements, and the information obtained in order to correct the data problems identified above, increase reporting compliance rates, and to better estimate the economics of the fishery.

7.2 Oregon Live Bait Fishery

Historically commercial capture of CPS for live bait has primarily occurred in the Umpqua River estuary where Pacific sardine, northern anchovy, and a number of other species not under Federal management may be taken by beach seine and sold as bait, some of which is sold as live bait. In 2009 the Oregon Fish and Wildlife Commission implemented rules to allow capture of northern anchovy in a limited number of Oregon estuaries. All other species must be released unharmed. This harvest of anchovy is limited to commercial vessels that use the anchovy as live bait in commercial fishing operations on the catching vessel. The gear used to capture anchovy is restricted to purse seines with a maximum length of 50 fathoms (300 ft), lampara nets, and hook and line. This live bait fishery is open from July 1 to October 31. Fishers intending to fish for anchovy in this manner must notify Oregon State Police with the vessel name, fishing location and estimated time of the activity 12 hours prior to fishing activity. Information on live bait catch must be recorded in logbooks provided by ODFW. In 2010, there was no record of live bait capture of anchovy in Oregon estuaries under these new rules.

7.3 Washington Live Bait Fishery

The majority of Washington's anchovy catch is harvested as live bait for use in recreational and commercial fisheries. Although all Washington anchovy landings are reported on fish tickets, no distinction is made between anchovy destined for packaged product versus anchovy destined for use as live bait.

Documented catch of anchovy has averaged about 108 mt a year since 1990, excluding 2009. Actual catch has likely been higher; until recent years commercial fishers were not required to report anchovy caught for their own use. To better account for this catch, the WDFW began in 2007 to require fishers to document all forage fish used for bait in another fishery on the fish receiving ticket for the target species. Incidentally caught species include other forage fish species which have various landing limits. Bycatch of non-forage fish species is not documented but includes rare encounters with sturgeon by purse seine gear. Since quality is paramount in the live bait fishery, fishermen avoid encountering non-forage fish species; any that are encountered are released quickly.

7.4 References:

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

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

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

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

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

Title 14, California Code of Regulations.

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

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

8.0 SAFETY AT SEA CONSIDERATIONS

The safety of fishing activities is an important management concern. Roundhaul fisheries operating off the Pacific Coast are often limited by environmental conditions, most notably inclement weather. Given that the average age of permitted CPS vessels in the LE fishery is 32 years and many older vessels are constructed of wood, concern has been raised regarding their safety and seaworthiness. Implementing time/area closures or restricting transferability could impact safety by making more difficult to replace an older vessel with a newer, safer vessel; or by promoting fishing during hazardous weather conditions. This concern in part is addressed by Amendment 10 to the CPS FMP (January 2003), which allows LE permits to be transferred to another vessel and/or individual.

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

In 2008, 2009, and 2010, the directed Pacific sardine fishery experienced seasonal closures because harvest guidelines dropped, although Pacific sardine continue to be available to the fishery and market demand is steady or increasing. The HGs declined based on the population assessments, which generally showed declining abundance. This has lead to a “derby style” fishery where vessels compete for a share of the seasonal harvest guideline over a short period of time. Such derby fisheries can create unsafe conditions, as season duration is compressed and competition increases.

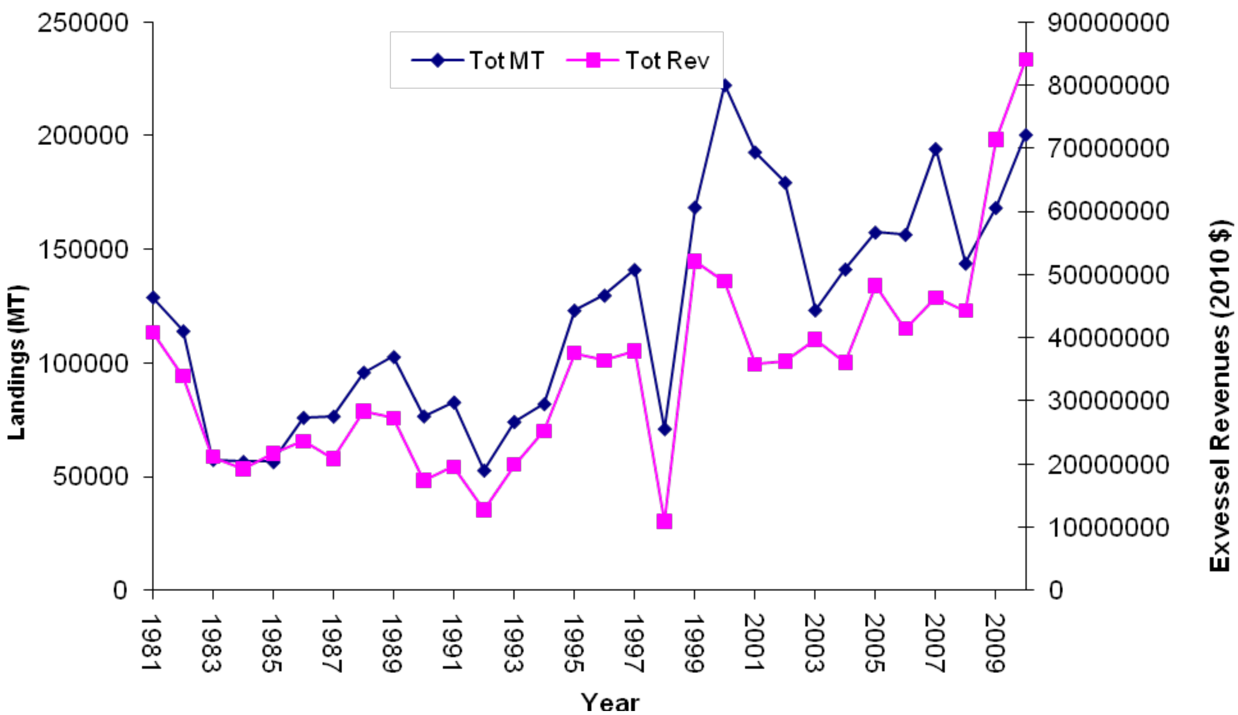
9.0 ECONOMIC STATUS OF WASHINGTON, OREGON, AND CALIFORNIA CPS FISHERIES IN 2010

This section summarizes economic data presented in Tables 9-1 through 9-5 (presented in the Tables section following Chapter 14) and Figures 9-1 through 9-8 (at the end of this chapter). Washington, Oregon and California landings of CPS totaled 200,428 mt in 2010, a 19 percent increase from 2009. Market squid landings, all in California, totaled 129,909 mt in 2010, up 40 percent from 2009. Pacific sardine landings of 66,817 mt in 2010 were virtually unchanged from 2009 (67,084 mt). The exvessel revenue from all CPS landings was $84.0 million in 2010, up 18 percent from 2009 (2009 converted to 2010 dollars).

Market squid accounted for 65 percent and Pacific sardine 33 percent of total West Coast, CPS landings in 2010. Landings of Pacific mackerel decreased 59 percent, and landings of northern anchovy fell 64 percent from 2009 to 2010. Real exvessel market squid revenues (2010 $) increased 24 percent from 2009. The increase in market squid landings was accompanied by a 12 percent decrease in exvessel price from $617 to $544 per mt (2010 $). There was a seven percent decrease in aggregate CPS finfish landings from 2009; exvessel revenue also decreased by seven percent. In 2010, market squid made up 15 percent of total west coast exvessel revenues, and CPS finfish accounted for almost three percent. Washington, Oregon and California shares of total west coast CPS landings in 2010 were six percent, 11 percent and 83 percent respectively.

California sardine landings were 33,688 mt in 2010 down 10 percent from 2009, 37,577 mt. Market squid ranked first in exvessel revenue generated by California commercial fisheries in 2010, with exvessel revenue of $70.7 million, $30.1 million greater than that for Dungeness crab, in second place. Landings of Pacific sardine ranked sixth highest in California exvessel revenues in 2010 at $4.4 million. California Pacific mackerel landings were 2,053 mt in 2010, down 60 percent from 2009. California landings of Northern anchovy were 1,026 mt in 2010, down 62 percent from 2009.

Figure 9-1. Annual west coast landings and real exvessel revenues for all CPS species 1981-2010.



Oregon's landings of Pacific sardine decreased 3 percent in 2010, from 21,481 mt to 20,749 mt. Sardine generated $5.2 million in exvessel revenue for Oregon in 2010, 5 percent of the state's total exvessel revenues, ranking it seventh behind Dungeness crab in total exvessel revenues. Washington landings of Pacific sardine increased 54 percent from 8,026 mt in 2009 to 12,381 mt in 2010. With exvessel revenue a little more than 1 percent of the Washington total in 2010, sardine ranked 12th behind Dungeness crab in exvessel value.

Oregon landings of Pacific mackerel decreased from 53 mt in 2009 to 49 mt in 2010, and anchovy landings rose from 39 mt to 138 mt. Washington landings of Pacific mackerel decreased from four mt in 2009 to two mt in 2010 and anchovy landings fell from 812 mt to 120 mt.

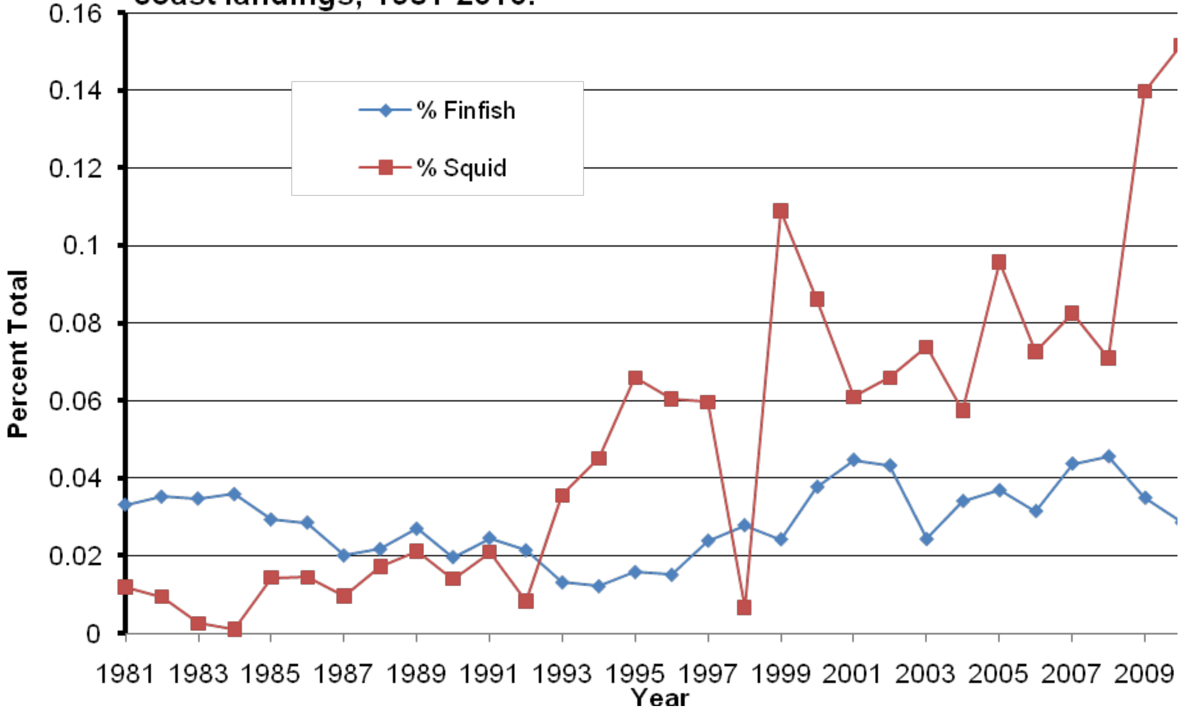
In 2010, the number of vessels with west coast landings of CPS finfish was 148, down from 173 in 2009. With the decrease in vessels and a decrease in total CPS finfish landings, finfish landings per vessel, 476 mt in 2010, increased 9 percent from 2009. Of the vessels landing CPS finfish in 2010, 17 percent depended on CPS finfish for the greatest share of their 2010 exvessel revenues. From 2009 to 2010, the number of vessels with west coast landings of market squid decreased from 166 to 157, with 55 percent of these vessels dependent on market squid for the largest share of their total 2010 exvessel revenue. Market squid landings were 827 mt per vessel in 2010, up 49 percent from 2009. Market squid total exvessel revenue shares for vessels that depend mainly on market squid, and finfish total exvessel revenue shares for vessels that depend mainly on CPS finfish have each averaged about 78 percent per vessel since 2000. In 2010 roundhaul gear accounted by far for the largest share of total CPS landings and exvessel revenue by gear in 2010, 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 the Columbia River port areas of Oregon and Washington. The exvessel markets for market squid are mainly in the Los Angeles, Santa Barbara-Ventura and Monterey port areas.

In 2010, 119,442 mt of market squid were exported through west coast customs districts with an export value of $146.3 million; a 69 percent increase in quantity, and a 53 percent increase in value of west coast market squid exports from 2009. The primary country of export was China, 71 percent of the total, which received 85,282 mt, up 78 percent from the quantity exported to China in 2009. Nearly 90 percent of market squid exports went to China and five additional countries: Philippines (7,159 mt), Japan (5,886 mt), Viet Nam (3,583 mt), Peru (2,282 mt), and Spain (1,829 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or for use as bait.

In 2010, 58,399 mt, of sardines were exported through west coast customs districts down four percent from 2009. Sardine exports were valued at $43.9 million in 2010, down nine percent from 2009. Japan was the primary export market in 2010, receiving 18,238 mt, a 16 percent increase in its imports from 2009, and representing 29 percent of total west coast sardine exports in 2010. Thailand was second with 15,637 mt, 27 percent of the total a 13 percent decrease from 2009, followed by China, Malaysia and South Korea. Together these five countries accounted for over75 percent of total west coast sardine exports in 2010.

Figure 9-2. Percentage contribution of west coast CPS finfish and market squid landings to the total exvessel value of all west coast landings, 1981-2010.



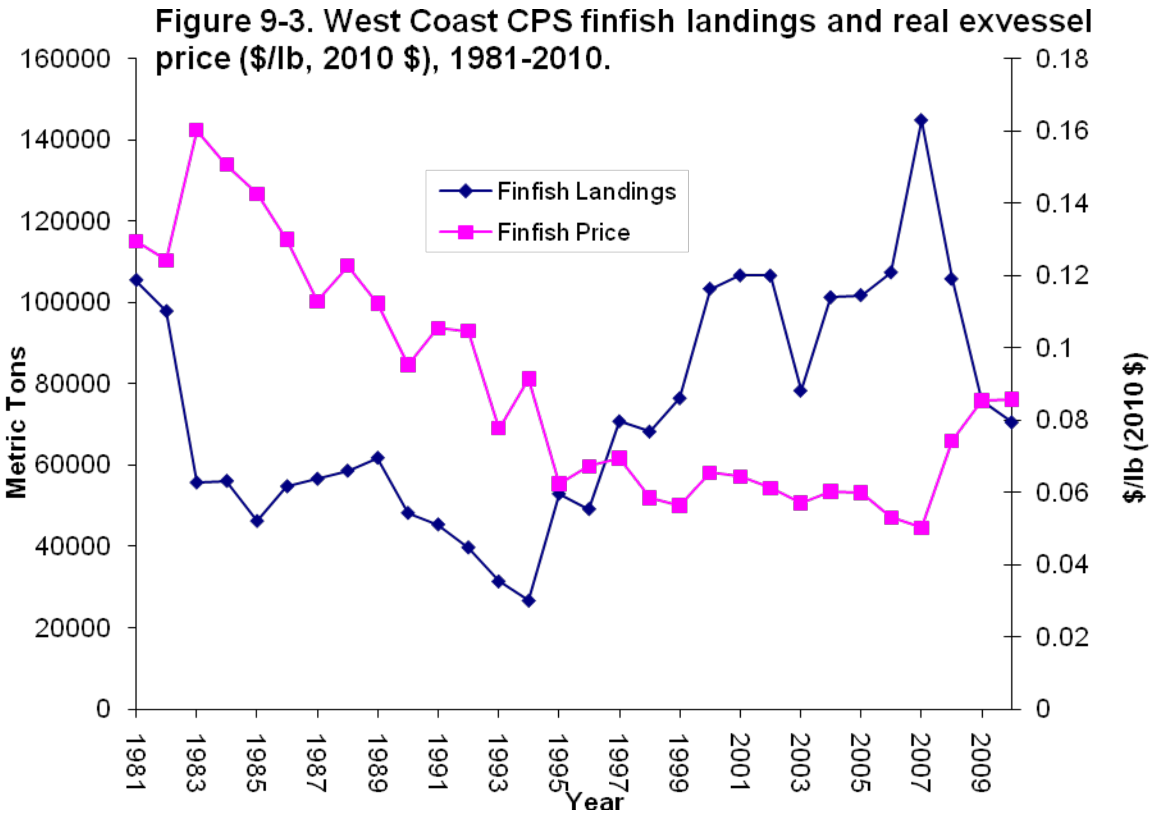


Figure 9-3. West Coast CPS finfish landings and real exvessel price ($/lb, 2010 $), 1981-2010.
Finfish Landings
Finfish Price
Metric Tons
$/lb (2010 $)
Year
160000
140000
120000
100000
80000
60000
40000
20000
0
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

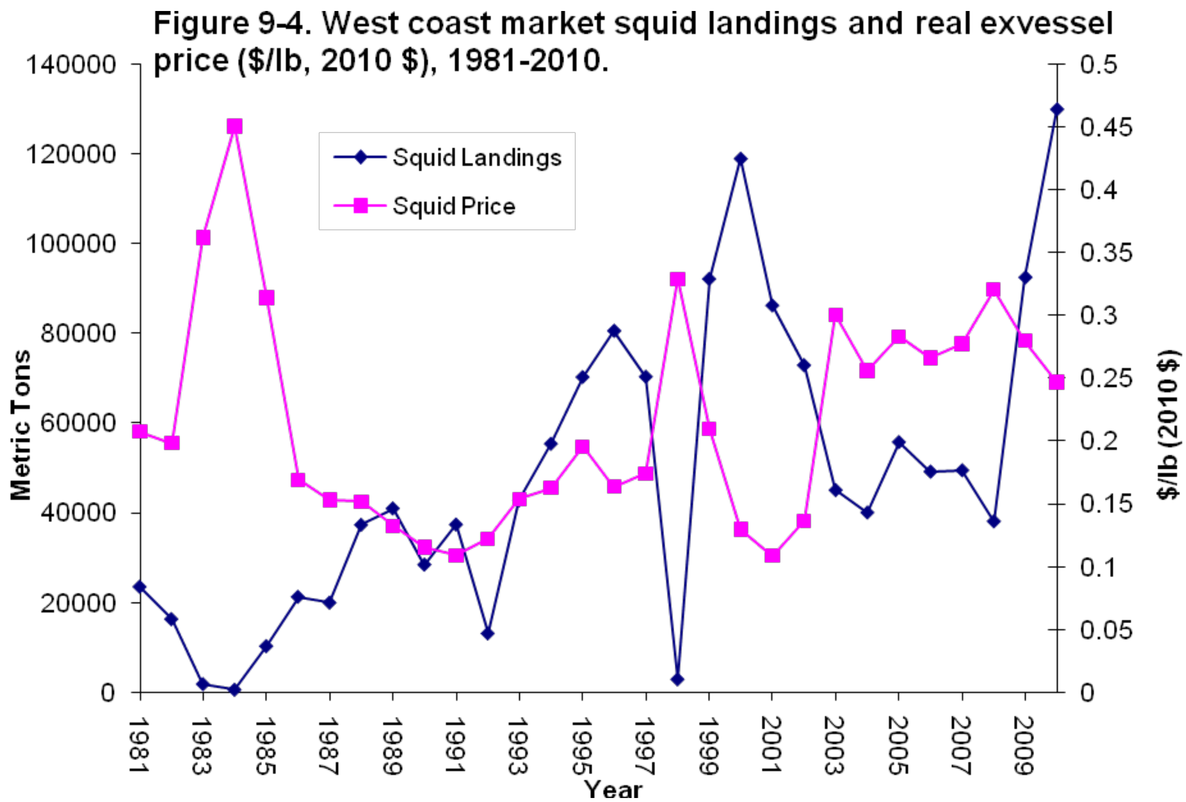
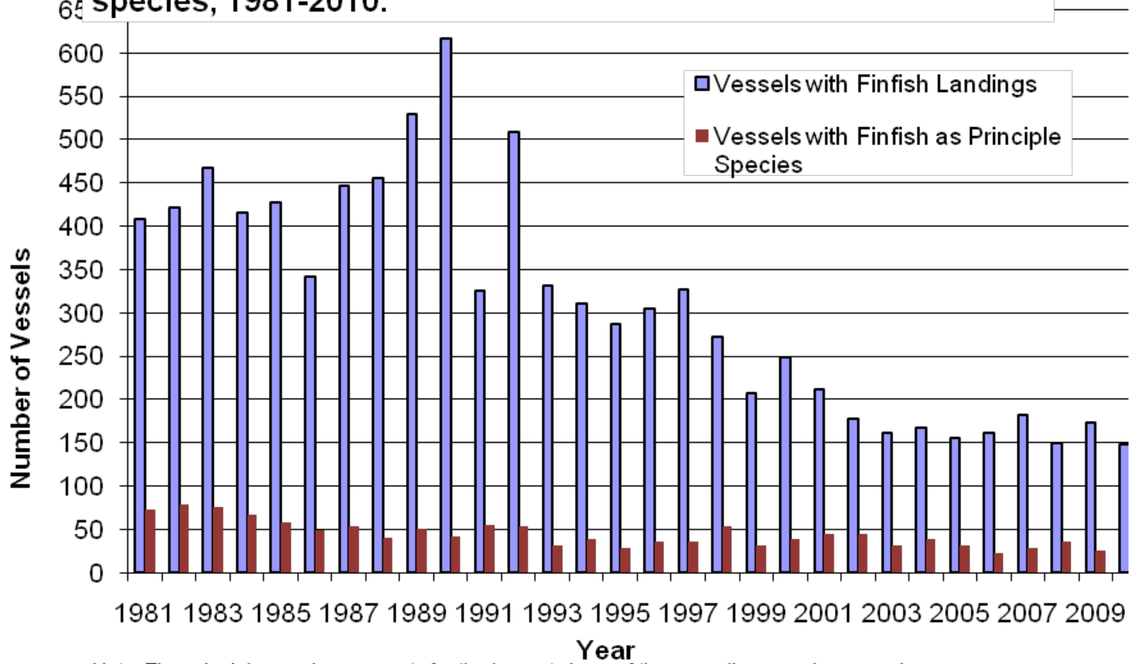
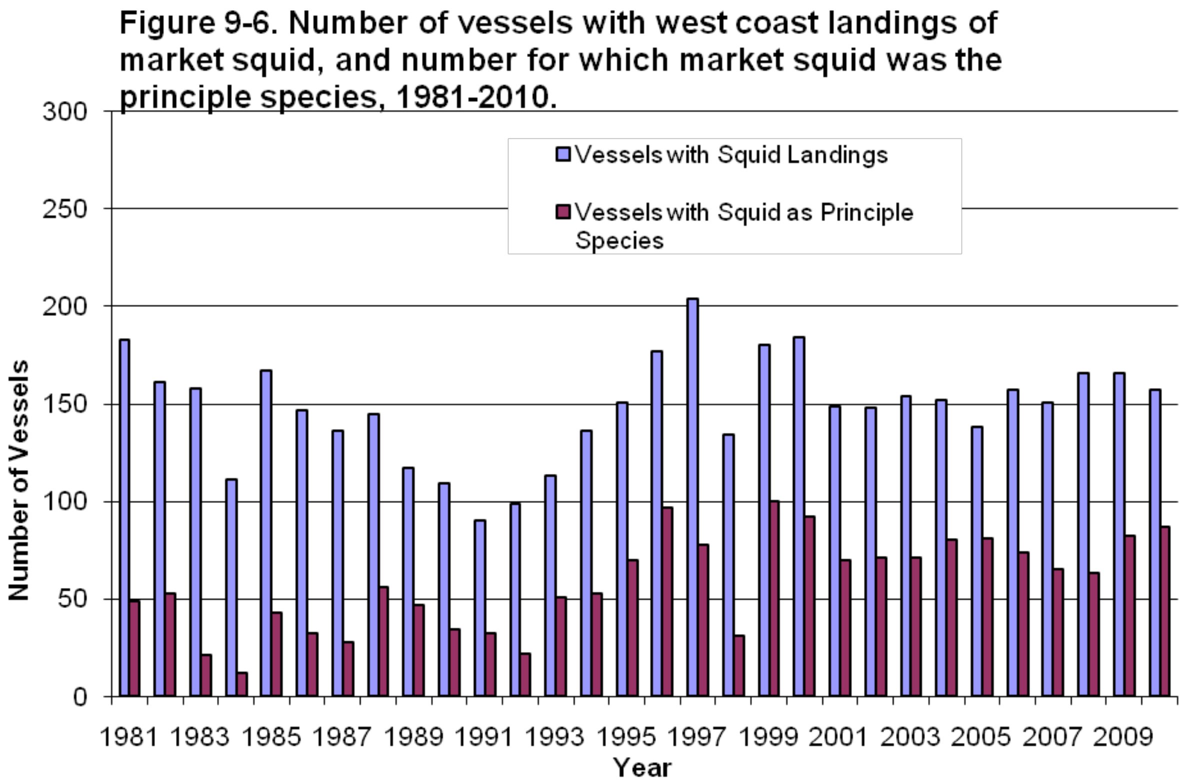


Figure 9-4. West coast market squid landings and real exvessel price ($/lb, 2010 $), 1981-2010.
Squid Landings
Squid Price
Metric Tons
$/lb (2010 $)
Year
140000
120000
100000
80000
60000
40000
20000
0
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009

Figure 9-5. Number of vessels with west coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2010.

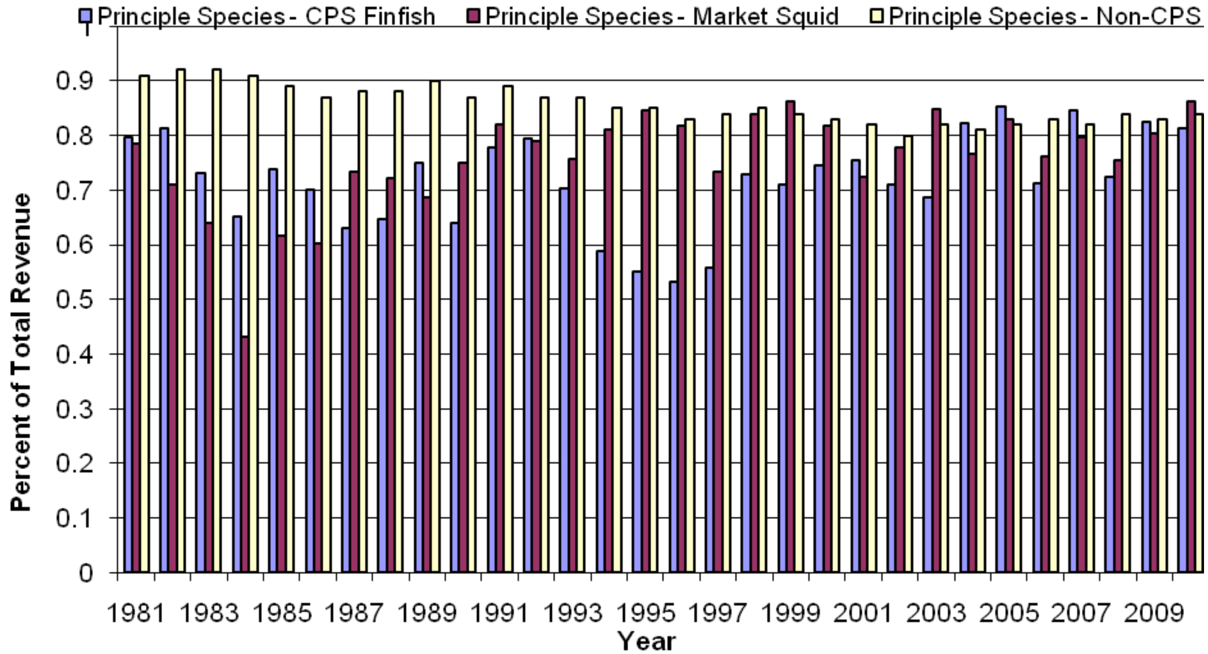


Note: The principle species accounts for the largest share of the vessel's annual exvessel revenue.



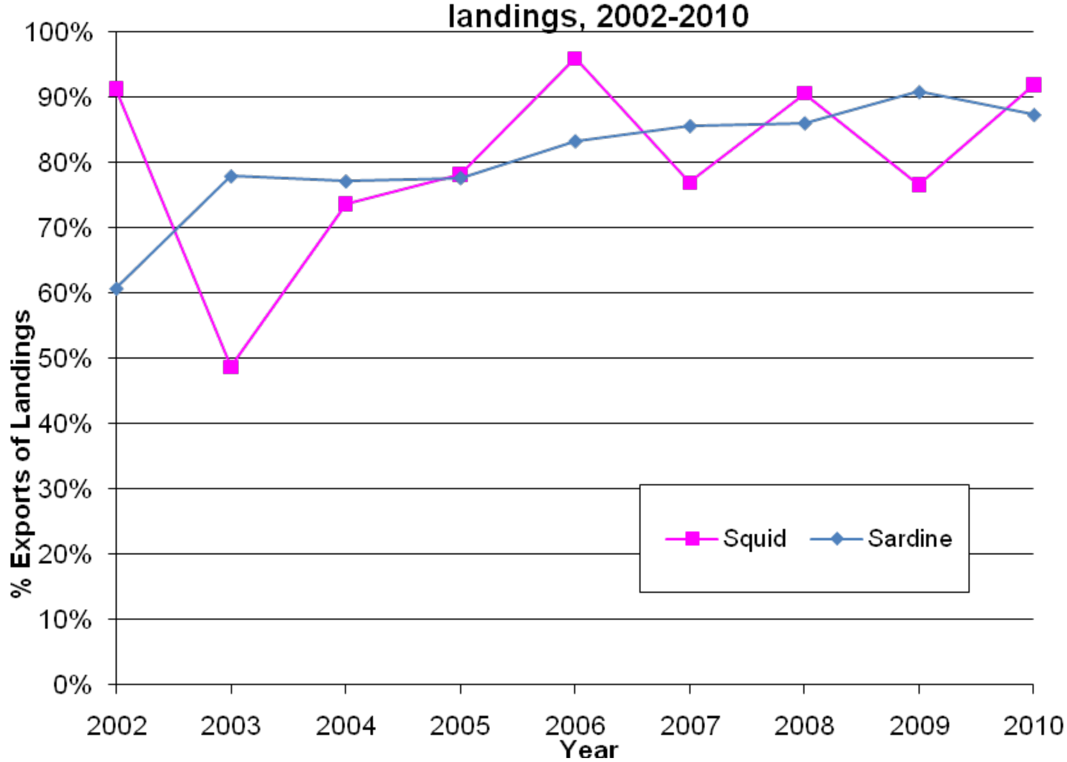
Note: The principle species accounts for the largest share of the vessel's annual exvessel revenue

Figure 9-7. Average share of principle species revenues of total revenues for vessels whose principle species was CPS finfish, market squid or non-CPS, 1981-2010.



Note: The principle species accounts for the largest share of the vessel's annual exvessel revenue.

Figure 9-8. West coast sardine and squid exports as a share of landings, 2002-2010



10.0 ECOSYSTEM CONSIDERATIONS

10.1 INTRODUCTION

There is a growing national interest in augmenting existing single-species management approaches with ecosystem-based fishery management principles that could place fishery management decisions and actions in a the context of a broader scope. NMFS Science Centers around the country have been working on improving the science behind ecosystem-based fishery management including status monitoring and reporting on ecosystem health. This section provides a summary of trends and indicators being tracked by NMFS. Additionally, Appendix A of Amendment 8 to the CPS FMP provides a review of the life-cycles, distributions, and population dynamics of CPS and discusses their roles as forage and can be found on the Council's web site. Appendix D provided a description of CPS essential fish habitat that is closely related to ecosystem health and fluctuation. Recent research efforts into ecosystem functions and trophic interactions will improve our knowledge base and improved CPS management decisions.

10.2 Description of the California Current Large Marine Ecosystem

The California Current (CC) (Figure 1) is formed by the bifurcation of the North Pacific Current. At approximately Vancouver Island, Canada, it begins to flow southward along the West Coast to mid-Baja, Mexico. The California Current flows southward year round off shore from the shelf break to ~200 miles. Other coastal currents generally dominate along the continental shelf including the northward Davidson Current and California Undercurrent, the Southern California Countercurrent, as well as many eddies and smaller shelf currents.

The California Current also defines the outer boundary

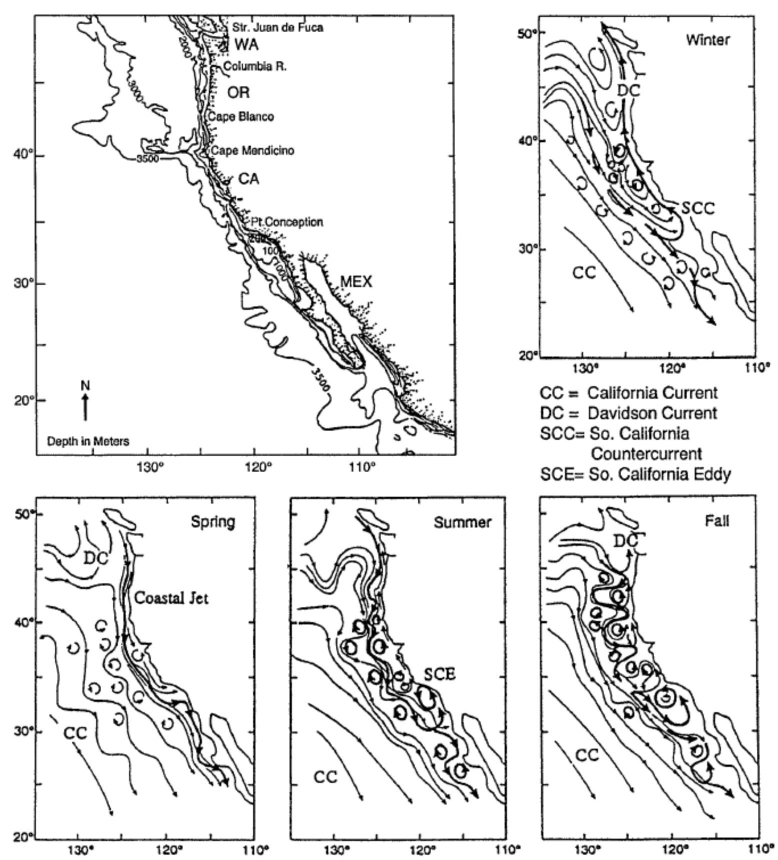


Figure 1. Seasonal variation of large-scale currents along the West Coast with bathymetry illustrating the dynamic conditions in the CCLME. The CC flows southward year round offshore from the shelf break to several hundred kilometers. Along the shelf break, several other currents are found, including the Davidson Current (DC), Southern California Countercurrent, and the Southern California Eddy (SCE). From Hickey and Royer 2001.

of the California Current Large Marine Ecosystem (CCLME) that is delineated by bathymetry, productivity and trophic interactions. The LME is an organizational unit to facilitate management of an entire ecosystem and recognizes the complex dynamics between the biological and physical components. NOAA's ecosystem based management approach uses the LME concept to define ecosystem boundaries.

The CCLME is characterized as often having very high biological productivity (>250 mg C/m^2/day) that is stimulated by the addition of nutrients that is either upwelled along the shelf break or advected in surface currents from the Gulf of Alaska into the northern region or beginning of the California Current. The biological productivity is reflected in the extensive nearshore kelp beds, large schools of CPS (e.g., sardine, anchovy, squid , etc.) and groundfish (Pacific hake) that, in turn, support large populations of marine mammals, sea birds and highly migratory species (e.g., tuna, sharks, billfish).

The CCLME is heavily influenced by climate at the annual, interannual and decadal time scales. Annually, between winter and spring, the large scale wind fields in the NE Pacific reverse (from southerly to northerly) and the prevailing shelf currents also reverse. The transition in currents and concurrent increase in solar radiation in the spring leads to the dramatic increase in productivity, and is called the 'Spring Transition'. The timing and duration of the Spring Transition and their anomalies off N California/ Oregon/Washington is determined by NMFS' Newport, OR laboratory for 45°N 125°W. The Spring Transition has been identified as the first day of the year when the value of the 10–day running average for upwelling is positive and the value of the 10–day running average for sea level is negative. Anomalies are calculated as the difference between the long-term averages (Figure 2). Additional oceanographic data from survey lines off Trinidad Head (Humboldt Co.), CA (NMFS) and Bodega, CA (Sonoma Water Agency-UCD) confirms the Newport prediction.

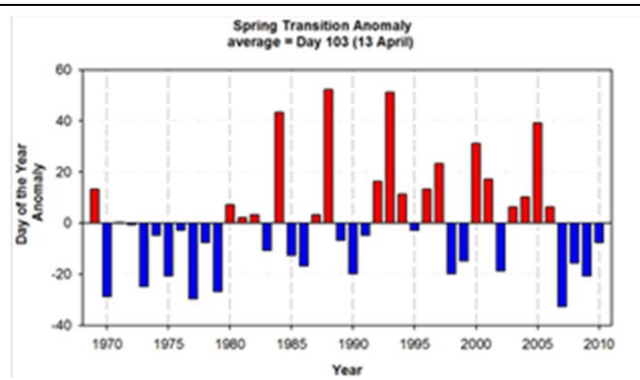


Figure 2. Anomaly of the date of the spring transition. William Peterson, NOAA, NMFS, NWFSC.

Along the OR coast, the timing and duration of the Spring Transition has been linked to coho salmon abundance in the Columbia River (Peterson et al. 2006). The connection between the Spring Transition and CPS is presently not known but it is suspected to affect recruitment of Pacific herring, smelt, northern anchovy and other coastal pelagic species.

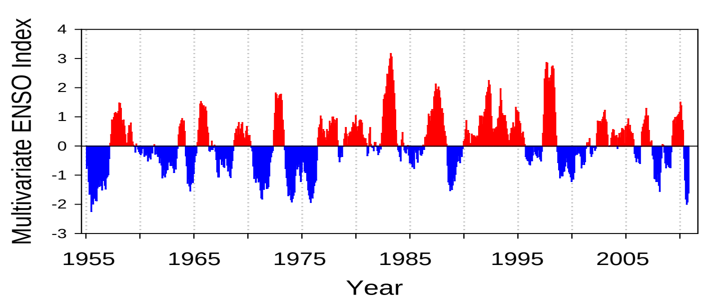


Figure 3. El Nino/Sothern Oscillation Index anomalies. Red indicates warm or El Nino conditions and blue cool La Nina conditions.

On an interannual time scale of 3-7 years, the CCLME is affected by the El Niño Southern Oscillation (ENSO) (Figure 3). During El Niño's upwelling is generally ineffective and warm salty surface waters move up from the south which reduces primary productivity. During La Niña's the productivity of the California Current is often enhanced by the addition of cool, nutrient rich waters from the north, and increased effective upwelling. During El Niño, CPS landings along the CA coast are mixed with a large decrease of market squid, anchovy and Pacific herring while the landings for sardine and mackerel remain relatively constant (Figure 4, CDFG 2009).

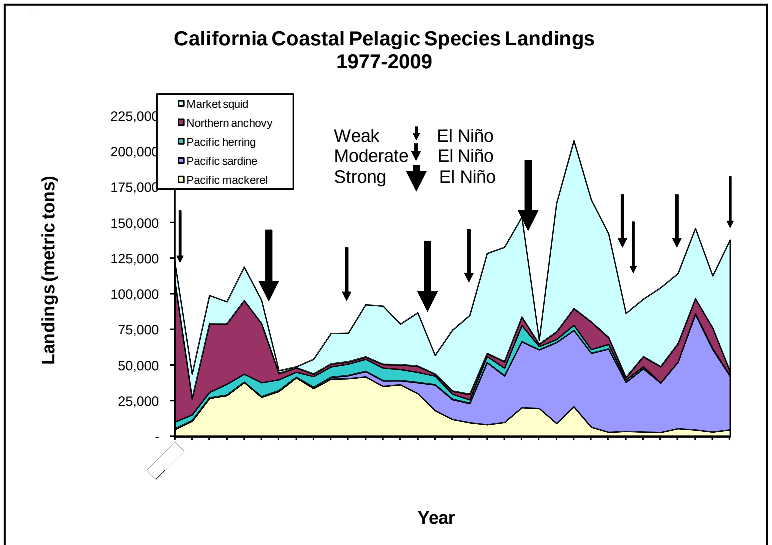


Figure 4. El Nino events and California CPS landings.

At periods between 20 to 50 years, low frequency climatic forcing from the Pacific Decadal Oscillation (PDO) affects the CCLME (Figure 5). The mechanism(s) behind the PDO are still being researched (Beamish et al. 2004). The PDO was mostly negative (warm in the central North Pacific Ocean and cool near the west coast of the Americas) from 1942-1976 and primarily positive from 1977-1998. Since 1998 the PDO has fluctuated positive and negative, perhaps indicating an unusual climatic period for the CCLME.

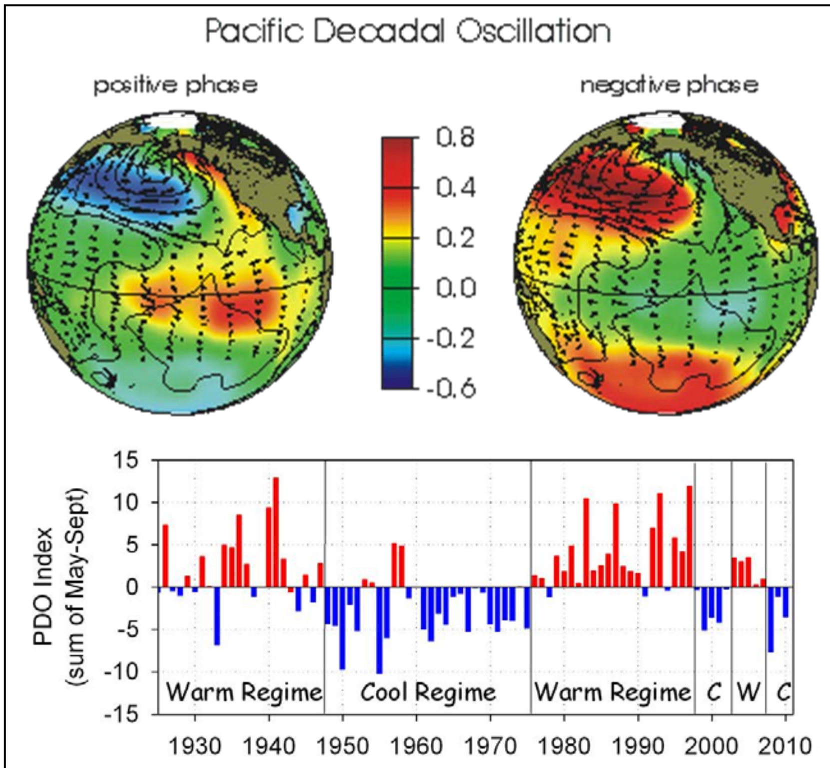


Figure 5. Time series of shifts in sign of the Pacific Decadal Oscillation (PDO), 1925 to 2010. Values are averaged over the months of May through September. Red bars indicate positive (warm) years; blue bars negative (cool) years. Note that 2008 was the most negative since 1956. http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ca-pdo.cfm

The effects of the PDO on fisheries are mixed. In general, the warm phase of the PDO is associated with warm ocean temperatures off the West Coast and reduced landings of coho and Chinook salmon while the cool phase is associated with higher salmon landings (Mantua et. 1997). For sardine, positive PDO indices seem to correlate with high landings along the CCLME while anchovy landings are reduced under positive PDO (Figure 6) (Takasura et al. 2008). Until a good understanding of the ecological mechanisms that affect the productivity of sardine and anchovy stocks is achieved, this correlation, which is essentially based on one cycle of the PDO must be viewed with caution.

Like all marine ecosystems, the CCLME is very complex, and despite 60 years of surveys from the California Cooperative Fisheries Investigation (CalCOFI) survey, understanding and predicting recruitment success for any fishery including CPS remains elusive. In light of the complexity, ecological indicators are have been used as surrogates of ecosystem health and status of fisheries. Preliminary physical indicators and sentinel species are being used to provide information on an ongoing Integrated Ecosystem Assessment of the CCLME. Since 2008, the Pacific Coast Ocean Observing System (PaCOOS) has produced a quarterly summary of climate and ecosystem science and management in the CCLME has tracked the indicators and sentinel species (www.pacoos.org). As scientists begin to examine and model the effects of changes in the ecology of the CCLME, the value of long term data sets monitoring such things as oceanographic parameters, relative abundance and geographic distribution of various species, and diet studies of higher order predators is becoming apparent.

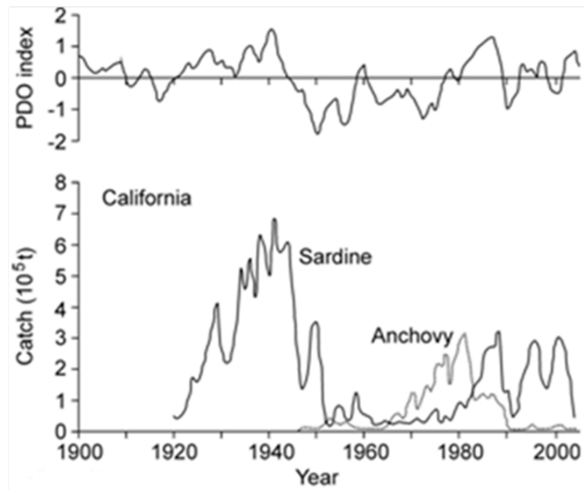


Figure 6. The relationships between sardine and anchovy landings in California and the PDO. From Takasura et al. 2008.

10.3 Current Climate and Oceanographic Conditions

10.3.1 Spring Transition

In 2010, the Spring Transition (Figure 2) was relatively early (5 April 2010), but was not as strong as 2009 (i.e., consistent). Northwest winds remained steady in spring (April) but frequently stopped or reversed in May and June. The Pacific Ocean also switched from a weak El Niño to a La Niña in June. As such, sea surface temperatures went from about normal to anomalously cold in May through September. However chlorophyll *a*, although high on the coast were not unusually high. These oceanographic conditions may be good for both sardine and anchovy, however, because we do not have a recruitment index (i.e., 0-age survey), we will have to wait until the 2010 age class enters the fishery before we know if ocean conditions in 2010 were conducive to spawning and recruitment for CPS.

10.3.2 El Niño/Southern Oscillation

The Multivariate ENSO Index for the Northeast Pacific reflects El Niño conditions for early 2010 and La Niña conditions from May on. Cold water dominated the CCLME during most of the year (Figure 3). Based on model forecasts, the La Niña is expected to be weakening or ending in the spring 2011.

10.3.3 Pacific Decadal Oscillation

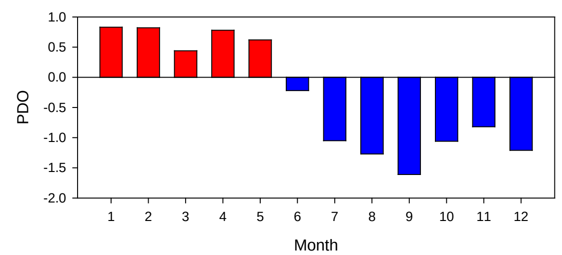


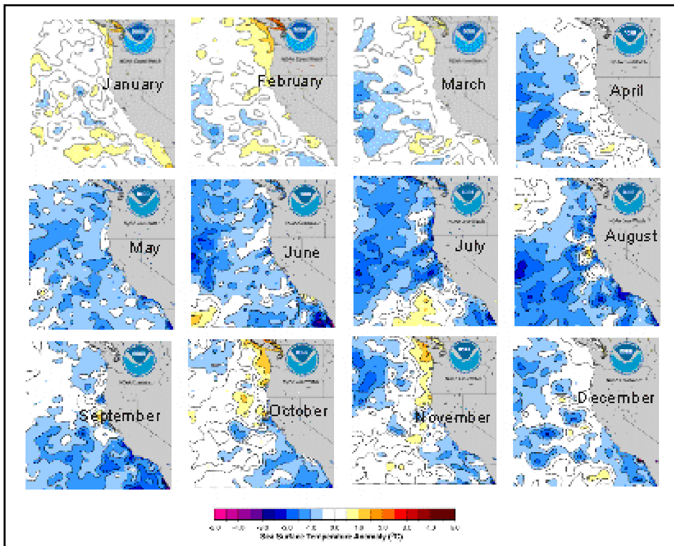
Figure 7. Monthly Pacific Decadal Oscillation index values in 2010. http://jisao.washington.edu/pdo/

The PDO was positive from January through May and then became strongly negative for the rest of the year (Figure 7). A negative PDO value is considered unfavorable for sardine and favorable for anchovy (Chavez et al. 2003). Effects on other CPS such as market squid is also probably positive. Since the change in the PDO occurred mid-year. It is possible that sardine benefitted by these ocean conditions. There were reports of sardine recruitment success off Oregon/Washington in 2010 (Emmett 2010)

10.4 Trends in Ecosystem Indicators

10.4.1 Sea Surface Temperatures

Sea surface temperatures appear to affect the abundance sardine, anchovy and other CPS species abundance (Chavez et al. 2003; Jacobson et al. 2001, 2005). In 2010 ocean temperatures were near normal during spring, but anomalously cold the rest of the year (Figure 8), probably reflecting the La Niña and negative PDO.



Figue 8. Monthly sea surface temperature anomalies in 2010. ttp://coastwatch.pfel.noaa.gov/

10.4.2 Ocean Productivity

Chlorophyll *a* is a phytoplankton pigment that can be measured at the surface by satellites. In 2010 coastal chlorophyll *a* was unusually high in March, April, and May (Figure 9). During the rest of the year Chlorophyll levels were either about normal or slightly less than normal.

10.4.3 Copepods

Copepod species richness is surveyed by the NMFS, NWFSC off Newport, OR and is highly correlated to the PDO (http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ea-copepod-biodiversity.cfm). In 2010

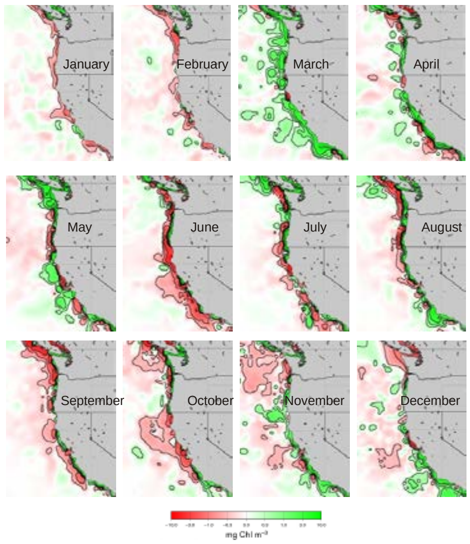


Figure 9. Chlorophyll *a* concentration anomalies in 2010. http://coastwatch.pfel.noaa.gov/

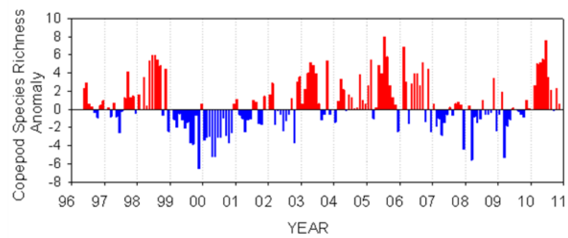


Figure 10. Monthly anomaly of copepod diversity found off Newport, OR. From William Peterson, NOAA, NMFS, Newport, OR.

(Figure 10) the copepod community was composed of primarily subtropical species, species not typical of "good" ocean conditions is the CCLME but reflective of El Niño conditions. This indicates the lag between changes in the physical environment and biological conditions. While the physical ocean switched to a La Niña, the biological environment did not. The presence of subtropical species is unfavorable for coho salmon returns to the Columbia River but has not been correlated to CPS in the area, although preliminary information indicates that when these warm-water copepods are abundant, Pacific herring and anchovy do not recruit as well as when the subarctic copepod community is present. However, sardines appear to recruit better during warm ocean conditions and when a subtropical copepod community is present (Emmett 2011).

10.4.4 Forage fishes and invertebrates

Surveys for juvenile fish and krill are conducted by the NMFS, SWFSC off the Central California coast in the May-June time period since 1983 (Figure 11). In 2010, juvenile sardine numbers dropped far below their long-term average, and juvenile anchovy abundance remained very low. Market squid encounters were below average but came closer to their long-term mean.

Pelagic fish surveys off the Columbia River by, NMFS, NWFSC indicate relatively higher

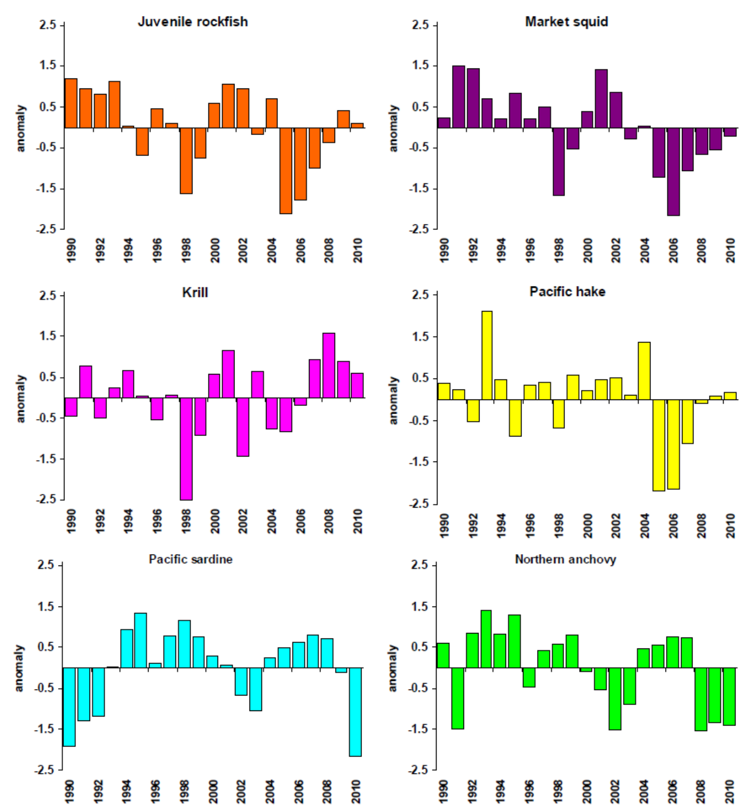


Figure 11. Long-term standardized anomalies of six pelagic forage species off central California. Steve Ralston, NOAA, NMFS, SWFSC.

abundance of forage fish in 2010 (Figure 12), evidently related to good recruitment in 2009. These surveys capture primarily all age-classes of forage fish. Overall forage fish densities started to come closer to the high densities observed from 2000-2005. Particularly high densities of whitebait smelt were observed in 2010, these were primarily 0-age fishes.

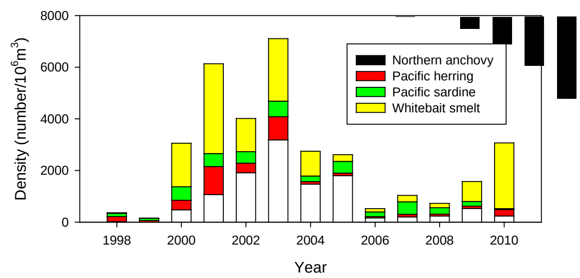


Figure 12. Annual densities of forage fishes off the Columbia River. Robert Emmett, NOAA, NMFS,

10.4.5 Humboldt squid

In 2009, record numbers of Humboldt squid were captured by sport and incidental in commercial fisheries from California to British Columbia, Canada. In 2010, no Humboldt squid were captured in pelagic fish surveys off Oregon and Washington in 2010 and few were reported in the commercial fishery. It appears that the Humboldt squid population has crashed or migrated back to Mexican waters.

10.6 Section References

Beamish, R.J, A.J. Benson, R.M. Sweeting, and C.M. Neville. 2004. Regimes and the history of the major fisheries off Canada’s west coast. Progress in Oceanography 60: 355–385.

CDFG. 2009. Review of Some California Fisheries for 2008. CalCOFI Report; 50:14-42.

Chavez, F. P., J. Ryan, S. E. Lluch-Cota, and M. Niguen 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299:217-221.

Emmett, R. 2010. Pers. Obs.

Emmett, R. 2011. Unpublished data. NOAA, NMFS, Hammond, OR.

Hickey and Royer. 2001. California and Alaskan Currents, p. 368-379. *In* J. H. Steele, S. A. Thorpe, and K. A. Turekian (eds.), Encyclopedia of Ocean Sciences. Academic Press, San Diego, California.

Jacobson, L. D., J. A. A. De Oliveira, M. Barange, M. A. Cisneros-Mata, R. Félix-Uraga, J. R. Hunter, J. Y. Kim, Y. Matusuura, M. Nĩguen, C. Porteiro, B. Rothschild, R. P. Sanchez, R. Serra, A. Uriare, and T. Wada. 2001. Surplus production, variability, and climate change in the great sardine and anchovy fisheries. Can. J. Fish. Aquat. Sci 58: 1891-1903.

Jacobson, L.D., S.J. Bograd, R.H. Parrish, R. Mendelssohn, and F.B. Schwing. 2005. An ecosystem-based hypothesis for climatic effects on surplus production in California sardine (*Sardinops sagax*) and environmentally dependent surplus production models. Can. J. Fish. Aquat. Sci. 62: 1782–1796.

Mantua N.J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. J. Amer. Meterol. Soc. 78:1069-1079.

Peterson, W.T., R. C. Hooff, C.A. Morgan, K. L. Hunter, E.Casillas, and J.W. Ferguson. 2006. Ocean Conditions and Salmon Survival in the Northern California Current. NMFS NWFSC http://www.nwfsc.noaa.gov/research/divisions/fed/ecosysrep.pdf.

Takasuka, A., Y. Oozeki, H. Kubota, and S. E. Lluch-Cota. 2008. Contrasting spawning temperature optima: Why are anchovy and sardine regime shifts synchronous across the North Pacific? Prog. Oceanog. 77 (2008) 225–232.

Climate Indicators:

PaCOOS Quarterly Update of Climatic and Ecological Conditions in the CA Current Large Marine Ecosystem V4 2010, V1 2010 (http://www.pacoos.org)

El Niño Southern Oscillation (ENSO):
Source: Bill Peterson, NOAA, NWFSC
Source: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/mei.html

Pacific Decadal Oscillation (PDO):
Source: The PDO
Source: http://jisao.washington.edu/pdo/, http://jisao.washington.edu/pdo/PDO.latest

California Current Ecosystem Indicators:
Copepods:
Source: Bill Peterson, NOAA, NWFSC

Coastal Pelagics:
Ecosystem indicators for the Central California Coast, May-June 2010
Source: Steve Ralston, John Field and Keith Sakuma, Fisheries Ecology Division, SWFSC

Forage fish densities off Oregon/Washington Coast 1998-2009
Source: Robert Emmett, Paul Bentley, Fisheries Ecology Division, NOAA, NWFSC

11.0 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. Seasonal closures and allocations, HGs, incidental landing allowances, and other management controls are used. Other CPS species (northern anchovy, jack mackerel, and market squid) are monitored to ensure their stocks are stable, but annual stock assessments and Federal fishery controls are not used.

While this document focuses on U.S. fisheries, many CPS stocks are distributed coastwide, hence, catch information from Mexican fisheries is of interest. See Table 11-1 for information on commercial harvest of CPS finfish landed into Ensenada, Mexico (1978-2008) (Table 15, García and Sanchéz 2003).

11.1 Actively Managed Species

11.1.1 Pacific Sardine

Hill *et al.* (2010; see Appendix 1) summarized the status of the Pacific sardine resource off the U.S. Pacific Coast, British Columbia, and northern Baja California, Mexico. Pacific sardine preliminary landings for these areas totaled 145,861 mt in calendar year 2010 (Table 11-4). Total international harvest of sardine was 138,328 mt in 2009 and 164,487 mt in 2008. During 2010, landings in California (33,688 mt) decreased from the previous year (37,576 mt in 2009). Combined Oregon-Washington landings for 2010 (33,130 mt) were slightly higher than in 2009 (29,507 mt) (Table 11-3). The U.S. figures include EFP landings of 2203 mt in 2009 and 3758 mt in 2010.

The U.S. sardine fishery is regulated using a quota-based HG management approach (see Section 11.1.1.1). From the mid-1990s through 2007, landings from the U.S.-based fisheries were typically lower than the recommended HGs (Table 11-3). HGs for 2008, 2009 were 42% and 25% lower than each of the previous years, and although there was an 8% increase in the HG in 2010, the U. S. fishery was subject to in-season closures in all three management years. The 2011 HG is 30% lower than in 2010 and there were again in-season closures during the first and second allocation periods.

Harvest of Pacific sardine by the Ensenada (Mexico) fishery is not regulated by a quota system, but there is a minimum legal size requirement of 150 mm standard length, and measures are in place to control fleet capacity. The Ensenada fishery landed 56,821 mt in 2010 (preliminary figures), up from 52,064 mt in 2009, but down from 66,866 mt in 2008 (Table 11-4). Canadian sardine landings have increased substantially from 10,435 mt in 2008, to 15,334 mt in 2009, and ~22,223 mt in 2010 (Table 11-4).

Estimated stock biomass (ages 1+) from the assessment conducted in 2010 (Hill et al. 2010) indicates a continued declining trend since the peak year (1.57 million metric tons (mmt) in 2000), with an estimate of 537,173 mt in July 2010 (Table 11-2). Current recruitments are considerably lower than the recent peak of 18.58 billion fish in 2003 (Table 11-2). Recent biomass and recruitment estimates (2000-2010) from the latest assessment are provided in Table 11-2 and Appendix 1.

Finally, estimates of Pacific sardine biomass from the 1930s (Murphy 1966 and MacCall 1979) indicate that the sardine population may have been more than five times its current size before the stock decline and eventual collapse observed in the 1960s. Considering this 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 indicate a downward trend in productivity (recruits per spawner) in recent years, which may be indicative of a stock that has reached a threshold under current environmental conditions.

11.1.1.1 Harvest Guideline for 2011

Based on results from the updated assessment model (Hill et al. 2010), the HG for the U.S. fishery in calendar year 2011 was calculated to be 50,526 mt. Parameters used to determine this HG are discussed below and presented in Table 11 of Appendix 1. The harvest control rule defined in Amendment 8 of the CPS FMP, Option J, Table 4.2.5-1, (PFMC 1998) was used to calculate the HG for 2011. This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over the long-term. The Amendment 8 harvest formula for sardines is:

$$HG_{2011} = (BIOMASS_{2010} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where HG_{2011} is the total USA (California, Oregon, and Washington) harvest guideline in 2011, $BIOMASS_{2010}$ is the estimated July 1, 2010 stock biomass (ages 1+) from the assessment (537,173 mt), CUTOFF is the lowest level of estimated biomass at which harvest is allowed (150,000 mt), FRACTION is an environmentally-based percentage of biomass above the CUTOFF that can be harvested by the fisheries, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters.

The value for FRACTION in the harvest control rule for Pacific sardines is a proxy for F_{msy}. Given that F_{msy} and the productivity of the sardine stock have been shown to increase when relatively warm-ocean conditions persist, the following formula has been used to determine an appropriate (sustainable) FRACTION value:

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

where T is the running average sea-surface temperature at Scripps Pier, La Jolla, California during the three preceding seasons (July-June). Ultimately, under Option J (PFMC 1998), F_{msy} is constrained and ranges between 5% and 15%. Based on the T values observed throughout the period covered by the stock assessment, the appropriate exploitation fraction has consistently been 15%; and this remains the case under current conditions (T_{2010} = 17.90 °C). The HG for 2011 (50,526 mt) is ≈30% lower than the 2010 HG and is the lowest since onset management under the federal CPS-FMP (Table 11-3).

<u>OFL, ABC, and ACL</u>

The MSA requires fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACLs) for species managed under federal FMPs. By definition, ABC and ACL must always be lower than the OFL based on uncertainty in the assessment approach. The Council's SSC recommended the P* (P-star) approach for buffering against scientific uncertainty when defining ABC, and this approach was incorporated in Amendment 13 to the CPS-FMP (see PFMC 2010a and Ralsong et al. 2011)..

The estimated biomass of 537,173 (ages 1+, mt), an F_{MSY} of 0.1985 based on a relationship between temperature and F_{MSY}, and an estimated distribution of 87% of the stock in U.S. waters lead to an OFL (U.S. only) for 2011 of 92,767 mt. For Pacific sardine, the SSC has recommended that scientific uncertainty (σ) be set to the maximum of either (1) the coefficient of variation (CV) of the biomass estimate for the most recent year or (2) a default value of 0.36, which was based on uncertainty across full sardine assessment models. During SSC review of the assessment update, it was determined that the model CV for the terminal year biomass was equal to 0.31; therefore scientific uncertainty (σ) was set to the default value of 0.36. The Amendment 13 ABC buffer depends on the probability of overfishing level determined by the Council (P*). Uncertainty buffers and ABCs associated with a range of discreet P* values are presented in Table 11 of Appendix 1.

At its November 2010 meeting, the Council adopted this assessment update and the stock biomass estimate of 537,173 metric tons (mt). For the 2011 Pacific sardine fishery, the Council adopted an OFL of 92,767 mt, a P* value of 0.40, and a corresponding ABC of 84,681 mt. The Council set an ACL equal to the ABC of 84,681 mt, and adopted a harvest guideline of 50,526 mt. In addition to the HG, the Council set aside 4,200 mt for EFP research, of which 2,700 mt was eventually requested and approved by NMFS (see Section 12.1.2).

11.1.1.2 References

Hill, K. T., N. C. H. Lo, P. R. Crone, B. J. Macewicz, and R. Felix-Uraga. 2010. Assessment of the Pacific sardine resource in 2010 for USA management in 2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-469. 142 p.

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

11.1.2 Pacific Mackerel

Total biomass (age-1+ biomass, *B*) has steadily declined from the mid 1980s to the early 2000s, at which time the population began to increase moderately in size, with some signs of rebuilding observed over the last several years. However, in historical terms, the population remains at a relatively low abundance level, due primarily to oceanographic conditions, given limited fishing pressure over the last decade has not likely compromised this species' biology (i.e., their role in the larger CPS assemblage off the Pacific coast). Finally, recent estimates of stock size are necessarily related to assumptions regarding the dynamics of the fish (biology) and fishery (operations) over the last several years, which generally confound long-term (abundance) forecasts for this species (see Crone *et al.* 2011). It is important to note that exploitation of this stock has changed considerably over the last two decades, i.e., during the 1990s, the directed fisheries off California had average annual landings of roughly 18,000 mt, whereas since 2002, average yearly landings have decreased substantially. This pattern of declining yields in recent years generally characterized all of the fisheries, including U.S. commercial and recreational sectors, as well as the commercial fishery of Mexico.

In summary, the Council adopted the most recent assessment for Pacific mackerel, i.e., determination of the status of the Pacific mackerel population for the 2011-12 fishing year was based on the Model *XA*, which generated a biomass estimate of 211,126 mt (see section 3.2 and Crone *et al.* 2011). However, based on model uncertainty (see Crone *et al.* 2011) and precautionary management strategies (PFMC 1998), the Council recommended a final quota (HG) below that typically derived from the formal harvest control rule (see section 11.1.2.1); this adjustment was done for Pacific mackerel stock assessments conducted previously as well (see section 3.2 and PFMC 2010a).

<u>OFL, ABC, and ACL</u>

For a detailed discussion of OFLs, ABC and ACLs, see Section 11.1.1.1.

For Pacific mackerel, the estimated biomass of 211,126 mt (age 1+ biomass), a F_{MSY} (FRACTION) of 0.30, and an estimated distribution of 70% of the stock in U.S. waters resulted in an OFL (U.S. only) for 2011 of 44,336 mt. For Pacific mackerel, the SSC recommended that 'scientific uncertainty' (σ) be set to the maximum of either: (1) the CV of the biomass estimate for the most recent year; or (2) a default value of 0.36 (roughly, a CV=37% on an arithmetic scale), based on overall stock- and group-specific estimates that provided a reasonable lower -bound proxy for coastal pelagic (and groundfish) species of interest (see PFMC 2010a and Ralston *et al.* 2011). The CV for the terminal year biomass estimate from the current assessment was equal to 0.21 and thus, scientific uncertainty (σ) was set to the default value of 0.36. The Amendment 13 ABC buffer depends on the probability of overfishing level determined by the Council (P*). Uncertainty buffers and ABCs associated with a range of discreet P* values are presented in Table 6 in Crone *et al.* (2011).

At its June 2011 meeting, the Council adopted the assessment results, which included a stock biomass estimate of 211,126 metric tons (mt), see Crone *et al.* (2011). For the 2011 Pacific mackerel fishery, the Council adopted an Overfishing Limit (OFL) of 44,336 mt, a P* value of 0.45, and a corresponding Acceptable Biological Catch (ABC) of 42,375 mt. The Council set an Annual Catch Limit (ACL) of 40,514 mt.

11.1.2.1 Harvest Guideline for 2010-11

For the 2011-12 fishing year, the Council recommended the following (see section 11.1.2.1):

- overfishing limit (OFL): 44,336 mt
- acceptable biological catch (ABC) of 42,375 mt
- harvest guideline (HG): 40,514 mt
- annual catch limit (ACL): 40,514 mt
- annual catch target (ACT): 30,386 mt

The Council adopted an HG equal to the ACL (40,514 mt) and set an ACT of 30,386 mt (derived by calculating 75% of the ACL). The difference between the ACT and the ACL is 10,128 mt, which effectively becomes an incidental set-aside. Should the directed fishery attain the ACT of 30,386 mt, the Council recommended that NMFS close the directed fishery and establish a 45% incidental catch allowance when Pacific mackerel are landed with other CPS, with the exception that up to 1 mt of Pacific mackerel could be landed without landing any other CPS. Any incidental harvest of Pacific mackerel shall be applied against the 10,128 mt de facto set-aside for incidental landings. Further, full assessments for actively managed CPS stocks (e.g., Pacific mackerel and Pacific sardine) typically occur every third year, with updates in interim years. However, in efforts to make progress with research and data needs critical to the ongoing assessment of this stock (see Section 13.2), the Council recommended no update assessment in 2012, with the next assessment scheduled in for 2013. A more adaptive assessment and research schedule for CPS is to be presented to the Council later in 2011.

11.2 Monitored Species

The monitored species category of the CPS FMP includes northern anchovy, jack mackerel, market squid, and krill.

11.2.1 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. There were no reported landings of northern anchovy in Oregon from 1981 through 1999. Washington reported about 42 mt in 1988, but didn't land more until 2003. From 2000 to 2010, northern anchovy landings averaged 322 mt for Washington, 71 mt for Oregon, and 9,028 mt for California. In California, northern anchovy were landed each year. The greatest northern anchovy landings in California occurred in 2001 (19,277 mt). In Washington, northern anchovy were landed in 2003 and 2007 to 2010, and the peak in landings occurred in 2009 (810 mt). In Oregon, northern anchovy were landed from 2002 to 2006 and from 2008 to 2010.

Anchovy (mt)	**WA**	**OR**	**CA**
2000	-	-	11,753
2001	-	-	19,277
2002	-	3	4,650
2003	214	39	1,676
2004	-	13	6,793
2005	-	68	11,182
2006	-	9	12,790
2007	153	-	12,390
2008	109	260	14,285
2009	810	39	2,668
2010	108	138	1,847

Through the 1970s and early 1980s, Mexican landings increased, peaking at 258,745 mt in 1981 (Table 11-1). Mexican landings decreased to less than 2,324 mt per year during the early 1990s, with a spike of 17,772 mt in 1995, primarily during the months of September through November. Catches in Ensenada decreased to 4,168 mt in 1996; and remained at less than 5,000 mt through 2007.

In 2010, with the reauthorization of the MSA, the Council adopted new management benchmarks for northern anchovy. The overfishing limit (OFL) values are based on past estimates of biomass and the ABC values account for a 75% uncertainty buffer in the OFL. The annual catch limit was set equal to the ABC. An annual catch target (ACT) for the northern subpopulation of northern anchovy was established.

Stock	OFL	ABC	ACL	ACT
Northern anchovy, northern subpopulation	39,000 mt	9,750 mt	Equal to ABC	1,500 mt
Northern anchovy, central subpopulation	100,000 mt	25,000 mt	Equal to ABC	

11.2.2 Jack Mackerel

Until 1999, jack mackerel were managed under the Council's groundfish FMP. Jack mackerel are now a monitored species under the CPS FMP. This species has not been significantly targeted on the West Coast and accordingly, regular stock assessments or efforts to collect biological information on jack mackerel. The SWFSC Acoustic-Trawl survey, which began in 2006 and was approved by a methodology review panel in early 2011, may be used to provide abundance estimates in the future. Management efforts to collect fishery-dependent age composition data, such as the CDFG Port Sampling Program, are in place for the two actively managed CPS (Pacific sardine and Pacific mackerel), but not for jack mackerel, aside from samples taken prior to 1995. Previous discussions of jack mackerel, such as in the groundfish FMP, are brief:

> Available data indicate that the current, nearly un-used spawning biomass is about one million mt, the natural mortality rate is in the range of 0.1 to 0.2, a fishery located north of 39° N latitude would harvest fish that are mostly older than age 16, and the long-term potential yield for this age range is 19,000 mt. The GMT recommended close tracking of this fishery and the age composition of the harvested fish, particularly if catches are begun outside the exclusive economic zone. (PFMC 1998.)

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. Currently, most landings of jack mackerel are incidental to Pacific sardine and Pacific mackerel in California; however, pure landings do occur sporadically. From

2000 to 2010, jack mackerel landings averaged 7 mt for Washington, 70 mt for Oregon, and 890 mt for California. In California and Oregon, jack mackerel landings occurred each year; however, in Washington, jack mackerel were landed in 2002 and 2003. In California and Oregon, the greatest landings occurred in 2001 (3,624 mt; 196 mt). In 2010, the vast majority of jack mackerel landings were made by midwater trawl gear, likely as incidental catch to over fisheries. In California, CDFG landing receipts for jack mackerel totaled 3,624 mt in 2001; however, these may be somewhat overreported – the jump in jack mackerel landings in 2001 coincided with an early closure of the Pacific mackerel HG.

Jack mackerel (mt)	**WA**	**WA (unspecified)**	**OR**	**CA**
2000	-		161	1,269
2001	-	371	196	3,624
2002	12	238	8	1,006
2003	2	54	74	156
2004	-	22	126	1,027
2005	-	24	70	213
2006	-		5	1,167
2007	-		14	631
2008	-		46	274
2009	-		2	119
2010	<1		3	306

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, since portions of the contemporary catch are sometimes found in small aggregations of young fish along rocky shores.

In 2010, in accordance with the reauthorized MSA, the Council adopted new management benchmarks for jack mackerel. The overfishing limit (OFL) value is based on past studies and the ABC value accounts for a 75% uncertainty buffer in the OFL. The ACL was set equal to the ABC.

Stock	OFL	ABC	ACL
Jack mackerel	126,000 mt	31,000 mt	Equal to ABC

11.2.3 Market Squid

The CDFG is currently monitoring the market squid fishery through a state-based management plan including an annual landings cap and various spatial/temporal constraints, such as weekend closures and the establishment of marine protected areas (CDFG 2005). In addition, the Egg Escapement Method has been used as an assessment tool, to evaluate population dynamics and biological reference points (MSY related) regarding this species (Section 4.3.4 and Dorval et al. 2008). The fishery control rules currently in place under the California MSFMP, including a restricted access program, and limits fishery participation, as well as the expansion of marine protected areas in California to protect spawning areas, are thought to preclude the need for active management. However, if fishery operations change substantially in the future (for example, spatially expands, harvest high amounts of immature squid) in the future, additional management measures may be required.

In 2010, the Council approved benchmarks for market squid:

Stock	OFL	ABC	ACL
Market squid	Fmsy proxy resulting in egg escapement ≥ 30%	Fmsy proxy resulting in egg escapement ≥ 30%	Exempt

11.2.3.1 California's Market Squid Fishery

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

In 2010, the market squid fishery was California's largest fishery, with landings estimated at 129,896 mt. This is a 141 percent increase over 2009 (92,371 mt) and greater than the record high set in 2000 (118,827 mt). The total ex-vessel value increased from $56.4 million in 2009 to $73.7 million in 2010. The median ex-vessel price per ton of market squid in 2010 was $500. The fishing permit season for market squid extends from April 1 through March 31 of the following year. During the 2009-2010 season (as opposed to the 2009 calendar year) 84,925 mt were landed, an increase from the 2008-2009 season (34,050 mt). Squid landings in northern California have remained low since the 2006-2007 season probably the result of environmental conditions observed during the past several years. In contrast, most of the market squid was taken from the southern California region during the season.

11.3 References

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

Crone, P. R., K. T. Hill, J. D. McDaniel, and N. C. H. Lo. 2009. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2009-10 fishing year. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 197 p.

Crone, P. R., K. T. Hill, J. D. McDaniel, and K. Lynn. 2011. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2011-12 fishing year. Pacific Fishery Management Council, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220, USA. 99 p.

Dorval, E., J. McDaniel, and P. Crone. 2008. Squid population modeling and assessment (January 2008). Final report submitted to the California Department of Fish and Game (Marine Region) and the Southwest Fisheries Science Center. 30 p.

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

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

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

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

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

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

Hill, K. T., E. Dorval, N. C. H. Lo, B. J. Macewicz, C. Show, and R. Felix-Uraga. 2008. Assessment of the Pacific sardine resource in 2008 for U.S. management in 2009. PFMC, Nov 2008, Agenda Item G.2.b, 236 p.

Hill, K. T., N. C. H. Lo, P. R. Crone, B. J. Macewicz, and R. Felix-Uraga. 2009. Assessment of the Pacific sardine resource in 2009 for USA management in 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-452. 182 p.

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

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

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

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

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

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

Pacific Fishery Management Council (PFMC). 2009. Terms of reference for a Coastal Pelagic Species Stock Assessment Review Process. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220.

PFMC. 2010b. Terms of reference for a coastal pelagic species stock assessment review process. November 2010. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220. 20 p.

Ralston, S., A. E. Punt, O. S. Hamel, J. D. DeVore, and R. J. Conser. 2011. A meta-analytic approach to quantifying scientific uncertainty in stock assessments. Fish. Bull. 109:217-231.

Stock Assessment Review (STAR) Panel. 2009. Pacific mackerel STAR panel meeting report. A. Punt (chair) and members O. Hamel, A. MacCall, G. Melvin, and K. Burnham. NOAA Fisheries, Southwest Fisheries Science Center, La Jolla CA, May 4-8, 2009. 18 p.

11.4 Ecosystem Component Species

In June 2010, the Council added Pacific herring (*Clupea pallassi*) and jacksmelt (*Atherinopsis californiensis*), two species not under Federal management, to the Ecosystem Component category of the CPS FMP. Several criteria should be met for a species to be included in the EC category (MSA Section 660.310(d)(5)(i)). These are 1) be a non-target stock/species; 2) not be subject to overfishing, approaching overfished, or overfished and not likely to become subject to overfishing or overfished in the absence of conservation and management measures; and 3) not generally retained for sale or personal use, although "occasional" retention is not by itself a reason for excluding a species from the EC category. Identifying and including EC species in an FMP is not mandatory but may be done for a variety of purposes, including data collection, for ecosystem considerations related to specification of OY for the associated fishery, as considerations in the development of conservation and management measures for the associated fishery, and/or to address other ecosystem issues.

A 2010 review of bycatch species in CPS fisheries confirmed that incidental catch and bycatch in CPS fisheries is dominated by other CPS and that bycatch/incidental catch of non-CPS is extremely low. However, jacksmelt and Pacific herring are infrequently caught with CPS gear and were therefore added to the FMP under Amendment 13 to ensure continued monitoring of incidental catch and bycatch of these species through sampling and logbook programs. This information will continue to be reported in the Stock Assessment and Fishery Evaluation (SAFE) report. The Council intends to continue and expand its consideration of ecological factors when developing status determination criteria (SDCs) and management measures for CPS management unit species. These considerations will evolve as improved information and modeling of ecological processes become available and will likely include predator/prey relationships and the overall status and role of forage species including these two EC species.

12.0 Emerging Issues

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

12.1 Pacific Sardine

12.1.1 Allocation

Beginning with the 2006 season, the Pacific sardine fishery has operated under a seasonal allocation framework adopted as Amendment 11 to the CPS FMP (see Section 2). When the Council approved Amendment 11, they scheduled a formal review of the allocation formula to provide a comparison of the performance of the fishery to the projections used to evaluate the adopted allocation scheme. Originally scheduled for June 2008, this review has been postponed indefinitely.

12.1.2 Exempted Fishing Permits and Aerial Survey

The 2011 HG included a 4,200 mt set-aside for survey research activities. At the April 2011 meeting, the Council voted unanimously in support of issuing an exempted fishing permit (EFP) for aerial sardine research in the Pacific Northwest. The EFP proposal lays out a detailed survey methodology to utilize 2,700 mt of the set-aside, with the remaining 1,500 mt to be re-allocated to the third period directed fishery.

The EFP applicants increased the transect spacing in areas expected to have more sardine schools, and are attempting more transect replicates. Each transect will extend from three miles to 38 miles offshore. The proposed survey involves a two-stage sampling design. First, aircraft fly over the transects, following methodology described in the application. Photos are taken of sardine schools, to estimate surface area and biomass. Then spotter planes will work in tandem with purse seine vessels to capture up to 76 sardine schools of sizes ranging between about 4 mt and 82 mt. These correspond with surface area of 100 m^2 and 10,000 m^2. This is intended to establish the relationship between surface area and biomass.

The proposal also includes biological sampling from captured point sets, and the proponents are pursuing a cooperative arrangement to extend aerial sampling into Canadian waters off Vancouver Island.

12.1.3 Harvest Control Rule

The current Pacific sardine harvest control rule includes stock-recruit and temperature-recruit relationships that determine the harvestable fraction of the stock. However, a November 2010 publication by McClatchie et al. (Can. J. Fish. Aquat. Sci. 67: 1782–1790, November 2010) re-evaluates the relationship between sea surface temperature (SST), recruitment, and stock abundance for Pacific sardines. This study indicates that sea-surface temperature data collected from Scripps Pier are no longer a reliable predictor of sardine recruitment success, and suggests that while environmental factors clearly affect recruitment success for Pacific sardine, other environmental variables should be used. The CPSMT recommended review of this publication, to explore the potential for amending the HCR at some point. Dr. McClatchie met with the CPSMT in La Jolla, CA in February, 2011, and to discuss the research and recommendations.

12.2 Pacific Mackerel

Pacific mackerel continue to be actively managed although recent landings have been well below the ABC. At the Council's recommendation, Pacific mackerel will not undergo an assessment 2012, with the next full assessment tentatively scheduled for 2013. To date, there has been no formal proposal to remove the stock from active management, although based on fishing pressure and recent landings, it may be a candidate if the current trend of low fishing pressure continues. However, industry members note that the species is subject to large fluctuations, and can quickly become more available based on location and density of schools.

12.3 Management Issues

Emerging management issues include implementation of new provisions in the reauthorized MSA, ecosystem-based fishery management, international CPS research, and concerns about the temperature component of the sardine HCR.

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

As noted above, the Council amended the CPS FMP to comply with provisions of the 2007 MSA reauthorization. In accordance, NMFS has revised guidance on preventing overfishing under MSA National Standard 1.

Precautionary HCRs for Pacific sardine and Pacific mackerel provide a solid foundation for the implementation of new fishery management provisions such as overfishing limits and annual catch limits. The CPS FMP's monitored stocks are either exempt from the new MSA requirements because of their short life-cycle (market squid) or are currently harvested at relatively low levels (anchovy, jack mackerel). ACLs for monitored stocks may be implemented with greater flexibility but greater precaution than the actively managed species because they are assessed with less frequency. Amendment 13 to the CPS FMP was approved by the Council in 2010, and NMFS issued draft regulations in June, 2011. Until Amendment 13 receives

Secretarial approval, annual management measures for sardine and Pacific mackerel will be crafted to under both a pre- and post-Amendment 13 management structure.

12.3.2 Ecosystem Based Fishery Management

In November 2006, the Pacific Council initiated development of an Ecosystem Fishery Management Plan (EFMP). The EFMP is intended to serve as an “umbrella” plan over the four existing FMPs, helping with coastwide research planning and policy guidance and creating a framework for status reports on the health of the CCLME. The plan envisioned by the Council would not replace the existing FMPs, but would advance fishery management under these FMPs by introducing new science and new authorities to the current Council process.

The Council formally established an Ecosystem Plan Development Team (EPDT), which is developing preliminary scoping documents. The Council also established an Ecosystem Advisory Subpanel. The two bodies held a joint kick off meeting in February, 2010.

In June, 2011, the Council chose to move forward with an advisory ecosystem plan, and adopted a purpose and need statement developed by the EPDT. In addition, the Council directed the EPDT to develop a list of species that are not currently managed or listed under the ESA, including a subset that could be subject to future target fishing.

12.4 International CPS Fisheries

There is interest in coastwide management for the Pacific sardine fishery, which would entail a more consistent forum for discussion between the U.S., Mexico, and Canada. Continued U.S.-Mexico bilateral meetings indicate Mexico’s willingness to continue scientific data exchange and cooperation on research, and to engage in discussions of coordinated management. The Trinational Sardine Forum has been a good venue for international exchange. The 2011 Trinational Sardine Forum will be held December 8-9, at the Scripps Institute for Oceanography, in La Jolla, California.

In June, 2011, the Council and NMFS sponsored the second installment of a workshop aimed at improving stock assessment science for CPS species. Participants shared information about several different survey methods. Participants from British Columbia and Mexico attended, in addition to fisheries scientists, industry representatives, and other stakeholders. The group produced a research plan that lays the groundwork for a coordinated survey designed to compare the various survey methods, and to collect important stock assessment data. The Council supported the report, and requested that Council staff draft a letter of support to be used in pursuing funding to support the research plan.

12.5 Catch Shares

NOAA issued a Catch Shares Policy in late 2009, encouraging fishery management councils to explore the potential for catch shares as a tool to address problems in management of fisheries. NOAA offers technical and financial support to councils exploring catch shares, but there is no requirement to explore or implement catch share systems.

The National Marine Fisheries Service (NMFS) sponsored a Catch Shares Workshop in February 2010 to explore the applicability and utility of catch shares in the CPS fishery. That workshop included representatives of the commercial and recreational fishing industries; Federal and state governments; and NGOs. Workshop proceedings were issued in early 2011, and are available from the NMFS Southwest Region Office. Although there is no movement toward implementing catch shares for CPS fisheries, there is still strong support from national leadership and the issue may re-emerge.

12.6 Ocean Renewable Energy

12.6.1 Summary

The development of ocean renewable energy is moving forward off the West Coast, particularly in Oregon (http://www.oregon.gov/ENERGY/RENEW/Hydro/Ocean_Wave.shtml). Proposed wave and wind energy projects could eventually affect thousands of acres of nearshore habitat. A variety of ocean energy structures have been proposed for deployment. The specific areas proposed are sandy habitat within 2.5 miles from shore. Areas targeted for wave energy are generally, but not exclusively, sandy or muddy habitat within three miles of shore. These areas provide the most energy, allow for appropriate anchoring, and are close to onshore support facilities. The deployment of these structures may change local currents, alter bottom sediments, and possibly have other effects on marine habitat.

12.6.2 Adverse Impacts

The biological effects of ocean energy parks on CPS and other species are highly uncertain but studies underway (Boehlert et al. 2008). Structures could act as large fish aggregating devices. They would likely be off limits to sport and commercial fishing, creating a defacto marine reserve. There are also concerns related to biological effects of anti-fouling paints, fuel spills, changes in water flows, increased predator abundance, and electro-magnetic forces on biological organisms.

References:

Boehlert, G.W., G.R. McMurray, and C. E. Tortorici (editors). 2008. Ecological Effects of Wave Energy Development in the Pacific Northwest: A Scientific Workshop, October 11–12, 2007" NOAA Technical Memorandum NMFS-F/SPO-92, 173 p..

12.7 Climate Change

12.7.1 Summary

Recent reports by the International Panel on Climate Change (IPCC) has made it clear that the earth's climate is changing, and with it the environmental conditions in the ocean are also changing (http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html). The Pacific and other oceans are expected to warm in the future. The California Current is known to historically have large natural fluctuations in its oceanography and CPS abundance. Baumgartner et al. (1992) and Field et al. 2009) looked at deposits of coastal pelagic fish scales and were able to identify historic periods or regimes of anchovy and sardine abundance, probably linked to large scale climate phenomena. For example, during the 1930s-1950ss when the California Current was undergoing a "warm" period as reflected in the Pacific Decadal Oscillation (Mantua et al. 1997) sardines were highly abundant, only to crash as the California

Current and the North Pacific entered a cool period. The biological mechanisms causing these abrupt shifts in abundance are still unclear (Checkley et al. 2009), but probably related to decadal changes in wind-stress curl (Rykaczewski and Checkley 2007) and ocean temperatures (Takasuka et al. 2008) linked to productivity and temperature tolerances. Scientists originally thought that anchovy and sardine populations fluctuated out of phase because of "competitive" interactions, but this may not be true (Barange et al. 2009).

12.7.2 Adverse Impacts

Changes in the North Pacific Ocean climate were recently identified as major factors in the decline and subsequent ESA listing of the anadromous smelt eulachon (*Thaleichthys pacificus*) (Eulachon Biological Review Team. 2010). Such changes are also affecting Pacific salmonid populations (Schindler et al. 2009). How climate change will alter the productivity of the California Current fish stocks, or if it will enhance decadal fluctuations in fish abundance is uncertain, but the future effects on fisheries could be modeled based on current knowledge (Hollowed et al. 2009).

12.8 References

Barange, M., J. Coetzee, A. Takasuka, K. Hill, M. Gutierrez, Y. Oozeki, C. van der Lingen, V. Agostini. 2009. Habitat expansion and contraction in anchovy and sardine populations. Prog. Oceanog. 83 (2009) 251–260.

Baumgartner, T. R., A. Soutar, and V. Ferreira-Bartrina. 1992 Reconstruction of the history of Pacific sardine and northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California. Calif. Coop. Oceanic Fish. Invest. Rep. 33:24-40.

Checkley, D. J. Alheit, Y. Oozeki, and C. Roy. 2009 Climate Change and Small Pelagic Fish. Cambridge Univ. Press, Cambridge, UK, 372 p.

Eulachon Biological Review Team. 2010. Status Review Update for Eulachon in Washington, Oregon, and California. NOAA, NMFS. Portland, OR. 443 p.

Field, D. B., T. R. Baumgartner, V. Ferreira, D. Gutierrez, H. Lozano-montes, R. Salvatteci, and A. Soutar. 2009. Variablilty from scales in marine sediments nd other historical records. Pp. 45-63. *In*, Checkley, D. J. Alheit, Y. Oozeki, and C. Roy (editors), Climate Change and Small Pelagic Fish. Cambridge Univ. Press, Cambridge, UK.

Hollowed, A. B., N.A. Bond, T.K. Wilderbuer, W.T. Stockhausen, Z. T. A'mar, R. J. Beamish, J.E. Overland, and M.J. Schirripa. 2009. A framework for modelling fish and shellfish responses to future climate change. ICES J. Mar. Sci. 66: 1584-1594.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. J. Amer. Meterol. Soc. 78:1069-1079.

McClatchie, S., R. Goericke, G. Auad, and K Hill. 2010. Reassessment of the stock-recruitment and temperature-recruitment relationships for Pacific sardine (*Sardinops sagax*). Can. J. Fish. Aquat. Sci. 67: 1782–1790. November 2010.

Rykaczewski, R. R. and D. M. Checkley, Jr.. 2007. Influence of ocean winds on the pelagic ecosystem in upwelling regions. Proc. Nat. Acad. Sci. 105(6):165-1970.

Schindler, D. E. , X. Augerot, E.Fleishman, N.J. Mantua, B.Riddell, M. Ruckelshaus, J. Seeb, and M. Webster. 2009. Climate change, ecosystem impacts, and management for Pacific salmon. Fisheries 33:502-506.

Takasuka, A., Y. Oozeki, H. Kubota, S. E. Lluch-Cota. 2008 Contrasting spawning temperature optima: Why are anchovy and sardine regime shifts synchronous across the North Pacific? Prog. Oceanog. 77 (2008) 225–232.

13.0 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 the relatively recent development of a high-volume fishery for Pacific sardine in Oregon and Washington, increasing recognition of the importance of CPS as principal forage for many salmon and groundfish stocks that are currently at low abundance levels, the importance of CPS biomass estimates to the Council's annual determination of allowable coastal pelagic harvests' and the need to monitor status of the market squid stock using data-intensive techniques. There is pressing need for stock assessments that accurately reflect the reproductive characteristics of CPS stocks throughout their geographic range and for additional stock assessment personnel in NMFS and the three Pacific Coast states to carry out these assessments.

In addition to research and data needs presented in this section, refer to the Council's comprehensive research and data needs document last revised in December 2008. The document includes a chapter dedicated to CPS matters and can be obtained by contacting the Council office or by visiting the Council web page. Also, the latest Pacific sardine and Pacific mackerel assessments and STAR Panel reports include detailed, species-specific, research and data needs.

The highest priority research and data needs for CPS are:

- Gain more information about the status of CPS resources in the north using egg pumps, trawl and sonar surveys, and spotter planes.
- Develop a coastwide (Mexico to British Columbia) synoptic survey of sardine and Pacific mackerel biomass; i.e., coordinate a coastwide sampling effort (during a specified time period) to reduce "double-counting" caused by migration.
- Develop a formal review process for the harvest control rules for Pacific sardine and Pacific mackerel. Currently this review is not part of the stock assessment process.
- Increase fishery sampling for age structure (Pacific sardine and Pacific mackerel) in the northern and southern end of the range. Establish a program of port sample data exchange with Mexican scientists.
- Evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and define predator-prey relationships.

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

13.1 Pacific Sardine

High priority research and data needs for Pacific sardine include:

1) gaining better information about Pacific sardine status through annual coastwide surveys that include ichthyoplankton, hydroacoustic, and trawl sampling;
2) standardizing fishery-dependent data collection among agencies, and improving exchange of raw data or monthly summaries for stock assessments;
3) obtaining more fishery-dependent and fishery-independent data from northern Baja California, México;
4) further refinement of ageing methods and improved ageing error estimates through a workshop of all production readers from the respective agencies. A sardine ageing workshop is scheduled for December, 2011, at the Trinational Sardine Forum;
5) further developing methods (e.g., otolith microchemistry, genetic, morphometric, temperature-at-catch analyses) to improve our knowledge of sardine stock structure. If sardine captured in Ensenada and San Pedro represent a mixture of the southern and northern stocks, then objective criteria should be applied to the catch and biological data from these areas;
6) exploring environmental covariates (e.g., SST, wind stress) to inform the assessment model, and to address recent research that brings into question the temperature-recruitment relationship.

13.2 Pacific Mackerel

Given the transboundary status of Pacific mackerel, it is imperative to encourage collaborative research and data exchange between NMFS SWFSC and researchers from both Canada's and in particular, Mexico's academic and federal fishery bodies. For example, such cooperation is critical to providing a synoptic assessment that considers available sample data across the entire range of this species in any given year.

Fishery-independent survey data for measuring changes in mackerel spawning (or total) biomass are currently lacking. Further, at this time, a single index of relative abundance is used in the assessment, which is developed from a marine recreational fishery (CPFV fleet) that typically does not (directly) target the species. Future research funds should focus on improving the current CPFV survey, with a long-term emphasis, which will necessarily rely on cooperative efforts between the industry, research, and management bodies. Finally, further sensitivity analysis related to this index of relative abundance, including issues surrounding catchability (and/or selectivity) and influences regarding time-varying vs. constant parameterization of these fishery time series should be examined.

Given the importance of age (and length) distribution time series to developing a sound understanding of Pacific mackerel population dynamics, it is critical that data collection programs at the Federal and state levels continue to be supported. In particular, CDFG/NOAA funding should be bolstered to ensure ongoing ageing-related laboratory work is not interrupted, and for long-overdue related biological research. For example, maturity-related time series currently relied upon in the assessment model are based on data collected over twenty years ago during a period of high spawning biomass that does not reflect current levels. Also, work is needed to obtain more timely error estimates from production ageing efforts in the laboratory; for example, accurate interpretation of age-distribution data used in the ongoing assessment requires a reliable ageing error time series. Finally, examinations of sex-specific age distributions will allow hypotheses regarding natural mortality/selectivity (i.e., absence of older animals in sex-combined age distributions) to be more fully evaluated.

13.3 Market Squid

Currently, market squid population dynamics are poorly understood which has hampered assessing the status (health) of this valuable marine resource found off California. General information concerning important stock- and fishery-related parameters suggests maximum age is less than one year, and the average age of squid harvested is roughly six to seven months. Under the National Standard 1 Guidelines, market squid are exempt from ACLs due to their short lifespan. However, the CPSMT recommends that current monitoring programs continue for this species, including tracking fishery landings, collecting reproduction data from the fishery, and obtaining logbook information.

Although some coastwide squid distribution and abundance has been extracted from fishery-independent midwater and bottom trawl surveys aimed at assessing other finfish species, there is no reliable measure of annual recruitment success beyond information obtained from the fishery. Since 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 are qualitative at this point in time. Better information on the extent and distribution of spawning grounds along the U.S. Pacific Coast is needed, particularly, in deep water and areas north of central California. Additionally, fecundity, egg survival, and paralarvae density estimates are needed from different spawning habitats in nearshore areas and oceanographic conditions associated with the population. Data on mechanisms and patterns of dispersal of adults, as well as paralarvae, along the coast is necessary 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 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, and satellite and aerial surveys would also provide useful information for developing alternative indices of abundance other than those derived from logbook data.

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

Currently, market squid fecundity estimates, based on the Egg Escapement Method (Dorval et al. 2008), are used informally to assess the status of the stock through evaluations of alternative biological reference points related to productivity and MSY (see Sections 4.3.4 and 11.2.3). 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, each must receive more 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 will provide information on the age and maturity stages of harvested squid. Further, laboratory work concerning mantle condition, especially the rate of mantle "thinning," will benefit our understanding of squid life history and subsequently help improve the overall assessment of this species. Finally, other poorly-understood biological parameters relate to spawning and senescence (for example, life history strategies concerning spawning frequency, the duration of time spent on spawning grounds, and the period of time from maturation to death).

13.4 Live Bait Fishery

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. Sardine typically represents a larger portion of the live bait catch, ranging from about 50% to 95% between 1994 and 2010. Total live bait landings in those years vary between about 2500 mt and 5000 mt, with effort increasing in summer months. However, these estimates are based only on logbooks provided by a limited number of bait haulers, and estimates provided by the CPFV industry. Since the sale of live bait in California is not permitted in a manner similar to that used for the commercial sale of CPS, estimates of tonnage and value are imprecise. Therefore, no estimates of volume or value for the sale of market squid for live bait are available at this time. However, the CDFG will reexamine reporting requirements and data needs to better estimate landings and value.

Although tonnage of CPS and market squid taken in the live bait fishery is minimal compared with volume taken in the commercial fishery, better estimates of live bait landings and sales of sardine, anchovy and market squid are essential to determine estimates of the overall economic value of these fisheries. Outdated estimates have live bait sardine fishery had equaled that of the commercial catch. However, there is no documentation of the dramatic expansion of live bait market squid sales in southern California made by commercial light vessels in recent years.

13.5 Socioeconomic Data

Economic analyses of management actions affecting coastal pelagic fisheries requires detailed, representative cost and earnings data for the sardine harvesters and processors making up each fishery sector. These data are used to evaluate the economic impacts of proposed management actions. Experience with the long-term allocation of the Pacific sardine HG emphasizes this need, and underscores the necessity routine data collection. Collecting such data on an irregular basis, or to address an issue at hand, often makes them suspect in terms of strategic bias and validity.

Under Ecosystem-based fishery conservation and management, economic analyses will need to examine changes in yields from a number of different species. This will involve finding a balance among the variety of ecosystem services CPS can provide. The tradeoffs of interest are between benefits CPS provide as directed harvests, food for higher trophic level commercial predators, food for recreationally important predators, and food for non-commercial but ecologically important predators. The economic data required to evaluate tradeoffs involving recreationally important versus non-commercial but ecologically important species will entail the development of non-market data acquisition and valuation techniques.

13.5.1 Commercial Fisheries

A comprehensive CPS vessel logbook program for Washington, Oregon, and California vessels would greatly contribute to economic analyses of the commercial CPS fishery. Such a program would not only serve as a means of collecting biological and stock assessment related data, but also vessel-trip-level fishery economic data (e.g., fuel cost and consumption, number of crew, cost of provisions) across all CPS fishery operations. A logbook program would also need to include other fishery operations in which vessels engage in order to fully evaluate their economic opportunities. To fully understand fleet economics, the at-sea data would need to be supplemented with annual expenditure data, and other data that are not trip-specific, such as interest payments.

A parallel effort should be taken with processors. To fully evaluate the economic impacts of proposed management actions detailed, representative cost and earnings data for West Coast sardine processors should be reported on a routine basis. This would entail periodic surveys of CPS processors to collect representative economic data on their processing operations.

13.5.2 Non-market Values

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

13.6 Observer Program

Bycatch in the California contingent of the CPS fishery has been qualitatively monitored by the CDFG's dockside monitoring program since the mid-1980s (Sweetnam and Laughlin, Pers. Comm., 2005). CDFG does not document the amount or quantity of bycatch, instead only documenting the species or type of bycatch encountered at the fish processing plant. In order to confirm bycatch rates derived from CDFG's dock-side sampling, NMFS conducted a pilot observer program from July 2004 through 2008 on the California purse seine fishing vessels landing CPS in the LE fishery. The pilot observer program's main focus was to gather data on total catch and bycatch, and on interactions between their fishing gear and protected species such as marine mammals, sea turtles, and sea birds. See Section 6.1.1 for additional information and preliminary results from this program.

13.7 References

Dorval, E., J. McDaniel, and P. Crone. 2008. Squid population modeling and assessment (January 2008). Final report submitted to the California Department of Fish and Game (Marine Region) and the Southwest Fisheries Science Center. 30 p.

Sweetnam, D., and L. Laughlin. 2005. Personal Communication, January 11, 2005. California Department of Fish and Game, La Jolla, California. Email address: Dale.Sweetnam@noaa.gov.

14.0 ESSENTIAL FISH HABITAT FIVE-YEAR REVIEW

Recognizing the importance of fish habitat to the productivity and sustainability of U.S. marine fisheries, in 1996 Congress added new habitat conservation provisions to the Magnuson Fishery Conservation and Management Act of 1976, the federal law that governs U.S. marine fisheries management. The re-named Magnuson-Stevens Fishery Conservation and Management Act (MSA) mandated the identification of essential fish habitat (EFH) for managed species as well as measures to conserve and enhance the habitat necessary to fish to carry out their life cycles. The MSA requires cooperation among the National Marine Fisheries Service (NMFS), the Councils, fishing participants, Federal and state agencies, and others in achieving EFH protection, conservation, and enhancement. Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The EFH guidelines under 50 *CFR* 600.10 further interpret the EFH definition as follows:

> *"Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle."*

The Councils and NMFS are expected to periodically review the EFH components of FMPs. Each FMP should include a procedure to review and update EFH provisions if newly-available information warrants revision of EFH. The schedule for this review should be based on an assessment of the quality of both the existing data and expectations when new data will be available. Such a review of information should be conducted at least once every five years (50 *CFR* 600.815).

Process for five-year Review of CPS EFH

The review process was initiated at a meeting of the Coastal Pelagic Species Management Team (CPSMT) in January, 2010, in La Jolla, California, with a discussion of the existing EFH, habitat needs, and new information. The team subsequently compiled publications (see References) relevant to CPS habitat needs and associations. The CPSMT discussed CPS EFH at its April 27-30, 2010 meeting in Portland, Oregon; and during the June 13-14, 2010 Council meeting. In addition, the CPS Subcommittee of the SSC, the CPSMT, and some members of the Coastal Pelagic Species Advisory Subpanel (CPSAS) attended the sardine assessment meeting in October, 2010 in La Jolla, CA, which included discussion of CPS EFH.

The Council's Habitat Committee (HC), Scientific and Statistical Committee (SSC), and the CPSAS considered the issue during the June, 2010 Council meeting in Foster City, California. The full Council also considered CPS EFH at that meeting, and added it to the November, 2010 Council meeting agenda in Costa Mesa, California, scheduled for final action.

In August, 2010, Council staff issued a request for comments on CPS EFH, via an email to the Council's HC, CPSMT, CPSAS, and the CPS subcommittee of the SSC. These advisory and management groups of the Council include representatives from the NMFS Northwest and Southwest Fisheries Science Centers; the NMFS Northwest and Southwest Regions; state agencies of California, Oregon, and Washington; commercial and recreational fishing interests; conservation interests; a port representative; and a tribal representative. No comments were received in response to that request.

The CPSMT considered new information, comments and discussion with Council advisory bodies, and best professional judgment to review CPS EFH in the context of three primary questions:

1. Does new information indicate that existing CPS EFH should be revised?
2. Does new information suggest establishing Habitat Areas of Particular Concern (HAPC)?
3. Are there emerging threats that could adversely affect CPS EFH?

Description of Existing EFH

The CPS fishery includes four finfish species, market squid, and krill:

- Pacific sardine (*Sardinops sagax*)
- Pacific (chub) mackerel (*Scomber japonicus*)
- Northern anchovy (*Engraulis mordax*)
- Jack mackerel (*Trachurus symmetricus*)
- Market squid (*Loligo opalescens*)
- Krill (*Euphasiid spp.*)

CPS finfish inhabit the water column, are not typically associated with bottom substrate, and generally occur above the thermocline in the upper mixed layer. For the purposes of EFH, the four CPS finfish species are treated as a single species complex, because of similarities in their life histories and similarities in the habitat requirements. Market squid inhabit the water column, but are also associated with bottom substrate during spawning events and egg development. Squid are treated in the same complex as CPS finfish because they are similarly fished above spawning aggregations (PFMC 1998).

Unless the Council and NMFS conclude that there are reasons to substantiate a change to the definition of CPS EFH at this time, the description of EFH will remain the same as that identified in Amendment 8 to the FMP (PFMC, 1998). A detailed description of existing EFH for CPS can be found in Appendix D of that document. In determining EFH for CPS, the estuarine and marine habitats necessary to provide sufficient production to support maximum sustainable yield and a healthy ecosystem were considered.

Using presence/absence data, EFH is "based on a thermal range bordered within the geographic area where a managed species occurs at any life stage, where the species has occurred historically during periods of similar environmental conditions, or where environmental conditions do not preclude colonization by the species" (PFMC 1998). The specific description and identification of EFH for CPS finfish accommodates the fact that the geographic range of all species varies widely over time in response to the temperature of the upper mixed layer of the ocean, particularly in the area north of 39° N latitude. For example, an increase in sea surface temperature since the 1970s has led to a northerly expansion of the Pacific sardine resource. With an environment favorable to Pacific sardine, this species can now be found in significant quantities from Mexico to Canada. Adult CPS finfish are generally not found at temperatures colder than 10° C or warmer than 26° C. Preferred temperatures (including minimum spawning temperatures) are generally above 13° C. Spawning is most common at 14° C to 16° C (PFMC 1998).

Essential fish habitat for West Coast CPS species was established in December, 1998, with the issuance of Appendix D to Amendment 8 of the Northern Anchovy Fishery Management Plan. Appendix D contains the identification and description of CPS EFH; information on life history and habitat needs; fishing and non-fishing effects on CPS EFH; and potential conservation and enhancement measures. CPS EFH is linked to ocean temperatures, which shift temporally and spatially, providing a dynamic description of CPS EFH.

This description is as follows:

> *The east-west geographic boundary of EFH for each individual CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the exclusive economic zone (EEZ) and above the thermocline where sea surface temperatures range between 10^0C to 26^0C. The southern boundary of the geographic range of all CPS finfish is consistently south of the US-Mexico border, indicating a consistency in SSTs below 26^0C, the upper thermal tolerance of CPS finfish. Therefore, the southern extent of EFH for CPS finfish is the US-Mexico maritime boundary. The northern boundary of the range of CPS finfish is more dynamic and variable due to the seasonal cooling of the SST. The*

northern EFH boundary is, therefore, the position of the 10^0C isotherm which varies both seasonally and annually.

Krill species were added to the CPS FMP in 2006, and EFH for krill was issued in 2008. The two most prevalent species of krill are *Euphausia pacifica* and *Thysanoessa spinifera*, although six other krill species are also included in the FMP. All are prohibited from harvest on the U.S. West Coast. The two species (*E. pacifica* and *T. spinifera*) form large aggregations of moderate density, while the other species are typically more dispersed. EFH is identified individually for *E. pacifica* and *T. spinifera*, and then collectively for the other krill species. The following descriptions are taken from Amendment 12 to the CPS FMP (PFMC 2006).

Euphausia pacifica EFH
Larvae, juveniles and adults: From the baseline from which the shoreline is measured seaward to the 1000 fm (1,829 m) isobath, from the U.S.- Mexico north to the U.S.-Canada border, from the surface to 400 m deep, from the U.S.- Mexico north to the U.S.-Canada border. Highest concentrations occur within the inner third of the EEZ, but can be advected into offshore waters in phytoplankton-rich upwelling jets that are known to occur seaward to the outer boundary of the EEZ and beyond.

Thysanoessa spinifera EFH
Larvae, juveniles and adults: From the baseline from which the shoreline is measured to the 500 fm (914 m) isobath, from the U.S.- Mexico north to the U.S.-Canada border, from the surface to 100 m deep. Largest concentrations in waters less than 200 m deep, although individuals, especially larvae and juveniles, can be found far seaward of the shelf, probably advected there by upwelling jets.

Other krill species EFH
Larvae, juveniles and adults: From the baseline from which the shoreline is measured seaward to the 1000 fm (1,829 m) isobath, from the U.S.- Mexico north to the U.S.-Canada border, from the surface to 400 m deep, from the U.S.- Mexico north to the U.S.-Canada border. Amendment 12 concluded that no biological, social or economic impacts are expected beyond administrative costs of reviewing federally regulated projects for potential impacts on this habitat, where krill and krill predators concentrate.

New Information

Existing EFH descriptions for CPS are based largely on presence/absence data and upon a thermal range within the broader geographic area in which CPS stocks occur. The 1998 EFH identification and descriptions also base EFH on historical presence or "where environmental conditions do not preclude colonization by the CPS" (PFMC 1998). Although temperature associations among individual species and life stages within the CPS complex exhibit some variation, the temperature range that describes existing EFH is sufficiently representative of habitat associations. This temperature range is between 10°-26° C, although CPS can be found at temperatures outside that range. The CPSMT considered information contained in several recent publications relevant to CPS. The new information continues to support the strong linkage between CPS distribution and sea surface temperature, which varies spatially and temporally, and thus does not present any significant change in existing documented habitat associations. All the new information considered during this process is included in the References section below.

Because krill EFH was only recently established (under Amendment 12, finalized in 2008), the CPSMT did not invest significant effort in reviewing information on which EFH designations for krill are based. However, this periodic review offers an opportunity to synchronize the timing of krill with the other CPS stocks for future EFH reviews.

Amendment 8 cited several research needs related to market squid habitat and potential adverse effects to EFH. More specifically, these research needs centered on spawning distribution, depth, and location; as well as egg and paralarvae production and survival. Dispersal of larvae was also cited as key information that could help to understand how local impacts could be mitigated by recruitment from other areas. There remains a relatively meager volume of literature on market squid habitat. However, there are recent reports and research that are either published or in submission.

A comparison of new and newly-available literature since the last EFH review in 2005, and from when CPS EFH was originally established in 1998, shows that the California Current (CC) and CPS EFH continues to have significant annual and decadal variations in its oceanographic conditions; this includes upwelling, currents, primary and secondary productivity, and plankton and nekton species abundance and distributions (e.g., Humboldt squid in 2009).

Zwoliniski et al. (2011) found that they could identify the pelagic habitat of Pacific sardine using satellite-derived SST and Chlorophyll information. Their information clearly shows the movement of this preferred habitat from southern California in winter/early spring to off the Pacific Northwest in summer. The pelagic habitat off northern Washington appears to have particularly high phytoplankton concentrations during summer (Hickey and Banas 2008; Hickey et al. 2009) and is probably why sardines track this particular habitat.

From 2003-2005 California Current Ecosystem (CCE) ocean temperatures were warmer than average. From 2006 and on, SST were colder – especially in 2008. The PDO also went from positive to negative in 2006. These colder temperatures appear to have had a negative effect on sardine recruitment (Chavez et al. 2005; Jacobson and MacCall 1995; Jacobson et al. 2001, 2005; Takasuka et al. 2008) and may have had a positive effect on squid (Vidal et al 2002; Zeidberg et al. 2006). This may be why the stock size of sardines appears to be lower now.

Climate change has the potential to alter CPS EFH significantly. However, there are still many unknowns regarding how climate change will affect the CCE. At this time it is still uncertain if the CC will actually get colder or warmer in the future. Increasing land temperatures could lead to larger air pressure differentials and cause more upwelling. However, these upwelled waters could be much less productive if ocean acidification affects primary and secondary production (Fabry et al. 2008; Juranek et al. 2009).

Habitat Areas of Particular Concern (HAPCs)

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) encourage the FMCs to identify specific types or areas of habitat within EFH as "habitat areas of particular concern" (HAPC), based on one or more of the following considerations: (1) the importance of the ecological function provided by the habitat; (2) the extent to which the habitat is sensitive to human-induced environmental degradation; (3) whether, and to what extent, development activities are, or will be, stressing the habitat type; and (4) the rarity of the habitat type. The intended goal of identifying such habitats as HAPCs is to provide additional focus for conservation efforts. While the HAPC designation does not add any specific regulatory process, it highlights certain habitat types as ecologically very important. This designation is manifested in EFH consultations where federally permitted projects with potential adverse impacts to HAPC are more carefully scrutinized during the consultation process.

Habitat Areas of Particular Concern were not considered in Appendix D of Amendment 8, for CPS. HAPCs for krill species were considered under Amendment 12, but were not adopted. CPS finfish and market squid are highly mobile, and generally associated with a range of thermal conditions rather than fixed physical habitat. In addition, CPS are somewhat unpredictable and not particularly dependent on any single habitat type or spatially discrete location. Their strong association with a dynamic habitat feature creates a challenge in proposing HAPCs, especially in open ocean waters where CPS stocks are found. This association, combined with the large range of habitats suitable for many CPS, makes it infeasible to provide appropriate justification for designating HAPCs at this time.

For the reasons described above, it was determined that the available information was insufficient to recommend designating HAPCs as part of this review.

Fishing Gear Effects

The MSA requires each FMP to identify fishing activities that may adversely affect EFH and to minimize adverse effects of those activities to the extent practicable. Fishing activities should include those regulated under the CPS FMP that affect EFH identified under any FMPs, as well as those fishing activities regulated under other FMPs that affect EFH designated under the CPS FMP.

Appendix D to Amendment 8 of the CPS FMP describes CPS fishing activities and gear that have the potential to adversely affect EFH, and notes that direct interactions with habitat are unlikely because CPS fisheries typically occur in waters deeper than the height of the net. However, it is important to clarify that while CPS fishing gear does interact with the water (which is EFH), a fishing net passing through the water column is not expected to adversely affect the functioning of that habitat. Direct interactions between gear and CPS EFH may occur when derelict gear comes into contact with the benthos, which could potentially harm squid eggs embedded in the benthos. Even so, Appendix D concludes that habitat impacts resulting from net interactions are rare, minimal, and transitory.

Although some sector shifts and species harvest has changed since Appendix D was written, the gear type, harvest levels, and methods have remained essentially the same over time. In the 1990s, the industry was dominated by roundhaul and lampara gear, which still was true in 2009 (PFMC 2010).

One notable change in fishing activities since 1998 has been a spatial shift in west coast CPS landings. In 1998, the Pacific Northwest sector harvested approximately 1-2% (by weight) of the total west coast CPS landings. More recently, the Pacific Northwest was responsible for harvesting approximately 28% of total CPS landings in 2009 (PFMC 2010). It is important to note that the increase in Pacific Northwest landings represents a shift in where landings are occurring, and not necessarily an overall increase in landings along the west coast. There is no reason to conclude any increase in effects, because methods and gear are essentially the same between California and the Pacific Northwest industry sectors.

This review concludes that based on fishery information and statistics, compared over time, there is no substantial change in gear or activities. Therefore, the description, adverse impacts, and mitigation measures contained in Appendix D are still relevant and valid, and do not suggest that any new evaluation is warranted.

Emerging Threats

Climate Change

Fluctuating oceanographic conditions are known to have significant effects on the abundance of CPS in the Pacific Ocean and worldwide. Ocean temperatures, which are known to have direct effects on CPS recruitment, distribution, and abundance, have increased worldwide (Domingues et al. 2008). The California Current, the dominant large-scale oceanographic feature along the US west coast, is known to fluctuate significantly at annual and longer time scales. At short time scales the El Niño/Southern Oscillation (ENSO) (http://www.esrl.noaa.gov/psd/people/klaus.wolter/MEI/mei.html) is a short-term cooling or warming of the ocean at the equator caused by altering wind patterns. El Niño periods can produce considerable warming and reductions in primary and secondary production in the CC and reduce some CPS abundances. Many CPS and other fishes show significant alterations in their coastal distributions during strong El Niño or warm ocean periods (Phillips et al. 2007). For example, jellyfish blooms appear to be having significant effects on fisheries all over the world. Recently, Brodeur et al. (2008) indicated that that jellyfish may compete directly with CPS in the California Current. The CC moved from an El Niño condition to a La Niña or cold condition in the summer of 2010. The PACOOS program (http://www.pacoos.org/Default.htm) is presently tracking many oceanographic (physical and biological) indices that are revealing how oceanographic fluctuations affect marine resources, including some CPS. Climate change is expected to alter ENSO frequencies and duration but the levels are still impossible to predict.

Recent research has also shown that the entire North Pacific Ocean oscillates (Pacific Decadal Oscillation, or PDO) between warm and cold states at decadal scales, with significant effects on living marine resources (both benthic and pelagic) (Mantua et al. 1997; Hare et al. 1999; Beamish et al. 2000; Hare and Mantua 2000; Hollowed et al. 2001; Kar et al. 2001; and Brinton and Townsend 2003). Sardines appear to become abundant during warm PDO periods and anchovy during cool PDO periods. However, the time series is short and the mechanisms involved are still uncertain.

The “source water” for the California Current appears to fluctuate depending on the status of the PDO and ENSO (DFO. 2010). This has significant effects on CPS and other species in the CC. In 2008, the North Pacific Current was very strong, as was the amount of water that split south from this current to become the CC. When the southern split is strong, much nutrient rich North Pacific waters enter the CC and appear to enhance primary and secondary productivity (DFO 2010; http://www.pac.dfo-mpo.gc.ca/science/oceans-eng.htm). In 2009 and spring 2010 North Pacific flows to the CC were reduced, which decreased overall productivity.

The most significant local feature along the west coast is wind induced upwelling (Bakun 1996). Upwelling is responsible for bringing nutrient rich waters from depth to the surface, thus enhancing primary production. Future climate change scenarios indicate much uncertainty as to whether winds and ocean conditions will be more conducive to upwelling or not, but Bakun (1990) thought that upwelling related winds would intensify because of higher pressure differentials between ocean and land. There is also concern that the phenology (i.e., timing of upwelling relative to the evolved life histories of various species) might be affected by alterations or changes in the seasonality and timing of upwelling periods along the west coast (Bograd et al. 2008).

One of the most significant impacts of climate change comes directly from the increased concentrations of carbon dioxide dissolving into the oceans and leading to decreased pH or ocean acidification. Lower ocean pH levels will have significant consequences on calcifying organisms, many of which are prey for sardines and other CPS (Feely et al. 2004; 2008; Kerr 2010).

Recently, periods of hypoxia, or very low levels of oxygen, were observed on the continental shelf off Washington and Oregon and are expected to occur more often in the future (Grantham et al. 2004; Chan et al. 2008). Hypoxia could be related to changes in wind and currents directly tied to climate change.

The last few years and particularly in 2009, large numbers of Humboldt squid (*Dosidicus gigas*) were observed in the CC from Canada to Mexico (Field 2008). It is unknown if the unusual abundance of this species in the CC was related to climate change or some other oceanographic condition. However, their occurrence does appear to be related to the recent abundance of the hypoxic area off the west coast (Gilly et al. 2006). Humboldt squid are very efficient predators that have some of the highest growth rates of any species. They can consume significant numbers of CPS and other species and may affect their abundance.

Finally, harmful algal blooms (HABs) have been observed more frequently in recently years and are expected to be more common in the future. The effects of various HAB on CPS are unknown at this time.

Ocean Energy Development

At this time there is a lot of interest in developing renewable ocean energy projects in the CC. Possible energy projects include wave, wind, tidal, ocean currents, and thermal gradient. All of these will have structures that may affect benthic and pelagic environments. Unfortunately, the environmental effects of these projects needs study (Boehlert et al. 2008; Boehlert and Gill 2010). Some energy structures may act as fish aggregating devices (FADs) for CPS or their predators. Very few studies have been done to look at the effects of electromagnetic effects on migrations/movements of CPS. As these energy projects become initiated, it will be important to identify how they interact with CPS.

Presently the nearshore areas that have the highest potential for wave energy development are also areas where many CPS and other fisheries (e.g., Dungeness crab, salmon) are focused. This nearshore habitat has also been identified as Essential Fish Habitat for CPS and other fishes (Boehlert et al. 2008). From an ecosystem management position, these habitats (both pelagic and benthic) have not been well studied and their utilization by various species is not well mapped or documented in time or space.

Many coastal pelagic species undertake broad migrations in the coastal region. Wave energy devices may directly affect this migration by their physical structure or by emitting electromagnetic, acoustic, or chemical field that interfere with fish navigation/orientation systems.

Forecasting the effects of wave energy on pelagic species is presently difficult because we have limited information on the effects of large versus small projects and our time series of data from these habitats is also limited. Besides directly altering habitats, these structures could possibly alter food webs and may leach anti-fouling chemicals into the environment which may affect the health and marketability of CPS fishes caught in their vicinity.

Finally, large scale wave energy developments have the potential to conflict with existing or potential CPS fisheries. CPS fish often congregate in very specific areas depending on currents, time of year, predator abundance, etc. If CPS fish are highly congregated in areas that are off-limits to fishing because of wave energy structures, they would significantly affect potential harvest.

Conclusions

After review of recently-published literature, discussion and presentation at several Council-related meetings, and based on the opportunity provided for public comment; the CPSMT makes the following conclusions:

- New information still supports the strong linkage between CPS habitat utilization and sea surface temperature, which along with other oceanographic conditions like upwelling and primary productivity, is both spatially and temporally variable. Therefore, although this information is likely to help inform EFH consultations, and provides additional background on CPS habitat, it does not warrant changes to the existing description of CPS EFH.
- The fishing impacts and non-fishing impacts sections of Appendix D to Amendment 8 sufficiently describe those adverse impacts as well as conservation measures to mitigate those impacts.
- New information on climate change and ocean energy development should be added to body of information on potential impacts to CPS EFH. This should be published in the 2011 SAFE document, to remain available for use in EFH consultations and for future EFH reviews.
- The timing of the periodic review of krill EFH should be synchronized with the future reviews of CPS EFH.

References

Bakun, A. 1990. Global climate change and intensification of coastal ocean upwelling. Science 247:(4939), 198. [DOI: 10.1126].

Bakun, A. 1996. Patterns in the ocean: ocean processes and marine population dynamics. California Sea Grant, San Diego, California, USA, in cooperation with Centro de Investigaciones Biológicas del Noroeste. 323 p.

Bakun, A., and K. Broad. 2003. Environmental 'loopholes' and fish population dynamics: comparative pattern recognition with focus on El Nino effects in the Pacific. Fish. Oceanogr. 12:4/5, 458-473.

Beamish, R.J, G.A. McFarlane and J.R. King. 2000. Fisheries climatology: understanding the interannual and decadal scale processes that regulate British Columbia fish populations naturally. p. 94-139, in T. Parsons and P. Harrison [eds.]. Fisheries Oceanography: An Integrative Approach to Fisheries Ecology and Management. Blackwell Science Ltd., Oxford UK.

Boehlert, G.W. and A.B. Gill. 2010. Environmental and ecological effects of ocean renewable energy development: a current synthesis. Oceanogr. 23(2):68-81.

Boehlert, G.W., G.R. McMurray, and C. E. Tortorici (editors). 2008. Ecological Effects of Wave Energy Development in the Pacific Northwest: A Scientific Workshop, October 11–12, 2007. NOAA Technical Memorandum NMFS-F/SPO-92, 173 p.

Bograd, S.J., I. Schroeder, N. Sarkar, X. Qiu, W.J. Sydeman, and F.B. Schwing. 2008. Phenology of coastal upwelling in the California Current. Mar. Biol. (2008) 154:649–659.

Brinton, E., and A. Townsend. 2000. Decadal variability in abundances of the dominant euphausiid species in southern sectors of the California Current. Deep-Sea Res. II. 50:2449-2472.

Brodeur, R.D., C.L. Suchman, D.C. Reese, T.W. Miller, and E.A. Daly. 2008. Spatial overlap and trophic interactions between pelagic fish and large jellyfish in the northern California Current. Mar. Biol.154:649–659.

Chan, F., J.A. Barth, J. Lubchenco, A. Kirincich, H. Weeks, W.T. Peterson, and B.A. Menge. 2008. Emergence of anoxia in the California current large marine ecosystem. Science 319 (5865): 920.

Chavez, F. P., J. Ryan, S. E. Lluch-Cota, M. Niquen C. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299:217-222.

DFO. 2010. State of the Pacific Ocean 2009. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.

Domingues, C. M., J. A. Church, N. J. White, P. J. Gleckler, S. E. Wijffels, P. M. Barker, and J.R. Dunn. 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise. Nature 453: 1090-1093.

Fabry,V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES J. Mar. Sci., 65: 414–432.

Feely, R. A., C. L. Sabine, K.Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F.J. Millero. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the oceans. Science 305:365-366.

Feely, R.A., C.L. Sabine, J.M. Hernandez-Ayon, D. Ianson, B. Hales. 2008. Evidence for upwelling of corrosive “acidified” water onto the continental shelf. Science 320:1490-1492.

Field, John. 2008. Jumbo squid (*Dosidicus gigas*) invasions in the eastern Pacific Ocean CalCOFI Reports 49:79-81.

Gilly, W.F., U. Markaida, C.H. Baxter, B. A. Block, A. Boustany, A. Zeidberg, K. Reisenbichler, B. Robison, G. Bazzino, and C. Salinas. 2006. Vertical and horizontal migrations by the jumbo squid *Dosidicus gigas* revealed by electronic tagging. Mar. Ecol. Prog. Ser. 324:1-17.

Grantham, B.A., F. Chan, K.J. Nielsen, D.S. Fox, J.A. Barth, A. Huyer, J. Lubchenco, B.A. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the Northeast Pacific. Nature 429(6993):749-754.

Hare, S.R. and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47:103-145.

Hare, S.R., N.J. Mantua, and R.C. Francis. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24(1):6-15.

Hickey, B.M., and N.S. Banas. 2008. Why is the northern California Current so productive? Oceanogr., 21(4), 90-107.

Hickey, B., R. McCabe, S. Geier, E. Dever, and N. Kachel. 2009. Three interacting freshwater plumes in the northern California Current System. J. Geophys. Res., 114, C00B03, doi:10.1029/2008JC004907, 2009

Hollowed, A.B., S.R. Hare, W.S. Wooster. 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. Prog. Oceanogr. 49:257-282.

Jacobson, L. D., J. A. A. De Oliveira, M. Barange, M. A. Cisneros-Mata, R. Felix-Uraga, J. R. Hunter, J. Y. Kim, Y. Matusuura, M. Niguen, C. Porteiro, B. Rothschild, R. P. Sanchez, R. Serra, A. Uriare, and T. Wada. 2001 Surplus production, variablility, and climate change in the great sardine and anchovy fisheries. Can. J. Fish. Aquat. Sci 58: 1891-1903.

Jacobson, L. J., and A. D. MacCall. 1995 Stock-recruitment models for Pacific sardine (*Sardinops sagax*). Can. J. Fish. Aquat. Sci. 52: 56-577.

Jacobson, L. D. et al. 2005. An ecosystem-based hypothesis for climatic effects on surplus production in California sardine (*Sardinops sagax*) and environmentally dependent surplus production models. Can J Fish. Aqua. Sci.; 62, 1782-1796.

Juranek, L. W. , R. A. Feely,W. T. Peterson, S. R. Alin,B. Hales, K. Lee,C. L. Sabine, and J. Peterson. 2009. A novel method for determination of aragonite saturation state on the continental shelf of central Oregon using multi-parameter relationships with hydrographic data. Geophys. Res.Let., 36, L24601, doi:10.1029/2009GL040778, 2009

Kar, D., R. Bidigare, and R. Letelier. 2001. Long-term changes in plankton community structure and productivity in the North Pacific Subtropical Gyre: the domain shift hypothesis. Deep-Sea Research II 48:1449-1470.

Kerr, R.A. 2010. Ocean acidification, unprecedented, unsettling. Science 328:1500-1501.

Litz, Marisa. 2008. Ecology of the northern subpopulation of northern anchovy (*Engraulis mordax)* in the California Current Large Marine Ecosystem. MS Thesis, Oregon State University.

Lo, Nancy, B. Macewicz, and D. Griffith. 2010. Biomass and reproduction of Pacific sardine (*Sardinops sagax*) off the Pacific northwestern United States, 2003-2005. In Fisheries Bulletin; 108:174-192 (2010).

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. J. Amer. Meterol. Soc. 78:1069-1079.

PFMC. 1998. Amendment 8 (to the northern anchovy fishery management plan) incorporating a name change to: the coastal pelagic species fishery management plan. Pacific Fishery Management Council, Portland, Oregon.

PFMC. 2006. Amendment 12 to the Coastal Pelagic Species Fishery Management Plan: Management of Krill as an Essential Component of the California Current Ecosystem. Pacific Fishery Management Council, Portland, Oregon.

PFMC 2010. Stock Assessment and Fishery Evaluation document. Pacific Fishery Management Council, Portland, Oregon.

PFMC 2011. Acoustic-Trawl Survey Method for Coastal Pelagic Species: Report of Methodology Review Panel Meeting. National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC). La Jolla, California, 3-5 February 2011.

Phillips, A.J., S. Ralston, R. D. Brodeur, T.D. Auth, R.L. Emmett, C. Johnson, and V. G. Wespestad. 2007. Recent pre-recruit Pacific hake (*Merluccius productus*) occurrences in the northern California Current suggest a northward expansion of their spawning area. CalCOFI Rep. 215-229.

Reiss, C.S., D. Checkley Jr, and S. Bograd. 2008. Remotely sensed spawning habitat of Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax)* within the California Current. In Fisheries Oceanography; 17:2, pgs 126-136.

Takasuka, A., Y. Oozeki, H. Kubota, S. E. Lluch-Cota. 2008. Contrasting spawning temperature optima: Why are anchovy and sardine regime shifts synchronous across the North Pacific? Prog. Oceanogr. 77 (2008) 225–232.

Vidal, E. A. G., F. P. DiMarco, J. H. Wormuth and P. G. Lee. 2002. Influence of temperature and food availability on survival, growth and yolk utilization in hatchling squid. Bull. Mar. Sci., 71(2): 915-931.

Weber, E.D. and S. McClatchie. 2010. Predictive Models of Northern Anchovy, *Engraulis mordax* and Pacific Sardine *Sardinops sagax* Spawning Habitat in the California Current. Mar. Ecol. Prog. Ser. 406: 251-263.

Zeidberg, Louis D., G. Isaac, C.L. Widmer, H. Neumeister, and W.F. Gilly. 2011. Egg capsule hatch rate and incubation duration of the California market squid, *Doryteuthis (= Loligo) opalescens*: insights from laboratory manipulations. Mar. Ecol.. DOI: 10.1111/j.1439-0485.2011.00445.x.

Zeidberg, L., J.A.T. Booth, and C. Miller. 2010. The area of suitable spawning habitat for the California market squid, *Dorytheuthis opalescens*. Poster at Sanctuary Currents 2010. Monterey Bay National Marine Sanctuary.

Zeidberg L.D., J.L. Butler, D. Ramon, A. Cossio, K. Stierhoff, A. Henry. 2011. In situ observations of the distribution and abundance of market squid (*Doryteuthis opalescens*) egg beds off Central and Southern California. *Unpublished manuscript*.

Zeidberg, L. D., W. M. Hamner, N. P. Nezlin, A. Henry. 2006. The fishery for California market squid (Loligo opalescens) (Cephalopoda: Myopsidafrom 1981 through 2003. Fish. Bull. 104:46-59.

Zwolinski, J.P., R.L., Emmett, and D.A., Demer. 2011. Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*). 2011 –ICES Journal of Marine Science 68(5), 867–879.