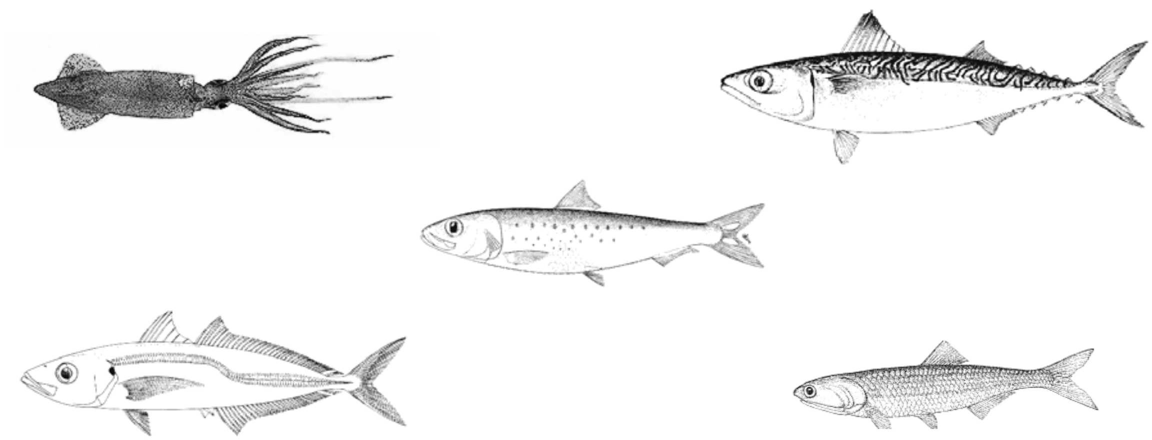
STATUS OF THE PACIFIC COAST COASTAL PELAGIC SPECIES FISHERY AND RECOMMENDED ACCEPTABLE BIOLOGICAL CATCHES

STOCK ASSESSMENT AND FISHERY EVALUATION 2010



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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
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.

This is the tenth *Status of the Pacific Coast Coastal Pelagic Species Fishery* SAFE document prepared for the Pacific Fishery Management Council (Council). Following NMFS guidelines, the purpose of this report is to briefly summarize aspects of the coastal pelagic species (CPS) FMP and to describe the history of the fishery and its management. Species managed under this FMP include: Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), 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, Southwest Fisheries Science Center (SWFSC), California Department of Fish and Game (CDFG), Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). Included in this report are descriptions of landings, fishing patterns, estimates of the status of stocks (including stock assessments for Pacific sardine and Pacific mackerel, Appendix 1 and Appendix 2), and acceptable biological catches (ABCs).

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

2.0 THE CPS FISHERY

2.1 Management History

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

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

In March 1995, after considering the four options, the Council decided to proceed with option four, developing an FMP for the entire CPS fishery. Final action was postponed until June 1995 when the Council adopted a draft plan that had been revised to address comments provided by NMFS and the Council's Scientific and Statistical Committee (SSC). Amendment 7 was submitted to the U.S. Secretary of Commerce (Secretary), but rejected by NMFS Southwest Region (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 to amend the FMP for northern anchovy to conform to the recently revised Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and to expand the scope of the FMP to include other species harvested by the CPS fishery.

In June 1999, NMFS partially approved the CPS FMP. Approved FMP elements included: (1) the management unit species, (2) CPS fishery management areas, consisting of a limited entry (LE) zone and two subareas, (3) a procedure for setting annual specifications including harvest guidelines (HG), quotas, and allocations, (4) provisions for closing directed fisheries when the directed portion of a 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 Magnuson-Stevens Act. The purpose of this action was to minimize the likelihood of overfishing the market squid resource.

On December 30, 2002, the Secretary approved Amendment 10. On January 27, 2003, NMFS issued the final rule and regulations implementing Amendment 10 (68*FR*3819).

2.2.4 Sardine Allocation Regulatory Amendment

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

2.2.5 Amendment 11

The Council began developing options for a new allocation framework for the coastwide Pacific sardine fishery in 2003 while the fishery operated under the regulatory amendment described in the previous section. This revision to the sardine allocation framework occured 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 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 the November 2004 meeting the Council initiated development of a formal prohibition on directed fisheries for krill, and directed staff to begin development of management measures to regulate directed fisheries for krill within Council-managed waters. The proposal for a krill ban was first proposed for West Coast National Marine Sanctuary waters by the National Marine Sanctuary Program.

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, respectively. 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 Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSRA 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 March, 2010 meeting, the Council adopted for review a draft preliminary alternatives document that will form the backbone of Amendment 13 to the Coastal Pelagic Species Fishery Management Plan. Amendment 13 is scheduled to be implemented for the 2011 CPS fishery.

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 reduced to meal and oil). In addition to fishing for CPS finfish, many of these vessels fish for market squid, Pacific bonito, bluefin tuna, and Pacific herring.

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

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

- Approximately 18 live bait vessels in southern California and two vessels in Oregon and Washington that landed about 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 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. Twenty-five permits were issued in 2009, but only 20 permits were actively utilized in the fishery. Table 2-5 contains information for vessels that participated in the 2009 fishery. Note that seven vessels landing sardine in Oregon also held either federal or Washington state permits.

ODFW held a series of three public meetings in late 2008 and early 2009 to discuss possible changes to regulations for the 2009 season. The OFWC enacted a number of rule changes for the Pacific sardine fishery in April 2009. 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. Second, the OFWC waived the 2008 annual landing requirements for permit renewal industry wide. 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 put in place for the sardine fishery defined catching vessels and limited catch sharing to permitted catching vessels.

Although the primary CPS fishery in Oregon targets sardine, developmental fishery permits for harvesting anchovy have been issued since 1995. 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 4 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 Oregon Fish and Wildlife Commission 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 fishery for northern anchovy is now an open access fishery off Oregon limited legal gear under the CPS FMP and state regulations.

2.3.2.2 Washington State Limited Entry Sardine Fishery

Pacific sardines are the primary coastal pelagic species harvested in Washington waters. Participation in the sardine fishery was managed under Emerging Commercial Fishery Act (ECFA) provisions, which provides for the harvest of a newly classified species or harvest of a classified species in a new area or by new means from 2000 through 2009. The ECFA gives two choices for fishery-permit designations: trial, which does not limit the number of participants or experimental, which limits 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.

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 WDFW Director's discretion. In combination, the number of permanent and temporary annual licenses cannot exceed 25.

In 2009, experimental fishery permits were issued to 16 fishers meeting the renewal criteria including that they previously held such a permit and also held a minimum of 50 percent ownership in the vessel designated on the sardine permit. Table 2-6 lists the vessels designated in 2009 on Washington sardine fishery permits. Of the 16 permits issued, only 6 were active in the 2009 fishery; two new vessels entered the fishery after the new legislation was passed making the purchase of a sardine license possible.

A mandatory state logbook program has been in place since the fishery began in 2000. The logbook data are maintained in electronic format at the WDFW regional office at Montesano, WA. From 2000 through 2004, WDFW conducted a 5-year observer program to document bycatch levels in the Pacific sardine fishery. Overall observer coverage in this program was in excess of 25 percent and was financially supported by fishery participants as part of their ECFA permit conditions. The results of the observer program showed by-catch of non-targeted species in the Washington sardine fishery to be relatively low. In addition to limiting participation in the fishery, WDFW also restricts the cumulative seasonal total of sardines that can go toward reduction to 15 percent for the individual vessels.

Pacific sardines are the targeted catch in the Washington fishery, but anchovy, mackerel, and squid can also be retained and landed. In 2009 landings for these other coastal pelagic species were as follows 0 mt of anchovies, 0 mt of jack mackerel, and 4.3 mt of mackerel.

2.3.2.3 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. Documented catch of anchovy has averaged about 108 mt a year since 1990. 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

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.

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 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 2009, 83 vessel permits, 63 light boat permits, 21 brail permits, and zero experimental permits were issued. Of the 83 vessel permits issued, 70 vessels made commercial landings in 2009, as compared to 71 active permitted vessels in 2008. Fifty vessels made 90 percent of the landings (by volume) in 2009. 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 non-transferable 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

Tribal fisheries on sardine may evolve in waters north of Point Chehalis, Washington. The CPS FMP recognizes the rights of treaty Indian tribes to harvest Pacific sardine and provides a framework for the development of a tribal allocation. 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 anticipated 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 used for 2010 management (Hill *et al*. 2009) 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 2010 management included catch and biological samples for the fisheries off Ensenada, Southern California, Central California, and the Pacific Northwest, 1981-2009. 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 (1986-2009), both based on annual surveys conducted off California (see Lo et al. 1996, 2005, 2006, 2007a, 2008, 2009). Finally, the tuned base model was run with the addition of the 2009 aerial survey estimate of absolute biomass (q=1) to derive population quantities for 2010 management. An environmental index (i.e., a time series of sea-surface temperatures recorded at Scripps Pier, La Jolla, California) is used to determine a fishing mortality-based proxy for MSY, which is an additional parameter used in the harvest control rule for determination of annual HGs (see Section 11.1.1.1). For details regarding the current assessment model, readers should consult Hill et al. (2009; see Appendix 1 of this SAFE document). For descriptions of methods used in previous Pacific sardine assessment models (CANSAR, CANSAR-TAM, and ASAP), see Deriso et al. (1996), Legault and Restrepo (1999), and Hill et al. (1999, 2006, 2007, 2008).

3.2 Pacific Mackerel

A Pacific mackerel stock assessment is conducted annually in support of the Pacific Fishery Management Council (PFMC) process, which ultimately establishes a harvest guideline ('HG' or quota) for the Pacific mackerel fishery that operates off the USA Pacific Coast. The HG for mackerel applies to a fishing/management season that spans from July 1st and ends on June 30th of the subsequent year (henceforth, presented as a 'fishing year'). In this context, in this document, both a two-year (e.g., 2009-10) and single-year (e.g., 2009) reference refer to the same fishing year that spanned from July 1, 2009 to June 30, 2010. 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).

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 (SS; Methot 2005, 2009) model provided the best (most flexible) platform for assessing the status of Pacific mackerel currently (i.e., the 2009-10 fishing year) and in the future, see STAR (2009).

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. The overall SS model is comprised of three sub-models: (1) a population dynamics sub-model, where abundance, mortality, and growth patterns are incorporated to create a synthetic representation of the true population; (2) an observation sub-model that defines various processes and filters to derive expected values for different types of data; and (3) a statistical sub-model that quantifies the difference between observed data and their expected values and implements algorithms to search for the set of parameters that maximizes goodness of fit. 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 2009 was based on the SS model (Model "AA" as referenced in the assessment document and STAR Panel Report) and included catch, biological distributions (age, length, and mean length-at-age), and a commercial-passenger fishing vessel (CPFV) index of relative abundance (i.e., catch-per-unit-effort time series), see Crone *et al.* (2009) for the complete stock assessment documentation. Following the STAR in May 2009, the completed assessment was presented, reviewed, and approved by the following management bodies in June 2009: Science and Statistical Committee (SSC); CPS Management Team (CPSMT); and the Pacific Fishery Management Council (PFMC).

Finally, the PFMC, generally supported by the SSC, CPSMT, AND CPSAS, recommended that no formal stock assessment be conducted for the 2010-11 fishing year (i.e., for management purposes, July 1, 2010 to June 30, 2011, see section 11.1.2 and PFMC 2009a), given: (1) limited fishing pressure on the stock is not likely to change dramatically in the short-term and thus, the population is not considered vulnerable to overfishing related to the currently operating fisheries; (2) critical areas of research that support the ongoing stock assessment would benefit from further evaluation (e.g., index of relative abundance associated with southern California-based recreational fisheries, maturity schedule, time-varying selectivity and/or catchability parameterization within the developing SS model, and collaborative efforts concerning data exchange with both Mexico and Canada; and lastly, (3) a ‘full’ assessment should be conducted for the 2011-12 fishing year (i.e., for management purposes, July 1, 2011 to June 30, 2012).

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

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

It is important to note that in 2010 and 2011, federally-mandated revisions to current regulations will be implemented in efforts to stem chronic overfishing, which will result in changes to some of the management-related statistics defined below. The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA) requires revisions to guidelines presented in *National Standard 1* (see Restrepo et al. 1998) to be in place in 2010-11.

4.1 Optimum Yield

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

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

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

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

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

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

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

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

4.3 MSY Control Rules for CPS

The Council may use the default MSY control rule for monitored species, unless a better species-specific rule is available. 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.

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:

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

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, e.g., 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 Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) 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.

4.3.2 MSY Control Rule for Pacific Sardine

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

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

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

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

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

4.3.3 MSY Control Rule for Pacific Mackerel

The MSY control rule for Pacific mackerel sets the CUTOFF and the definition of an overfished stock at 18,200 mt and the FRACTION at 30%. Overfishing is defined as any fishing in excess of the ABC calculated using the 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.

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

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

5.1 Definition of Overfishing

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

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

5.2 Definition of an Overfished Stock

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

5.3 Rebuilding Programs

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

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

6.0 Bycatch and Discard Mortality

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

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

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

CPS vessels fish with roundhaul gear (purse seine or lampara nets of approximately one-half mile in total length). These are encircling type nets, which are deployed around a school of fish or part of a school. When the school is surrounded, the bottom of the net may be closed, then the net drawn next to the boat. The area including the free-swimming fish is diminished by bringing one end of the net aboard the vessel. When the fish are crowded near the fishing vessel, pumps are lowered into the water to pump fish and water into the ship’s hold. Another technique is to lift the fish out of the net with netted scoops (e.g., brails). Roundhaul fishing results in little unintentionally caught fish, primarily because the fishers target a specific school, which usually consists of pure schools of one species. The tendency is for fish to school by size, so if another species is present in the school, it is typically similar in size. The most common incidental catch in the CPS fishery is another CPS species (e.g., Pacific mackerel incidental to the Pacific sardine fishery). If larger fish are in the net, they can be released alive before pumping or brailing by lowering a section of the cork-line or by using a dip-net. The load is pumped out of the hold at the dock, where the catch is weighed and incidentally-caught fish can be observed and sorted. Because pumping at sea is so common, any incidental catch of small fish would not be sorted at sea. Grates can be used to sort larger non-CPS from the catch. Grates are mandatory in Oregon to sort larger non-CPS from the catch. At-sea observers have 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, which enables fishermen to pump squid directly from the sea or to encircle them with a net. California actively manages the market squid fishery in waters off California and has developed an FMP for the state-managed fishery. California’s market squid FMP established a management program for California’s market squid resource with goals that are aimed at ensuring sustainability of the resource and reducing the potential for overfishing. The tools to accomplish these goals include:

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

- Instituting a restricted access program, including provisions for initial entry into the fleet, types of permits, permit fees, and permit transferability.
- Establishing a general habitat closure area in northern California rarely used by the squid fishery to eliminate the potential of future negative interactions with seabirds, marine mammals, and important commercial and sport fishes, and adding limitations on using lights to attract squid around several of the Channel Islands, an effort intended to protect nesting seabirds.

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

1. Most of what would be called bycatch under the Magnuson-Stevens Act is caught when roundhaul nets fish in shallow water over rocky bottom. Fishers try to avoid this to protect gear. Also, they may be specifically prohibited to fish these areas because of closures.
2. South of Pt. Buchon, California, many areas are closed to roundhaul nets under California law and the FMP, which reduces the chance for bycatch.
3. In California, a portion of the sardine caught incidentally by squid or anchovy fishers can be sold for reduction, which reduces discard.
4. The five tons or less allowable landing by vessels without LE permits under the FMP should reduce any regulatory discard, because those fish can be landed.
5. From 1996 to 2003, bycatch from the live bait logs was reported with an incidence of 10%. The primary species taken as incidental catch was barracuda. Virtually all fish caught incidentally in this fishery are either used for bait, for personal use, or released alive. See Table 16-11.
6. CDFG has implemented a logbook program for the squid fishery. The data to be collected includes bycatch.

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

See Amendment 9 to the CPS FMP (Environmental Assessment (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 conducted eight 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) for the implementation of Amendment 11 to the CPS FMP. PRD completed a formal section 7 consultation on this action and in a Biological Opinion dated March 10, 2006, determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species. Specifically, the current status of the Lower Columbia River Chinook, Snake River Fall Chinook, Upper Willamette Chinook, Puget Sound Chinook, and Lower Columbia River coho were deemed not likely to be jeopardized by the Pacific sardine fishery.

NMFS also initiated an ESA section 7 consultation with USFWS regarding the possible effects of implementing Amendment 11 to the CPS FMP. USFWS concurred with NMFS and determined that implementing Amendment 11 may affect, but was not likely to adversely affect: the endangered tidewater goby, the threatened western snowy plover, the Santa Ana sucker, the endangered short tailed albatross, the endangered California brown pelican, the endangered California least-tern, the threatened marbled murrelet, the threatened bald eagle, the threatened bull trout, and the candidate Xantus's murrelet. Formal consultation, however, was deemed necessary on the possible effects to the southern sea otter. The resulting biological opinion (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 are obtained verbally from the vessel operator. Position and time data are recorded by the observer directly from hand-held or on-board electronics.

Data from this ongoing program has been compiled though January 2006 (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. Although incidental catch and bycatch data collected during this time is continuing to be analyzed and categorized, no marine mammals, sea turtles, or seabirds were observed as bycatch.

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

6.2 Fishery South of Pigeon Point

Information from at-sea observations of the CDFG and conversations with CPS fishers suggest that bycatch is not significant in these fisheries. However, some individuals have expressed concern that game fish and salmon might constitute significant bycatch in this fishery. This is a reasonable concern, because anchovy and sardine are forage for virtually all predators, but there are no data to confirm significant bycatch of these species. CDFG port samples indicate minimal incidental catch in the California fishery (Tables 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 Monterey and ports to the south. Biological samples are taken to monitor the fish stocks, and port samplers report incidentally caught fish. Reports of incidental catch by CDFG port samplers confirm small and insignificant landings of bycatch at California off-loading sites (Tables 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. Fishers do not sort catch at sea or what passes through the pump;

however, large fishes and other animals that cannot pass through the pump are not observed by the port sampler. Unloading of fish also occurs with pumps. The fish is either pumped into ice bins and trucked to processing facilities in another location or to a conveyor belt in a processing facility, where fish are sorted, boxed, and frozen.

From 1985 through 1999, there were 5,306 CDFG port samples taken from the sardine and mackerel landings. From 1992 to 1999, incidental catch was reported on only 179 occasions, representing a 3.4 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 in recent years has the harvest of sardine increased. The incidental catch reported are primarily those species that are marketable and do not meet the definition of bycatch in the Magnuson-Stevens Act. During this period, unless an incidental species represented a significant portion of the load (at least a whole percentage point) the amount of the incidental catch was not recorded. Of the incidental catch reported from 1992 to 1999, the two most prevalent species were market squid at 79 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 for all areas in Table 6-5 for the last 5 years (2005 – 2009). 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 2009 were kelp, northern anchovy, jellyfish, Pacific sanddabs, market squid, and white croaker. Sixty 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 has placed observers on a number of California purse seine vessels beginning in the summer of 2004 (see Sec. 11.6).

6.2.1 Incidental Catch Associated with the Market Squid Fishery

Because market squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur intermittently. In 2009, about 1 percent of round haul market squid landings (by volume) 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 (i.e., species that are landed along with market squid that are not recorded through landing receipt processes [i.e., not sold] as is typically done for incidentally-caught species) has been documented through CDFG's port sampling program. The port sampling program records incidental catch observed (i.e., presence or absence), but actual amounts of incidental catch have not been quantified to date. During 2009, incidental catch consisted of 29 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 subsequently may contribute to mortality of early life stages is not definitively 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 2009, market squid egg cases were identified in 5.2 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. In this context, further investigations regarding potential damage to market squid spawning beds from fishery-related operations would likely benefit status-based analyses concerning the overall market squid population off California, given eggs-per-recruit theory underlies the recently adopted market squid assessment method. In 2007, CDFG developed a protocol to retain egg capsules in order to determine first, if capsule age can be quickly determined in the laboratory, and second whether a measure of egg bed disturbance can be produced. Based on market squid embryo development and the condition of the outside of the egg capsule, determining if the egg case was laid in the net or collected from the bottom is possible.

6.3 Fishery North of Point Arena

Since 1999, limited fisheries for Pacific sardines have occurred off the Pacific Northwest. Oregon and Washington closely monitor these fisheries and collect information about landings. Information on bycatch from Oregon and Washington is summarized in Tables 6-8 through 6-10.

6.3.1 Oregon

Vessels landed 20,298 mt of Pacific sardine in 371 Oregon landings in 2009. The harvest was down 23 percent from the 22,948.7 mt of sardines landed in Oregon in 2008. All of the directed fishery harvest took place in allocation periods 2 and 3 during July and September. The decrease in harvest reflected the 25 percent reduction in the coastwide HG in 2009 from 2008 (Table 11-3). The early closures of all three allocation periods limited fishing during the traditional peak months of August and September and prevented fishing off Oregon during June and October a time when the fishery was open and sardines were landed in past years. As in the past, spotter planes hired by the industry were used to locate fish schools. Sardines were landed by state permitted LE vessels primarily in Astoria and Warrenton at seven different processors. Sardine value varied from $0.00 to $0.12 per pound, with 96.6 percent of fish landed valued at greater than $0.05/lb. The exvessel value of sardine landed in Oregon in 2009 was roughly $4.98 million with the average price slightly more than $0.11/lb or $246.6 per mt.

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 on sardine vessels and document bycatch of non-target species and no federal observers were placed on the vessels. Available state staff made attempts to observe trips, however only one of the 371 trips (0.2 percent) was successfully observed. No sets were made during that trip due to poor weather conditions. 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. Non-target species caught in the 2009 season included Pacific and jack mackerel, American shad, Northern anchovy, Pacific hake, salmon, sharks, skates, and jellyfish. Oregon LE sardine permit rules require logbooks that record incidental catch including salmonids and other species (Table 6-9). The estimated total catch of salmon for the fishery, based on log data, was 248 salmon. Based on this estimate, the incidental catch rate was 0.012 salmon per mt of sardines landed. An estimated 53 percent of all salmon were released alive. Based on Oregon fish tickets, bycatch in the fishery continues to be relatively low, with approximately 52.6 mt of non-target species landed (Table 6-10) with 20,298 mt of sardine. Almost 98% of the non-target species landed in the sardine fishery was other coastal pelagic species. Pacific mackerel accounted for 49.5 mt and had an ex-vessel value of approximately $4,767. Jack mackerel accounted for 2.0 mt of incidental catch.

6.3.2 Washington

The Washington fishery opened by rule on April 1, 2009; however, the first landing into Washington did not occur until July 1 because fishers reached the first period allocation by February 20, 2009. WDFW issued a total of 16 permits and 6 of the permit holders participated in the fishery in July. Another two vessels joined the sardine fishery in September. These two vessels were new entrants, having just obtained sardine licenses when the fishery moved from emerging to standard rules in July. A total of 8,026 mt of sardines were landed into Washington in 2009; three vessels accounted for 62 percent of the catch. Of the 173 landings in 2009, 59 percent were made in July and 41 percent were made in September. The average landing into Washington was about 46 mt. All landings were made into Westport or Ilwaco with the majority of the catch (95%) occurring in waters adjacent to Washington. A total of 238 sets were made with 203 (85%) of them successful. The average catch per successful set was about 44 mt.

From 2000 through 2004, WDFW required fishers to carry at-sea observers, as well as provide financial support for this observer effort. Bycatch information was collected in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether alive, dead, or in poor condition. During the five-year period of the program, overall observer coverage averaged over 25 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 5-year average bycatch rates. Bycatch and mortality estimates of incidentally captured salmon by year and species are shown in Table 6-8.

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 2009, 4.31 tons of mackerel were landed in the 2009 season; other species recorded on fish tickets included sharks (less than 0.1 ton) and jellyfish (coded as miscellaneous).

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 other particular species were taken, with space for comments related to fishing. Other species noted, but not consistently enumerated in the live bait harvest, include white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), Pacific and jack mackerels, 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

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 utilize the anchovy as live bait in commercial fishing operations on the catching vessel. The gear utilized to capture anchovy is restricted to purse seines with a maximum length of 50 fathoms (300 ft), lampara nets, and hook and line. This 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 2009, there was no record of live bait capture of anchovy in Oregon under these new rules. There has also been interest expressed in commercial operations to capture and hold anchovy to be sold as live bait in some of these estuaries. There is no provision in rule to date for commercial operations to capture, hold and sell anchovy as live bait in any of these estuaries except in the Umpqua estuary where Pacific herring, Pacific sardine, northern anchovy, smelt and American shad may be taken by beach seine and sold as bait, some of which is sold as live bait.

7.3 Washington Live Bait Fishery

A portion of Washington's anchovy landings include live bait destined for use in recreational and commercial fisheries. Although all Washington anchovy landings are listed on fish tickets regardless of their ultimate use, Washington does not distinguish 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. 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.

7.4 References:

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8.0 Safety at Sea Considerations

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

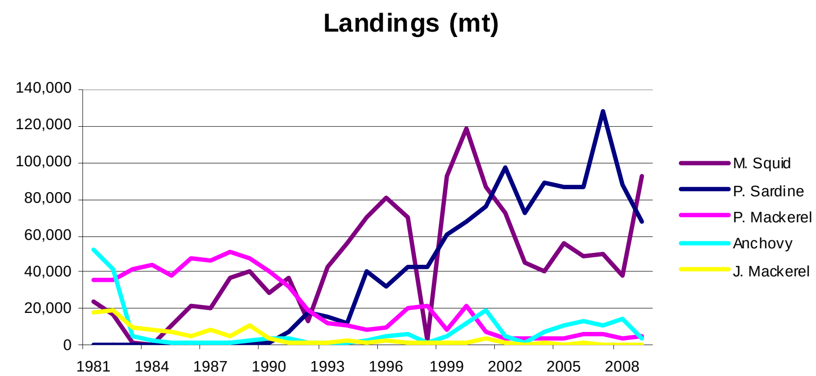
In January 2003, NMFS published final regulations to implement Amendment 10 to the CPS FMP, which allows LE permits to be transferred to another vessel and/or individual.

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

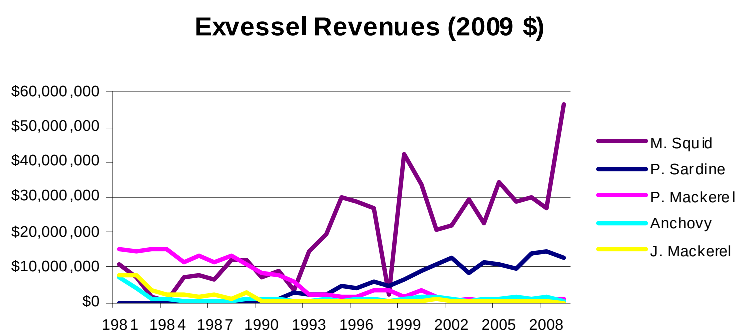
In 2008 and 2009 the directed Pacific sardine fishery experienced seasonal closures because harvest guidelines in these years have dropped while Pacific sardine continue to be available to the fishery and market demand is steady or increasing. This has lead to a “derby style” fishery where vessels compete for a share of the seasonal harvest guideline over a short period of time. This circumstance can create situations where safety considerations may be compromised as season duration is compressed and competition increases.

9.0 ECONOMIC STATUS OF WASHINGTON, OREGON, AND CALIFORNIA CPS FISHERIES IN 2009

This section summarizes economic data presented in Tables 25-29 (presented in the Tables section following Chapter 13) and Figures 9-1 through 9-8 (at the end of this chapter). Washington, Oregon and California landings of CPS totaled 168,198 mt in 2009, a 17 percent increase from 2008. Market squid landings, all in California, totaled 92,372 mt in 2009, up 142 percent from 2008. Pacific sardine landings of 67,050 mt in 2009 decreased 23 percent from 2008 (87,190 mt). The exvessel revenue from all CPS landings was $70.6 million in 2009, up 61 percent from 2008 (2008 converted to 2009 dollars).



Market squid accounted for 55 percent and Pacific sardine 40 percent of total West coast, CPS landings in 2009. Landings of Pacific mackerel increased 43 percent, and landings of northern anchovy fell 76 percent from 2008 to 2009. Real exvessel market squid revenues (2009 $) increased 111 percent from 2008. The increase in market squid landings was accompanied by a 13 percent decrease in exvessel price from $702 to $611 per mt (2009 $). There was a 28 percent decrease in aggregate CPS finfish landings from 2008; exvessel revenue decreased 18 percent, while the overall finfish exvessel price increased 15 percent from 2008. In 2009, market squid made up 15 percent of total West coast exvessel revenues, and CPS finfish accounted for almost 4 percent. Washington, Oregon and California shares of total west coast CPS landings in 2009 were 5 percent, 13 percent and 82 percent respectively.



California sardine landings were 37,543 mt in 2009 down 35 percent from 2008, 57,806 mt. Market squid ranked first in exvessel revenue generated by California commercial fisheries in 2009, with exvessel revenue of $56.5 million, $25.9 million greater than that for Dungeness crab, in second place. Landings of Pacific sardine ranked sixth highest in California exvessel revenues in 2009 at $5.6 million. California Pacific mackerel landings were 5,080 mt in 2009, up 44 percent from 2008. California landings of Northern anchovy were 2,668 mt in 2009, down 81 percent from 2008.

Oregon's landings of Pacific sardine decreased six percent in 2009, from 22,949 mt to 21,481 mt. Sardine generated $5.3 million in exvessel revenue for Oregon in 2009, 5 percent of the state's total exvessel revenues, ranking it fifth behind Dungeness crab in total exvessel revenues. Washington landings of Pacific sardine increased 25 percent from 6,435 mt in 2008 to 8,026 mt in 2009. With exvessel revenue a little more than 1 percent of the Washington total in 2009, sardine ranked 12th behind Dungeness crab in exvessel value.

Oregon landings of Pacific mackerel decreased from 58 mt in 2008 to 53 mt in 2009, and anchovy landings fell from 260 mt to 39 mt. Washington landings of Pacific mackerel decreased from 9 mt in 2008 to 4 mt in 2009 while anchovy landings rose from 109 mt to 810 mt.

In 2009, the number of vessels with West coast landings of CPS finfish was 173, up from 149 in 2008. With the increase in vessels and a decrease in total CPS finfish landings, finfish landings per vessel, 438 mt in 2009, decreased 38 percent from 2008. Of the vessels landing CPS finfish in 2009, 14 percent depended on CPS finfish for the greatest share of their 2009 exvessel revenues. From 2008 to 2009, the number of vessels with West coast landings of market squid remained unchanged at 166, with 51 percent of these vessels dependent on market squid for the largest share of their total 2009 exvessel revenue. Market squid landings were 557 mt per vessel in 2009, up 142 percent from 2008. 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 2009 by far roundhaul gear accounted for the largest share of total CPS landings and exvessel revenue by gear in 2009, 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 2009, 70,800 mt of market squid were exported through West Coast customs districts with an export value of $95.5 million; a 105 percent increase in quantity, and a 90 percent increase in value of West coast market squid exports from 2008. The primary country of export was China, 68 percent of the total, which received 47,944 mt, up 100 percent from the quantity exported to China in 2008. Ninety percent of market squid exports went to China and five additional countries: Japan (4,912 mt), Philippines (3,431 mt), Greece (3,063 mt) and Viet Nam (2,727 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or for use as bait.

In 2009, 60,956 mt, of sardines were exported through West coast customs districts down 19 percent from 2008. Sardine exports were valued at $48.3 million in 2009, also down 19 percent from 2008. Seventy-six percent of sardine exports were in the fresh/frozen form, the balance were in the preserved form. Thailand was the primary export market in 2009, receiving 17,907 mt, a 31 percent increase in its imports from 2008, and representing 29 percent of total West Coast sardine exports in 2009. Japan was second with 15,770 mt, 26 percent of the total a 20 percent decrease from 2008, followed by Australia, Malaysia and China accounting for 11 percent, 9 percent and 9 percent respectively. Together these five countries accounted for nearly 85 percent of total West Coast sardine exports in 2009.

Figure 9-1. Annual West coast landings and real exvessel revenues for all CPS species, 1981-2009.

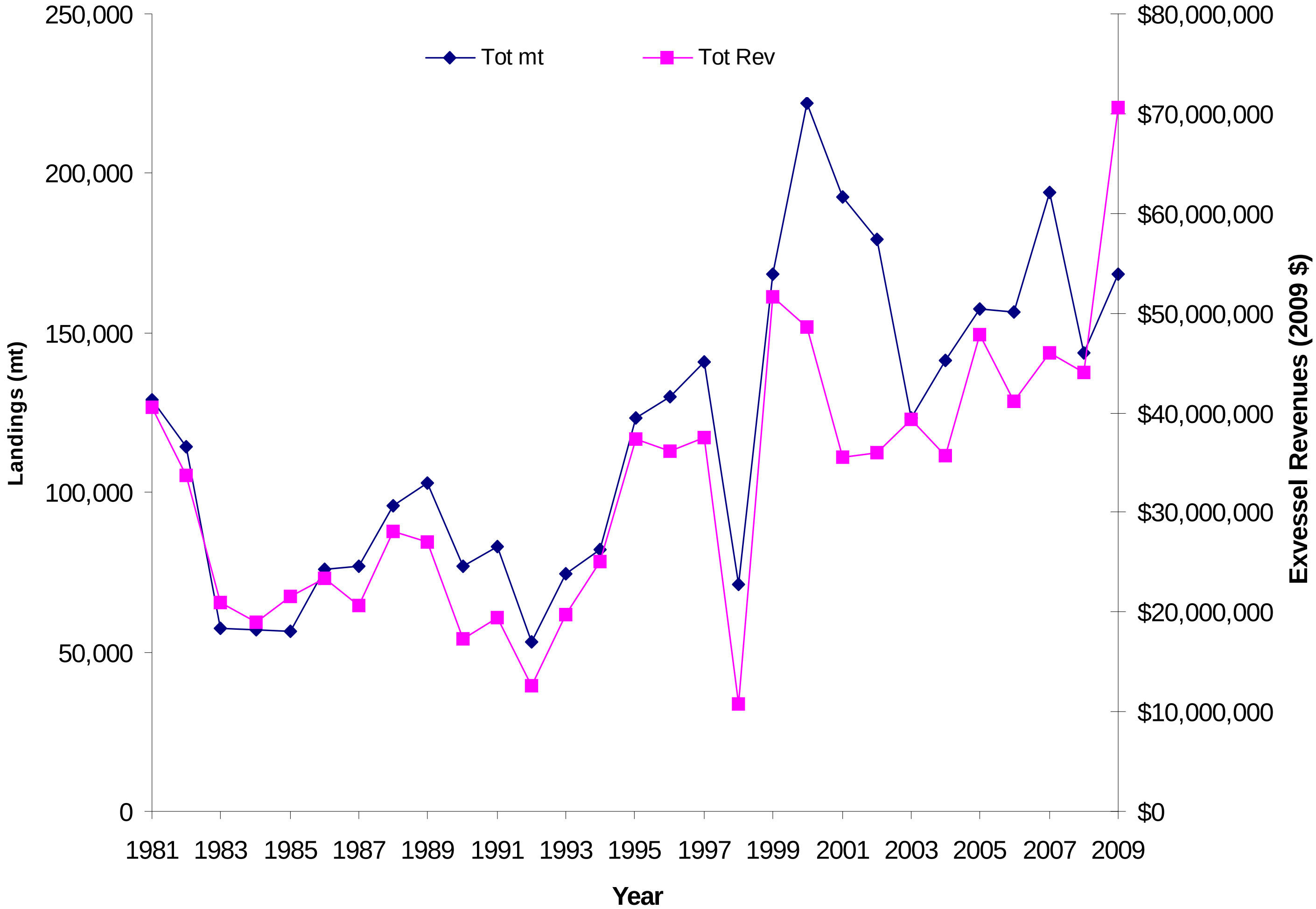


Figure 9-2. Percentage contribution of Pacific coast CPS finfish and market squid landings to the total exvessel value of all Pacific coast landings, 1981-2009.

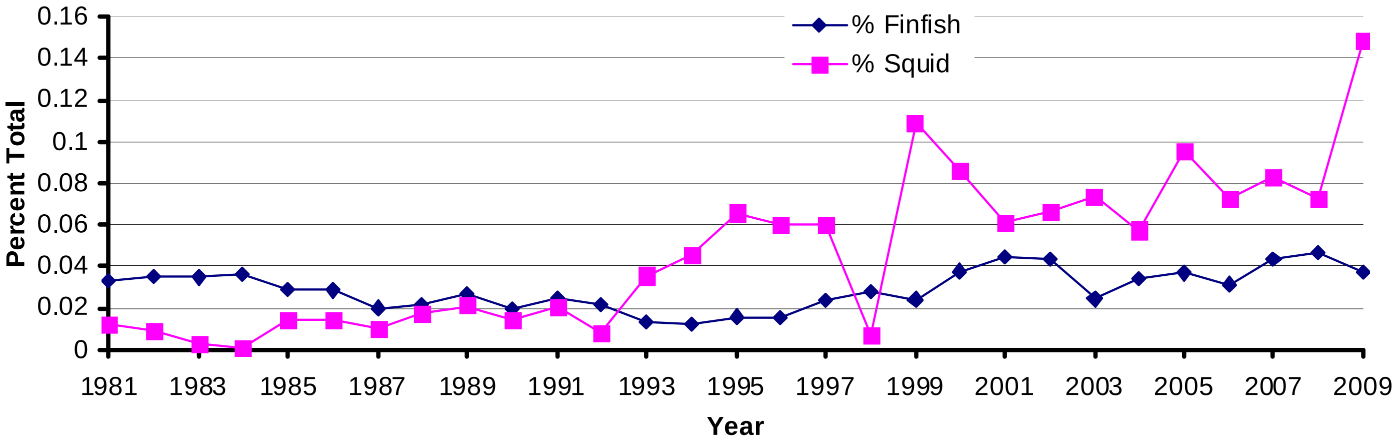


Figure9-3. West coast CPS finfish landings and real exvessel price ($/lb, 2009 $), 1981-2009.

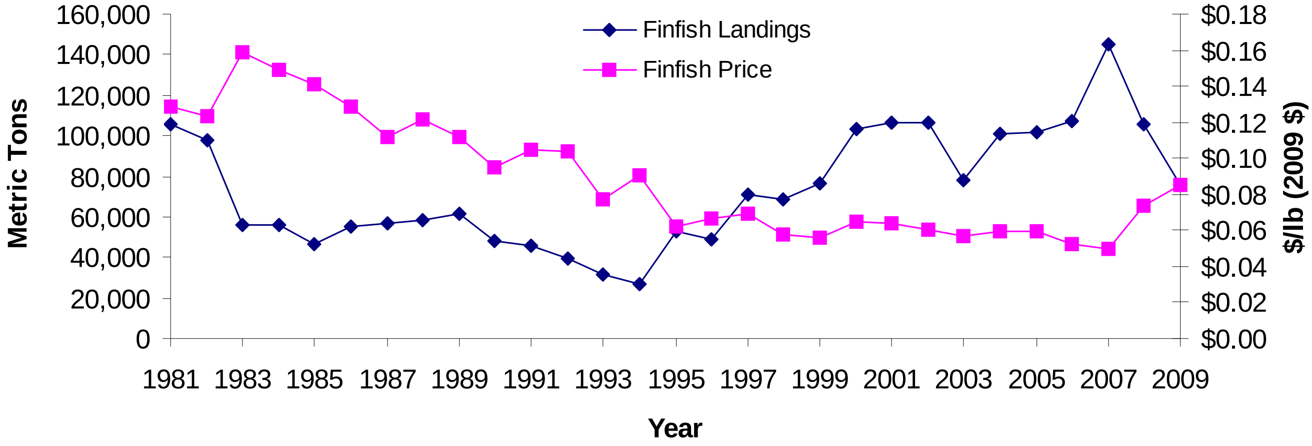


Figure 9-4. West coast market squid landings and real exvessel price ($/lb, 2009$), 1981-2009.

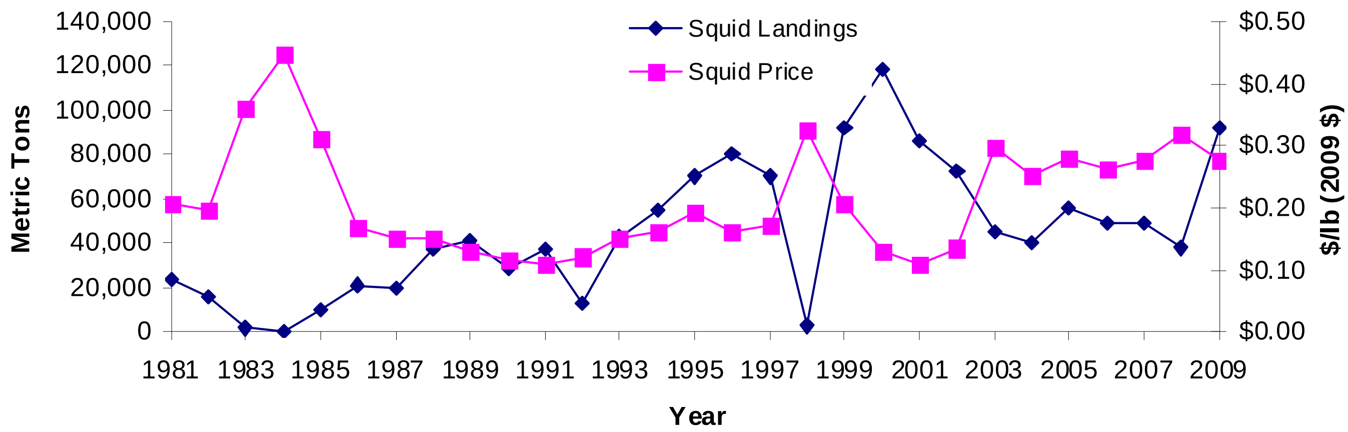
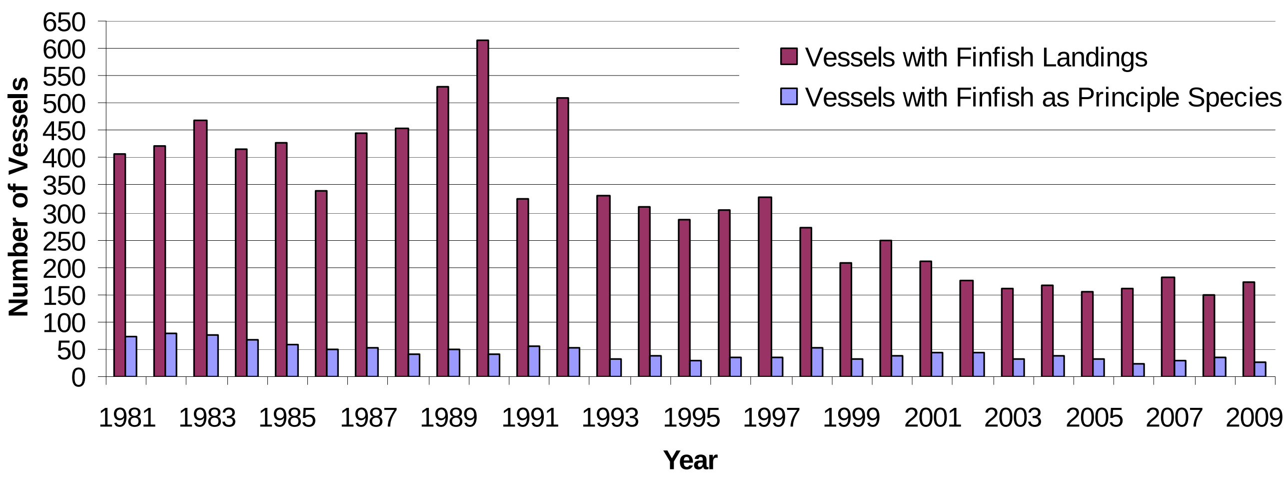
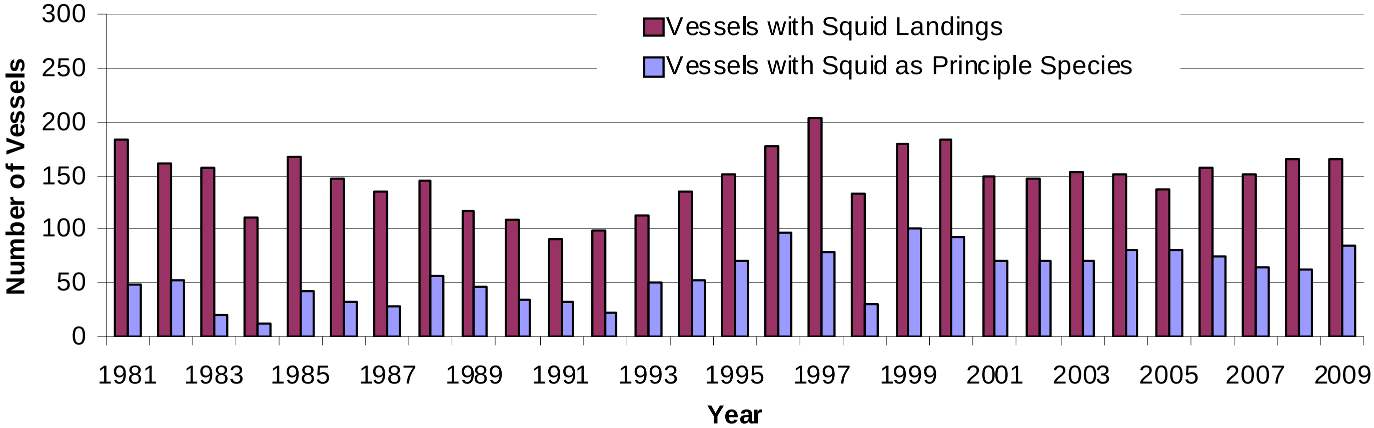


Figure 9-5. Number of vessels with Pacific coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2009.



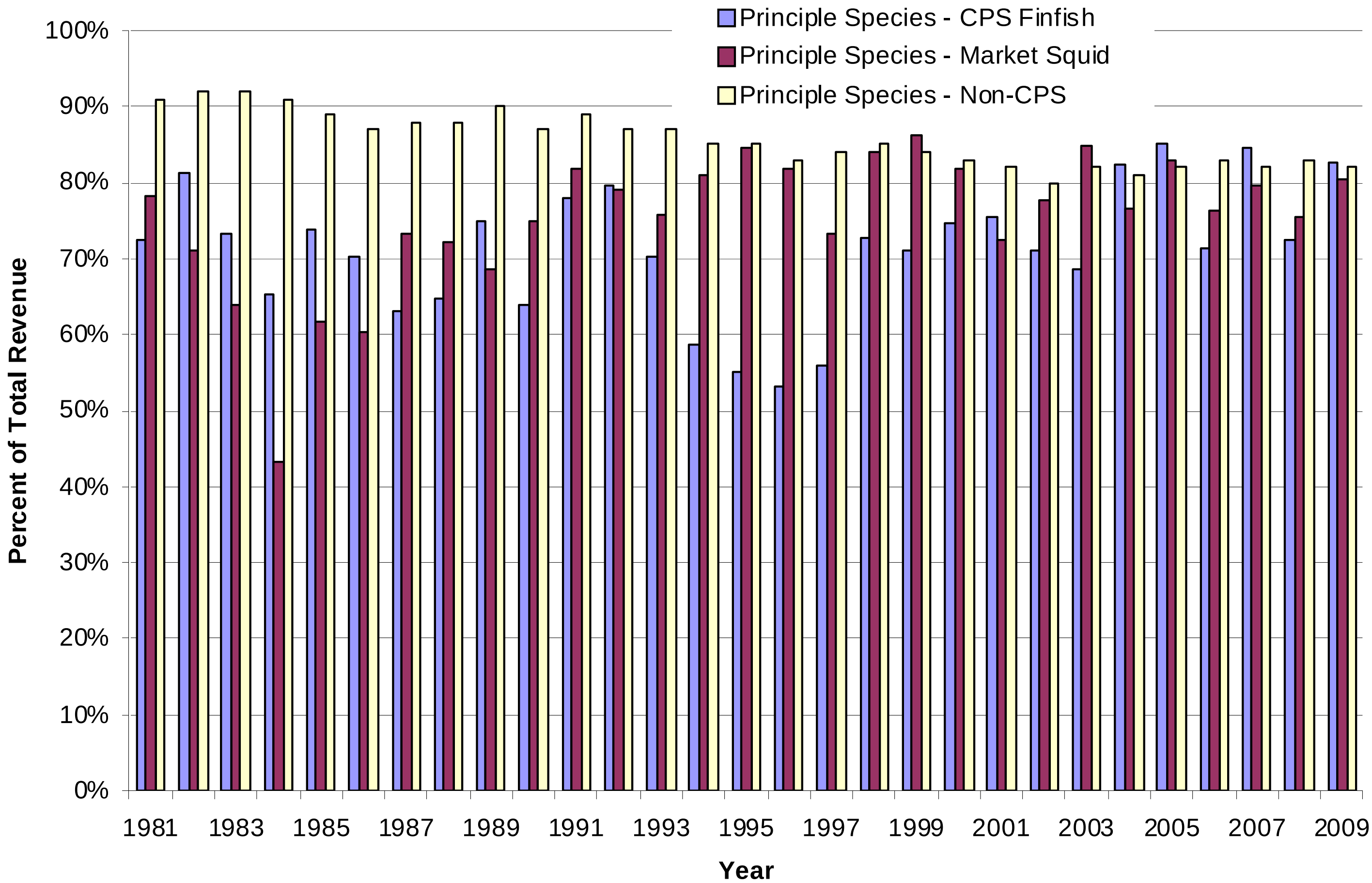
Note: The principle species accounts for the largest share of the vessels annual exvessel revenue.

Figure 9-6. Number of vessels with Pacific coast landings of market squid, and number for which market squid was the principle species, 1981-2009.



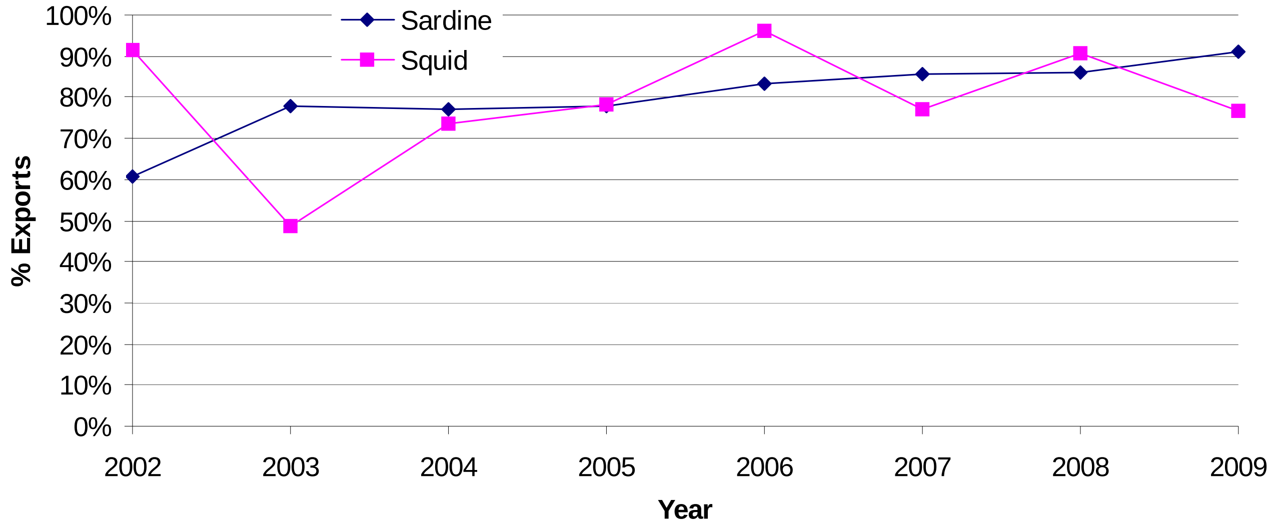
Note: The principle species accounts for the largest share of the vessels annual exvessel revenue.

Figure 9-7. Average share principle species revenues of total revenues for vessels whose principle species was CPS finfish, market squid or non-CPS, 1981-2009.



Note: The principle species accounts for the largest share of the vessels annual exvessel revenue.

Figure 9-8. West coast sardine and squid exports as a percentage of total landings, 2002-2009.



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.

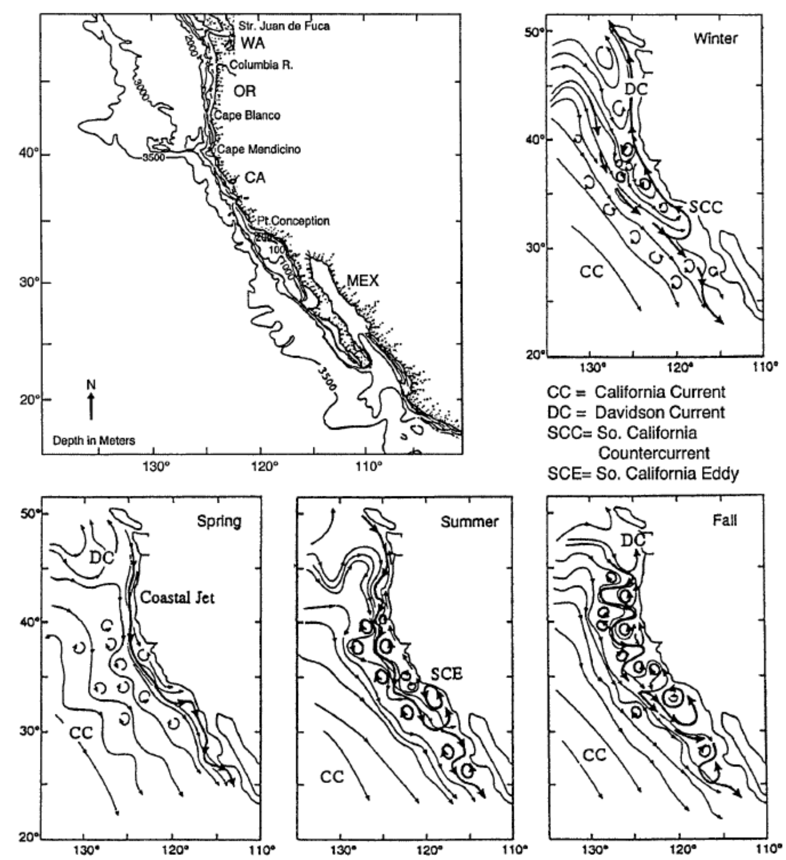


Figure 1. Seasonal variation of large-scale currents along the West Coast with bathymetry illustrating the dynamic conditions in the CCLME. The CC flows southward year round offshore from the shelf break to several hundred kilometers. Along the shelf break, several other currents are found, including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

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 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 is determined by NMFS' Newport, OR laboratory, which conducts monthly surveys of the CCLME since 1997 (Figure 2). Additional data from new survey lines off Trinidad Head (Humboldt Co.), CA (NMFS) and Bodega, CA (Sonoma Water Agency-UCD) confirms the Newport prediction.

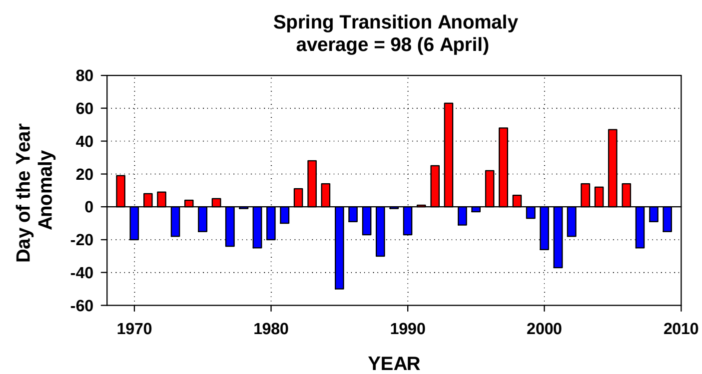


Figure 2. Anomaly of the date of the spring transition. William Peterson, NOAA, NMFS, NWFSC.

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 effect recruitment of herring, smelt, anchovy and other coastal pelagic species.

On an interannual time scale of 3-7 years, the CCLME is affected by ENSO (El Niño Southern Oscillation) (Figure 3), whereby either warmer, salty surface water from the equator (El Niño) or cool, upwelled water (La

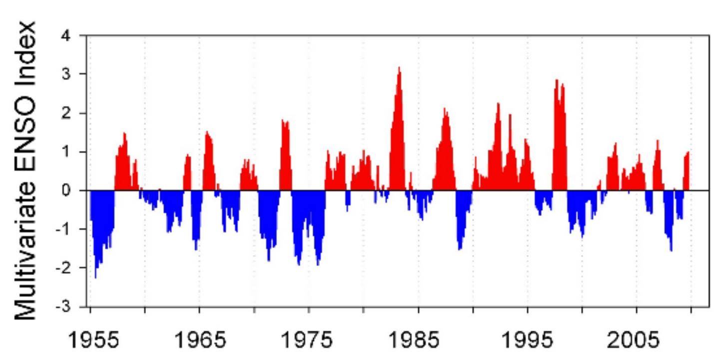


Figure 3. El Nino/Sothern Oscillation Index anomalies. Red indicates warm or El Nino conditions and blue cool La Nina conditions.

Niña) affects the ecosystem. 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).

At periods between 20 to 50 years, low frequency climatic forcing from the Pacific Decadal Oscillation (PDO) affect 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 from 1998-2001 and positive from 1977 to 1998. Since 2001, the PDO has fluctuated between positive and negative signaling an unusual climatic period for the CCLME.

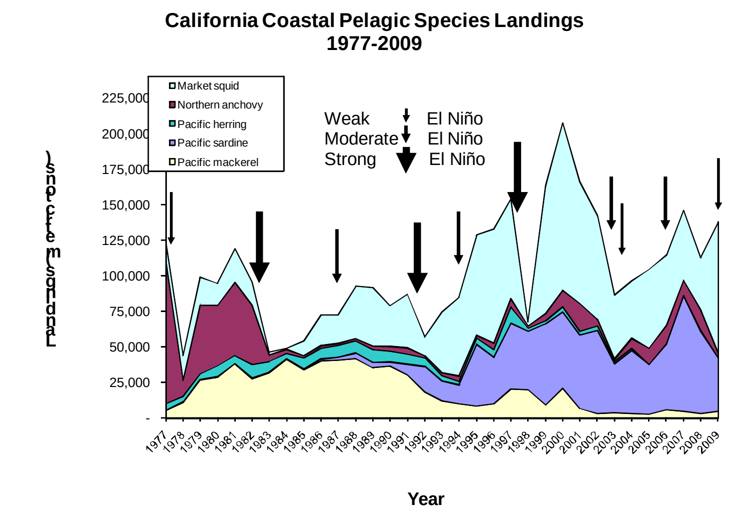


Figure 4. El Nino events and California CPS landings.

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 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).

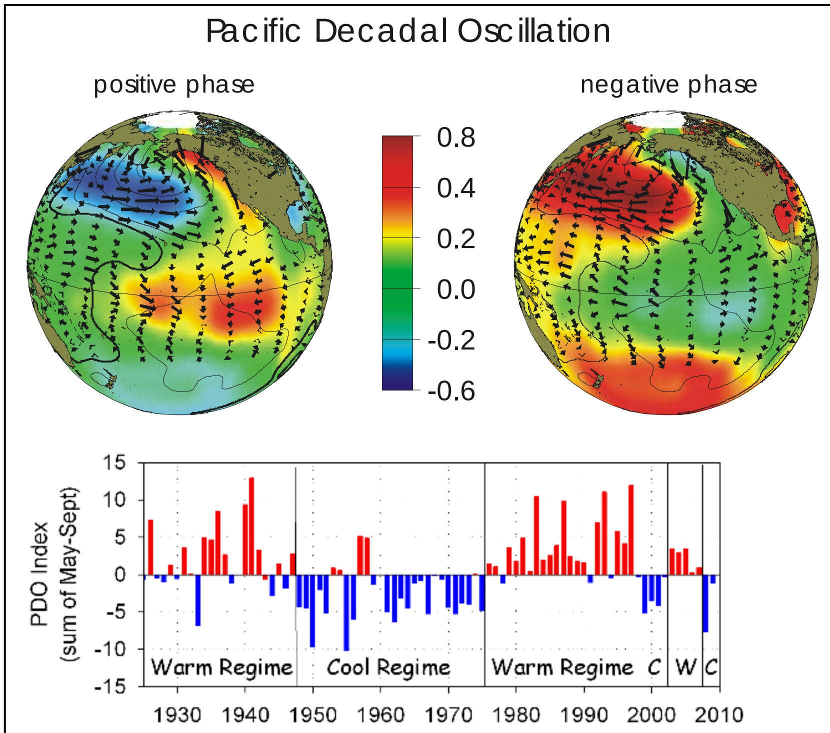
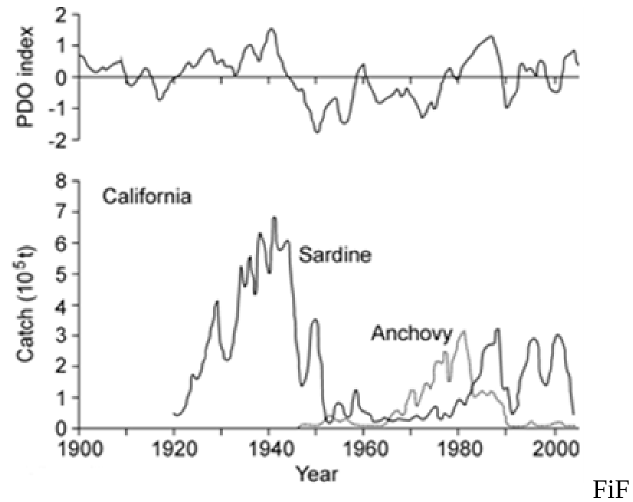


Figure 5. Time series of shifts in sign of the Pacific Decadal Oscillation (PDO), 1925 to 2009. Values are averaged over the months of May through September. Red bars indicate positive (warm) years; blue bars negative (cool) years. Note that 2008 was the most negative since 1956. http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ca-pdo.cfm

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 used as surrogates of ecosystem health and status of fisheries. Preliminary physical indicators and sentinel species are under development by NMFS and will take on increased importance as the agency embarks on an Integrated Ecosystem Assessment in 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 (visit www.pacoos.org).



FiF
igure 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 2009, the Spring Transition (Figure 2) was relatively early (26 March 2009), but was not as strong as 2008. Northwest winds remained steady in spring but frequently stopped or relaxed from June-October. This probably accounted for the anomalous high sea surface temperatures and low chlorophyll *a* levels observed.

10.3.2 El Niño/Southern Oscillation

The Multivariate ENSO Index for the Northeast Pacific reflects El Niño conditions for late 2009 and early 2010, with warm water dominating the CCLME and bringing with it lower primary productivity along the coast (Figure 3). Based on model forecasts, the El Niño is expected to be weakening or ending in the spring.

10.3.3 Pacific Decadal Oscillation

The PDO became positive in mid-2009 (Figure 7). A positive PDO value is considered favorable for sardine but not anchovy. Effects on other CPS such as market squid is also probably negative.

10.4 Trends in Ecosystem Indicators

10.4.1 Sea Surface Temperatures

Sea surface temperatures are known to affect sardine, anchovy and other CPS

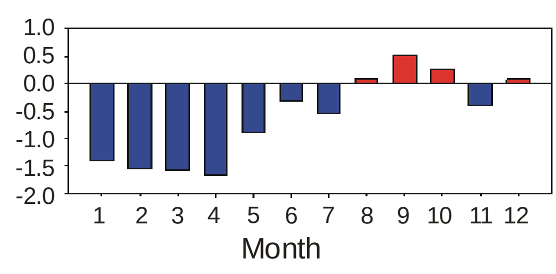


Figure 7. Monthly Pacific Decadal Oscillation index values in 2009. http://jisao.washington.edu/pdo/

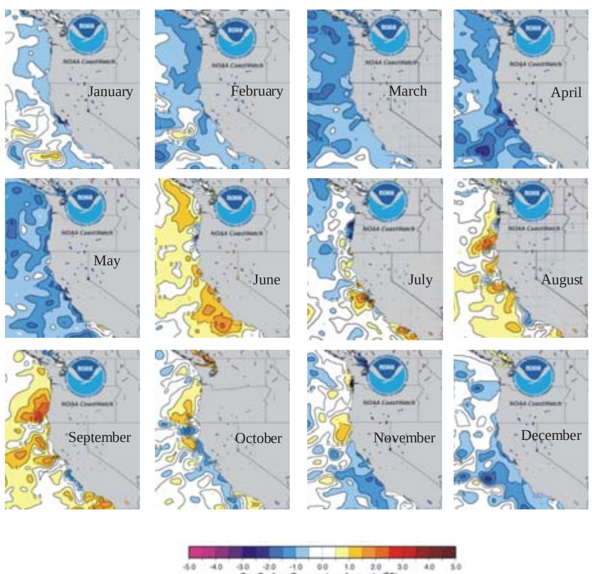
species abundance.   In 2009 ocean temperatures were anomalously cold at the beginning of the year, but were anomalously warm during summer and early fall (Figure 8), probably reflecting the El Nino.

10.4.2 Ocean Productivity

Chlorophyll *a* is a phytoplankton pigment that can be measured at the surface by satellites. In 2009 coastal chlorophyll *a* was low in February, March, April, July, August, and September (Figure 9). The low summer values reflect the warmer ocean temperatures and change in the PDO sign.

10.4.3 Copepods

The copepod species richness, is surveyed by the NMFS, NWFSC off Newport, OR and is highly correlated to the PDO. In 2009 (Figure 10) the copepod community was composed of primarily sub-arctic species in the spring but became more diverse (more subtropical species) as the summer and fall progressed. The presence of sub-arctic species is favorable for coho salmon returns to the Columbia River but has not been correlated to CPS in the area, although preliminary information indicate that Pacific herring and anchovy recruit better when these cold-water copepods are abundant.



Figue 8. Monthly sea surface temperature anomalies. http://coastwatch.pfel.noaa.gov/

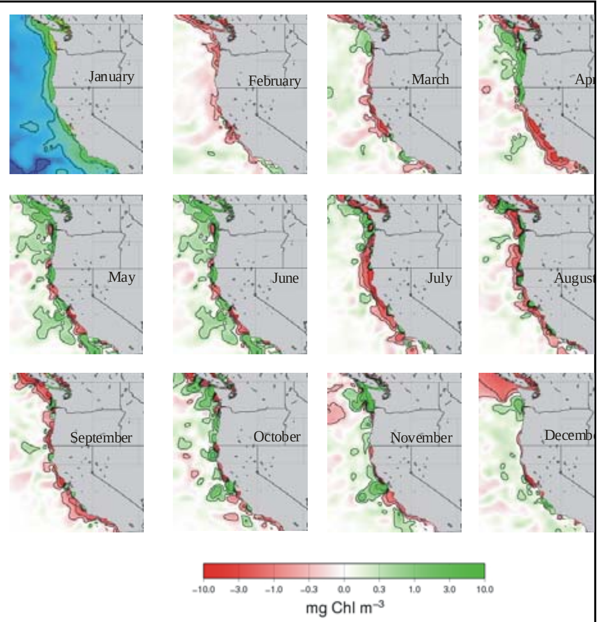


Figure 9. Chlorophyll *a* concentration anomalies in 2010. http://coastwatch.pfel.noaa.gov/

10.4.4 Juvenile Fish

Surveys for juvenile fish and krill are conducted by the NMFS, SWFSC off the Central California coast in the May-June time period

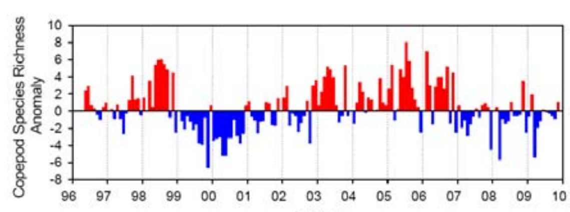


Figure 10. Monthly anomaly of copepod diversity found off Newport, OR. From William Peterson, NOAA, NMFS, Newport, OR.

since 1983 (Figure 11). In 2009, sardine numbers dropped 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 abundance of forage fish in 2009 (Figure 12), evidently related to good recruitment in 2008. These surveys capture primarily older age-classes forage fish. Overall forage fish densities continued to be much lower than the high densities observed from 2000-2005.

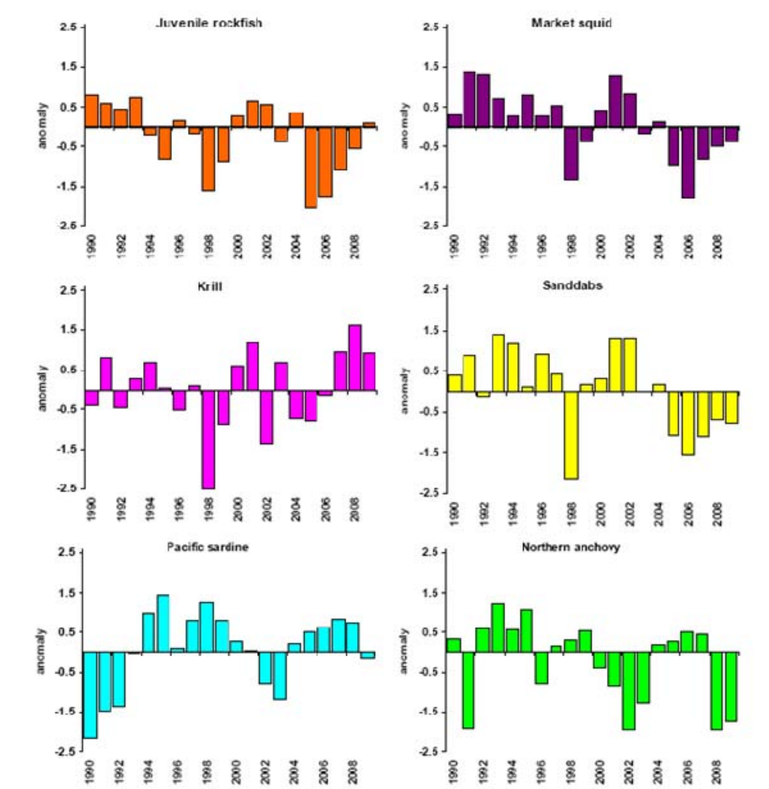


Figure 11. Long-term standardized anomalies of six pelagic forage species off central California. Steve Ralston, NOAA, NMFS, SWFSC.

10.4.5 Humboldt squid

During the summer, fall and winter 2009, record numbers of Humboldt squid were captured by sport and incidentally by commercial fisheries from California to British Columbia, Canada. Extremely high Humboldt squid densities were observed off the Columbia River in 2009 (Figure 13). We suspect that large numbers of sardines, anchovy, and other CPS were eaten by Humboldt squid in 2009. This predation may have affected overall CPS abundance but we were unable to quantify this predation mortality.

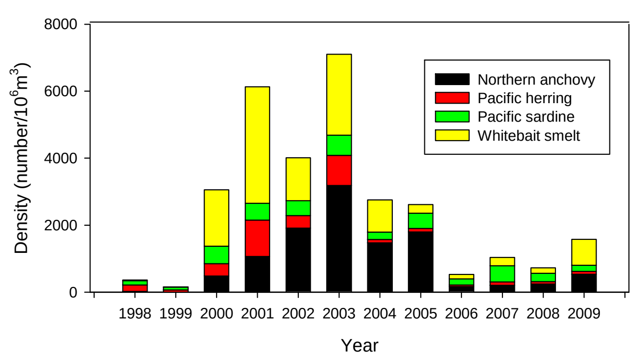


Figure 12. Annual densities of forage fishes off the Columbia River. Robert Emmett, NOAA, NMFS, NWFSC.

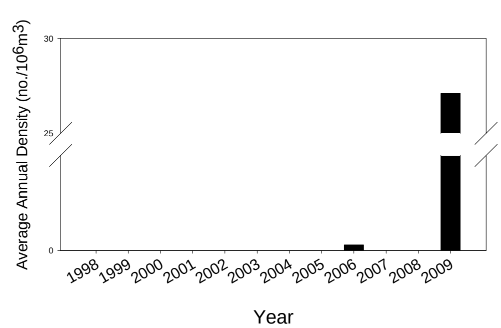


Figure 13. Annual abundance of Humboldt squid off the Columbia River. Robert Emmett, NOAA, NMFS, NWFSC.

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Climate Indicators:

PaCOOS Quarterly Update of Climatic and Ecological Conditions in the CA Current Large Marine Ecosystem V4 2009, V1 2009 (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 2009
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

Humboldt Squid:
Annual abundance of Humboldt Squid identified during pelagic surveys.
Source: Robert Emmett, Richard Brodeur, 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.* (2009; see Appendix 1) summarized the status of the Pacific sardine resource off the U.S. Pacific Coast and northern Baja California, Mexico. Pacific sardine landings for Canada, the U.S., and Mexico (Ensenada) totaled 134,269 mt in calendar year 2009 (Table 11-4). In 2009, landings in California (37,699 mt) decreased considerably from the previous year (57,736 mt in 2008); combined Oregon-Washington landings for 2009 (29,507 mt) were slightly higher than 2008 (29,384 mt) (Table 11-3). The U.S. sardine fishery is regulated using a quota-based HG management scheme (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 and 2009 were 42% and 25% lower than each previous year, respectively, so the U.S. fishery was subject to in-season closures throughout these two management years. 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 52,064 mt in 2009, down from 66,866 mt in 2008 (Table 11-4). Canadian sardine landings increased substantially to10,435 mt in 2008 and ~15,000 mt in 2009 (Table 11-4).

Estimated stock biomass (ages 1+) from the assessment conducted in 2009 (Hill et al. 2009) indicates a declining trend since the recent peak year (1.68 mmt in 2000), with an estimate of roughly 702,024 mt in July 2009 (Table 11-2). Current recruitments are considerably lower than the recent peak of 18.62 billion fish in 2003 (Table 11-2). Biomass and recruitment estimates (1981-2009 from the most recent assessment are provided in Table 11-2 and Appendix 1). Based on the most recent assessment's estimate of total (age 0+) mid-year biomass (Table 11-2) and total catch from Ensenada to Vancouver Island (Table 11-4), the coast-wide harvest rate was approximately 17.6% during 2009.

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 2010

Based on results from the base model in Hill et al. (2009), the HG for the U.S. fishery in calendar year 2010 was determined to be 72,039 mt. To calculate the HG for 2010, the Council used the maximum sustainable yield (MSY) control rule defined in Amendment 8 of the Coastal Pelagic Species-Fishery Management Plan, Option J, Table 4.2.5-1, PFMC (1998). This formula is intended to prevent Pacific sardine from being overfished and maintain relatively high and consistent catch levels over the long-term. The Amendment 8 harvest formula for sardines is:

HG_{2010} = ($BIOMASS_{2009}$ – CUTOFF) • FRACTION • DISTRIBUTION;

where HG_{2010} is the total USA (California, Oregon, and Washington) harvest guideline in 2010, $BIOMASS_{2009}$ is the estimated July 1, 2009 stock biomass (ages 1+) from the assessment (702,024 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 MSY control rule for Pacific sardines is a proxy for F_{msy} (i.e., the fishing mortality rate that achieves equilibrium 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 or $F_{msy} = 0.248649805(T^2) - 8.190043975(T) + 67.4558326$,

where T is the running average sea-surface temperature at Scripps Pier, La Jolla, California during the three preceding seasons (July-June). Ultimately, under Option J (PFMC 1998), F_{msy} is constrained and ranges between 5% and 15%. Based on the T values observed throughout the period covered by this stock assessment (Figure 55), the appropriate F_{msy} exploitation fraction has consistently been 15%; and this remains the case under current conditions (T_{2009} = 17.92 °C).

11.1.2 Pacific Mackerel

Total biomass (age-1+ biomass) of Pacific mackerel remained low from the early 1960s to the mid 1970s, at which time the population began to rapidly increase in size, reaching a peak in the early 1980s. From the mid 1980s to early 2000s, the stock declined steadily, with some signs of "rebuilding," i.e., on an increasing limb of a cyclical, historical distribution. However, as noted previously, 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 confounds long-term (abundance) forecasts for this species (see Crone *et al.* 2009). 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 over 70 percent to approximately 5,000 mt/yr. This pattern of declining yields in recent years generally characterized all of the fisheries, including U.S. commercial and recreational fleets, 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 2009-10 fishing year was based on the SS model *AA*, which generated a biomass estimate of 282,049 mt (see section 3.2 and Crone *et al.* 2009). However, based on model uncertainty (see Crone *et al.* 2009) and precautionary management strategies (PFMC 1998), the Council set a final quota (HG) below that typically derived from the formal harvest control rule (see section 11.1.2.1); this general adjustment was done in the two previous Pacific mackerel stock assessments conducted in 2007 and 2008.

For the 2009-10 fishing year, the Council recommended an acceptable biological catch (ABC) of 55,408 mt (see section 11.1.2.1) and an overall HG of 10,000 mt that included a 2,000 mt set-aside for incidental landings should the directed fishery close. Additionally, the Council reviewed historic Pacific mackerel landings, which have rarely exceeded 15,000 mt in recent years, with an average annual harvest of approximately 5,000 mt. Alternatively, the Council considered the resiliency of the Pacific mackerel stock and industry reports of increasing Pacific mackerel availability at a time when opportunities for Pacific sardine and market squid are declining. Should the directed fishery attain the harvest guideline of 8,000 mt, the Council recommended that NMFS close the directed fishery and establish a 45% incidental catch allowance when Pacific mackerel are landed with other coastal pelagic species (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 2,000 mt 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 2010, with a full assessment scheduled in 2011. Finally, the above management stipulations for the 2009-10 fishing year, inclusive, are applicable to the 2010-11 fishing year as well, with a full assessment as the basis for management recommendations in the 2011-12 fishing year.

11.1.2.1 Harvest Guideline for 2010-11

All Council stipulations related to Pacific mackerel harvest in the 2009-10 fishing year are also applicable to the 2010-11 fishing year (see section 11.1.2 above).

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

2009, northern anchovy landings averaged 322 mt for Washington, 65 mt for Oregon, and 9,446 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 2009, and the greatest landings occurred in 2009 (810 mt). In Oregon, northern anchovy were landed from 2002 to 2006 and in 2008.

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	-	10,390
2008	109	260	14,285
2009	810	39-	1,668

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.

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

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

particularly if catches are begun outside the exclusive economic zone. (PFMC, 1998.)

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 2009, jack mackerel landings averaged 7 mt for Washington, 70 mt for Oregon, and 949 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 California, CDFG landing receipts for jack mackerel totaled 3,624 mt in 2001; however, these may be somewhat over-reported – 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	248	9	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

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.

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 in the past as an informal assessment tool, i.e., within a research context only, to evaluate population dynamics and biological reference points (MSY-related) regarding this species (section 4.3.4 and Dorval et al. 2008). Although it is presumed that market squid would be exempt from new annual catch limits and accountability measures provisions due to its short life cycle, the fishery control rules currently in place under the MSFMP, including a restricted access program, which 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 (e.g., spatially expand, harvest high amounts of immature squid) in the future, additional management measures may be required.

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 2009, the market squid fishery was California's largest fishery, with landings estimated at 92,371 mt. This is a 142 percent increase over 2008 (38,100 mt) and 22 percent less than the record high set in 2000 (118,827 mt). The total ex-vessel value more than doubled from to $26.5 million in 2008 to $56.4 million in 2009. The ex-vessel price per ton of market squid decreased from 2008 with three prices accounting for 93% of the 2009 landings: $496/t (15%), $551/t (49%), and $771/t (29%). The fishing permit season for market squid extends from 1 April through 31 March of the following year. During the 2008-2009 season (as opposed to the 2008 calendar year) 34,050 mt were landed, a 26 percent decrease from the 2007-2008 season (45,935 mt). There was an increase in catch in the northern fishery near Monterey with 877 mt landed. However, squid landings in northern California have remained low since the 2006-2007 season probably the result of unusual environmental conditions observed during the past several years and the lingering La Niña Southern Oscillation event. In contrast, most of the market squid was taken from the southern California region during the season, accounting for 98.9 percent of the total catch (82,603 mt), similar to the previous two seasons, 2006-2007 (98.5 percent) and 2007-08 (99.9 percent). This regional domination of catch last occurred during the 1998-1999 and 1999–2000 seasons (99.7 percent and 99.8 percent respectively), and was also influenced by a La Niña event.

11.3 References

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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 2010 Harvest Guidelines include a 5,000mt set-aside for survey research activities. This represents an increase over the 2009 set-aside, which was 2,400mt. At the April, 2010 meeting, the Council voted unanimously in support of issuing an Exempted Fishing Permit (EFP) for aerial sardine research. The EFP proposal lays out a detailed survey methodology to utilize the 5,000mt set-aside that was included in the 2010 Harvest Guidelines.

4,200mt are to be used for a nearly coastwide survey between Cape Flattery in the north, to (and including) the Channel Islands in the south. The applicants established 66 transects, each extending 38 miles offshore. The proposed survey involves a two-stage sampling design. First, aircraft fly over the transects, following explicit 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 112 sardine schools of various sizes. This will establish the relationship between surface area and biomass.

The proposal also includes a pilot survey in the Southern California Bight, to investigate alternative survey methods, utilizing the remaining 800mt of the set-aside. For this portion of the research, the applicants will fly a total of 36 replicates over six transects, half during daylight and half at night. They will be testing 1) day versus night detection, photogrammetry versus lidar detection, and 3) acoustic versus lidar detection. There are likely fish behavior differences between day and night, such as swimming closer to the surface or schooling density. This research is designed to help establish those potential differences, as well as to explore whether the alternative survey methods might be adapted to spatially broader surveys, inclement weather, and nighttime surveying.

The National Marine Fisheries Service is to consider the EFP application, and, if approved, issuance of the EFP by early summer, 2010.

12.2 Pacific Mackerel

Pacific mackerel continue to be actively managed although recent landings have been well below the ABC. Pacific mackerel are not undergoing the full assessment process in 2010, having undergone a full assessment in 2009. See Appendix 2**.**

12.3 Management Issues

Emerging management issues include implementation of new provisions in the reauthorized MSA, ecosystem-based fishery management, and international CPS fisheries.

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

Although not unique to CPS management, implementation of new provisions in the MSA as reauthorized in 2007 will involve a reevaluation and amendment of the CPS FMP to incorporate mechanisms to prevent overfishing such as annual catch limits and accountability measures. In accordance, NMFS has revised guidance on preventing overfishing under MSA National Standard 1.

Precautionary harvest control rules exist for Pacific sardine and Pacific mackerel which 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 requirements because of their short life-cycle (market squid) or are currently harvested at relatively low levels (anchovy, jack mackerel). Annual catch limits for monitored stocks may be appropriately implemented with greater flexibility but greater precaution than the actively managed species because they are assessed with less frequency. Scoping comments on amending the Council's CPS FMP for National Standard 1 guidelines included recommendations to: assess scientific and management uncertainty, include krill and other forage species as ecosystem components of the FMP, improve accountability of live bait harvest and overall fishery discards, and to improve inseason harvest reporting. Council staff prepared a scoping summary and the Council is scheduled to adopt preferred CPS FMP amendment alternatives in June 2010.

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, 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.

12.4 International CPS Fisheries

There has been interest in coastwide management for the Pacific sardine fishery, which would entail a more consistent forum for discussion between the U.S., Mexico, and Canada. Continued U.S.-Mexico bilateral meetings indicate willingness from Mexico to continue scientific data exchange and cooperation on research, and engage in discussions of coordinated management. The Trinational Sardine Forum has been a good venue for international exchange. Victoria, British Columbia is tentatively scheduled to host the 2010 Trinational Sardine Forum.

12.5 Catch Shares

The National Ocean and Atmospheric Administration (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 CS, but there is no requirement to explore or implement CS systems.

The National Marine Fisheries Service (NMFS) sponsored a Catch Shares Workshop in February, 2010, to explore the applicability of using a form of CS system for the CPS fishery. That workshop included representatives of the commercial and recreational fishing industries; Federal and state governments; and NGOs. The Council also received an informational report on CS from Margaret Spring, NOAA Chief of Staff, at the March, 2010 meeting. Ms. Spring noted that CS may be one tool that councils should consider as a way to achieve maximum economic yield of their fisheries, and that the 2010 Federal budget includes a $36 million increase to support CS.

12.6 Wave Energy

12.6.1 Summary

The development of wave energy is moving rapidly forward off the West Coast, particularly Oregon (http://www.oregon.gov/ENERGY/RENEW/Hydro/Ocean_Wave.shtml). Proposals are calling for possibly thousands of acres of nearshore habitat that will have wave energy parks. A variety of wave energy structures have been proposed for deployment. The specific areas proposed are sandy habitat within 2.5 miles from shore. These areas: 1) allow appropriate anchoring and b) provide the most wave energy to be gathered. The deployment of these structures will change local currents, alter bottom sediments, and possibly many other aspects of the habitats they are placed.

12.6.2 Adverse Impacts

The biological effects of these wave energy parks on CPS and other species are highly uncertain but studies are just beginning (Boehlert et al. 2008). Some of the concerns are that these structures would act like large fish aggregating devices (FADs). They will also be off limits to sport and commercial fishing, essentially creating a “reserve” for marine resources. Other concerns are related to biological effects of anti-fouling paints, fuel spills, changes in water flows, increased predator abundance, and electro-magnetic forces on biological organisms.

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 1930's-1950's 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 actual 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) and linked to productivity and temperature tolerances. Scientist originally thought that anchovy and sardine populations fluctuated out of phase because of "competitive" interactions, but this does not appear to be true (Barange et al. 2009).

12.7.2 Adverse Impacts

Changes in the North Pacific Ocean climate was recently identified a major factors in the decline and ESA listing of the anadromous smelt eulachon (*Thaleichthys pacificus*) (Eulachon Biological Review Team. 2010) and affecting Pacific salmonid population (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 (Hollowed et al. 2009).

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

In addition to research and data needs presented in this 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 predatory-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 workshop is scheduled for June, 2010, to address these and other issues;

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.

13.2 Pacific Mackerel

Given the transboundary status of this fish population, it is imperative that efforts continue in terms of encouraging collaborative research and data exchange between NMFS SWFSC and researchers from both Canada's and in particular, Mexico's academic and federal fishery bodies, i.e., 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. In this context, it is imperative that future research funds be focused on improvement of the current CPFV survey, with emphasis on a long-term horizon, 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.

Given the importance of age (and length) distribution time series to developing a sound understanding of this species' population dynamics, it is critical that data collection programs at the federal and particularly, the state-level continue to be supported adequately. In particular, CDFG/NOAA funding should be bolstered to ensure ongoing ageing-related laboratory work is not interrupted, as well as providing necessary funds for related biological research that is long overdue. 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, further work is needed to obtain more timely error estimates from production ageing efforts in the laboratory, i.e., accurate interpretation of age-distribution data used in the ongoing assessment necessarily 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, there exists limited understanding of market squid population dynamics, which has hampered assessing the status (health) of this valuable marine resource found off California. General information concerning important stock- and fishery-related parameters suggests maximum age is less than one year, and the average age of squid harvested is roughly six to seven months. Under the proposed National Standard 1 Guidelines, market squid will not be considered for updated annual catch limits and accountability measures provisions due to the short lifespan. However, in this context, the CPSMT advises that current monitoring programs continue for this species, including tracking fishery landings, collecting reproductive-related data from the fishery, and obtaining fishermen-related logbook information.

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

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

Potential impacts to EFH-related issues would most likely arise in concert with fishing activity by the purse-seine fleet on spawning aggregations in shallow water when gear potentially makes contact with the sea floor. 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, it is imperative that each receive further scrutiny in the future, through continuation of rigorous sampling programs in the field that generate representative data for analysis purposes, as well as further histological evaluations in the laboratory and more detailed assessment-related work. For example, data collected through the CDFG port sampling program currently in place will provide information on the age and maturity stages of harvested squid. Further, laboratory work concerning general mantle condition, especially the rate of mantle “thinning,”, will likely benefit the current understanding of squid life history and subsequently, help improve the overall assessment of this species. Finally, other biological-related parameters that are currently poorly understood generally relate to spawning and senescence (e.g., life history strategies concerning spawning frequency, the duration of time spent on spawning grounds, and the period of time from maturation to death).

13.4 Live Bait Fishery

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

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

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 impact on net economic benefits in the commercial fisheries associated with a proposed management action. Experience with the long-term allocation of the Pacific HG emphasizes this need, and moreover underscores the necessity to collect these data on a routine basis. Collecting such data as needed to address an issue at hand often makes them suspect in a number of regards, particularly in terms of strategic bias.

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

13.5.1 Commercial Fisheries

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

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

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

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 only gives qualitative descriptions of bycatch meaning they do not document the amount or quantity of bycatch but rather only document the species or type of bycatch encountered at the fish processing plant. In order to confirm bycatch rates derived from CDFG's dock-side sampling, NMFS started a pilot observer program in July 2004 on the California purse seine fishing vessels landing CPS in the LE fishery. The pilot observer program's main focus is to gather data on total catch and bycatch, and on interactions between their fishing gear and protected species such as marine mammals, sea turtles, and sea birds. See Section 6.1.1 for additional information and preliminary results from this program.

13.7 References

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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-Stevens Act (MSA), the federal law that governs U.S. marine fisheries management. The re-named Magnuson-Stevens Act mandated the identification of 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 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 EFH identification recommendation and amendment should include a provision to review and update EFH information and prepare a revised FMP amendment 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 (62 *FR* 66531, December 19, 1997).

14.1 Process for five-year Review of CPS EFH

The CPSMT initiated review of recent relevant literature, and is working with NMFS to determine whether new information warrants amending the existing description of EFH for CPS species. Council Staff will coordinate continued review of CPS EFH, soliciting input from interested parties, and will make a recommendation during summer, 2010. Below is more information regarding the status or CPS EFH five-year review.

The following questions are being considered in determining whether newly-available information warrants revisions to CPS EFH:

1. Is the original data used to identify and describe CPS EFH still accurate and relevant?
2. Is there new data is available that may help describe CPS EFH?
3. Is the original fishing gear impacts analysis consistent with any new data, including any analyses of similar gear used in other fisheries?
4. Are there new non-fishing impacts that warrant a change in CPS EFH?
5. Does the CPS to provide adequate forage for dependent species?

The review process was initiated at a meeting of the CPSMT in January, 2010, in La Jolla, California, with a discussion of the existing EFH, habitat needs, and new information. The team compiled three publications and one unpublished manuscript (see Section 1.3, References) relevant to CPS habitat needs and associations. The CPSMT again discussed CPS EFH at their April 27-30, 2010 CPSMT meeting in Portland, Oregon.

14.2 Description of EFH

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 EFH for CPS may be found in Appendix D. In determining EFH for CPS, the estuarine and marine habitat 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. 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.

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 definition of EFH. This definition 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.*

14.3 References

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