

MEASURES FOR INTEGRATING NEW PROVISIONS OF THE MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT AND NATIONAL STANDARD 1 GUIDELINES INTO COASTAL PELAGIC SPECIES MANAGEMENT

*AMENDMENT 13 TO THE COASTAL PELAGIC SPECIES FISHERY MANAGEMENT PLAN
PARTIAL DRAFT ENVIRONMENTAL ASSESSMENT*

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1.0 INTRODUCTION

The Pacific Fishery Management Council's (Council's) Coastal Pelagic Species (CPS) FMP includes harvest control rules for actively managed species (Pacific sardine and Pacific mackerel) that are intended to prevent overfishing while maintaining relatively high and consistent catch levels over the long-term. The CPS FMP's monitored stocks (northern anchovy, jack mackerel, market squid) are either State-managed or are currently harvested at low levels. The CPS FMP has a third category of prohibited harvest species that currently includes all west coast species of Euphausiids (krill). Background material on the history and status of CPS stocks and CPS fisheries can be found in the latest version of the *Stock Assessment and Fishery Evaluation* document which is posted on the Council's web page. The final Environmental Assessment (EA) will be developed after the June 2010 Council meeting when the final preferred alternative for Amendment 13 is decided.

1.1 PURPOSE AND NEED

The proposed action is to revise relevant sections of the CPS FMP to ensure they are consistent with advisory guidelines published in Federal regulations at Section 600.310. The guidelines describe fishery management approaches to meet the objectives of National Standard 1 found in the Magnuson-Stevens Fishery Conservation and Management Act (MSA), Section 301. National Standard 1 (NS1) states "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry."

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA) amended the MSA to include new requirements for annual catch limits (ACLs) and accountability measures (AMs) and other provisions regarding preventing and ending overfishing and rebuilding fisheries. NMFS revised NS1 Guidelines in response to these changes in the MSA. The NS1 Guidelines were published in the Federal Register on January 16, 2009. These revisions to the NS1 guidelines address, among other things, new requirements for fisheries undergoing overfishing, to have ACLs and AMs to end overfishing by 2010, and all fisheries to have ACLs and AMs in place to prevent or end overfishing by 2011, and beyond. A stock or stock complex may not require an ACL and AMs if it qualifies for a statutory exception under the Magnuson-Stevens Act. The NS1 Guidelines also discuss how stocks should be classified in the FMP. As part of this action the CPSMT evaluated all the species and stocks identified in the FMP in light of available information on catch to consider possible reclassification.

The Guidelines are intended to meet the objectives of NS1 by providing guidance on:

1. Specifying maximum sustainable yield (MSY) and OY;
2. Specifying status determination criteria (SDC) so that overfishing and overfished determinations can be made for stocks and stock complexes that are part of a fishery;
3. Preventing overfishing and achieving OY, incorporation of scientific and management uncertainty in control rules, and adaptive management using annual catch limits (ACL) and measures to ensure accountability (AM); and

4. Rebuilding stocks and stock complexes.

The Council is revising the CPS FMP to be consistent with revised NS1 Guidelines in order to more effectively prevent overfishing and rebuild overfished stocks, or stocks that may become overfished.

1.2 AMENDMENT 13 PROCESS AND SCHEDULE

The Council held scoping sessions at its March and November 2009 meetings on amending the CPS FMP to address the National Standard 1 guidelines. A complete record of the scoping comments received is available on the Council web site or by contacting the Council office. Scoping comments 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 improve inseason harvest reporting. Additionally, the review of CPS harvest control rules has been identified by the Council as a high priority research need.

In November 2009, the Council supported alternatives proposed by Council staff regarding stock status determination criteria and alternative management frameworks. Specifically, the Council supported analyses of sector- specific ACLs and requested an analysis of ACTs to address management uncertainty and to buffer against overfishing. As additional guidance, the Council placed a higher priority on time-sensitive MSA requirements such as ACLs and ABC control rules and put a lower priority on the consideration of optional provisions such as including additional forage species in the CPS FMP and the development of mechanisms to streamline inseason management.

In March 2010, the Council reviewed a draft analysis of proposed alternatives and, for some, identified a preliminary preferred action and provided guidance on further alternative development and analysis. Also, the Council moved to not consider alternatives at this time that propose to remove species from the CPS FMP thus transferring them to State management. The Council's preliminary preferred alternatives for Amendment 13 are noted in this document where applicable.

This draft Environmental Assessment (EA) was prepared by the Council's CPSMT, Council staff, and NMFS staff. This report presents Amendment 13 alternatives derived from Council deliberations, Council Advisory Body recommendations, scoping comments, and Council staff to bring the CPS FMP into compliance with the reauthorized MSA.

2.0 DESCRIPTION OF ALTERNATIVES

Legal requirements of the MSRA and the MSA combined with the policy guidance from NMFS on implementing NS1 require new provisions such as overfishing limits (OFLs) and ACLs be included in FMPs and management practices to end and prevent overfishing within a specific timeframe.

2.1 STOCK CLASSIFICATIONS

2.1.1 STOCKS "IN THE FISHERY"

According to NS1 guidelines (' 600.310(d)(1)), all stocks in an FMP are considered to be "in the fishery" by default, unless they are identified as ecosystem component (EC) species. Species "in the fishery" are generally targeted and sold commercially or retained for personal use. All species in the fishery require specification of SDCs, including: OFL; MSY; allowable biological catch (ABC); optimum yield (OY); and most require ACLs and AMs to prevent overfishing. Stocks that exhibit annual life cycles or stocks managed under international agreements to which the United States is a party are exempt from the new measures, such as the ACL, AM, etc. requirements. No CPS are currently managed under international agreements, but market squid would be considered exempt, given this species' longevity is less than one year.

The NS1 guidelines identify reference points for stocks "in the fishery" which will likely include FMP species in the actively managed and monitored categories and may include krill in the prohibited harvest category. Market squid are exempt from ACL and AM requirements because of their annual life cycle.

Species in the actively managed category as well as market squid and northern anchovy in the monitored species category are target species and thus, would be considered "in the fishery". The other species in the monitored category, jack mackerel, is currently targeted to a much lesser degree than the two actively managed species, but when encountered is generally retained for sale.

Harvest for krill is currently prohibited under the FMP and Federal regulation. Ecosystem considerations were a key element of the rationale for the prohibition; krill may be a candidate for an EC species.

2.1.2 ECOSYSTEM COMPONENT SPECIES

The specification of EC species is optional and there are several criteria that should be met for a species to be included in the EC category (' 660.310(d)(5)(i)). These are:

- Be a non-target stock/species;
- Not be subject to overfishing, approaching overfished, or overfished and not likely to become subject to overfishing or overfished in the absence of conservation and management measures; and,
- Not generally retained for sale or personal use, although "occasional" retention is not by itself a reason for excluding a species from the EC category.

Comments received during the scoping sessions have requested that the Council consider the addition of forage species not currently in the FMP as EC species (i.e., Pacific saury,

myctophids, Pacific sand lance, white bait smelt, and other smelts). The intent of the request is to monitor a set of forage species and to report on their trends, status, and ecological roles, and not to develop a fishery.

2.1.3 SUMMARY OF STOCK CLASSIFICATION ALTERNATIVES

Alternative 1, No Action Alternative– All species currently in the CPS FMP, including krill are included “in the fishery” in their existing category and no EC species are established.

Alternative 2, Preliminary Preferred Alternative - All species currently in the actively managed and monitored species categories of the CPS FMP are “in the fishery” and krill are reclassified as an EC species.

Alternative 3 – Add additional forage and/or bycatch species to the CPS FMP as EC species. (This alternative can be eliminated or coupled with Alternative 1 or 2 above.

2.2 STATUS DETERMINATION CRITERIA

Status Determination Criteria exist in the current CPS FMP with the exception of the new OFL provision (see Section 3.2). Although the Council and the CPSMT have identified the review of some of the existing SDCs as priority research needs, the process of reviewing and potentially revising the existing SDCs is outside the scope and the allotted time of Amendment 13.

The use of an MSY control rule for actively managed stocks is designed to provide 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.

The main use of an MSY control rule for a monitored stock is to help gauge the need for active management and to trigger such consideration before a stock is experiencing overfishing. While landings are low and the stock remains in the monitored category, its status is assessed infrequently making estimates of MSY or minimum stock size thresholds (MSST) difficult and impractical. MSY control rules and harvest policies for monitored CPS stocks may be more generic, precautionary, 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.

The CPS FMP currently does not include an estimate of or proxy for MSY or OY for the Northern subpopulation of Northern Anchovy. As for other species in the monitored category, an estimate of biomass and a proxy MSY harvest level is an important part of establishing reference points for determining if and when the stock status warrants active management (see section 2.3).

2.2.1 SUMMARY OF STOCK DETERMINATION CRITERIA ALTERNATIVES

Alternative 1, No Action Alternative – Maintain existing SDCs for CPS FMP stocks.

Alternative 2, Preliminary Preferred Alternative - Maintain existing SDCs for CPS FMP stocks and develop an MSY proxy for the Northern subpopulation of Northern anchovy.

2.3 OVERFISHING LEVELS, ACCEPTABLE BIOLOGICAL CATCH, AND ANNUAL CATCH LIMITS

The NS1 guidelines envision OFL to correspond to the best available estimate of MSY stock size. The guidelines also call for an assessment of scientific uncertainty in the estimate of MSY and the development of an ABC control rule that addresses scientific uncertainty and management risk when setting an ABC level below the OFL. Given the differences in harvest levels and available information on stock status between actively managed and monitored stocks, it is recommended that the existing “tiered” system be modified to meet new provisions to prevent overfishing while recognizing the amount of available data for each tier or category and the appropriate management response based on fishing pressure.

2.3.1 ACTIVELY MANAGED SPECIES

Because of their importance to current fisheries, Pacific sardine and Pacific mackerel are actively managed. Assessments and management measures are revised, reviewed, and adopted on an annual basis. This relatively intensive management strategy responds to year-to-year changes in stock dynamics for these productive stocks and places these species in the top management tier due to a greater understanding of stock status and management performance.

Determining the degree to which the provisions in the existing harvest control rules adequately buffer CPS stocks from overfishing will be a critical step in ensuring the amended CPS FMP meets the new NS1 requirements. The SSC Groundfish and CPS Subcommittees have worked on the development of a framework for factoring scientific uncertainty into harvest control rules by quantifying assessment variability for stocks with a history of multiple assessments as a basis for evaluating the size of a scientific uncertainty buffer (i.e., the difference in yield between the OFL and the ABC) and the risk of overfishing the stock. Scientific uncertainty would be expressed in terms of a BUFFER that is a combination of quantified assessment uncertainty and a policy choice by the Council regarding the estimated risk of overfishing (see Agenda Item G.5.b, Supplemental SSC Groundfish and CPS Subcommittees Report, *An Approach to Quantifying Scientific Uncertainty in West Coast Stock Assessments*, from the November 2009 Council Briefing Book available on the Council web page). Revised SSC recommendations were brought forward at the March 2010 meeting and are also available on the Council web site.

Alternative 1, No Action Alternative – Maintain the existing harvest control rules to specify the new management reference points.

Overfishing Definition	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ABC	
HG	

Alternative 2 – Modify existing harvest policy to specify the new management reference points with no additional buffering for scientific uncertainty.

OFL	BIOMASS * F_{MSY} * DISTRIBUTION
ABC	BIOMASS * F_{MSY} * DISTRIBUTION
HG	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ACL	EQUAL TO HG OR ABC, WHICHEVER VALUE IS LESS

Alternative 3 – Scientific Uncertainty Buffer – Modify the existing harvest control rules to include a buffer or reduction in ABC relative to OFL to account for scientific uncertainty.

OFL	BIOMASS * F_{MSY} * DISTRIBUTION
ABC	BIOMASS * BUFFER * F_{MSY} * DISTRIBUTION
ACL	LESS THAN OR EQUAL TO ABC
HG	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ACT	EQUAL TO HG OR ACL, WHICHEVER VALUE IS LESS

2.3.2 MONITORED FINFISH AND SQUID SPECIES

Monitored stocks are either currently landed at relatively low levels or are managed primarily at the State level. The default MSY control rule for monitored stocks sets the ABC at 25 percent of estimated MSY levels making it more conservative than the MSY control rules for actively managed species for which more data and more current assessments exist. This approach is similar to “tiered” approaches used in North Pacific Fishery Management Council FMPs and the Council’s Groundfish FMP where harvest specifications and reference points differ for categories or tiers of species based on the amount and quality of data that is available for management. Because monitored stocks are not annually assessed or managed, the Council may recommend that ACLs for monitored species be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

Alternative 1 – Maintain the default harvest control rules as modified to specify the new management reference points. ACLs would be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

OFL	STOCK SPECIFIC MSY PROXY
ABC	OFL * 0.25
ACL	Equal to ABC or reduced by OY considerations.

Alternative 2 – Scientific Uncertainty Buffer – Modify the existing harvest control rules to include a buffer or reduction in ABC relative to OFL to account for scientific uncertainty. This reduction would be in addition to the precautions build into the default control rule. In practice either a BUFFER recommended by the SSC could be added to the ABC control rule as shown below, or a greater than 75 percent reduction from OFL could be instituted. ACLs would be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

OFL	STOCK SPECIFIC MSY PROXY
ABC	OFL * 0.25 * BUFFER
ACL	Equal to ABC or reduced by OY considerations.

Market squid are also a monitored species under the CPS FMP, but the current MSY proxy for market squid is completely different from the finfish species and uses an escapement method detailed in Section 4.3.2.1.

2.3.3 SECTOR-SPECIFIC ACLS

The NS1 guidelines allow for sector specific ACLs and recommend their use if a stock is targeted by multiple fishery sectors, each with their own level of monitoring and inseason management. Alternatively, the landings associated with the following activities could be incorporated into management as AMs or ACTs (see section 2.4).

The Council has expressed an interest in continuing the practice of setting aside a portion of the Pacific sardine harvest for the purpose of conducting research under an exempted fishing permit (EFP). In November 2009, the Council recommended including this EFP research in the management framework as fishery sector with a specific ACL. Mortality associated with other research programs with NMFS or other agencies is not intended to be included in this EFP research sector and are proposed to be considered as AMs.

California live bait fishery may be a candidate for a sector specific portion of the overall ACL. In November 2009, the Council did not recommend this management approach. However, the CPSMT and Council staff discussed the merits of establishing a sector-specific ACL for the live bait fishery and is asking the Council to reconsider or reaffirm their November 2009 recommendation. This fishery is small but important and supplies bait fish primarily for recreational vessels. The fishery is not actively monitored or managed inseason, but landings are estimated at the end of the year. The Council could choose to adopt one or both of Alternatives 2 and 3.

Alternative 1, No Action Alternative – No sector-specific ACLs.

Alternative 2 - Assign a sector-specific ACL to EFP research activities.

Alternative 3 – Assign a sector-specific ACL for the live bait fishery.

Alternative 4 – Add sector-specific ACLs to the FMP framework as a management tool and assess their applicability on an annual basis.

2.4 ANNUAL CATCH TARGETS AND ACCOUNTABILITY MEASURES

Annual catch targets (ACTs) are optional reference points designed to account for management uncertainty when setting target levels below ACLs. Accountability Measures (AMs) are management controls to prevent ACLs from being exceeded and to correct or mitigate overages of the ACL if they occur. Good inseason management of CPS fisheries exists through catch monitoring, and the fishery can be closed quickly by NMFS through an automatic regulatory action. However, several aspects of CPS fisheries warrant the consideration of ACTs.

2.4.1 MANAGEMENT UNCERTAINTY

Harvest levels for the directed Pacific sardine fishery have been declining in recent years and have created a derby-style fishery. This has increased the rate at which the seasonal allocations are taken and added additional management uncertainty. The Council has recently begun setting aside portions of the Pacific sardine and Pacific mackerel harvest to account for “management uncertainty” or the potential errors in monitoring and reporting landings and closing the fishery before overfishing occurs. This proactive approach could be included as part of the establishment of an ACT. In recent years, the CPSMT and the CPSAS have assessed the nature of the fishery, the effectiveness of inseason reporting mechanisms, and the regulatory processes necessary to close the fishery when recommending buffers to account for management uncertainty.

2.4.2 TOTAL CATCH ACCOUNTING

Under the NS1 guidelines “catch” is defined to include all sources of mortality associated with a fishery (discards, research impacts, incidental landings, etc.). To meet the NS1 requirements and account for total mortality in the catch, a consideration of additional sources of mortality when setting an ACT could be prudent.

Discard Mortality

Discards do occur in CPS fisheries when a vessel captures more fish than can be brought onboard or when a school of an undesirable species composition is captured and then released. There is limited observer and logbook data available to enumerate the mortality associated with these discards. To meet the NS1 requirements and account for total mortality in the catch, the estimation of discard mortality when setting an ACT could be analyzed as an alternative. The CPSMT has discussed ways of assessing discard mortality and could, on an annual basis, make recommendations on discard mortality.

Incidental Fishery Impacts

Under the current management regime, the Council has been in the practice of setting aside a portion of the Pacific mackerel and the Pacific sardine HGs for the purpose of protecting other CPS fisheries that may land these species incidentally after their respective directed fisheries close. The Council may recommend an approach within the scope of the existing management strategies that would set aside a portion of an ACT to cover incidental landings.

Research Impacts (not including set asides for EFPs)

The California Cooperative Oceanic Fisheries Investigations and NMFS conduct annual research cruises for the purpose of monitoring many ecological and biological parameters in the support of fishery management. A substantial portion of these research initiatives is focused on CPS. Although small (generally assessed at around 1 mt for Pacific sardine in recent years), these sources of mortality are well documented and can easily be incorporated into the annual management cycle.

Live Bait Fisheries

In November 2009 the Council recommended that mortality associated with live bait harvest not be included as a separate fishery sector with its own ACL, but rather be treated as an AM in the directed commercial fishery. Under this scenario, a preseason estimate of mortality, however small, from live bait fisheries would be taken into account when establishing an ACT for the directed fisheries.

2.4.3 ANNUAL CATCH TARGETS FOR MONITORED STOCKS

The current management framework for monitored stocks is intended to provide a mechanism for alerting the CPSMT and the Council to potential conservation concerns that may warrant elevating a species from the monitored category to the actively managed category. Current OYs or proposed ACLs currently function as the level of landings that are generally used to assess the need for active management. The CPSMT and the SSC CPS Subcommittee have discussed using either a recent average catch or a recent highest catch level as an ACT that would alert the Council of increasing landings to allow time to plan for the management response to moving to an actively managed status (i.e., scheduling a stock assessment and revising harvest control rules and SDCs).

2.4.4 SUMMARY OF ACT AND AM ALTERNATIVES

The Council does not have to include ACTs in the CPS FMP and could choose Alternative 1. Additionally, the Council could choose to adopt one or both of Alternatives 2 and 3.

Alternative 1, No Action Alternative – No ACTs.

Alternative 2 – Develop ACTs only for actively managed stocks.

Alternative 3 – Develop ACTs for actively managed and monitored stocks.

2.6 ALTERNATIVES CONSIDERED BUT REJECTED

The following alternatives are not required by the MSRA or the NS1 guidelines, but were identified during the scoping of Amendment 13 as issues that may be addressed as time and workload allows. At this time, the Council has determined that these alternatives will not be considered under Amendment 13.

2.6.1 IMPROVED INSEASON MONITORING

Several preseason and inseason accountability measures exist in the CPS fisheries. In March 2009, under the scoping period for this amendment, the CPSMT and the CPS Advisory Subpanel

recommended several ways to improve the inseason monitoring and management of CPS fisheries.

Recommended actions for consideration include:

- Improving inseason management flexibility to open or close the fishery faster by revising reporting requirements (e.g., processors faxing information daily), setting daily trip limits, and opened/closed days, and
- Exploring a shift in the start date of the Pacific sardine fishery from January 1 to July 1 to allow additional time for stock assessment work and the development of new fishery-independent indices of abundance.

Council has been receptive to the potential management improvements these measures could provide, but Council direction since March 2009 has consistently recommended focusing efforts on those aspects of Amendment 13 that are required to be in place by 2011 and only address these improvements to the FMP as time and workload allows. The CPSMT briefly discussed the merits of these alternatives, but has not had time to fully consider their implementation under this amendment. The Council has not elevated the priority of these optional alternatives and is no longer considering this action under Amendment 13.

2.6.2 STATE AND FEDERAL MANAGEMENT OF CPS

In recent years, the CPSMT has discussed the suite of stocks in the CPS FMP and their appropriate classification as monitored or actively managed species (e.g., moving Pacific mackerel to the monitored species category in light of multiple years of low harvest and diminished data series for assessing stock status, and potentially moving northern anchovy to the actively managed category). The CPSMT has also reviewed the science and harvest policies for market squid in recent years to determine the need, if any, to revise management. The CPSMT has discussed the costs and benefits of including two monitored species in the CPS FMP versus transferring management authority to the State of California. Commercial landings of market squid and jack mackerel occur almost exclusively in California and are either currently managed under a California State FMP (market squid) or have been landed at low and generally declining levels for many years (jack mackerel). There are a considerable number of research and data needs identified for the CPS FMP and focusing available science and management resources on fewer FMP stocks may have benefits. Given the need to review stock classifications and reference points for Amendment 13, exploring Federal versus State management of CPS FMP stocks could be prudent at this time. At its November 2009 meeting, the Council directed the CPSMT to consider the following alternatives:

- Alternative 1, – All species, including market squid and jack mackerel remain in the CPS FMP and no species is transferred to state management.
- Alternative 2 – Remove market squid from the CPS FMP and Federal management and transfer that authority to the State of California.
- Alternative 3 – Remove jack mackerel from the CPS FMP and Federal management and transfer that authority to the State of California.

At its March 2010 meeting the Council moved for no further consideration these alternatives or the removal of species from the CPS FMP under Amendment 13.

3.0 AFFECTED ENVIRONMENT

Background material on the history and status of CPS stocks and CPS fisheries can be found in the latest version of the *Stock Assessment and Fishery Evaluation* document which is posted on the Council’s web page. The following sections contain background information that may be particularly pertinent for the review of Amendment 13.

3.1 STOCK CLASSIFICATIONS

Stocks in the CPS FMP are classified under the following management categories: actively managed; monitored; and prohibited harvest species (Table 2.1-1). The CPS FMP is based on a management framework designed to react quickly to changes in the fisheries and/or stocks, with the CPSMT providing advice on classification changes in accordance with fishery/stock dynamics.

Table 3.1-1 Stocks currently managed under the CPS FMP.

Management Category	Common Name	Scientific Name
Actively Managed	Pacific sardine	<i>Sardinops sagax</i>
	Pacific (chub) mackerel	<i>Scomber japonicus</i>
Monitored	Northern anchovy Central and Northern Subpopulations	<i>Engraulis mordax</i>
	Market squid	<i>Loligo opalescens</i>
	Jack mackerel	<i>Trachurus symmetricus</i>
Prohibited Harvest	Krill or Euphausiids All West Coast EEZ Species Eight dominant species First two species are common and are the most vulnerable to fishing.	<i>Euphausia pacifica</i> <i>Thysanoessa spinifera</i> <i>Nyctiphanes simplex</i> <i>Nematocelis difficilis</i> <i>T. gregaria</i> <i>E. recurva</i> <i>E. gibboides</i> <i>E. eximia</i>

3.2 STATUS DETERMINATION CRITERIA

Table 3.2-1 describes SDCs as specified under the CPS FMP. Some SDCs for monitored stocks are not specified. Landings of these species are currently small and assessment data are often either dated or non-existent. The CPSMT is working on methods for determining a biomass estimate for the Northern subpopulation of Northern anchovy and some preliminary values are presented in Section 3.3.

Table 3.2-1. CPS FMP specifications for Status Determination Criteria

	MSY	MFMT	MSST	ABC	OY
Pacific sardine	MSY control rule	Catch exceeding ABC	50,000 mt	Equal to MSY control rule calculation	Currently at or below MSY
Pacific (chub) mackerel	MSY control rule	Catch exceeding ABC	18,200 mt	Equal to MSY control rule calculation	Currently at or below MSY
N. anchovy Northern Subpop.	Not specified	Catch exceeding ABC	Not specified	25% of MSY Catch level	Not specified
N. anchovy Central Subpop.	Estimated at 123,000 mt	Catch exceeding ABC	50,000	25% of estimated MSY or 31,000mt 25,000mt in U.S.	Currently at or below ABC
Market squid	F_{MSY} resulting in egg escape-ment $\geq 30\%$	F_{MSY} resulting in egg escape-ment $\leq 30\%$	Not specified	F_{MSY} resulting in egg escape-ment $\geq 30\%$ mt	107,049mt
Jack mackerel	Age/Area based potential yield	Catch exceeding ABC	Not specified	48,000mt 31,000mt in U.S.	Currently at or below ABC
Krill or Euphausiids	Not specified	Not specified	Not specified	Not specified	0

3.3 HARVEST CONTROL RULE FOR ACTIVELY MANAGED SPECIES

The following is a brief summary of the default harvest control rule for actively managed species. See the CPS SAFE document and Section 4.3 for additional background information.

The harvest control rule for actively managed species.

$$\text{HARVEST GUIDELINE} = (\text{BIOMASS-CUTOFF}) \times \text{FRACTION} \times \text{DISTRIBUTION}$$

where:

FRACTION is the fraction of the BIOMASS above the CUTOFF value that can be harvested, for Pacific sardine this is an environmental driven component that is based on sea surface temperature.

DISTRIBUTION is the percentage of the stock assumed to be in U.S. waters.

CUTOFF is the estimated biomass below which directed harvest is not allowed. 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 for the spawning stock that is protected from fishing and available for use in rebuilding if a stock becomes overfished. An additional parameter for Pacific sardine, MAXCAT (maximum catch per the HCR, regardless of BIOMASS), was set at 200,000 mt under Amendment 8 to the CPS FMP.

3.4 HARVEST CONTROL RULES FOR MONITORED AND PROHIBITED HARVEST SPECIES

Table 3.4-1 presents potential reference points for monitored species under the proposed Amendment 13 framework. Values for the northern subpopulation of northern anchovy are based on preliminary work of the CPSMT and will likely be revised as more data are analyzed. The Council will likely revisit some or all of these reference points after a final preferred alternative is adopted and approved by the Secretary.

Table 3.4-1 Potential Reference Points in the CPS FMP		
Jack Mackerel	Source: MacCall and Stauffer (1983)	
OFL	$B * F_{MSY} * \text{Distribution}$ 195,000mt*0.65	124,800 mt
ABC	OFL * 0.25	31,000 mt
ACL	Equal to ABC	31,000 mt
Northern Anchovy, Northern Subpop.	Source: Preliminary acoustic biomass estimate, Zwolinski et al., in prep; Advanced Survey Technologies-SWFSC, 2010	
OFL	$B * F_{MSY}$ 159,800 mt (CV>0.88) * F_{MSY} ?	Not specified
ABC	OFL * 0.25	Not specified
ACL	Equal to ABC	Not specified
Northern Anchovy, Central Subpop.	Source: Conrad (1991) 123,000 F_{MSY} at biomass of 733,000mt	
OFL	$B * F_{MSY} * \text{Distribution}$ 123,000mt*0.82	100,860 mt
ABC	OFL * 0.25	25,215 mt
ACL	Equal to ABC	25,215 mt
Market Squid	Source: CPS FMP Amendment 10 and California State FMP for market squid.	
OFL/MSST	F_{MSY} Resulting in Egg Esc > 30%	NA
ABC	F_{MSY} Resulting in Egg Esc > 30%	NA
ACL	California Landing Limit	107,047 mt
Krill	Source: Amendment 12 to the CPS FMP	
OFL	No Operational Purpose	
ABC	No Operational Purpose	
ACL	Prohibited Harvest, de minimus amounts tolerated	0

Section References

CDFG. 2005. Market Squid Fishery Management Plan. March 25, 2005.

PFMC 2002. Coastal Pelagic Species Fishery Management Plan. Limited Entry

Conrad J. M. 1991. A bioeconomic analysis of the northern anchovy. NMFS, Southwest Fisheries Science Center Admin. Rep. LJ-91-26: 34 p.

MacCall, A.D., and G. D. Stoufer. 1983. Biology and fishery potential of jack mackerel (*Trachurus symetricus*) CalCOFI Rep. 24: 46-56.

PFMC (1998) CPS FMP Amendment 8 Appendix B.

PFMC (2002) CPS FMP Amendment 10

4.0 ANALYSES OF THE ALTERNATIVES

4.1 STOCK CLASSIFICATION CONSIDERATIONS

Alternative 1 – All species currently in the CPS FMP, including krill are included “in the fishery” in their existing category and no EC species are established.

Species in the actively managed category as well as market squid and northern anchovy in the monitored species category are target species and thus, would be considered “in the fishery”. The other species in the monitored category, jack mackerel, is currently targeted to a much lesser degree than the two actively managed species, but when encountered is generally retained for sale.

Regarding the krill species in the prohibited harvest category, harvest for krill is currently prohibited in any fishery within the West Coast Exclusive Economic Zone (EEZ) under the FMP and Federal regulation. Until the EC designation is more fully developed, maintaining krill “in the fishery” may be the more appropriate course to ensure the intent of Amendment 11 and the current harvest ban. Although ecosystem considerations were a key element of the rationale for the prohibition krill are not an explicit component of CPS fisheries and because of this and the existing broad prohibition, which also prevents the conceivable development of a targeted fishery in the future, may be rationale to continue to include krill and its broad regulatory harvest prohibition as a species “in the fishery”. Additionally, the requisite SDCs for krill were established or omitted with good rationale under Amendment 12 to the CPS FMP. Currently OY for krill is defined as zero and harvest has been prohibited. Because of these reasons it was determined during the implementation of Amendment 12 that specifications of MSY and of SDC do not have any operational purpose. As with the management reference points adopted for krill under Amendment 12, establishment of new SDCs such as OFLs and ABCs may also not be needed and NMFS staff are reviewing cases around the nation for similar applications to draw from in this unique situation.

Alternative 2, Preliminary Preferred Alternative - All species currently in the actively managed and monitored species categories of the CPS FMP are “in the fishery” and krill are reclassified as an EC species.

As noted above, ecosystem considerations were a critical component of the rationale behind prohibiting their harvest. Recognition of the vital role krill play in the food web and the importance of this species to the productivity and recovery of groundfish stocks declared overfished and salmon stocks listed under the Endangered Species Act. However, the EC category is in part intended as a vehicle to monitor fishery impacts to non-target species to determine if such impacts could be contributing to the overfishing of an EC species. This is may not be a good fit for krill which is not targeted in any fishery and is not a substantial bycatch species in CPS fisheries.

The Council has initiated the development of an Ecosystem Fishery Management Plan (E-FMP) and has appointed a plan development team and advisory subpanel. The identification and monitoring of indicator species and the role species play in the food web are likely to be important issues for

the E-FMP, which is intended as an over-arching framework for all four of the Council's existing FMPs. It may become more practical to monitor species for their ecological role and associated ecosystem functions under the E-FMP rather than in the EC categories of the Council's four FMPs.

Alternative 3 – Add additional forage and/or bycatch species to the CPS FMP as EC species. (This alternative can be eliminated or coupled with Alternative 1 or 2 above).

A review of available landings and bycatch information from the CPS fisheries indicates that the incidence of what might be considered EC species in the landings and in the bycatch of West Coast CPS fisheries appears to be very low (Harrington et al. 2005; PFMC 2008, 2009).

There are many small pelagic nekton species (primarily fish and squid) that are not presently a target of commercial fisheries and not likely to be subjected to overfishing. However, these species are critical for the ecosystem services (forage) they provide to living marine resources in the California Current. These forage species are not generally retained for sale or personal use, but may be caught as bycatch in many fisheries. These forage species, together with presently managed coastal pelagic species, comprise the forage base for the California Current ecosystem. Large and small upper-trophic level species feed on this suite of forage. At this time, the abundance, status, and trends of many forage species are poorly understood. However, the abundance and distribution of these forage species probably affects the total number of the CPS that are consumed by upper-trophic species. As the Council moves to developing an E-FMP, it is important that key populations of forage species are monitored, their role in the food web identified, as well as identifying how fluctuations in forage species abundances affect CPS abundance.

4.1.1 EVALUATION OF ADDITIONAL ECOSYSTEM COMPONENT SPECIES

A review of incidental and bycatch data reported in the CPS SAFE (Section 6) was completed; landings and bycatch data in CPS fisheries were compiled from logbooks, observer records, and landing receipts. Across all CPS fisheries, incidental catch by weight is comprised largely of other CPS species. A number of finfish, invertebrates and elasmobranchs constitute incidental catch and bycatch in nominal amounts.

This analysis confirmed that incidental catch and bycatch in CPS fisheries is dominated by other CPS and that bycatch/incidental catch of non-CPS is extremely low. In California the most encountered species occur at annual levels of approximately 5 mt or less and include Pacific bonito, white croaker and jacksmelt. In Oregon and Washington levels are much lower, 1 mt or less and include Pacific hake and spiny dogfish.

Additionally, these data was cross-referenced with a list of forage fish species, some of which are already FMP species (Table 4.1.1). The scope of this review is limited to the identification of forage species which might fit in the CPS FMP as EC species and since measures by which to evaluate species for inclusion in the FMP have not been previously been identified, the factors specified in the NS1 guidelines for EC designation were considered.

TABLE 4.1-1. Important forage species. YOY indicates young-of-the-year.

Common Name	Scientific Name
Euphausiid (krill)	Euphausiidae
California market squid	<i>Loligo opalescens</i>
Neon flying squid	<i>Ommastrephes bartramii</i>
Boreal Clubhook Squid	<i>Onychoteuthis borealijaponica</i>
American shad	<i>Alosa sapidissima</i>
Pacific herring	<i>Clupea pallasii</i>
Smelts	Osmeridae
Surf smelt	<i>Hypomesus pretiosus</i>
Night smelt	<i>Spirinchus starksi</i>
Longfin smelt	<i>Spirinchus thaleichthys</i>
Eulachon	<i>Thaleichthys pacificus</i>
Whitebait smelt	<i>Allosmerus elongatus</i>
Topsmelt	<i>Atherinops affinis</i>
Jacksmelt	<i>Atherinopsis californiensis</i>
Californian grunion	<i>Leuresthes tenuis</i>
Lantern fish	Myctophidae
Codfishes YOY	Gadidae
Pacific tomcod	<i>Microgadus proximus</i>
Pacific saury	<i>Cololabis saira</i>
Rockfishes YOY	<i>Sebastes</i> spp.
Greenlings YOY	<i>Hexagrammos</i> spp.
Pacific sandlance	<i>Ammodytes hexapterus</i>
Sanddab spp.	<i>Citharichthys</i> spp.

Forage species that have been suggested by public comment for consideration for inclusion in the FMP as EC species include Pacific saury, Pacific sandlance, whitebait smelt and myctophids. These species are not targeted by any CPS fishery, nor is there any documented incidental catch or bycatch in logbooks, fish tickets or observer data. Therefore, inclusion of these species in the FMP as EC species might be considered for other “ecosystem issues”.

Although those species proposed through public comment are not caught while fishing for CPS, other forage species are caught in CPS fisheries including sanddabs (currently in the Council’s groundfish FMP), smelts, California grunion and American shad. Therefore these species potentially could be added to the CPS FMP and designated as EC species of the CPS fishery. The following species are not specifically targeted by CPS fisheries, are landed at levels that overfishing or overfished concerns are unlikely, and except for one species of smelt (jacksmelt) are generally not retained for sale or personal use.

- Sanddabs: Reported in California bycatch observations of CPS finfish and market squid fisheries. Observations are made for presence or absence of bycatch in sampled landings; amounts are not quantified but the percent frequency is calculated. For 2004-2008 the

percent frequency for sanddabs in CPS finfish fishery landings ranged from 2.1 to 5.1 and ranged from 1.3 to 4.9 in CPS market squid fishery landings. In Washington, sardine fishery onboard observer data from 2000-2004 noted fewer than two dozen individual sanddabs total; and in Oregon sanddabs have not been recorded by observers or in logbooks and appear on fish tickets in two of ten years, totaling less than 0.002 mt in those years.

- Smelts: Except for jacksmelt, smelt species are infrequently observed in California CPS finfish and market squid fisheries based on bycatch observations (maximum percent frequency of any observed smelt spp. was 0.6 from 2004-2008). Jacksmelt are landed and sold; landings were noted in each year from 2000 through 2009, and averaged 5.79 mt. Smelt were not documented as bycatch in the Washington sardine observer program suggesting they rarely occur in the fishery, and smelt have not been reported on fish tickets. The sardine fishery in Washington is limited to fishing outside 3 miles and, therefore, is not likely to encounter forage species that typically inhabit estuaries or nearshore areas. Smelt species are not recorded on fish tickets from landings in the Oregon sardine fishery, nor are they reported in logbooks.
- California Grunion: From 2004-2008, California grunion was only observed in 3 years and at a percent frequency of 0.3 or less. Oregon and Washington are beyond the typical range for California grunion.
- American shad: Landings of shad are documented on fish tickets in both Oregon and Washington. Since 2002, landings were recorded in four years in Oregon and two years in Washington. Landings in Oregon ranged from 0.3 to 1.2 mt, and were 0.18 mt and less than 0.01 mt for Washington.

Herring and jacksmelt are also both listed as important forage species but are either landed and sold routinely under State management (jacksmelt only in California) or are landed relatively infrequently but in more substantial quantities than the forage species addressed above.

- Herring: In California, herring are infrequently incidental catch in the CPS fisheries. The 10-year averages for landing and value is less than 9 mt and \$900, respectively for Pacific and round herring combined. Herring are a prohibited species in the Washington sardine fishery; therefore there is no incentive to target them; since 2000 two landings neither exceeding 5 mt have been reported on fish receipts at zero value. Pacific herring landings in the Oregon sardine fishery since 2001 have varied considerably, from several years with zero reported catch up to 55.8 mt in 2008. The 9-year average for landings and value in Oregon are 8.9 mt and \$431 respectively with no landings in 4 of the 9 years.
- Jacksmelt: As indicated above, incidental catches of jacksmelt are routinely landed and sold in the California CPS fisheries. The 10-year averages for landing and value are approximately 6 mt and \$2,800.

Beyond the evaluation of which species may be considered for inclusion in a plan as an EC species, are the questions of why such action should be taken and what purpose is served, or what value is achieved by doing so. Identifying and including EC species in the CPS FMP is not mandatory but may be done for a variety of purposes:

- Data collection;
- For ecosystem considerations related to specification of OY for the associated fishery;
- As considerations in the development of conservation and management measures for the associated fishery;
- and/or to address other ecosystem issues.

Inclusion of the species identified above, or any other species that might be considered, in the absence of new or expanded data collection programs will not change what data are available to inform management. The expectation for EC species is that they “should be monitored to be the extent any new pertinent scientific information becomes available (e.g., catch trends, vulnerability) to determine changes in their status or vulnerability to the fishery. Monitoring incidental catch and bycatch is not dependent on an EC designation and already occurs in CPS fisheries through sampling and logbook programs. Incidental catch and bycatch in CPS fisheries will continue to be reported in the SAFE.

Under the CPS FMP conservation and management measures for targeted stocks are achieved directly through harvest control rules and regulations. The current harvest control rules for sardine were developed with significant ecosystem considerations relative to OY specifications (Section 4.2).

Finally, including some or all of these species as EC species might be considered for “ecosystem issues” which in this case would reasonably be their importance as part of the forage base of the California Current ecosystem. However, without any criteria or decisional framework guiding actions relative to EC species, there exists a risk of a piecemeal approach applied to a single FMP to address all forage and ecosystem issues which runs counter to a holistic “ecosystem” approach. This combined with the relatively low bycatch of these species in CPS fisheries, suggests that the Council’s developing EFMP may be a more appropriate framework for monitoring and evaluating forage and predator species and their respective roles in the management of all Council managed fisheries.

4.2 STATUS DETERMINATION CRITERIA CONSIDERATIONS

Revising SDCs in the CPS FMP is not required by the MSRA. Reviewing and potentially revising some SDCs (such as the harvest control rule for Pacific sardine) has been identified as a priority research need, but completing that analysis would require more time than the current Amendment 13 timeframe allows.

Alternative 1, No Action Alternative – Maintain existing SDCs for CPS FMP stocks.

Alternative 2, Preliminary Preferred Alternative - Maintain existing SDCs for CPS FMP stocks and develop an MSY proxy for the Northern subpopulation of Northern anchovy.

The Northern subpopulation of Northern anchovy currently lacks an estimate of biomass or MSY harvest levels making the development of OFLs and ACLs problematic for this species. In March, the Council directed the CPSMT to work with NMFS on the establishment of these reference points in advance of the June 2010 Council meeting. Preliminary biomass estimates have been derived for the Northern subpopulation by the SWFSC using hydro acoustic data collected in 2008 (see Table 3.4-1). This method has not been fully developed and reviewed and the Council is not expected to adopt these values in June. The CPSMT is continuing to refine the biomass and MSY values for this subpopulation and anticipates final adoption of these reference points under the annual management cycle in November 2010.

Additionally, funding constraints in Oregon, have led the Oregon Fish and Wildlife Commission and the Oregon Department of Fish and Wildlife to suspend the Oregon Developmental Fishery Program that, in turn, has removed State permitting requirements and regulations from limiting potential fishing pressure on Northern anchovy.

4.3 OFL, ABC, ACL AND ACT CONSIDERATIONS

The NS1 guidelines envision OFL to correspond to the best available estimate of MSY stock size. The guidelines also call for an assessment of scientific uncertainty in the estimate of MSY and the development of an ABC control rule that addresses scientific uncertainty and management risk when setting an ABC level below the OFL.

The CPSMT has proposed that the MSY control rules for actively managed species could serve as an adequate buffer to account for scientific uncertainty as it explicitly and significantly reduces harvest as biomass approaches an overfished condition, or in the case of Pacific sardine as biomass approaches a level three times the current designation of MSST. The SSC has not supported this approach stating that the MSY control rules “were selected to maximize long-term yield given variation in recruitment (an MSY control rule).”

4.3.1 ACTIVELY MANAGED SPECIES

This section is comprised of two preliminary analyses completed by the CPSMT, one on Pacific sardine and the other on Pacific mackerel. These two analyses provide background on the development of the existing harvest control rules for actively managed species and a preliminary analysis of the potential need for additional buffering of these harvest policies due to scientific uncertainty in estimated biomass. Please note, these analyses are based, in part, on preliminary recommendations of the CPS and groundfish SSC Subcommittees. The Council may consider revised analyses and recommendations of the SSC and the CPSMT at the June 2010 meeting before adopting a preferred alternative.

Alternative 1 – Maintain the existing harvest control rules to specify the new management reference points.

Overfishing Definition	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ABC	
HG	

Alternative 2 – Modify existing harvest policy to specify the new management reference points with no additional buffering for scientific uncertainty.

OFL	BIOMASS * F_{MSY} * DISTRIBUTION
ABC	BIOMASS * F_{MSY} * DISTRIBUTION
HG	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ACL	EQUAL TO HG OR ABC, WHICHEVER VALUE IS LESS

Alternative 3 – Scientific Uncertainty Buffer – Modify the existing harvest control rules to include a buffer or reduction in ABC relative to OFL to account for scientific uncertainty.

OFL	BIOMASS * F_{MSY} * DISTRIBUTION
ABC	BIOMASS * BUFFER * F_{MSY} * DISTRIBUTION
ACL	LESS THAN OR EQUAL TO ABC
HG	(BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION.
ACT	EQUAL TO HG OR ACL, WHICHEVER VALUE IS LESS

4.3.1.1 PACIFIC SARDINE

Background

The harvest control rule (HCR) in the Coastal Pelagic Species Fishery Management Plan (CPS FMP) was first implemented for northern anchovy and Pacific mackerel management in the early 1980s (Huppert et al 1980; MacCall et al. 1985; Jacobson and Thomson 1989). The HCR formula for Pacific sardine is specified:

HARVEST GUIDELINE = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION, where:

- HARVEST GUIDELINE is the target harvest level for each management year;
- BIOMASS is the population biomass of sardine ages 1 and older;
- CUTOFF is the threshold below which fishing is prohibited; typically CUTOFF is the overfished threshold but it is 150,000 mt for sardine, 3x the overfished level;
- FRACTION is the temperature-dependent exploitation fraction;
- DISTRIBUTION is the average portion of the coastwide biomass in U.S. waters, assumed to be 87%;
- MAXCAT is the maximum allowable catch regardless of biomass. MAXCAT is 200,000 mt for Pacific sardine.

Simulations for evaluating management options for sardine are fully documented in Amendment 8 to the CPS FMP, Appendix B (PFMC 1998). The FRACTION term of the HCR has also been referred to as F_{MSY} , however this is somewhat of a misnomer for sardine because FRACTION levels explored along with other variables (e.g., CUTOFF, MAXCAT) were in some cases lower or higher than 'true' F_{MSY} values. Jacobson and MacCall (1995) examined the relationship between sea surface temperature (SST) and sardine productivity, and their analysis formed the theoretical basis for the temperature-based control rule currently used for management (PFMC 1998). In developing management options for Amendment 8, the relationship between SST and F_{MSY} was reexamined using new simulations that included: 1) time series extended through 1997; 2) different assumptions regarding spawning stock biomass (SSB) (age 1+ instead of age 2+) and age at recruitment (age 1 instead of age 2); and 3) limited SST from 16.6 °C to 18.1 °C. The relationship

from Amendment 8, currently used for management, is described by a second order polynomial equation (Figure 4.3.1-1), where 'T' is the 3-season SST at SIO pier.

It is important to note that scientific uncertainty around biomass estimates (stock assessment error) was accounted for in all simulations used to evaluate the sardine HCRs. Amendment 8, Appendix B states:

“Simulated biomass estimates used to set quotas in the model were imprecise. Measurement errors for biomass estimates used in the simulations to set quotas were lognormally distributed with arithmetic scale CV equal to 60%. Recent sardine biomass estimates for 1997 had an arithmetic scale CV of about 50% (Hill et al. 1998), so a CV for errors in biomass estimates from stock assessments of 50% was assumed in simulations.”

The Councils' HCR for Pacific sardine is theoretically already robust to errors with respect to biomass estimation. The simulations accounted for scientific uncertainty by applying a CV of 50% to biomass in each run, with biomass errors being randomly drawn from a normal distribution with a mean of zero. A CV of 50% is higher than that estimated in the SSC's recent analysis for sardine ($CV_{within} = 41\%$; $SD_{within} = 0.39$).

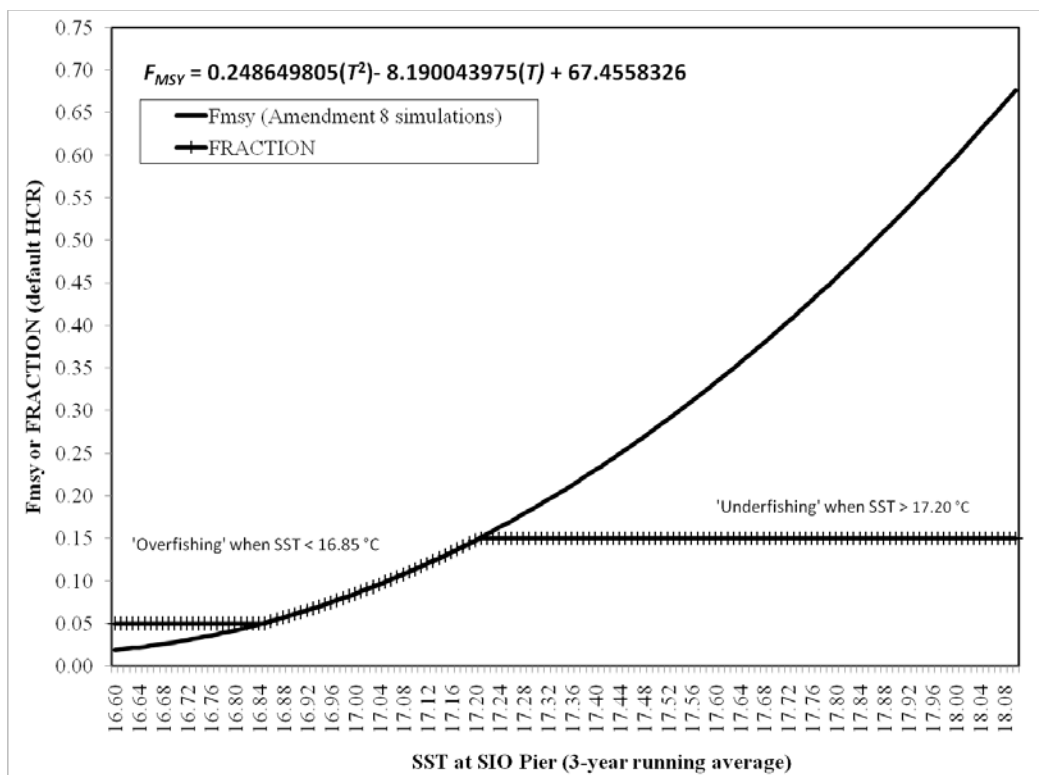


Figure 4.3.1-1. Relationship between SST (°C) at SIO pier and F_{MSY} for Pacific sardine (solid line). Harvest 'FRACTION' in the PFMC's HCR policy, bracketed between 0.05 and 0.15, is represented by the segmented line. Simulations included SSTs from 1916-19 through 1994-97.

The upper range of FRACTION chosen by the Council was capped at 15%, so the control rule currently in place is already more conservative than F_{MSY} when temperature exceeds 17.2 °C. Conversely, the lower bound for FRACTION (5%) actually specifies harvest at a rate higher than

F_{MSY} when temperatures are lower than 16.85 °C, a policy that is inconsistent with the NS1 goal of preventing overfishing (Figure 4.3.1-1).

Accounting for Uncertainty in Pacific Sardine Stock Assessments (P^* and the ABC/OFL 'Buffer')

The revised NS1 guidelines require FMPs to define an overfishing limit (OFL), acceptable biological catch (ABC), and annual catch limit (ACL) for each managed stock. In this plan amendment, each of the new NS1 parameters is compared to HARVEST GUIDELINE (HG), the default management approach which includes OY considerations. For Pacific sardine, the values are defined:

$$\begin{aligned} \text{OFL} &= \text{BIOMASS} * F_{MSY} * \text{DISTRIBUTION} \\ \text{ABC} &= \text{BIOMASS} * \text{BUFFER} * F_{MSY} * \text{DISTRIBUTION} \\ \text{HG} &= (\text{BIOMASS} - \text{CUTOFF}) * \text{FRACTION}_{(0.05-0.15)} * \text{DISTRIBUTION} \\ &\quad (\text{HG upper bound 'MAXCAT'} = 200,000 \text{ mt}) \\ \text{ACL} &= \text{HG or ABC, whichever amount is less} \end{aligned}$$

In November 2009, the SSC's Groundfish and CPS Subcommittees presented an approach to account for uncertainty in biomass estimates, both within and among stock assessments. Their approach was further refined and documented for the March 2010 Council meeting (Agenda Item E.4.b., Supplemental SSC Report 1). Three full sardine assessments (Conser et al. 2004, Hill et al. 2007, and Hill et al. 2009) were examined in their analysis, with the following estimates of variation: $\sigma_{total}=0.206$; $\sigma_{within}=0.39$ (see SSC report Table 2). On first principles variance within cannot be greater than total variance, so the SSC considered $\sigma_{within} = 0.39$ to better represent biomass uncertainty for Pacific sardine. Applying $\sigma = 0.39$ to the normal probability distribution, a range of uncertainty buffers was obtained, where P^* is the probability of overfishing, and 'Buffer' is the corresponding ratio of ABC/OFL applied to BIOMASS (Table 4.3.1-1, Figure 4.3.1-2).

Table 4.3.1-1. Uncertainty buffers for various P^* values when $\sigma = 0.39$. See also Figure 4.3.1-2.

P^*	Buffer (ABC/OFL)
0.50	1.00000
0.45	0.95217
0.40	0.90592
0.30	0.81504
0.20	0.72020

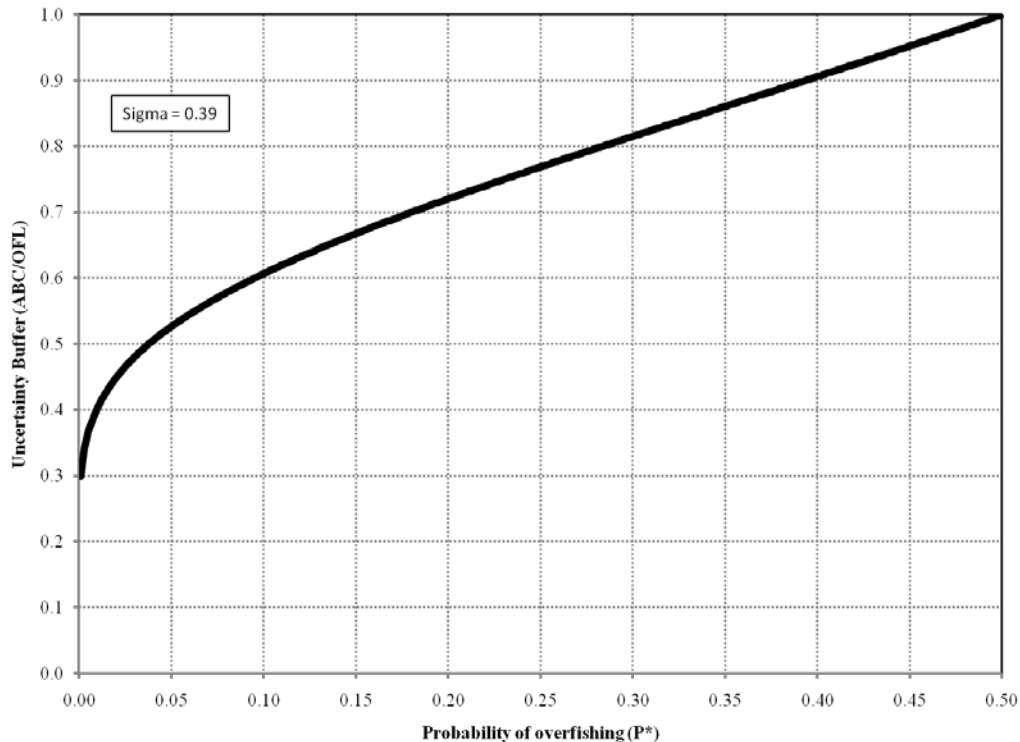


Figure 4.3.1-2. Relationship between the probability of overfishing (P^*) and uncertainty buffers (ABC/OFL) for $\text{Sigma}=0.39$.

Application of the Uncertainty Buffer to Pacific Sardine

Impact of a scientific uncertainty buffer on Pacific sardine harvests will depend upon three factors: 1) the P^* policy chosen by the Council, 2) biomass, and 3) SST. To determine potential impacts of a scientific uncertainty buffer, ABC was calculated for a range of biomass, SST, and P^* policies. Resulting ABCs were compared to default HGs obtained for the same biomass and SST values. ACL is defined as being equal to ABC or HG, whichever value is less, so when the buffered ABC is less than the calculated HG a reduction in catch would occur (negative change from status quo).

The P^* approach proposed by the SSC and implemented herein addresses uncertainty in biomass estimates derived from stock assessment models. As the SSC noted in their March 2010 report (Agenda Item H.2.b), it is quite likely that there is uncertainty in the SST-dependent F_{MSY} function, especially for warmer SSTs. An analysis of uncertainty around F_{MSY} was not practicable for this plan amendment, and there is ongoing research to better define the relationship between the environment and sardine productivity and develop a new index for management. In the interim, the CPSMT recommends constraining the range of temperatures used to calculate OFL and ABC to a some intermediate range of values. One approach could be to limit OFL and ABC calculations to the interquartile range of SSTs used in the Amendment 8 simulations, which spanned 3-season averages from 1916-19 through 1994-97. The lower quartile SST for this period was 16.61 °C, with a corresponding F_{MSY} of 0.0200. The upper quartile SST was 17.33 °C, with an F_{MSY} of 0.1985.

The relationship between SST and catch (OFL, ABC, HG) is summarized for four biomass levels (high, medium, current, and low) in Figures 4.3.1-3a-d. During warm conditions (generally, SST > 17.20 °C), default HGs are lower than buffered ABCs. During cooler conditions (e.g. SST < 16.8 °C), default HGs are higher than buffered ABCs and the OFL, so catch reductions would be necessary to prevent overfishing. The temperature threshold below which catch reductions would occur

depends upon both biomass and the P^* policy chosen by the Council. The relationship for current biomass and SST is displayed in Figure 4.3.1-3c. The HG used for 2010 management (72,039 mt) is well below ABC for buffer policies considered for this analysis, so no catch reduction would occur under present conditions.

The relationship between biomass and catch (OFL, ABC, HG) is summarized for quartiles of SST observed at SIO pier from 1919-1997 (Figures 4.3.1-4a-c). Under warm conditions, characterized here as the upper quartile of SST (17.33 °C), the default HG is lower than buffered ABC at all biomass levels so no reductions in catch would occur due to application of a P^* policy (Figure 4.3.1-4a). At median SST (16.98 °C), the buffered ABC is less than the HG at higher biomasses and can be higher than HG at lower biomasses, depending upon the P^* policy of choice (Figure 4.3.1-4b). For example, when $P^* = 0.45$ the HG is lower than ABC when biomass is less than 535,000 mt. For $P^* = 0.40$, the HG is lower than ABC when biomass is less than 475,000 mt (Figure 4.3.1-4b). Under cool conditions (lower quartile SST = 16.61 °C), the buffered ABC is less than HG when biomass is greater than 200,000 mt (Figure 4.3.1-4c), so catch reductions would occur in most cases.

Assessing catch reductions under a P^* policy for Pacific sardine is a multidimensional problem in that potential impacts will vary with biomass, SST, and the P^* policy of choice. Catch reductions for a range of biomass and SST are displayed in Figures 4.3.1-5a-d and summarized in Tables 4.3.1-2a-d. Impacts for P^* policies of 0.45, 0.40, 0.30, and 0.20 are displayed and tabulated on separate pages. Catch reductions are defined as the difference between HG and ABC when ABC is less than HG. As summarized above, impacts of the scientific uncertainty buffer are greatest under highest biomass and coldest SST conditions. Much of the impact under any given P^* policy can be attributed to the application of 'true' F_{MSY} rather than bounding the harvest FRACTION at 5% for lower temperatures. The oddly-shaped three-dimensional surfaces shown in Figures 4.3.1-5a-d are due to interactions between BUFFER, CUTOFF, MAXCAT, and FRACTION vs. F_{MSY} in the calculation of ABC and HG. Catch reductions are averaged for a range of SST and biomass categories in Tables 4.3.1-2a-d.

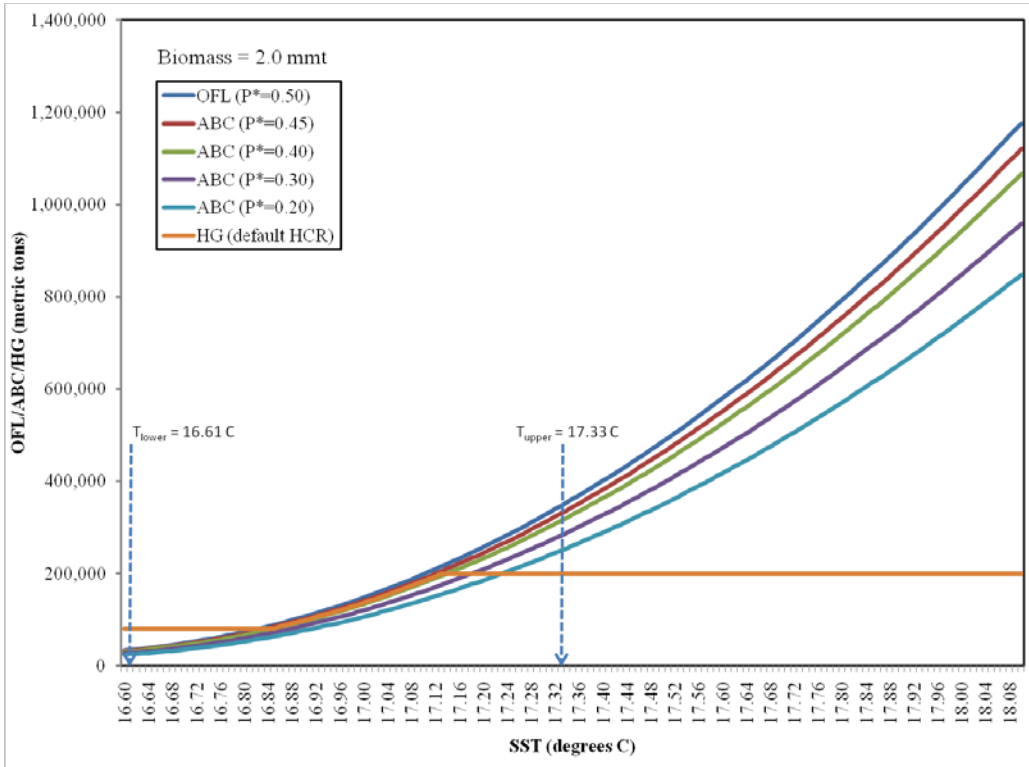


Figure 4.3.1-3a. Relationship between SST and catch (OFL, ABC, HG) when biomass = 2.0 mmt. ACL would be equal to ABC or HG, whichever value is less. The CPSMT recommends bounding OFL and ABC calculations by the upper and lower quartiles of SST observed from 1919 to 1997.

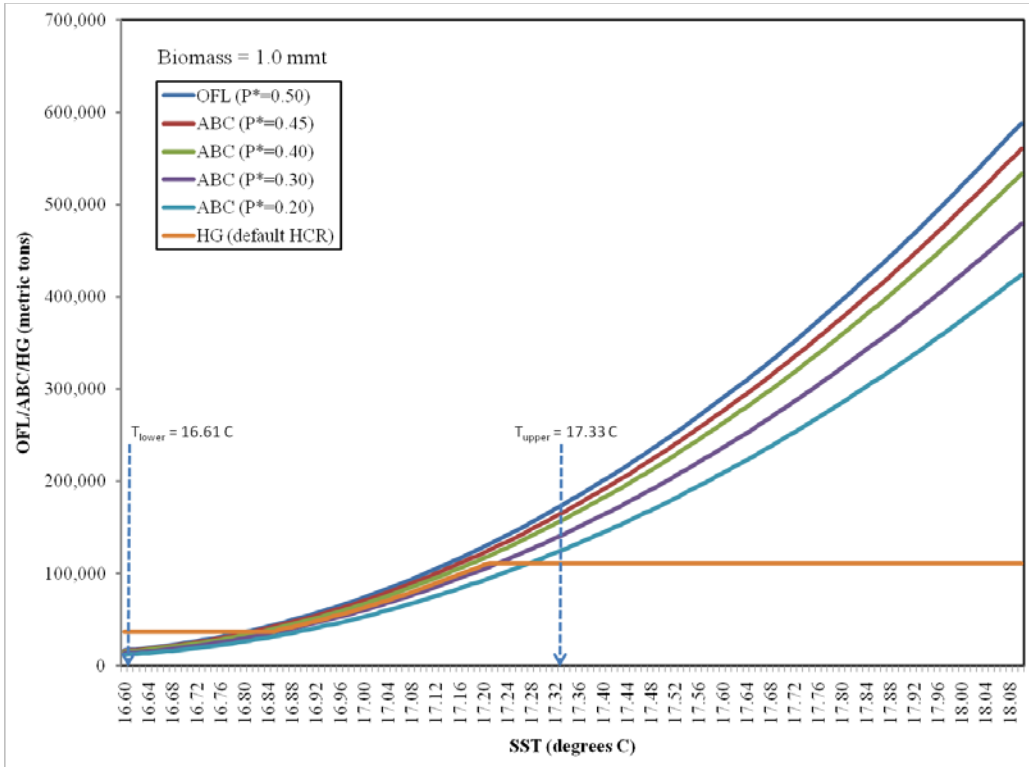


Figure 4.3.1-3b. Relationship between SST and catch (OFL, ABC, HG) when biomass = 1.0 mmt. ACL would be equal to ABC or HG, whichever value is less. The CPSMT recommends bounding OFL and ABC calculations by the upper and lower quartiles of SST observed from 1919 to 1997.

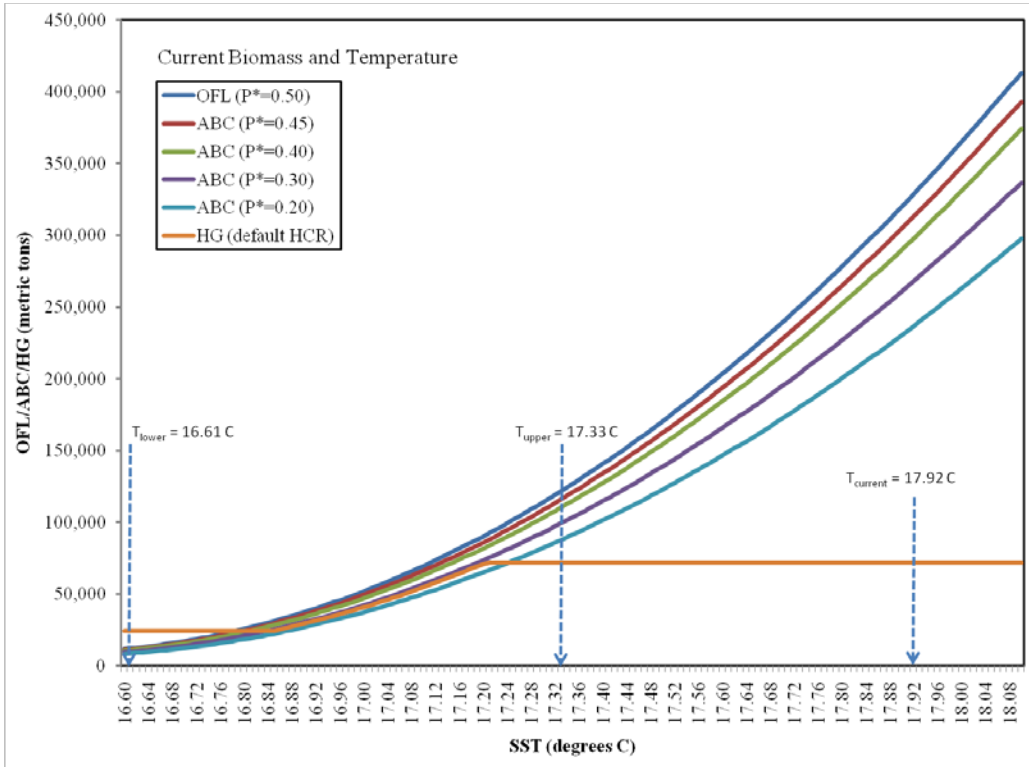


Figure 4.3.1-3c. Relationship between SST and catch (OFL, ABC, HG) when biomass = 0.702 mmt (2010 management). ACL would be equal to ABC or HG, whichever value is less. The CPSMT recommends bounding OFL and ABC calculations by the upper and lower quartiles of SST observed from 1919 to 1997.

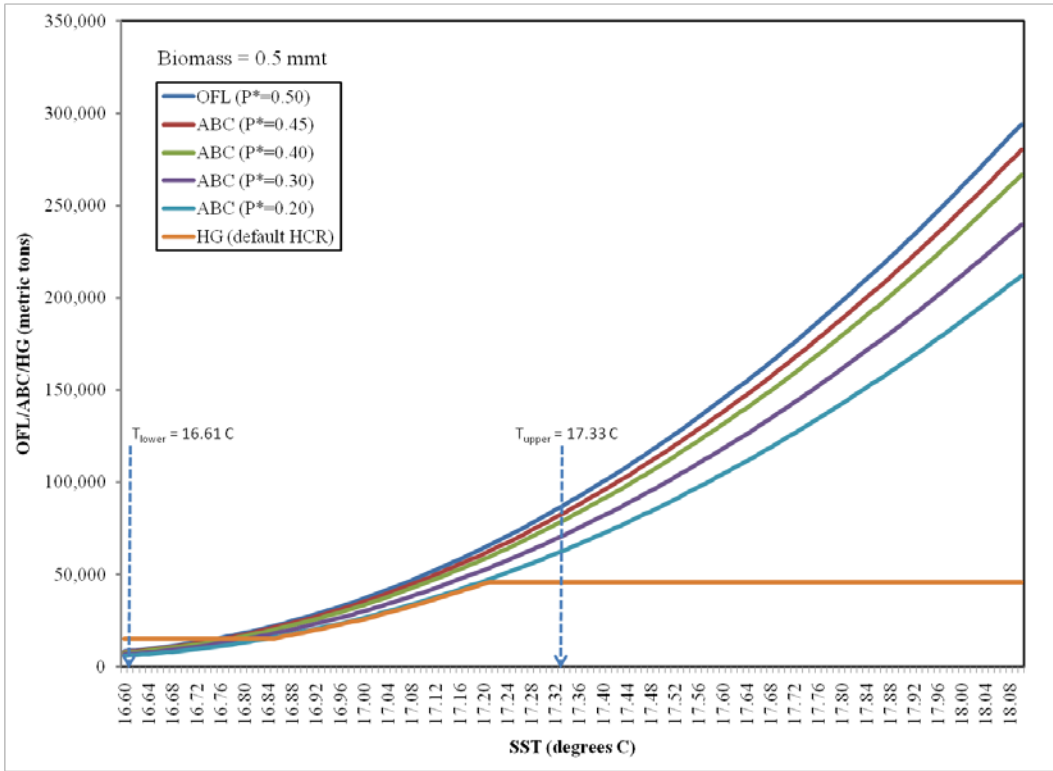


Figure 4.3.1-3d. Relationship between SST and catch (OFL, ABC, HG) when biomass = 0.5 mmt. ACL would be equal to ABC or HG, whichever value is less. The CPSMT recommends bounding OFL and ABC calculations by the upper and lower quartiles of SST observed from 1919 to 1997.

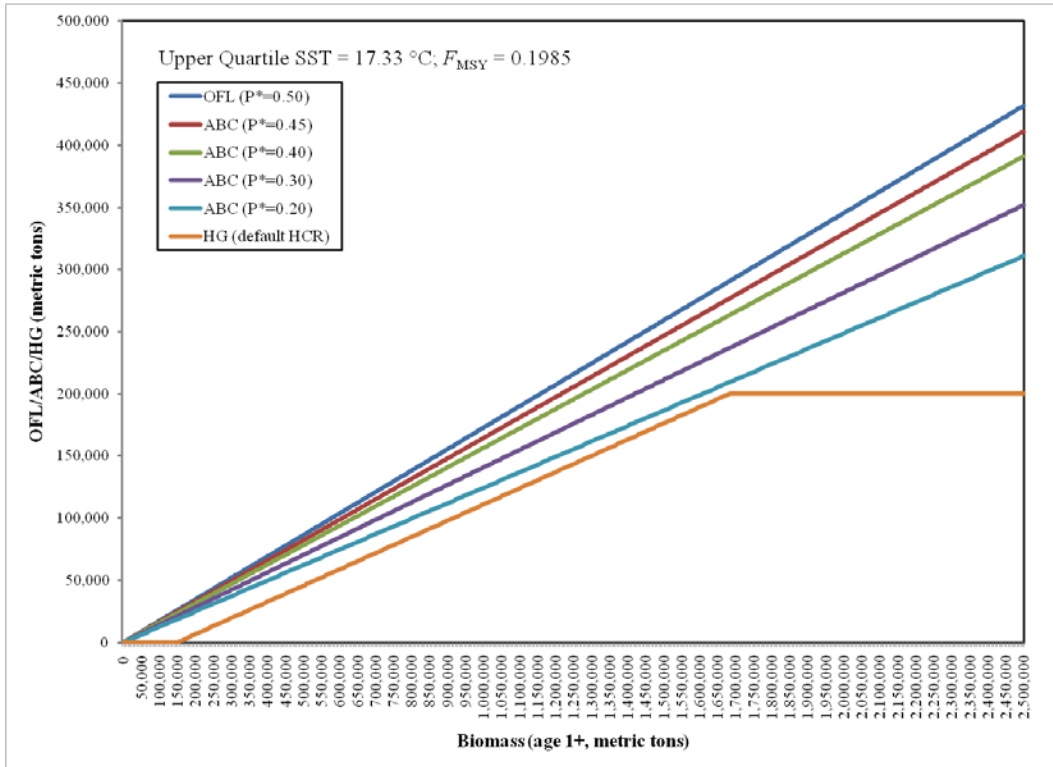


Figure 4.3.1-4a. Relationship between biomass and catch (OFL, ABC, HG) for the upper quartile of SSTs observed from 1916 to 1997. ACL would be equal to ABC or HG, whichever value is less.

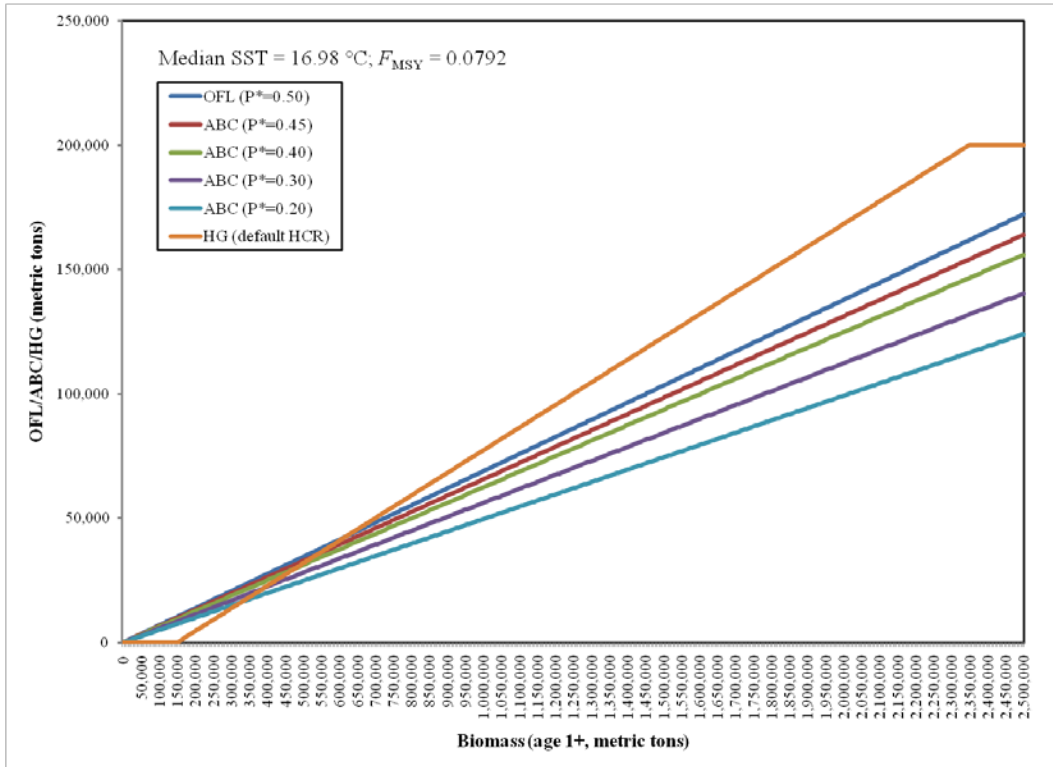


Figure 4.3.1-4b. Relationship between biomass and catch (OFL, ABC, HG) for the median of SSTs observed from 1916 to 1997. ACL would be equal to ABC or HG, whichever value is less.

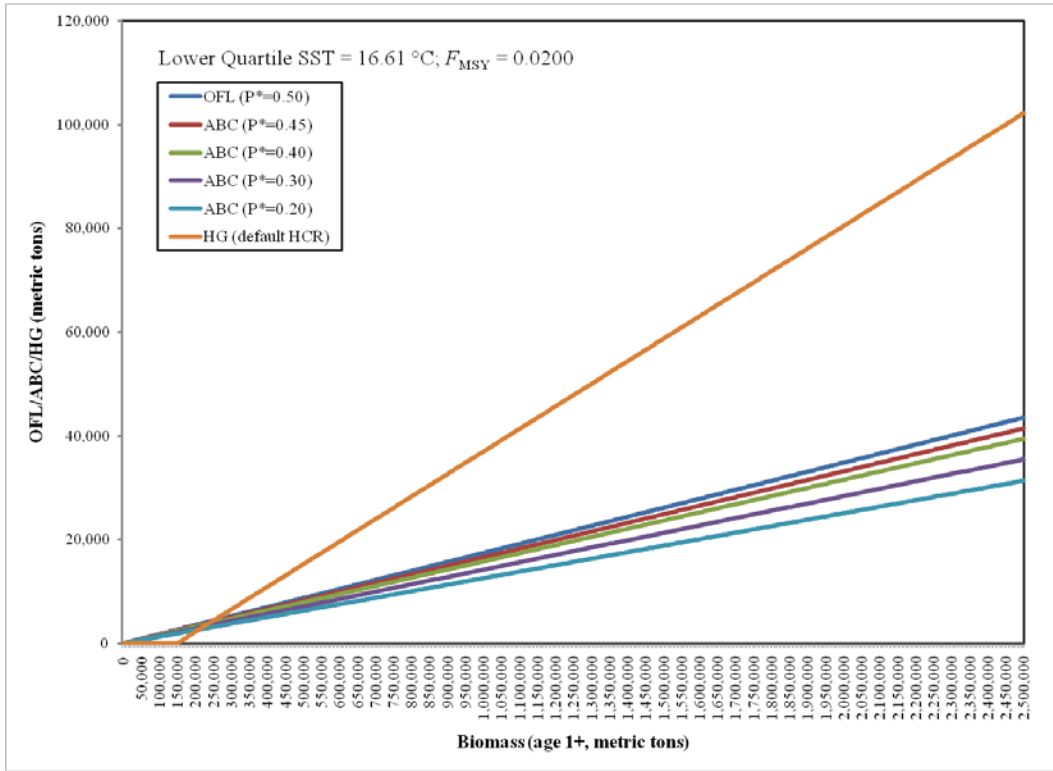


Figure 4.3.1-4c. Relationship between biomass and catch (OFL, ABC, HG) for the lower quartile of SSTs observed from 1916 to 1997. ACL would be equal to ABC or HG, whichever value is less.

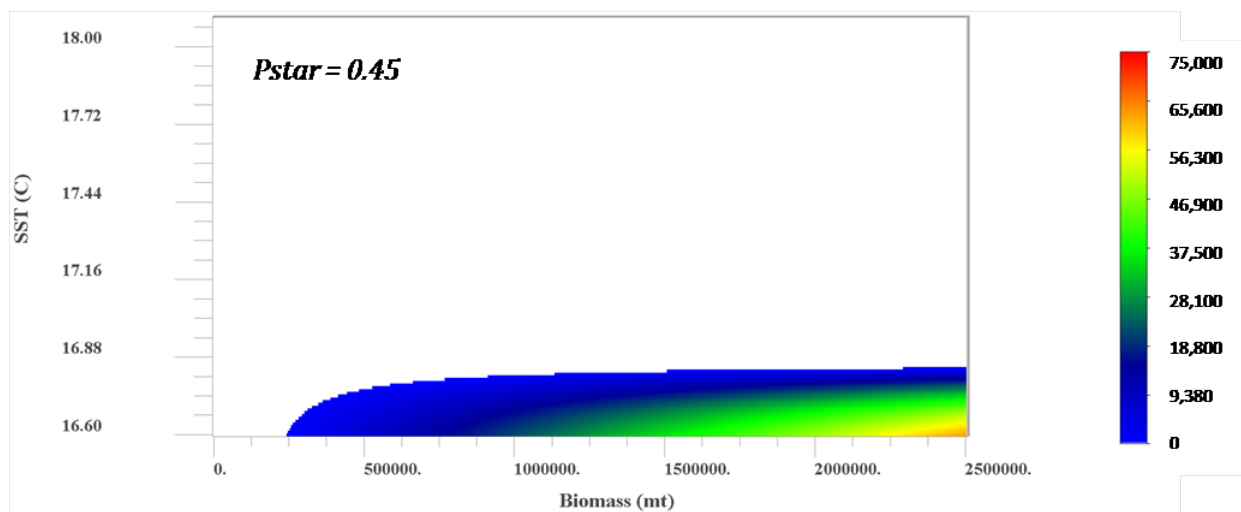


Figure 4.3.1-5a. Impact of scientific uncertainty buffer (for $P^*=0.45$) on sardine catch (mt) for a range of biomass and SST values. Catch reductions occur when HG is greater than buffered ABC (colored areas). White areas represent cases where HG is less than buffered ABC (i.e. no impact on catch from status quo).

Table 4.3.1-2a. Impact of scientific uncertainty buffer (for $P^*=0.45$) on sardine catch (mt) for a range of biomass and SST values (per Figure 4.3.1-5a above). Catch reductions occur when HG is greater than buffered ABC. Reductions are averaged for each biomass and SST category.

<i>Pstar = 0.45</i>	Biomass range (million metric tons)					
	SST range (°C)	0.00-0.49	0.50-0.99	1.00-1.49	1.50-1.99	2.00-2.50
	17.31-18.10	0	0	0	0	0
	17.20-17.30	0	0	0	0	0
	17.10-17.19	0	0	0	0	0
	17.00-17.09	0	0	0	0	0
	16.90-16.99	0	0	0	0	0
	16.80-16.89	0	61	781	1,988	3,330
	16.70-16.79	193	5,018	12,688	20,389	28,128
	16.60-16.69	1,359	11,946	24,301	36,656	49,073

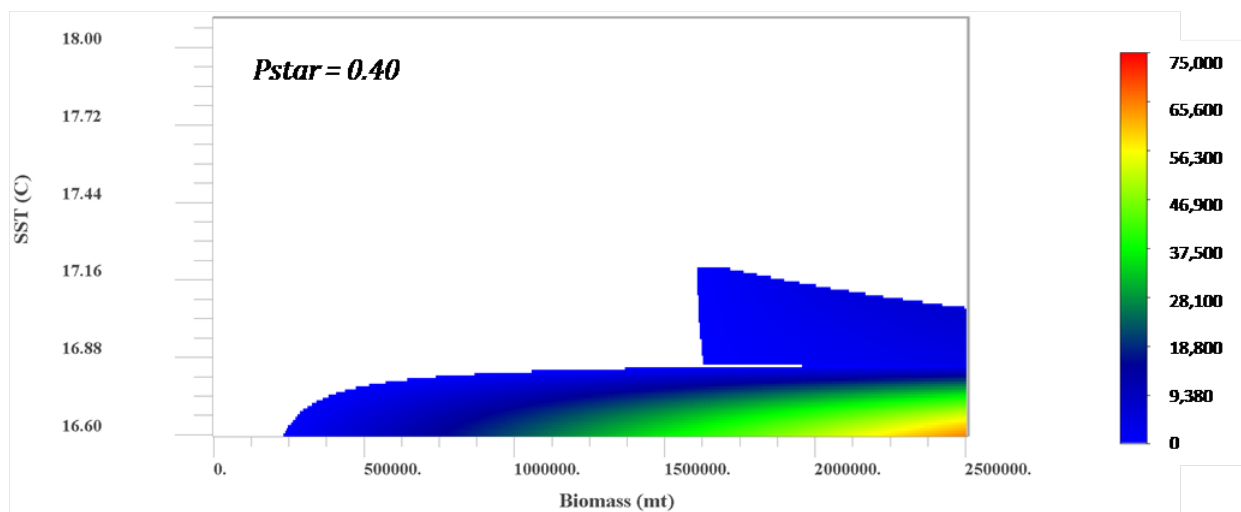


Figure 4.3.1-5b. Impact of scientific uncertainty buffer (for $P^*=0.40$) on sardine catch (mt) for a range of biomass and SST values. Catch reductions occur when HG is greater than buffered ABC (colored areas). White areas represent cases where HG is less than buffered ABC (i.e. no impact on catch from status quo).

Table 4.3.1-2b. Impact of scientific uncertainty buffer (for $P^*=0.40$) on sardine catch (mt) for a range of biomass and SST values (per Figure 4.3.1-5b above). Catch reductions occur when HG is greater than buffered ABC. Reductions are averaged for each biomass and SST category.

<i>Pstar = 0.40</i>	Biomass range (million metric tons)					
	SST range (°C)	0.00-0.49	0.50-0.99	1.00-1.49	1.50-1.99	2.00-2.50
	17.31-18.10	0	0	0	0	0
	17.20-17.30	0	0	0	15	0
	17.10-17.19	0	0	0	1,147	428
	17.00-17.09	0	0	0	1,296	4,387
	16.90-16.99	0	0	0	949	3,827
	16.80-16.89	0	229	1,581	3,742	6,683
	16.70-16.79	288	6,012	14,391	22,774	31,199
	16.60-16.69	1,521	12,628	25,440	38,251	51,127

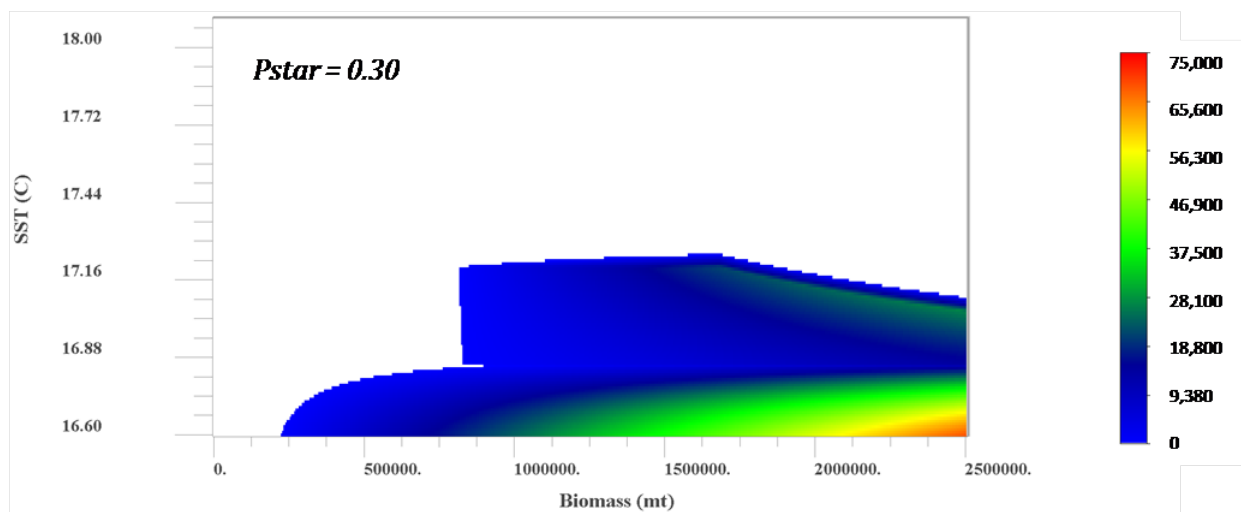


Figure 4.3.1-5c. Impact of scientific uncertainty buffer (for $P^*=0.30$) on sardine catches (mt) for a range of biomass and SST values. Catch reductions occur when HG is greater than buffered ABC (colored areas). White areas represent cases where HG is less than buffered ABC (i.e. no impact on catch from status quo).

Table 4.3.1-2c. Impact of scientific uncertainty buffer (for $P^*=0.30$) on sardine catch (mt) for a range of biomass and SST values (per Figure 4.3.1-5c above). Catch reductions occur when HG is greater than buffered ABC. Reductions are averaged for each biomass and SST category.

<i>Pstar</i> = 0.30	Biomass range (million metric tons)					
	SST range (°C)	0.00-0.49	0.50-0.99	1.00-1.49	1.50-1.99	2.00-2.50
	17.31-18.10	0	0	0	0	0
	17.20-17.30	0	130	2,681	3,238	0
	17.10-17.19	0	720	9,033	17,452	5,427
	17.00-17.09	0	546	6,846	14,688	21,126
	16.90-16.99	0	399	5,009	10,747	16,513
	16.80-16.89	1	1,169	5,608	10,592	15,601
	16.70-16.79	558	8,012	17,736	27,460	37,233
	16.60-16.69	1,853	13,969	27,677	41,385	55,162

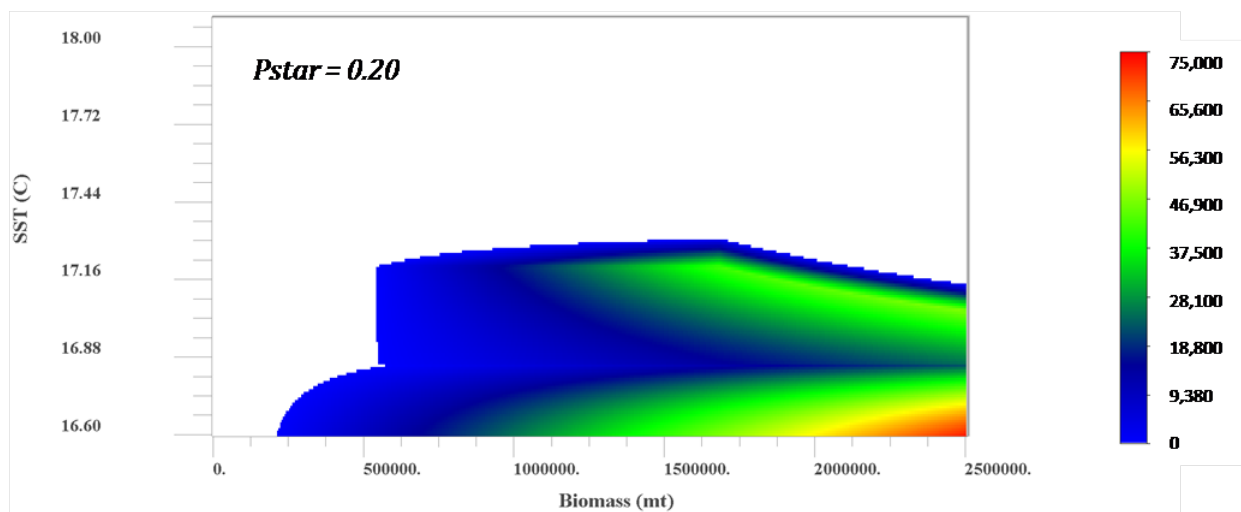


Figure 4.3.1-5d. Impact of scientific uncertainty buffer (for $P^*=0.20$) on sardine catches (mt) for a range of biomass and SST values. Catch reductions occur when HG is greater than buffered ABC (colored areas). White areas represent cases where HG is less than buffered ABC (i.e. no impact on catch from status quo).

Table 4.3.1-2d. Impact of scientific uncertainty buffer (for $P^*=0.20$) on sardine catch (mt) for a range of biomass and SST values (per Figure 4.3.1-5d above). Catch reductions occur when HG is greater than buffered ABC. Reductions are averaged for each biomass and SST category.

<i>Pstar = 0.20</i>	Biomass range (million metric tons)					
	SST range (°C)	0.00-0.49	0.50-0.99	1.00-1.49	1.50-1.99	2.00-2.50
	17.31-18.10	0	0	0	0	0
	17.20-17.30	0	2,726	13,036	15,352	368
	17.10-17.19	0	6,665	22,271	35,980	19,787
	17.00-17.09	0	5,051	16,880	28,743	39,222
	16.90-16.99	0	3,696	12,350	21,030	29,753
	16.80-16.89	45	3,729	10,768	17,821	24,908
	16.70-16.79	952	10,105	21,228	32,352	43,531
	16.60-16.69	2,214	15,368	30,012	44,656	59,373

Scientific Uncertainty in Biomass Estimates and OY Considerations in the Pacific Sardine HCR

Development of the current HCR for Pacific sardine was part of Amendment 8. The options explored are detailed in Section 4 of Appendix B to Amendment 8. The analyses included 1,000 year simulations for each of the options under consideration. It is important to note that these analyses are theoretically robust to scientific uncertainty errors in biomass estimates because they included CV for errors in biomass of 50 percent which is higher than that recently estimated by the SSC (Agenda Item E.4.b March, 2010). In addition to accounting for scientific uncertainty in biomass estimates, the analysis of potential HCRs and parameters were evaluated for OY considerations. The determination of OY is a decisional mechanism for resolving the Magnuson-Stevens Act's conservation and management objectives, achieving FMP objectives, and balancing the various interests that comprise the greatest overall benefits to the Nation. Several performance measures were utilized to evaluate potential HCRs and parameter values for OY considerations of ecological, social, and economic reasons for CPS fisheries. Appendix B states that in evaluating OY performance measures "biological factors and sustainability are most important". It is recognized that species in the CPS FMP (especially anchovy and sardine at the time of Amendment 8, and euphausiids after Amendment 12) are important as forage for fish, mammals and birds; therefore, measures of CPS biomass were deemed to be key performance measures and were given a higher priority than catch when the Council adopted the current HCR. Thirteen HCR/parameter combinations were evaluated. The sardine HCR that was recommended and ultimately adopted sought to maintain the sardine stock biomass at levels well above those of a single-species MSY based management strategy.

Similarly, social and economic factors were important considerations in evaluating OY for CPS fisheries, thus options for maintaining fishing opportunity and biomass were evaluated. The OY performance measures for ecological, social and economic consideration included:

- Average midyear biomass
- Median biomass
- Average log midyear biomass
- Percentage of years with biomass above 400,000 mt
- Average catch
- Standard deviation of average catch
- Percent of years with no catch
- Average log catch
- Median catch

The results of these simulations were not used to find the "optimal" combination of parameter values in any given HCR, but rather to find HCRs and parameter values that give good results for most of the performance measures. It was noted that results of the simulations should not be regarded as precise, nor were they useful for predicting exact quantities. Indeed uncertainty in results from the model simulations was noted as one of the primary factors in making it difficult to choose among several of the HCRs; the other factor was uncertainty regarding the relative importance of the OY performance measures to policy makers.

Briefly, the average midyear biomass and percentage of years with biomass above 400,000 mt were utilized to give an indication of the relative availability of sardine as forage for marine predators under the different HCRs and parameter values. Midyear biomass and median biomass are also

measures of fishery performance over both the long and short term as are average log catch and median catch. Average log catch and average log biomass were used as measures of the degree to which the HCRs were risk averse. These performance measures and their specific uses in evaluating HCRs are discussed more fully in Appendix 4. Table 4.3.1-3 is adapted from Appendix 4 and displays the modeled performance measures for the 13 HCR scenarios. The Council adopted Option J, the option with relatively low risk, high mean biomass, and low average catch.

When selecting alternatives for further analysis from among the infinite options for the HCR and the parameters for CUTOFF, FRACTION, and MAXCAT, higher priority was placed on biomass than catch (as measured in terms of average and median) because sardine are a key forage species in California Current Ecosystem.. Yet for social and economic reasons, options with high parameter values for CUTOFF (i.e. 1,000,000 mt) and FRACTION (95%) were modeled, but not included in the final set of options. Also, for social and economic reasons, the MAXCAT values were selected to allow substantial harvest and revenues when sardine are abundant without risk to the stock, without generating extreme variability in harvest, and without encouraging overcapitalization. Fisheries biologist Dr. Richard Parrish, who evaluated simulation model outputs for Amendment 8 wrote in a letter to the Council in May 2008 (Agenda Item G.1.d June 2008), “The rationale for the CPSMT’s recommended HCR was dominated by a concern for maintaining the sardine stock at population levels well above that which would occur with a single-species, MSY-based management strategy. In fact, the principal basis for the present [HCR] was to maintain a large population of sardine due to their importance as forage.” Clearly, OY considerations were of primary importance even in selecting the range of options for further analysis. The options that were fully examined are listed below (Table 4.3.1-3).

TABLE 4.3.1-3 Adapted from Amendment 8 App. B, Table 4.2.5-1. *MSY control rule options for Pacific Sardine*. Option J adopted. 1/

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

1/ Overfishing Definitions for all Options: Overfishing Rate is Catch > ABC, Overfished threshold is 50,000 mt.

2/ Stochastic F_{MSY}

3/ Determ. Equil. F_{MSY} in a Stochastic Model

After examination of the simulation results and evaluating the OY considerations for 13 options the Council chose the following HCR for Pacific sardine:

$$\text{HG} = (\text{BIOMASS} - \text{CUTOFF}_{(150,000 \text{ mt})}) * \text{FRACTION}_{(0.05-0.15)} * \text{DISTRIBUTION}$$

(HG upper bound 'MAXCAT' = 200,000 mt)

This HCR was the most conservative HCR considered and resulted in the highest biomass (both mean and median), the highest percentage of years with a biomass >400,000 mt. This HCR also produced nearly the lowest percentage of years with no catch and highest median catch of the HCRs considered. It is clear the HCR for sardine was selected for OY considerations. This HCR has been in place since 2000 and has served well as a management target for Pacific sardine.

The new NS1 guidelines state, “The most important limitation on the specification of OY is that the choice of OY and the conservation and management measures proposed to achieve it must prevent overfishing.” The CPSMT and SCC have had ongoing discussions about quantifying the degree to which the current sardine HCR adequately prevents overfishing given the scientific uncertainty in biomass estimates resulting from stock assessments. In November 2009 the SSC proposed a method for quantifying scientific uncertainty in biomass estimates, both within and among stock assessments, and refined their approach for the March 2010 Council meeting (Agenda Item E.4.b., Supplemental SSC Report 1). The SSC suggested that Sigma = 0.39 be utilized to characterize scientific uncertainty in biomass estimates for sardine, and that the CPSMT calculate OFL and the resultant ABCs as a function of P*, SST, and biomass.

The HCR for sardine is unique in that it incorporates an environmental variable, SST. There is evidence that sardine stocks go through extended periods of approximately 60 years of high and low biomass and have done so for approximately 2,000 years, even in the absence of fishing (Baumgartner et al. 1992). Environmental factors are thought to play a key role in these biomass fluctuations but the mechanism(s) driving the fluctuations are not presently well understood. Sea surface temperature (SST) was one environmental factor identified to have a relationship with sardine productivity (Jacobson and MacCall, 1995). The relationship between SST, sardine productivity and F_{msy} was reanalyzed during the development of the current sardine HCR. SST measured at Scripps pier in California was incorporated in the HCR as a determinate of the FRACTION term in the temperature-based sardine HCR. Upper and lower bounds of FRACTION, 0.15 and 0.05, were placed on the temperature-dependent F_{msy} values (PFMC 1998). In the simulation experiments, temperature data and reproductive success were related functionally and autocorrelated such that years of good and bad recruitment occurred on a decadal time scale. Additionally a weak 60-year temperature cycle was incorporated into the simulation work. It was noted during the development of the sardine HCR that refining the nature of the relationship between environmental factors and sardine productivity was a topic for further research. The SSC also noted that uncertainty exists in the SST relationship. Research on the relationship between environmental factors and sardine productivity is still ongoing. If and when a better environmental index is identified the sardine HCR can be modified without an amendment to the FMP.

In comparing the HCR, the CPSMT utilized the following formulas for OFL and the P* buffered ABC:

OFL	$\text{BIOMASS} \times F_{\text{msy}} \times \text{DISTRIBUTION}$
ABC	$(\text{BIOMASS} \times \text{BUFFER}) \times F_{\text{msy}} \times \text{DISTRIBUTION}$

The full analysis revealed scenarios in which P* buffering would be required during regimes with lower SSTs; where the HCR would need additional buffering at low temperatures. Temperatures at Scripps pier have been relatively warm during the period that the HCR has been in effect. A comparison of the result of the HCR output with proposed calculations for OFL and ABC for the time period may be helpful in examining how well the HCR accounts for both scientific uncertainty and OY considerations.

Table 4.3.1-4 presents historic biomass estimates and management output of the HG for the years 2000-2010 and compares these results to the proposed calculations for OFL and the resulting ABC values under various P* choices. The CPSMT recommends constraining the use of the temperature derived F_{msy} to values below the upper quartile of SST values examined ($F_{\text{msy}}=0.1985$ at SST = 17.33°C) when used to calculate OFL and an ABC buffered for scientific uncertainty in biomass estimates using the P* method proposed by the SSC (Table 4.3.1-4). The current HCR has not exceeded the ABC even at P* buffer levels = 0.20 (20% chance of overfishing) during the time it has been in place. Note also that OFL and ABC calculations for some years exceed the MAXCAT of 200,000 mt that is part of the HCR, again demonstrating the OY considerations that are part of the current HCR. Given these analyses the CPSMT concluded that the current HCR has prevented overfishing and should continue to serve as the annual management target or ACT under the new NS1 guidelines unless the ABC calculated using the P* approach falls below the output of the HCR.

Table 4.3.1-4. 2000 – 2010 Harvest Guideline (HG) output of current Pacific sardine Harvest Control Rule, Overfishing Limit (OFL), and Acceptable Biological Catch (ABC) at various P* values to buffer for scientific uncertainty at varying levels using Sigma = 0.39. OFL and ABC are calculated using temperature dependent F_{msy} from Jacobson and MacCall (1995) constrained to values below the upper quartile value of sea surface temperature examined.

Management Year	Biomass from Stock Assessments	Fmsy (constrained)	Fraction	HG from HCR	OFL	ABC for P*=.45	ABC for P*=.40	ABC for P*=.30	ABC for P*=.20	ABC(P*=0.20) - HG
2000	1,581,346	0.1985	0.15	186,791	273,091*	260,029*	247,398*	222,580*	196,680	9,889
2001	1,182,465	0.1985	0.15	134,737	204,206*	194,439	184,994	166,436	147,069	12,332
2002	1,057,599	0.1985	0.15	118,442	182,642	173,906	165,459	148,861	131,539	13,097
2003	999,871	0.1985	0.15	110,908	172,673	164,414	156,428	140,735	124,359	13,451
2004	1,090,587	0.1985	0.15	122,747	188,339	179,331	170,620	153,504	135,642	12,895
2005	1,193,515	0.1985	0.15	136,179	206,114*	196,256	186,723	167,991	148,443	12,264
2006	1,061,391	0.1985	0.15	118,937	183,297	174,530	166,052	149,394	132,010	13,073
2007	1,319,072	0.1985	0.15	152,564	227,797*	216,902*	206,366*	185,664	164,059	11,495
2008	832,706	0.1985	0.15	89,093	143,804	136,926	130,275	117,206	103,568	14,475
2009	662,886	0.1985	0.15	66,932	114,477	109,002	103,707	93,303	82,446	15,514
2010	702,024	0.1985	0.15	72,039	121,236	115,437	109,830	98,812	87,314	15,275

*Note that OFL and some ABCs are greater than the MAXCAT value of 200,000 mt used in the HCR.

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4.3.1.1 PACIFIC MACKEREL

As is presented for Pacific sardine above, the general form of the harvest control rule (HCR) in the Coastal Pelagic Species Fishery Management Plan (CPS-FMP) was first implemented for management of northern anchovy and Pacific mackerel in the early 1980s (Huppert et al. 1980; PFMC 1983, 1990; MacCall et al. 1985; Jacobson and Thomson 1989). The formula for Pacific mackerel is:

HARVEST GUIDELINE = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION, where

HARVEST GUIDELINE is the target harvest level for each management year;

BIOMASS is the population biomass of fish ages 1 or older;

CUTOFF is the threshold below which fishing is prohibited (also the overfished threshold = 18,200 mt);

FRACTION is an F_{MSY} proxy (an exploitation fraction = 30%); and

DISTRIBUTION is the distribution of the stock, on average, in USA waters (70%).

MacCall et al.(1985) conducted an analysis for evaluating management options for Pacific mackerel in the early 1980s (pertinent statistics and discussion are also presented in *Amendment 8 to the CPS-FMP*, Appendix B (PFMC 1998). Since the inception of the HCR, the HARVEST term has been defined as a Harvest Guideline (essentially equivalent to an Acceptable Biological Catch (ABC)), but is more akin to an Annual Catch Limit (ACL) in terms of the required statistics stipulated in the 2006 Magnuson-Stevens

Reauthorization Act. The CUTOFF parameter is intended "to provide a buffer of spawning stock biomass that is protected from fishing and available for use in rebuilding if a stock becomes overfished" (PFMC 1998). The FRACTION term has also been referred to as F_{MSY} (i.e., a proxy for the fishing level that produces MSY). However, it is important to note that the F_{MSY} parameter in this regard should not be considered a strict MSY-based term, given it is based on analysis that considered a suite of exploitation rates in combination with a fixed CUTOFF value and alternative models of stock-recruitment (S/R) compensation, with the current $F_{MSY} = 30\%$ based largely on qualitative decisions concerning the 'best' rate for management over a long-term horizon.

The following sections describe important aspects of the simulation that addressed management options for the Pacific mackerel stock (MacCall et al. 1985).

The fishery opened from 1929-69, closed from 1970-76 (due to low estimated abundance), and re-opened in 1977 (due to increased abundance). Fishery harvest was substantially higher during the 1980s and 1990s than during the 2000s. Pacific mackerel population dynamics (biology, distribution, abundance, etc.) are highly variable, which necessarily hinders robust model development, as well as long-term (equilibrium-based) recommendations regarding appropriate exploitation strategies. The temporal pattern of reproductive success was cyclical, with high points in a recruits per spawning biomass trend following a 5-10 yr cycle. The historical relationship between spawners and recruits (S/R) was also highly variable, with strong recruitment years happening rarely, approximately every 50 years or so. The most recent strong recruitment period occurred in the 1970s and early 1980s. Recruitment strength was much less variable when spawning biomass exceeded 100,000 mt.

Abundance (age-specific) estimates using cohort analysis for the time period 1929-84 assumed F to be 0.3-0.5/year and the selectivity (i.e., availability to the fishery) of the oldest (age 4) and plus (age 5) age groups was assumed to be fully and equally available to the fishery (i.e., F -ratio = 1). The *potential productivity* of the stock was investigated via simulations involving alternative S/R models and results generated from the cohort analysis. In other words, simulated average standing stock biomass (SSB) estimates were compared to historical estimates.

The overall simulation preserved the history of reproductive success, and two null models (i.e., 'states of nature') were considered. One assumed constant reproductive success (based on historic reproductive success without modification), and one assumed a constant recruitment (based on historical recruitment estimates used without modification). Other elements of the simulations included:

- The two extremes provide a reasonable bound for the estimated productivity of the stock;
- Intermediate compensation was represented as a suite of modified Ricker S/R relationships;
- Average harvests were compared over a 40-yr time frame, given the HCR and suite of alternative S/R compensation assumptions; and the comparison ultimately examined the set of harvest formulas consisting of various FRACTIONS, given a CUTOFF = 18,144 mt;
- The average annual yields were consistent between FRACTIONS from 0.2 to 0.25 (however, see additional sensitivity analysis below);
- The influence of different assumed models of compensation (S/R) was minimal;

Sensitivity analysis considered HARVEST in concert with varying CUTOFFs and FRACTIONS, and included the following elements:

- Estimated HARVEST (via yield isopleths) indicated higher CUTOFFs required higher FRACTIONS to maximize yield;
- Standard deviation of estimated HARVEST increased with larger FRACTIONS, but nearly independent of the range of CUTOFFs considered;
- Resource 'collapse' was not associated with positive CUTOFFs, which inherently protected the stock's ability to rebound from low abundance levels;
- FRACTIONS between 0.2 to 0.3 were the most robust in terms of similarities in estimated simulated SSB and the historical average;

Examination of the management strategy required consideration of *both* interacting components of the policy (the HCR and the abundance estimates used to implement it).

- In terms of the CUTOFF, "there is little reason to change the present *cutoff* level of 18,144 mt (i.e., currently, 18,200 mt is used), given this level provides sufficient protection from severe depletion while allowing a fishery in nearly all years";
- In terms of the FRACTION, "it is more amenable to change, given the simulations indicated that a higher *fraction* is likely to increase average yield up to a maximum of about 29,000 mt/yr at a *fraction* of 0.28";
- In terms of a harvest policy adopted in other fisheries globally, such as $F_{0.1}$ (as the proxy for F_{MSY}), would translate to a $FRACTION_{0.1} = 0.24$;
- In terms of bottom-line advice, "the effective *fraction* must be considered to be somewhat larger than the nominal *fraction* wording of the official management policy" (i.e., at that time 0.20).

An HCR has been in place since 1978, with an initial FRACTION of 20%. This initial HCR was not based on extensive fishery analysis, yet provides a perspective for the evaluation of the formula in concert with a range of alternative management measures. Between the late 1980s and early 1990s, the California Department of Fish and Game (CDFG) increased the FRACTION from 0.2 to 0.3 and added the DISTRIBUTION parameter to the overall HCR, i.e., strictly state-based (California) management law transitioned to federal law in the late 1990s.

Based on the above analysis and recent stock assessment efforts, the CPSMT generally supports the current form of the HCR as a reasonable exploitation strategy that provides stable yields to the fishery, while not jeopardizing the long-term sustainability of the stock. However, further deliberations will likely be necessary to ensure consensus is realized as methods/policies are developed to meet the new requirements.

Application of the uncertainty buffer to Pacific mackerel was generally similar to that presented above for Pacific sardine, with the exception that a fixed FRACTION (F_{MSY} proxy) was employed in the HCR (as stipulated in the current FMP for this species) and related uncertainty analysis. Tables 4.3.1-5 and 4.3.1-6 and Figures 4.3.1-6 and 4.3.1-7 are based on the most recent guidance from the Scientific and Statistical Committee (SSC) for addressing scientific uncertainty and stipulations in the MSRA, see SSC 2010. Finally, Table 4.3.1-5 provides a useful summary of catch reductions pertaining to a suite of 'probability of overfishing' (P^*) levels and estimated biomass (B), based on the current HCR for Pacific mackerel, i.e., catch is reduced when the HG (default HCR) is greater than the buffered ABC, otherwise, no reduction in catch is required.

Table 4.3.1-5. Probability of overfishing (P^*) and associated 'buffers' for Pacific mackerel, based on σ -total = 0.411 (SSC 2010).

P^*	Buffer (ABC/OFL)
0.50	1.0000
0.45	0.9497
0.40	0.9011
0.30	0.8061
0.20	0.7076

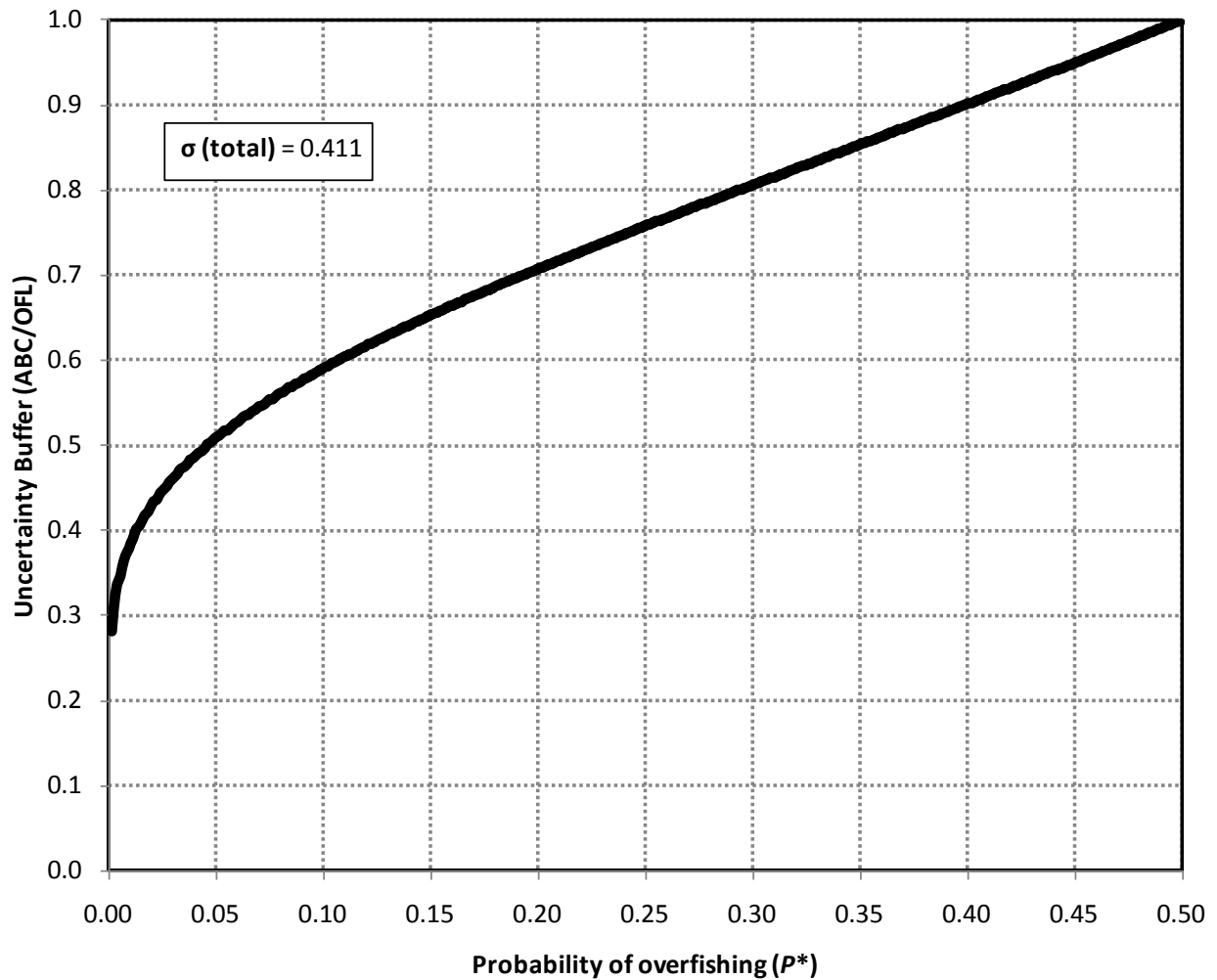


Figure 4.3.1-6. Relationship between Probability of overfishing (P^*) and associated 'buffers' (ABC/OFL) for Pacific mackerel, based on σ -total = 0.411 (SSC 2010).

Catch (OFL/ABC/HG in mt)

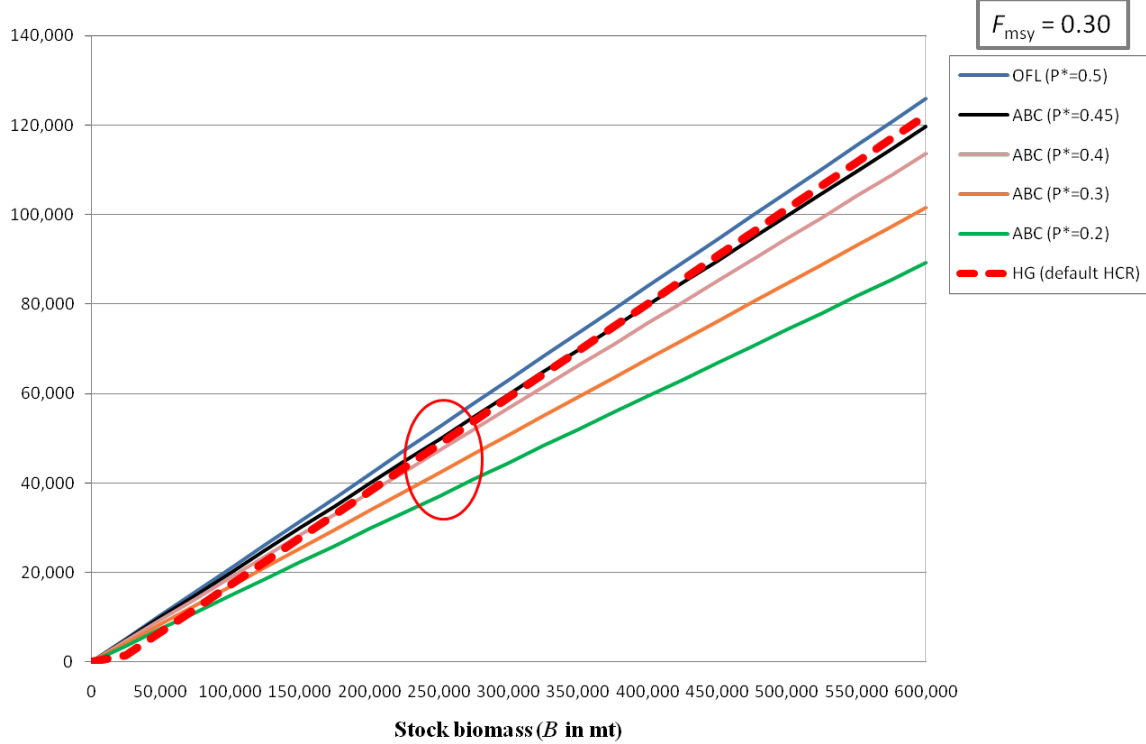


Figure 4.3.1-7. Relationship between stock biomass (B in mt) and catch (OFL, ABC, HG in mt) across a range of probability of overfishing (P^*) levels, based on a FRACTION (F_{MSY} proxy) equal to 0.3. The ACL would be equal to ABC or HG, whichever value is less. Recent estimated biomass (B) is denoted by red oval.

Table 4.3.1-6. Impact of probability of overfishing values (P^*) on Pacific mackerel catch (mt) for different biomass (B) values (also, see Figure 2 above), based on a FRACTION (F_{MSY} proxy) equal to 0.3. Catch reductions occur when the HG is greater than the buffered ABC, otherwise, catch reduction is zero (e.g., for $P^*=0.40$ and $B=300,000$ mt, the catch reduction=2,408 mt). Recent levels of B are presented in bold (200,000 to 300,000 mt).

P^*	B (1,000s mt)				
	100	200	300	400	500
0.50	0	0	0	0	0
0.49	0	0	0	0	0
0.45	0	0	0	406	1,463
0.40	0	331	2,408	4,485	6,561
0.30	250	4,321	8,393	12,464	16,536
0.20	2,319	8,460	14,601	20,741	26,882

Section References

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Jacobson, L. D., and C. J. Thomson. 1989. Evaluation of options for managing northern anchovy--a simulation model. NMFS, SWFSC Admin. Rep. LJ-89-26. 98 p.

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

PFMC. 1983. Northern anchovy fishery management plan (Amendment NO. 5). Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220.

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

PFMC. 1990. Sixth amendment to the northern anchovy fishery management plan. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR, 97220.

Scientific and Statistical Committee (SSC). 2010. An approach to quantifying scientific uncertainty in West Coast stock assessments (March 1, 2010). Working report of the Groundfish & CPS Subcommittees and Scientific and Statistical Committee. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384. 31 p.

4.3.2 MONITORED SPECIES

Alternative 1 – Maintain the default harvest control rules as modified to specify the new management reference points, ACLs would be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

OFL	BIOMASS*F _{MSY} * DISTRIBUTION
ABC	OFL * 0.25
ACL	Equal to ABC or reduced by OY considerations.

The default control rule specified for monitored species reduces the MSY harvest level by 75 percent, in part, to account for the relatively data-poor status of these species. Under this system ACLs are intended more as a decision point for moving the species into an actively managed category than to signal a conservation concern or potential overfishing. Under both of these alternatives, it is presumed that as landings approach the ACL, the CPSMT and the SSC may recommend an elevation of a species to the higher actively managed tier

Alternative 2 – Scientific Uncertainty Buffer – Modify the existing harvest control rules to include a buffer or reduction in ABC relative to OFL to account for scientific uncertainty. This reduction would be in addition to the precautions built into the default control rule. In practice either a BUFFER recommended by the SSC could be added to the ABC control rule as shown below, or a

greater than 75 percent reduction from OFL could be instituted. ACLs would be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

OFL	BIOMASS* F_{MSY} * DISTRIBUTION
ABC	OFL * 0.25 * BUFFER
ACL	Equal to ABC or reduced by OY considerations.

The SSC's CPS Subcommittee has preliminarily reviewed the management approach listed under Alternative 1 above. There are concerns regarding the dated nature of the assessment used to estimate both biomass and F_{MSY} . The full SSC will review these two alternative approaches and may recommend additional analyses to further inform a decision on management reference points for monitored stocks to prevent overfishing. The degree to which these species are targeted and the magnitude of recent landings should be considered when investing limited financial and human resources to developing and analyzing alternate control rules for monitored stocks.

4.3.2.1 ADDITIONAL CONSIDERATIONS FOR MARKET SQUID

Market squid is a short-lived species, and the relationship between F_{MSY} and stock abundance is poorly understood. Current management establishes a threshold egg escapement of at least 30 percent as a proxy for MSY.

$OFL = F_{MSY} * \text{Biomass (egg esc. Proxy)}$	(PFMC 2002)
$ABC = 245,348 \text{ mt}$	(PFMC 2002)
$ACL/ACT = 107,049 \text{ mt}$	(CDFG 2005)

Although an ACL is not required for market squid, the California Department of Fish and Game implements an annual landings cap on the fishery. This cap is intended as an accountability measure and approaching or exceeding this harvest level could trigger the elevation of this species to the actively managed category.

Additional accountability measures currently in place for market squid include:

1. Temporal closures (weekend closures);
2. Spatial closures (marine protected areas, which include Channel Islands MPAs and new and proposed MPAs under the California Marine Life Protection Act);
3. Gear closures (i.e., Santa Monica Bay, leeward side of Catalina, lighting restrictions in Gulf of the Farallones Marine Sanctuary);
4. Gear restrictions for light shields and wattage limits;
5. Continued monitoring programs used to evaluate the impact of the fishery on the resource;
6. Restricted access program designed to limit fleet participation in order to maintain a moderately productive and specialized fleet; and
7. State management framework (Marine Life Management Act), which provides specific guidelines for making management decisions.

Other constraints that protect squid from overfishing include:

8. The population is utilized for commercial purposes within a fraction of the geographic range;

9. Fishing occurs within a limited portion of the depth range; and
10. Fishing pressure does not usually shift from traditional fishing areas to new areas when there is a decrease in availability of squid.

Section References

CDFG. 2005. Market Squid Fishery Management Plan. March 25, 2005.

PFMC 2002. Coastal Pelagic Species Fishery Management Plan. Limited Entry

4.3.3 SECTOR-SPECIFIC ANNUAL CATCH LIMITS

Alternative 1, No Action Alternative – No sector-specific ACLs.

The Council has practiced the setting aside a portion of the overall Pacific sardine HG ? for “sector-like” segments of the directed fisheries (i.e. incidental fisheries and EFP research). EFP set-asides have traditionally been “taken off the top” or deducted from the overall harvest guideline before distributing harvest across the seasonal allocation schedule of Amendment 11. Incidental fishery set-asides are often established for each allocation period under Amendment 11 in response to the seasonal availability of other CPS. These set-asides are deducted from harvest otherwise allocated to the directed fishery. The Council often adopts preseason accountability measures that rollover set-aside overages and deficits where appropriate to maximize the utilization of harvestable surplus while preventing overfishing. Because of the interrelation of these set-asides to the directed fishery in some years and because these portions of the fisheries do not operate as distinct sectors, the Council may choose to forego sector-specific ACLs.

Alternative 2 - Assign a sector-specific ACL to EFP research activities.

The use of EFPs in Council managed CPS fisheries has increased in recent years and the CPS industry is increasingly involved in CPS research and is seeking further cooperative research activities in the future. Although existing EFPs have been accounted for through the setting aside of a portion of the directed fishery HG, future EFP proposals may not fit this model well and the Council may choose to consider a sector-specific ACL for EFP activity.

Alternative 3 – Assign a sector-specific ACL for the live bait fishery.

The overall take from this fishery is a small proportion of the total commercial landings of Pacific sardine. Therefore, the use of AMs as a means of including this fishery in the total catch is reasonable and is explored in the next section. However, this low volume high value fishery is important to the California commercial passenger fishing vessel and recreational fishery sectors and under the current FMP this fishery remains open after the directed commercial fishery is closed. The Council may consider further analysis of using sector-specific ACLs for this fishery as a means of preserving the regulatory framework that allows this fishery to operate outside the directed fishery. Additionally, this fishery is not monitored inseason to the degree that the directed fishery is managed and impacts are estimated postseason via logbook data. This alternative would allow the Council to further prevent overfishing or a fishery closure by considering an ACT for this sector that is commensurate with its lower tier of monitoring.

Alternative 4 – Add sector-specific ACLs to the FMP framework as a management tool and assess their applicability on an annual basis.

This alternative would provide the Council with maximum flexibility to respond to the varying annual needs of CPS fisheries and the cyclic nature of CPS population levels. CPS fisheries experience changes in target species, incidental species, and live bait species between seasons and years in response to population fluctuations, markets, oceanographic conditions, etc. This alternative would allow the Council to consider sector-specific ACLs on an annual basis which is in keeping with current management practices and the NS1 guidelines. The intent of this alternative would be to prevent overfishing regardless of the mechanism chosen (sector-specific ACL, AMs, or ACTs, or a combination thereof).

4.4 ANNUAL CATCH TARGET AND ACCOUNTABILITY MEASURE CONSIDERATIONS

Alternative 1, No Action Alternative – No ACTs.

Recent CPS management strategies have proactively attempted to prevent overfishing while preserving harvest opportunities for exploitable stocks. The Council has a history of accounting for management uncertainty and has set aside a portion of the directed harvest to cover incidental landings of a limiting CPS stock in pursuit of a harvestable CPS stock and to forego lost opportunity associated with the closing of all fisheries to the retention of a particular species.

Alternative 2 – Develop ACTs only for actively managed stocks.

Alternative 2 best matches the current management regime and is more likely to minimize the chance of exceeding the ACL than Alternative 1. Framework language in the FMP would generally describe methods for assessing management uncertainty and total catch accounting and specific amounts for these AMs could be developed, reviewed, and approved on an annual basis when the Council adopts annual fishery specifications for actively managed stocks.

Alternative 3 – Develop ACTs for actively managed and monitored stocks.

Developing ACTs is optional for all stocks and, unlike the actively managed species, this approach has not been applied to monitored species. The CPSMT discussed the potential benefits to establishing early trigger points or ACTs for monitored species that could act as an early indicator of increasing harvest. There is no requirement to take management actions if an ACT is exceeded, this approach would simply provide an opportunity for advanced planning if a monitored stock is a candidate for active management. However, the Council and the CPSMT monitor CPS fisheries closely and can elevate a species to active management in response under the current FMP. Should harvest of a monitored stock exceed its ACL in more than one of four years, the Council would be required to address the situation with additional AMs and may consider moving the stock to the actively managed category.

5.0 AMENDMENT SCHEDULE

The implementation of Amendment 13 and the promulgation of associated fishery regulations are targeted for the 2011 fishing year. The Council is scheduled to review a range of amendment alternatives and adopt a preliminary preferred alternative at its March 2010 meeting. Final Council action is scheduled for the June 2010 Council meeting to allow for full implementation by 2011.

Table 5.0-1 Proposed Timeline for CPS FMP Amendment 13

Stage	Date
Council Announces Scoping –Initiates FMP Amendments	March 2009
Potential alternatives for draft FMP Amendment	November 2009
Adopt Preliminary Preferred Alternative for Public Review	March 2010
Final Council Action	June 2010
Proposed and Final Rulemaking	Late 2010
Secretarial Approval	Late 2010
Council adoption of harvest specifications and management measures under Amendment 13 for Pacific sardine and monitored species. Pacific mackerel management is offset six months and would be adopted by the Council in June 2011.	November 2010 Council meeting
Changes in Existing Fishing Regulations	2011